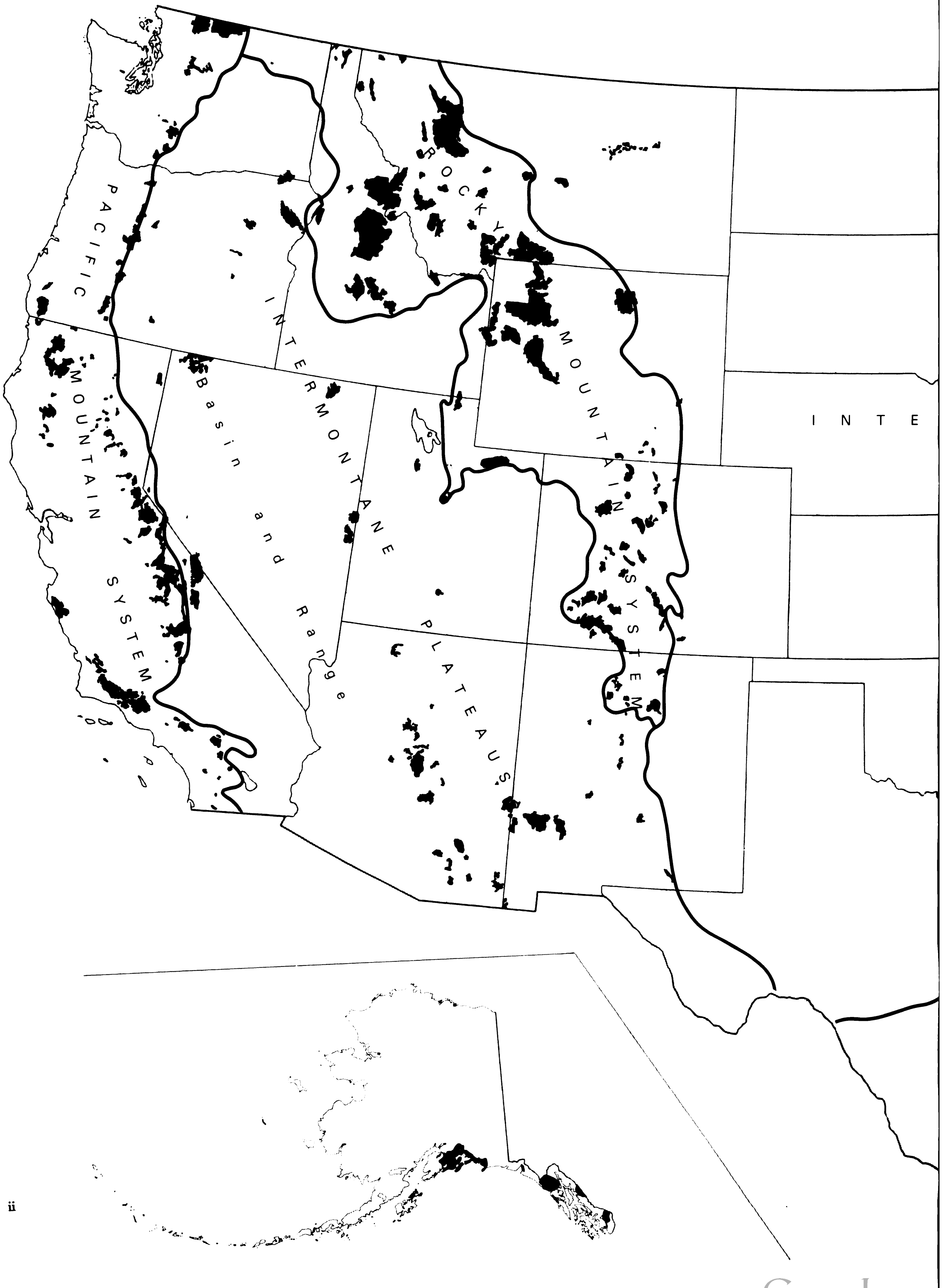
WILDERNESS MINERAL POTENTIAL

ASSESSMENT OF MINERAL–RESOURCE POTENTIAL IN U.S. FOREST SERVICE LANDS STUDIED 1964–1984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ROCKY MOUNTAIN SYSTEM
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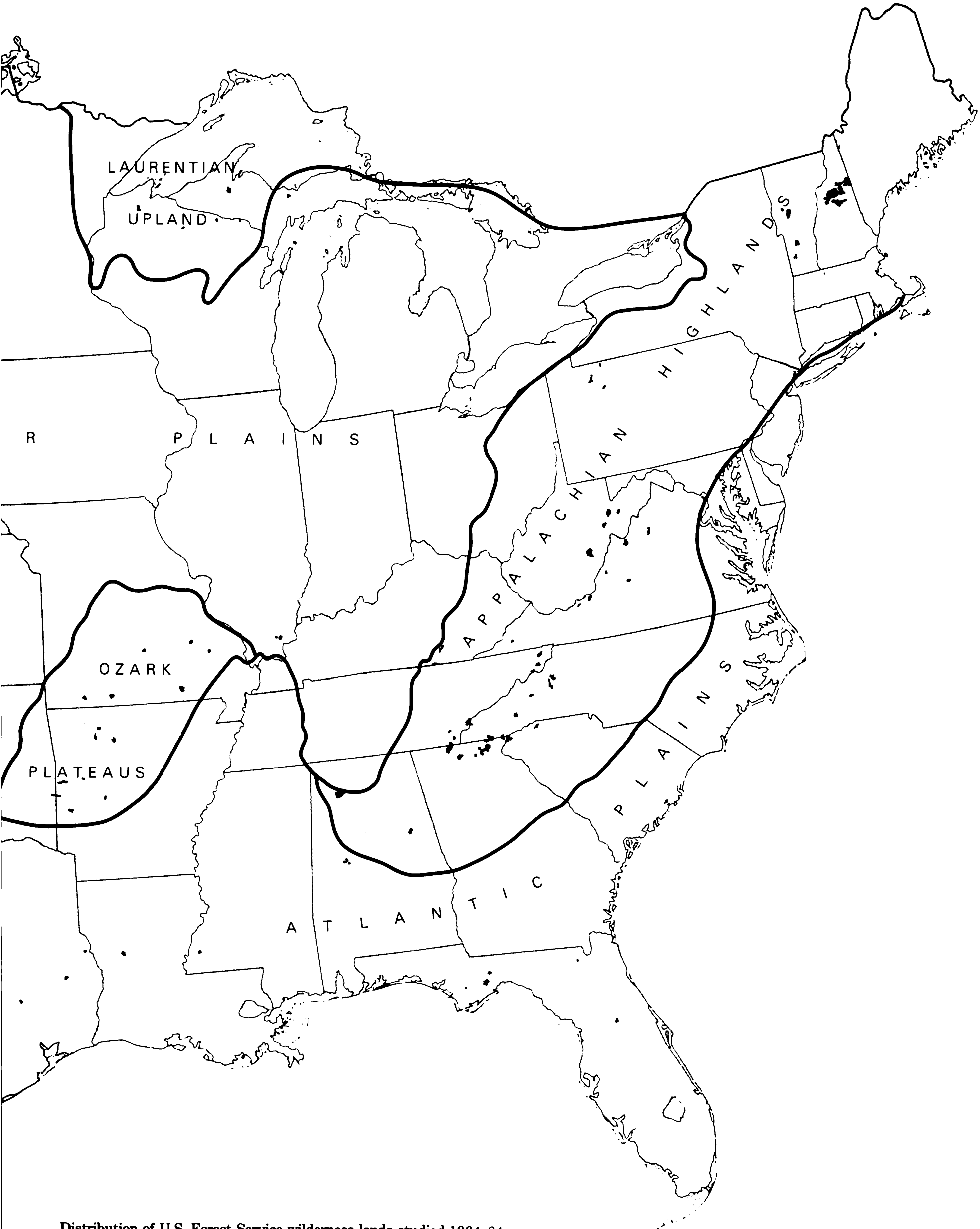

Distribution of U.S. Forest Service wilderness lands studied 1964-84.

Cover design by Arthur Isom.

Diagrammatic east-west cross section of the United States.

WILDERNESS MINERAL POTENTIAL

Assessment of Mineral-Resource Potential in U.S. Forest Service Lands Studied 1964–1984

Edited by S. P. MARSH, S. J. KROPSCHOT, *and* R. G. DICKINSON

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Dallas L. Peck, *Director*

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FOREWORD

For nearly three decades our Nation has been debating how the national domain should be used. This has led to much study of the resources of the land, especially renewable resources such as timber and wildlife, and nonrenewable resources such as minerals and mineral fuels. This book contains information on the mineral resources of part of the public lands.

Provided here are summaries of the mineral resources of many present and potential wilderness areas primarily in the national forest lands. The summaries—which cover about 45 million acres distributed over nearly 800 areas—are distillations of longer, more technical reports prepared during the last 20 years by geologists and mining engineers of the U.S. Geological Survey and the U.S. Bureau of Mines. This work was required by the Wilderness Act of 1964 (Public Law 88-577) and a number of subsequent acts.

The mineral endowment of the Nation is the sum of the deposits that have been discovered and the deposits that have not been discovered. Earth science in its present state of development can deal more precisely with discovered deposits than with undiscovered deposits, although it is by no means powerless in dealing with the latter. Deposits that have already been discovered are generally discussed in terms of tons of reserves and resources and estimates of grades of specific commodities. Undiscovered deposits are generally considered from the point of view of favorable ground assessments—the demarkation of land areas favorable for the occurrence of minerals accompanied by a listing of the types of minerals that are expected to occur in them.

One point about our studies needs emphasis. Resource assessments are influenced by the eras in which they are prepared. They reflect the economic circumstances of the time and a variety of considerations linked to them; they reflect the state of development of the earth sciences as they pertain to detecting concealed deposits; they reflect the needs of the audience for which they are prepared; and they reflect the inherent limitations of manpower, time, and budget. It follows that more refined and penetrating resource assessments will be made in the future, especially in the domain of undiscovered deposits.

These reservations notwithstanding, it should also be emphasized that the resource assessments presented here are in advance of any executed on comparable tracts and acreage anywhere in the World. In our 20 years of wilderness surveys we have broken much new scientific ground in understanding the geological structure and mineral endowment of the United States and in improving the methodologies of resource assessment. Because the methods developed appear to be reliable and applicable to all the public lands, when they are carried forward, they will furnish a practical assessment of the mineral value of the national domain.

Dallas L. Peck
Director, Geological Survey

Robert C. Horton
Director, Bureau of Mines

PREFACE

The work on these volumes began in February 1982, but in a broader sense the production began nearly 20 years ago with passage of the Wilderness Act of 1964 that required the Geological Survey and the Bureau of Mines to conduct mineral surveys of Forest Service lands. This two-volume professional paper consists of summaries of the results of those mineral surveys and represents about 1,000 man-years of effort by professionals in the two agencies. Since the program began in 1964, the amount of land to be studied has increased from the original 14.8 million acres to 45 million acres, of which about 14 million acres have been added since 1979.

In February 1982, we began identifying the areas that should be included in this professional paper. The names and approximate boundaries of about 800 areas included in these 332 summaries are usually the same as they were at the time the work was done, but may differ somewhat from the current boundaries of the lands. These discrepancies are the result of revisions in boundaries and changes in names by legislative and executive acts during the 20 years of the program. After we had identified the areas that were to be included in these volumes, definitions of resources and resource potential for all metallic, nonmetallic, and energy minerals and a standardized outline for writing these summaries were determined. Resource and resource potential terminologies have changed during the last 20 years and differences may be seen from other published works. Techniques used for resource assessment have also evolved; those used in the early years of the program often are not those in use today. The summaries in these volumes reflect this evolution of methodology, as well as development of more advanced concepts about the assessment of mineral-resource potential. With all these differences, the use of a single set of definitions allows for comparison of resource potential described in work done within the 20-year framework of the wilderness program, including work that was not quite completed when this professional paper was being prepared.

The summaries in these volumes, which have been organized alphabetically by State, include a description of the character and geologic setting, a discussion of the resource potential, and a reference list of selected material published as part of the wilderness program. Many of the summaries include suggestions for further study. Our hope is that these summaries, designed to provide a quick overview of a 20-year program, will be of use to concerned individuals as well as to those legislators and administrators who must make difficult and critical land-use decisions that will affect our nation now and in the future.

From the inception of this project, the support and assistance of a large number of colleagues and administrators in the Geological Survey and Bureau of Mines have made it possible for us to collect, edit, and present these summaries. Special acknowledgment and appreciation are extended to those colleagues who reviewed the papers in these volumes; they are C.S. Bromfield, L. C. Craig*, R. E. Erickson, G. H. Goudarzi, M. E. MacLachlan, W. P. Pratt, P. K. Sims, V. E. Swanson, and R. B. Taylor, of the Geological Survey, and L. W. Gibbs of the Bureau of Mines. In addition, we wish to acknowledge the contributions of E. J. Swibas, who with the assistance of W. J. Gerstel and V. H. Sable, coordinated the preparation of the illustrations; and J.E.H. Taylor, who coordinated the typing and telecommunication of the text. The generous assistance of D. C. Schnabel was invaluable in speeding these volumes to completion. Finally, we appreciate the support, guidance, and advice of members of the Branch of Central Technical Reports and the Office of Scientific Publications of the Geological Survey during all phases of this project.

Sherman P. Marsh
Susan J. Kropschot
Robert G. Dickinson

*Deceased.

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INTRODUCTION

By Donald A. Brobst and Gus H. Goudarzi

PURPOSE

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and subsequent related legislation, the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) have been conducting mineral surveys of wilderness and primitive areas, and of other national forest lands being considered for wilderness designation. The Wilderness Act directs that the results of these surveys are to be made available to the public and are to be submitted to the President and the Congress. This professional paper is a synopsis of the mineral surveys made from 1965 to 1983. It summarizes our current knowledge of mineral and energy resources and of the potential for the occurrence of undiscovered mineral and energy resources in 45 million acres of Federal lands, chiefly in national forests.

This book, in two volumes, consists of 332 summary articles, arranged alphabetically by State, in which the mineral-resource potential of about 800 individual areas is discussed. The summaries of the mineral surveys were written during 1982-83, generally by those who made the surveys. Index maps of each state show the location of the areas studied, numerically keyed to an alphabetic list. The national distribution of the wilderness lands studied is shown on the frontispiece. Where lands were in proximity or were added to expand previously designated areas, they often are described in a single article.

Each article begins with a short summary of the results of the mineral survey followed by a discussion of the character and geologic setting of the area. Mineral resources (if any) are discussed, and the potential for undiscovered mineral resources is assessed; these are keyed to the generalized geographic and geologic map of each area. Areas that have geologic characteristics indicative of different degrees of potential for the occurrence of mineral resources are shown in shades of red on each map. Some articles have a section on suggestions for further study to better define the mineral-resource potential of the area. A list of pertinent references (including many of the maps and reports prepared during the mineral survey) is provided at the end of each article.

This introduction contains some basic concepts about mineral resources and mineral-resource potential to try to make the book more useful to those who are not familiar with the fields of earth science and mineral-resource assessments. The legislation dealing with the wilderness program is reviewed briefly, because this evolving legislation has imparted a continuing and changing influence on the mineral-resource surveys. The introduction concludes with a description of the publications of the Geological Survey that report in greater detail the results of the joint wilderness studies by the Geological Survey and the Bureau of Mines.

REASONS FOR ASSESSING WILDERNESS MINERAL POTENTIAL

Minerals can be subdivided into metallic, nonmetallic, and energy (including uranium, fossil fuels, and geothermal waters) and these resources often are referred to as commodities. They are vital to our everyday lives. Nobody passes through a single day without using materials that have been made from, processed by, fertilized with, or are in some other way affected by products from mineral resources. Our highly productive agriculture has been made possible by extensive mechanization and efficient use of fuel, fertilizer, and soil conditioners. Most of our foods come from fields that are treated with phosphate and potash mineral fertilizers or with nitrogen-based fertilizers made from natural gas. Our food is cooked in metal pots (recovered from minerals) and is served on chinaware (made from clay minerals). Energy for cooking and baking comes from mineral fuels (gas or petroleum products) or from electricity produced from coal, oil, gas, or uranium in plants using generators made of metal. Even solar energy is collected and distributed by equipment made from metals and petroleum. Buildings, other than those made of wood, consist chiefly of processed materials of mineral origin—brick, concrete, glass, rock wool, insulation, ceramics, tile, metal fixtures, and plasterboard. Plastic products, which are pervasive in our society, are derived from oil, natural gas, or coal. We travel in vehicles made of metal and plastics and powered by mineral fuels.

Silver is used in the film for our cameras, and several rare metals (such as europium in color television picture tubes) are essential to electronic equipment.

Mineral resources are the foundation of our national economy, which now generates a gross national product (GNP) of slightly more than $3 trillion annually. The role of nonfuel minerals in the United States economy in 1982 is shown in figure 1. The value of domestically produced mineral raw materials (excluding fuels) was about $20 billion and the value of imported mineral raw materials was about $4 billion. On the basis of 1981 U.S. Department of Energy estimates, domestically produced fuels had a value of $178 billion and imported fuels, mostly oil and gas, had a value of $70 billion. The value of all the minerals (including fuel) represents an indispensable part of the GNP, about 10 percent.

The major metallic commodities produced in the United States in 1982, ranked by dollar value, are shown in table 1. Our reliance on imports, shown in this table as a percentage of domestic primary consumption, varies greatly from commodity to commodity because of some combination of geologic availability and economic conditions, such as price, demand, and cost of production. For example, although the United States has sufficient iron ore to increase production, the current economic conditions and those of the recent past make importing ore less costly. For bauxite, an ore of aluminum, the circumstances are quite different. Domestic deposits are small and their geologic nature make it unlikely that any new large deposits of bauxite will be found in the United States. Molybdenum, an element essential for alloying special types of steel, is abundant in the United States; our Western States supply nearly 65 percent of the world's production.

The domestic production of major nonmetallic mineral commodities in 1982, ranked by dollar value, is shown in table 2. The net import reliance, shown as a percentage of domestic primary consumption, is controlled by geologic and economic factors. The United States has large resources of phosphate rock, borates, and sodium carbonate, and is a leading producer and exporter of these nonmetallic minerals. Construction

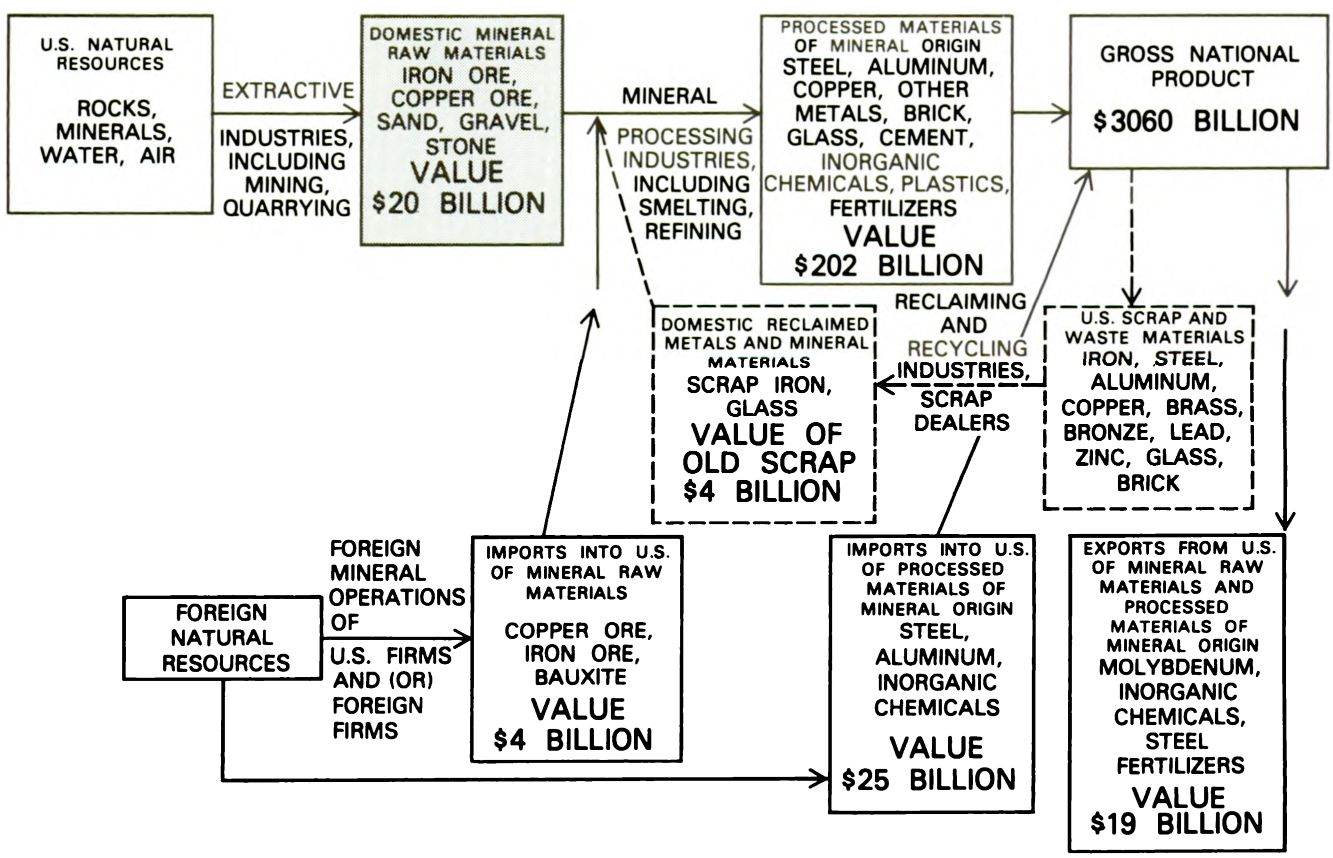

Figure 1.—The role of nonfuel minerals in the United States economy for the first 8 months of 1982. Statistical data from U.S. Department of Commerce.

TABLE 1.—*Domestic production of major metallic mineral commodities in 1982*

[Data from the U.S. Bureau of Mines]

Metallic mineral commodity	Estimated production (metric tons)	Estimated value (million dollars)	Estimated net import reliance (in percent) of domestic primary consumption
Copper ------	1,100,000	1,800	7
Iron ore -----	[1]35,900,000	1,500	36
Molybdenum -	36,500	362	Net export.
Lead --------	510,000	292	1
Silver -------	1,120	286	59
Zinc --------	300,000	255	53
Vanadium ---	[1]4,260	55	14
Tungsten ----	1,450	20	48
Bauxite -----	700,000	17	97
Mercury -----	860	[2]10	43
Platinum ---- group metals.	.19	1	85

[1]Preliminary estimate.
[2]Value calculated is based on an average price of $390 per flask.

materials (cement, crushed stone, and sand and gravel), are mined or produced close to where they are used because of their bulk, weight, and resulting high cost of transport.

With few exceptions, most minerals are consumed in use. Mineral commodities either are committed to an irretrievable use in a permanent structure (for example, sand, gravel, crushed rock, cement, glass, and steel and other metals used in roads and buildings); are converted into a useful product from which they cannot be reclaimed (chemicals, paints, plastics); or are converted chemically to products that are dispersed into the ground or into the atmosphere (fertilizers and fossil fuels). Although some metals, including aluminum, antimony, copper, lead, gold, iron, and silver, can be recovered by recycling and provide a substantial part of domestic consumption, a steady source of mineral raw materials, available in limited supply, is essential to maintain our present standard of living.

Concentrations of useful minerals rich enough to form ore deposits are rare phenomena. Commercially extractable concentrations form only where special physical and chemical conditions have favored their accumulation. Certain types of mineral deposits are associated with certain geologic environments as characterized by the type of rocks and structures, depth of formation, and source and nature of mineralizing fluids. For example, throughout the world many major deposits of copper, lead, zinc, silver, and gold are associated with granitic igneous rocks such as those found in the Western United States and in Western South America. Chromium deposits commonly are associated with other kinds of igneous rock; although these deposits are rare in North America, they are abundant in southern Africa. Large deposits of bauxite occur in deeply weathered rocks formed in tropical climates. Many of the world's largest deposits of lead and zinc are associated with limestone strata, like those of southeastern Missouri. The organic fuels—oil, gas, and coal—are formed from materials deposited in specific sedimentary environments. Field and laboratory observations and studies provide information about where and why minerals accumulate. Studies formulating the theoretical basis for resource accumulation have provided for the understanding of some of the many types of geologic environments that offer potential for the occurrence of mineral deposits (Brobst and Pratt, 1973). As a result of these studies, criteria have been established that define geologic, geochemical, and geophysical properties of these deposits (which may be referred to as modeling); that is, a comparison of data with known occurrences.

Just as not every haystack has a needle, not every favorable geologic environment has a mineral deposit of economic value. For example, of every 1000 mineral prospects examined in Canada in 1969, only one was favorable for mine development (Roscoe, 1971).

As might be expected from the wide geographic distribution of the wilderness lands (see frontispiece), these lands contain rocks formed in a great variety of geologic environments. Many of these environments are favorable for the occurrence of mineral resources and many kinds of resources may be present. As the authors of the Wilderness Act of 1964 realized, prudent use of land requires knowledge of its resources, including water, timber, wildlife, and recreational assets as well as minerals. In recognition of the importance of metallic, nonmetallic, and energy mineral resources to the economy, the Congress specifically required that these resources be surveyed on land in, or being considered for,

TABLE 2.—*Domestic production of major nonmetallic mineral commodities in 1982*

[Data from the U.S. Bureau of Mines]

Nonmetallic mineral commodity	Estimated production (thousand metric tons)	Estimated value (million dollars)	Estimated net import reliance (in percent) of domestic primary consumption
Cement ----------	57,500	3,260	4
Crushed stone -----	717,000	2,920	0
Sand and gravel ----	568,000	2,020	Net export.
Sulfur -----------	9,800	980	4
Phosphate rock ----	37,400	950	Net export.
Clays ------------	32,200	830	Net export.
Sodium carbonate --	7,090	721	Net export.
Lime ------------	12,800	700	2
Salt -------------	34,050	673	11
Boron (boria ------- B_2O_3).	550	385	Net export.

inclusion in the National Wilderness System, in order to aid those who must make decisions about land use.

THE NATURE OF MINERAL-RESOURCE ASSESSMENTS

The term "mineral resource" refers to a concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such a form and amount that economic extraction is currently or potentially feasible. The assessment of mineral resources in a designated area requires both the estimation of the amount and grade of identified resources and the assessment of the potential for the presence of as yet undiscovered mineral resources. Identified resources are specific bodies of mineralized rock whose location, quality, and quantity have been measured. The likelihood of the presence of undiscovered mineral resources is determined from earth science information and is presented as a statement of mineral-resource potential.

The major difficulty in making assessments of mineral-resource potential is the need to describe and quantify an unknown that can be neither seen nor measured. At present, the best approach to assessment is to collect all available data on an area, to synthesize and integrate this data using geologic theories, and to compare all this with similar data from areas that have identified mineral deposits. This process of comparison, combined with experience and judgement, enables the earth scientist to reason the likelihood and types of deposits that might occur in an area.

CLASSIFICATION OF MINERAL RESOURCES AND MINERAL-RESOURCE POTENTIAL

If a body of rock containing concentrations of useful minerals is exposed at the Earth's surface or has been penetrated by drill holes, it can be sampled and its dimensions measured. The samples can be analyzed, and the size of the body can be calculated. The result is a quantitative measurement or estimate of the amount of mineral-bearing rock that is known to occur, and the quantities of metals, nonmetals, or mineral fuels that it contains. Most of the resource assessments in these volumes are for study areas in which mineralized rocks are not exposed or are only partly exposed at the surface and have not been penetrated by drill holes. Assessments of resources in these areas are qualitative rather than quantitative. Of equal importance is the assessment of the likelihood that mineral or energy resources may or may not occur in the area. Mineral-resource potential is the characteristic attributed to a geologic terrane that suggests the possible presence of mineral resources—metallic, nonmetallic, or energy. For consistency in these volumes only, therefore, the following terms and definitions were established so that uniform terminology would be used in these summaries of the many reports produced through two decades by many individuals.

1. Areas that have **substantiated** mineral-resource potential are shown in red on the maps. The term "substantiated" is based on a record of past production or the occurrence of identified resources, and (or) on an assemblage of geologic data that strongly indicate the presence of undiscovered mineral resources.

2. Areas that have **probable** mineral-resource potential are shown in pink on the maps. The term "probable" is based on an assemblage of data that support the interpretation that undiscovered mineral resources may be present. In some areas, probable and substantiated mineral-resource potential overlap. In these areas, a darker shade of red is used.

3. Where data could be obtained, the resources at mines, deposits, or quarries are specified by tonnage and grade (concentration of the desired material or materials per unit of measure, commonly expressed in such terms as percent, ounces per ton, grams per metric ton, or barrels per acre). Where a mineral resource is defined in terms of tonnage and grade, it is referred to as "identified," "demonstrated," and (or) "inferred" using the following definitions of the U.S. Bureau of Mines and the U.S. Geological Survey (1980, p. 2).

> **Identified resources** are those whose location, grade, quality, and quantity are known or estimated from specific geologic evidence.
>
> **Demonstrated resources** is a term for the sum of measured and indicated resources whose quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes and whose grade and (or) quality are computed from the results of detailed sampling.
>
> **Inferred resources** is a term for resource estimates that are based on assumed continuity beyond those of the measured and (or) indicated categories for which there is geologic evidence that might or might not be supported by samples or measurements.

Mines, quarries, or deposits of limited extent for which demonstrated or inferred resources are reported in the text are shown on the maps by a red mine symbol. Mines discussed in the text but for which no quantity of demonstrated or inferred resources can be reported are shown by a black mine symbol. Mineral occurrences for which no quantity of demonstrated or inferred resources is reported are shown by a black "X".

Subdivisions in use by the U. S. Geological Survey					Age estimates[1] of boundaries in million years (m.y.)	
Phanerozoic Eon	Cenozoic Era	Quaternary Period		Holocene Epoch	0.010	
				Pleistocene Epoch	2	(1.7-2.2)
		Tertiary Period	Neogene Subperiod	Pliocene Epoch	5	(4.9-5.3)
				Miocene Epoch	24	(23-26)
			Paleogene Subperiod	Oligocene Epoch	38	(34-38)
				Eocene Epoch	55	(54-56)
				Paleocene Epoch	63	(63-66)
	Mesozoic Era	Cretaceous Period		Late Cretaceous Epoch	96	(95-97)
				Early Cretaceous Epoch	138	(135-141)
		Jurassic Period		Late, Middle, and Early Jurassic Epochs	205	(200-215)
		Triassic Period		Late, Middle, and Early Triassic Epochs	∼240	
	Paleozoic Era	Permian Period		Late and Early Permian Epochs	290	(290-305)
		Carboniferous Periods	Pennsylvanian Period	Late, Middle, and Early Pennsylvanian Epochs	∼330	
			Mississippian Period	Late and Early Mississippian Epochs	360	(360-365)
		Devonian Period		Late, Middle, and Early Devonian Epochs	410	(405-415)
		Silurian Period		Late, Middle, and Early Silurian Epochs	435	(435-440)
		Ordovician Period		Late, Middle, and Early Ordovician Epochs	500	(495-510)
		Cambrian Period		Late, Middle, and Early Cambrian Epochs	∼ 570[2]	
Proterozoic Eon	Late Proterozoic[3] or Proterozoic Z[4]				900	
	Middle Proterozoic[3] or Proterozoic Y[4]				1,600	
	Early Proterozoic[3] or Proterozoic X[4]				2,500	
Archean Eon	Late Archean[3]				3,000	
	Middle Archean[3]				3,400	
	Early Archean[3]				3,800?	

[1] Ranges reflect uncertainties of isotopic and biostratigraphic age assignments. Age of boundaries not closely bracketed by existing data shown by ∼. Decay constants and isotope ratios employed are cited in Steiger and Jäger (1977).

[2] Rocks older than 570 m.y. also called Precambrian, a time term without specific rank.

[3] Geochronometric units

[4] Formerly used time terms

Figure 2.—Geologic time scale, showing major goechronologic units (Geologic Names Committee, U.S. Geological Survey, 1983).

4. For coal resources and coal resource potential, the reporting system was modified slightly. Demonstrated coal resources are estimated separately for coal in beds more than 28 in. thick and for coal in beds between 14 and 28 in. thick. Areas underlain by coal beds more than 28 in. thick are shown on the map in each summary as areas of substantiated coal resource potential. Areas underlain by coal beds between 14 and 28 in. thick are discussed in the text, but are not shown on the map.

5. The remaining areas are those that do not have identified mineral resources and (or) those lacking evidence of mineralization indicative of a potential for the occurrence of mineral resources.

PROCEDURES OF MINERAL-RESOURCE ASSESSMENTS

The staffs of the Geological Survey and the Bureau of Mines collaborated on the many investigations required to assess the mineral resources of the wilderness lands designated by Congress for study. The work involved geologic, geochemical, and geophysical studies by the Geological Survey. The Bureau of Mines sampled and mapped mines and prospects, compiled information on claims, and compiled data from exploration, mining, and production records.

A geologic map was prepared for each area. Data from field observations and measurements, with existing geologic maps as a starting point, were used to compile the map that shows the distribution and structure of the various types of rocks—features that generally control the location of mineral resources. The geologic maps were prepared at scales appropriate to show the information necessary to make the assessment, generally at scales between 1:50,000 and 1:100,000 (1 inch equals 0.8 miles and 1 inch equals 1.6 miles). A geologic time scale, which is a key to the ages of rocks discussed in the summaries, is shown in figure 2. In addition, more detailed geologic studies were made where they were considered necessary to the mineral-resource assessment. These studies included examination of rock sequences that may contain mineral resources; determination of the age and temporal sequence of the emplacement of intrusive rocks; determination of the time and nature of rock deformation and chemical alteration; and examination of hydrothermal (hot water) alteration zones and features that might be related to mineral deposits.

Geochemical surveys were made of most areas as a means of determining patterns of anomalous (unusually high) metal values that might indicate undiscovered mineral deposits. Many kinds of mineral deposits are characterized by suites of elements that can be used to classify deposit types. Geochemical studies are used to identify these suites and to help find and classify the areas that may have resource potential. The sampling and analytical techniques used were designed specifically to identify resource potential in the geologic environment of each particular area. Most geochemical samples were of stream sediments, but samples of rocks, soils, and waters, and of heavy concentrates from stream sediments, were also collected and analyzed in many areas. Mineral deposits that are being eroded impart anomalously high metal values to stream sediments and concentrates. These high values can readily be distinguished from the normal or background values from drainage areas in which no mineral deposits are exposed. Analyses of stream sediments and their heavy-mineral fractions provide information not only about the metals present in mineral and rock fragments, but also about metals adsorbed by clay minerals from surface or ground water.

Geophysical surveys using aeromagnetic, gravity, electromagnetic, and airborne gamma-ray techniques were made in many areas. These techniques provide information about the physical properties of the rocks and their distribution below the surface of the ground, and information that may be indicative of mineral and fuel deposits or of structures that might have controlled resource accumulation.

Studies of mines, prospects, and mining claims included some surveying and geologic mapping, the sampling of specific areas, the analyzing of samples, and the collecting of data on production and reserves on present and past exploration and mining operations. Possible extensions of mineralized structures in existing workings were evaluated and the quantity and grade of resources were determined where possible. Detailed studies included sampling of mineralized areas identified in the geochemical survey; metallurgical tests were made when necessary.

The results of all these studies were then integrated to compile a mineral-resource assessment report that describes the identified resources and outlines areas favorable for the occurrence of mineral resources.

Singer and Mosier (1981) reviewed more than 100 papers on regional mineral-resource assessment and found that of 15 methods of assessment the most widely used was one based on extrapolation from known areas, in which estimates were made directly by one or more individuals on the basis of their knowledge and experience. The extrapolation method has been used in the mineral assessments of wilderness lands because of constraints in time, money, and staff; the problems in dealing with undiscovered resources; and the lack of available subsurface data. The method necessitated that knowledgeable, experienced people be assigned to study the lands in question and to make the assessments.

The extrapolation method applied in the wilderness assessment starts with the synthesis of all available information on the geology, geologic history, and identified mineral and energy resources. The information thus generated sets general limits on the types of mineral deposits that might occur in a given area. The area under investigation could then be compared with areas of known ore deposits, petroleum reservoirs, geothermal fields, or other resources. In such a way can be reasoned the likelihood of the occurrence of resources, and hence the mineral potential of the area under study.

Activity by the mineral industry is one factor that must be considered in the assessment of an area. The presence of known deposits is a favorable attribute for any area, but the absence of known deposits does not necessarily indicate that the area has no mineral-resource potential. Even the lack of evidence of mineral development and exploration may not be a negative sign about mineral-resource potential, especially for remote areas in which high costs discourage activity, or for areas in which newly recognized types of deposits can now be postulated. The studies summarized in these volumes assumed that undiscovered mineral deposits might be present in any area until information indicated that there was little likelihood for the occurrence of resources. Thus, a positive approach was maintained and the resource potential of areas was not reduced merely because adequate data were unavailable.

The credibility of all assessments of mineral-resource potential is a matter of concern. The data available for virtually all wilderness lands are incomplete; subsurface data are lacking. Assessment of mineral-resource potential is by its nature speculative and involves considerable uncertainty. Construction of uniform quantified assessments is currently impossible. Assessing the resources of any mineral commodity on any parcel of land is a continuing process that as yet lacks universally applicable methods (Harris and Agterberg, 1981; Harris and Skinner, 1982). Thus, professional but subjective judgement is important to the assessments summarized in these volumes.

THE NEED FOR CONTINUING ASSESSMENTS

Assessments of mineral-resource potential are of a dynamic nature regardless of how they are conducted, or of the methods that are used. Final, once-and-for-all assessments of mineral-resource potential cannot be made. Areas should be reassessed periodically as new data become available, as new concepts of the factors that influence the concentration of minerals are developed, as new uses and extractive technologies for minerals are devised, and as the world's economy changes. For these reasons, the Congress specified that "recurring mineral surveys" of the wilderness lands should be made.

Geology, technology, and economics are tightly entwined in mineral-resource assessment. Mineral resources have geologic limits and controlling technologic and economic factors that govern their utility (DeYoung and Singer, 1981). This perspective was expressed by Downing and Mackenzie (1979) who favored continuing reevaluation of exploration and development data. They pointed out that geology offers information based on observation and concept, mineral-deposit genesis, and deposit modeling; that technology offers information on extraction methods, beneficiation, smelting, and refining and material use; and that economics offers information on market dynamics, the ability of a deposit or material to compete with other deposits or materials, and the effect of byproducts and coproducts on costs. Thus, the three fields are interrelated, and each has an important bearing on the others; communication between these fields needs to be nurtured and increased.

Man cannot create mineral deposits, but he does create mineral resources as he learns to use the materials of the Earth, or, as Zimmerman (1964) said, "Resources are not, they become." Most regions on the Earth's crust may contain mineral deposits of some possible use if a market for the materials in the deposit should develop. To say that an area has no mineral-resource potential is inadvisable, even though some areas may be classified as having little chance for the occurrence of resources of a particular mineral. Some of the areas that have no identifiable resource potential may contain new types of mineral deposits, recognizable and exploitable only in the future. For example, gold deposits of the Carlin-type (Nevada) in which the gold is too finely disseminated to be visible would not have been recognized prior to 1962; their characteristics were not known. Many common rocks contain small amounts of valuable minerals, but are not considered resources at present because extraction is too costly, or requires too much energy. Technology of the future may change what is now considered common rock into a useful resource if lower cost energy can be made available, a trend not currently seen.

LEGISLATIVE HISTORY OF THE WILDERNESS SURVEYS

The wilderness concept was formalized by the Forest Service, U.S. Department of Agriculture, in 1924 with the designation of the Gila Wilderness in the Gila National Forest in New Mexico. The designated wilderness areas (Wild and Primitive) totalled 88 units, containing 14.6 million acres by 1964.

The Wilderness Act of 1964 designated as wilderness 54 National Forest System areas comprising 9.3 million acres. It also required a study of each of the 34 National Forest primitive areas totaling 5.5 million acres, with a report to Congress by 1974 as to their suitability or nonsuitability for wilderness. Included in the provisions of the Wilderness Act was a requirement for the Secretary of the Interior to direct mineral surveys of suitable areas under his jurisdiction in the National Park and National Wildlife Refuge Systems.

The mineral-resource assessments of Federal lands described in these volumes were made in response to the Wilderness Act, Public Law 88-577, September 3, 1964. The Act specified in Sec. 4(d)(2) that the Geological Survey and the Bureau of Mines shall conduct mineral surveys of wilderness lands on a planned and recurring basis. The law also specified that the wildernesses would remain open to mining access until January 1, 1984, at which time all the areas would be closed to access under existing mining and leasing laws.

The resource assessments of the primitive areas began in 1965 because those areas had to be reported upon by September 1974. By the time the studies of the primitive areas were completed in 1973, many of the boundaries had been revised and 1.6 million acres had been added, an increase in area of about 30 percent.

In 1970, the Forest Service, because of public and congressional interest, began to add new areas as candidates for wilderness designation. By 1973, these parcels, now referred to as study areas, included 3.7 million acres in 53 designated areas.

In October 1973, the Forest Service added 274 more study areas in a program sometimes referred to as RARE (Roadless Area Review and Evaluation) that comprised about 12.3 million acres, including 1.9 million acres previously designated for study.

In 1974, interest in establishing some wildernesses in the Eastern States led to a request by the Forest Service for mineral studies in about 600,000 acres in 58 proposed areas in that region. Congress passed the Eastern Wilderness Act (Public Law 93-622) on January 3, 1975, which designated 207,000 acres as wilderness and 125,000 acres of study areas to be examined and reported to the Congress by January 1980.

In 1974, Interior Secretary Rogers C. B. Morton requested a mineral survey of about 7.8 million acres in six areas administered by the Interior Department. These areas included: Glacier Bay National Monument, Alaska; Charles M. Russell Wildlife Refuge, Montana; Charles Sheldon Antelope Range, Sheldon National Antelope Refuge, and Desert Game Range, Nevada; and Kofa Game Range and Cabeza Prieta Game Range, Arizona.

By early 1975, a total of 32.2 million acres of National Forest land had been designated wilderness or wilderness study areas, a designation that necessitated management according to wilderness standards, and that also required mineral surveys.

The second Roadless Area Review and Evaluation (RARE II) was begun in June 1977. It identified 2,920 roadless areas encompassing 62 million acres in National Forest and National Grasslands. The administration released the results of the study on April 16, 1979, and recommended that 36 million acres be assigned to nonwilderness, that 15.4 million acres be assigned to wilderness, and that decisions on 10.6 million additional acres be deferred for further planning for all options. The status of lands in the "further planning" category was to be decided by 1985 through the regular land-management planning process by the Forest Service.

In 1980, the 96th Congress established several wildernesses and wilderness study areas in New Mexico, Idaho, Alaska, Colorado, South Carolina, Missouri, Louisiana, and South Dakota. Mineral surveys were required in wilderness study areas (totaling 2.7 million acres) within 3 years of the passage of these "State" bills. The rapid increase in the amount of land that required mineral surveys is shown on figure 3.

The legislative acts, with their dates, that are pertinent to the evolution of the wilderness system can be obtained from the U.S. Forest Service. The legislative history and the texts of all the acts are available for inspection at the Library of Congress in Washington, D.C.

WILDERNESS PROGRAM PUBLICATIONS

Many of the results of mineral-resource assessments have been published as U.S. Geological Survey Bulletins. Some information was released as Open-File Reports to meet legislative and adminstrative requirements, and some were republished as more complete, formal reports. In 1979, a new publication format was introduced that uses maps for presentation of most data. The joint report on mineral-resource potential by the Geological Survey and the Bureau of Mines is a map with a marginal text and an accompanying pamphlet, in the U.S. Geological Survey Miscellaneous Field Studies Map (MF) series. The mineral-resource potential report summarizes the information that led to the conclusions and outlines the areas of mineral-resource potential of each area. Other maps in the MF series on each area generally include the following: (1) a geologic map with a marginal text; (2) geochemical maps showing distribu-

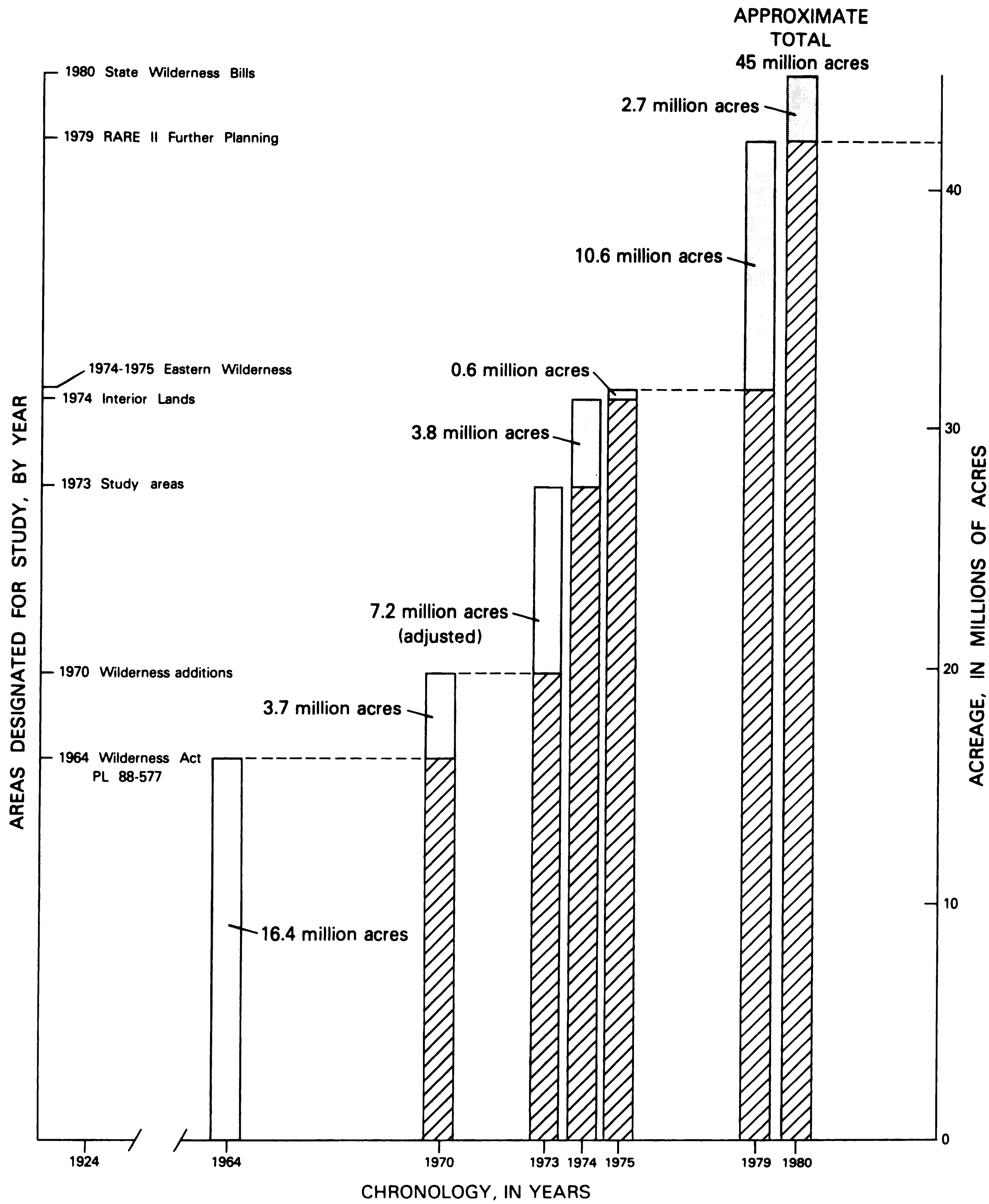

Figure 3.—Graph showing cumulative acreage of Federal lands designated for mineral surveys, 1965–1983.

tion of analytical values and anomalous areas for one or more chemical elements, with a marginal text; (3) geophysical maps showing various kinds of data and marginal notes of explanation; and (4) mine, prospect, claim, and sample-site maps with explanatory text prepared by the Bureau of Mines.

Much of the raw geochemical and geophysical data supporting the resource assessment have been released as Open-File Reports by the Geological Survey. Much of the Bureau of Mines data have been released as Open-File Reports; these are available at their field centers and in Washington, D.C. Both the Geological Survey and the Bureau of Mines announce the release of their respective Open-File Reports in their monthly list of publications.

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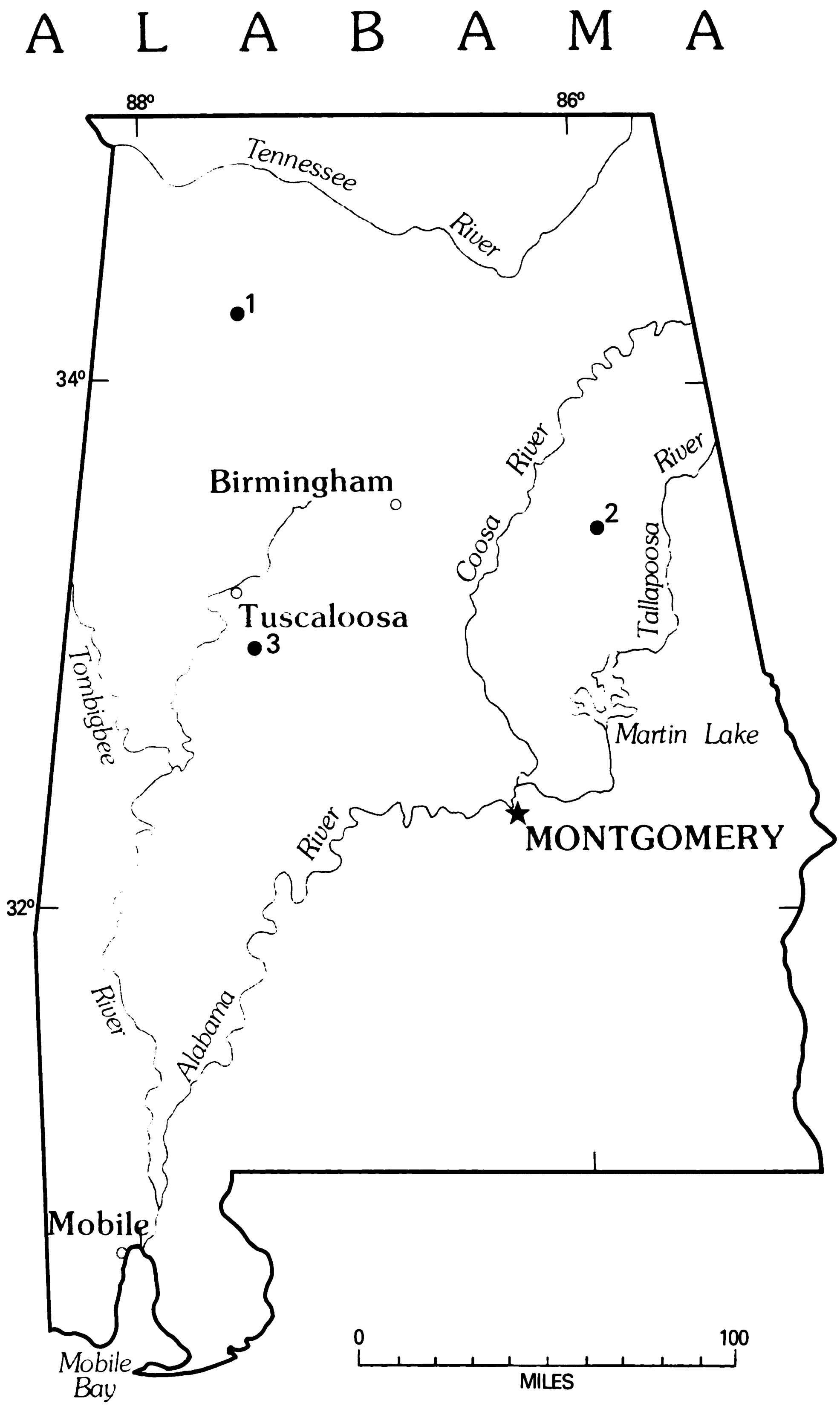

Location of areas studied.

ALABAMA

Map No.	Name of Area
2	Adams Gap and Shinbone Creek Roadless Areas
3	Big Sandy, West Elliotts Creek, and Reed Brake Roadless Areas
1	Sipsey Wilderness and Additions

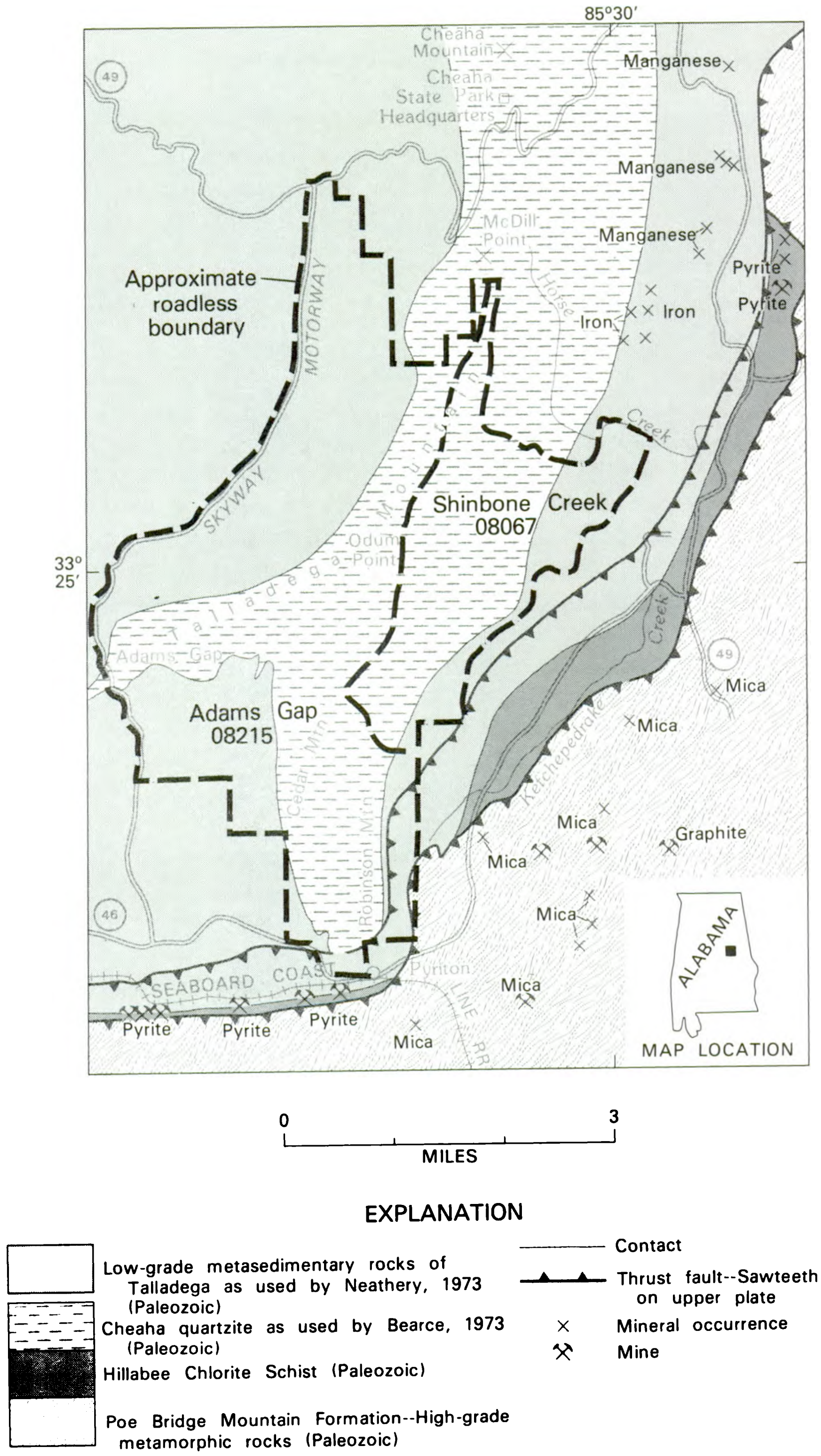

Figure 4.—Adams Gap and Shinbone Creek Roadless Areas, Alabama.

ADAMS GAP AND SHINBONE CREEK ROADLESS AREAS, ALABAMA

By T. L. KLEIN,[1] U.S. GEOLOGICAL SURVEY, and

DONALD K. HARRISON, U.S. BUREAU OF MINES

SUMMARY

The Adams Gap and Shinbone Creek Roadless Areas were evaluated for their mineral potential in 1982. The only resource within the established boundary of the roadless area is quartzite suitable for crushed rock or refractory-grade aggregate. The quartzite contains deleterious impurities and is found in abundance outside the areas. No other mineral or energy resources were identified in the roadless areas.

CHARACTER AND SETTING

The Adams Gap and Shinbone Creek Roadless Areas, Clay County, Alabama, cover approximately 15 sq mi. The areas, which are contiguous, were examined together and are referred to in this report as the study area. They are bounded on the north by the Cheaha State Park and the Horse Creek drainage, on the west by USFS Route 600 (the Skyway Motorway), on the south by County Road 46, and on the east near County Road 31 and State Road 49. The study area includes Cedar Mountain, Robinson Mountain, and Talladega Mountain from Adams Gap to near McDill Point. Altitudes range from a low of 1000 ft above sea level where Horse Creek leaves the study area in the northeast to 2342 ft above sea level at Odum Point.

The study area contains low-grade regionally metamorphosed sedimentary rocks (Talladega group as used by Neathery, 1973) that are exposed from the coastal plain overlap in east-central Alabama to Cartersville, Georgia where they have been overthrust by rocks of the Blue Ridge Province, which lie to the east. The Talladega forms the frontal crystalline thrust sheet of the southern Appalachians in Alabama. The Talladega overlies the easternmost fold and thrust belt of sedimentary rocks in the Valley and Ridge Province along a low-angle fault which dips eastward. The Talladega is composed of interlayered sandstones, siltstones, phyllites, slates, and lenses of conglomerate (Robinson and others, in press).

Outcrops of the Hillabee Chlorite Schist and high-grade metamorphic rocks of the Poe Bridge Mountain Formation occur nearby to the south and east of the study area, but are separated from the Talladega within the study area by two eastward-dipping thrust faults.

The USGS made a reconnaissance geochemical survey of the Adams Gap and Shinbone Creek Roadless Areas (Robinson and others, in press) to test for unidentified or unexposed mineral deposits that might be recognized by their geochemical halos. The rock, soil, and bulk stream-sediment samples collected by the USGS were analyzed by semiquantitative methods for 31 elements in the USGS laboratories, Denver, Colorado (Erickson and others, 1983). No metallic deposits or unusual metal concentrations are reported to be in the study area, and none were found during the reconnaissance geologic mapping or reconnaissance geochemical survey.

MINERAL RESOURCES

Manganese, iron, and silica aggregate occur in the low-grade metasedimentary rocks of the Talladega within the study area but only the silica aggregate is considered to be a resource. Natural gas or petroleum may exist at depth (Robinson and others, 1983).

Manganese and limonite prospects in the Talladega northeast of the study area occur along a trend which enters the eastern edge of the study area. The manganese- and iron-bearing units in the study area are small in size, low in grade, have high phosphorous content, and are difficult to beneficiate. Therefore, no iron or manganese resource potential was identified.

Quartzite from the Cheaha quartzite unit as used by Bearce (1973) was quarried for silica refractory brick at

[1]With contributions by G. R. Robinson, Jr., USGS.

the southern end of the study area. Operations were discontinued because of excessive iron content, but two samples of quartzite collected several miles north of the quarry meet standards for refractory brick (Harrison and Armstrong, 1982, p. 14). Impurities in much of the rock and prohibitive quarrying and crushing costs make the Cheaha in the study area unattractive for both silica refractory or silica sand use. The quartzite in the study area is suitable for crushed stone, riprap, or common building stone but abundant resources for this commodity exists outside the area.

The Hillabee Chlorite Schist, outside the east and south boundary of the study area, contains pyrite, copper, zinc, and gold which occur in lenticular pods or zones. However, the geologic relationships of this unit indicate that it is not present in the study area.

Mineral resources associated with the high-grade metamorphic rocks of the Poe Bridge Mountain Formation include mica, graphite, and gold. Mica has been mined outside the study area from small tabular or lens-shaped coarse-grained granitic rocks within the formation. Graphite, associated with graphitic schists, and gold, associated with quartzite layers, also occur in this formation. There is no current or recent production of mica, graphite, or gold from this group of rocks. The Poe Bridge Mountain Formation occurs only in a small southern part of the study area, and geological relationships indicate it does not underlie the rocks in the study area.

The rocks of the Talladega in the study area have been thrust over younger unmetamorphosed sedimentary rocks (Thomas and others, 1980). These younger sedimentary rocks may contain oil and gas resources. The low degree of metamorphism implies that both oil or natural gas could be present at appropriate depths. Because of the thrust fault contact separating the Talladega from underlying rocks, surface structures in the Talladega cannot be used to determine subsurface structures (and possible hydrocarbon traps) beneath the plane of the thrust fault.

SUGGESTIONS FOR FURTHER STUDIES

Detailed seismic studies and deep drilling tests are needed before a reasonable estimate of hydrocarbon potential can be made.

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BIG SANDY, WEST ELLIOTTS CREEK, AND REED BRAKE ROADLESS AREAS, ALABAMA

By SAM H. PATTERSON,[1] U.S. GEOLOGICAL SURVEY, and

MICHELLE K. ARMSTRONG, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys done in 1979–80 in the Big Sandy, West Elliotts Creek, and Reed Brake Roadless Areas, Alabama, indicate that the areas have little promise for the occurrence of metallic mineral resources. The three areas, however, have a probable potential for oil or gas. Probable coal resource potential exists in the Big Sandy and the West Elliotts Creek Roadless Areas. Clay and abundant sand resources occur in the roadless areas. Clayey sand has been used to stabilize USFS roads and in road grade construction. The clay and sand have little value as mineral resources because these commodities are abundant elsewhere in the region.

CHARACTER AND SETTING

The Big Sandy, West Elliotts Creek, and Reed Brake Roadless Areas are located about 10 mi south of Tuscaloosa in west-central Alabama. The Big Sandy Roadless Area occupies 5 sq mi of which most is in Tuscaloosa County but small parts extend into Hale and Bibb Counties. The West Elliotts Creek Roadless Area containing 6.6 sq mi is in Hale County. The Reed Brake Roadless Area of 1 sq mi is in Bibb County.

The exposed rocks in the three areas consist of the Coker and Gordo Formations that make up the Cretaceous Tuscaloosa Group and Pleistocene and Holocene alluvium (Szabo and Patterson, 1983). The two Cretaceous formations consist chiefly of sand, silt, and clay and contain minor quantities of gravel and sandstone. The Coker is 400–500 ft thick and the Gordo is 100–400 ft thick. The alluvium is composed of lenticular beds of fine- to coarse-grained sand, gravel, and clay. It occurs under the flood plains of the major streams.

The Tuscaloosa Group is unconformably underlain by Paleozoic sedimentary rocks. The Paleozoic rocks underlying the Big Sandy and West Elliotts Creek Roadless Areas are equivalent to the Pennsylvanian Pottsville Formation of Pennsylvania. Where exposed in the central and northern parts of Tuscaloosa County this formation consists of sandstone, shale, clay, and coal, and it has a thickness of 2500–4400 ft. The Pottsville Formation is probably missing below the Tuscaloosa Group in the Reed Brake Roadless Area where it is presumably underlain, at depths of no greater than 700–800 ft below the surface, by one or more of the 19 pre-Pottsville formations known to be present in outcrops in easternmost Tuscaloosa County and the central part of Bibb County.

The Cretaceous Tuscaloosa Group in the three areas has undergone little deformation, but older rocks are more disturbed. The strata in the Tuscaloosa Group dip uniformly to the southwest at 30–40 ft/mi; no faults or folds were found in them in the three areas. The Pottsville Formation below the major unconformity between the Cretaceous and Paleozoic formations dips approximately 175 ft/mi to the southwest. The pre-Pottsville rocks that probably underlie the Tuscaloosa Group in the Reed Brake Roadless Area are likely to be folded and faulted much like those cropping out farther to the northeast.

MINERAL RESOURCES

Bituminous coal of the Pottsville Formation is currently mined in northern and central Tuscaloosa County, and in northeastern Bibb County. Eight coal groups, each containing two to six coal beds, are recognized in Tuscaloosa County. Approximately half of the estimated 34 coal beds exposed in the county have been mined commercially. Coal has been mined 9.5 mi northeast of the Big Sandy Roadless Area in Tuscaloosa

[1]With contributions from Peter C. Mory, USBM.

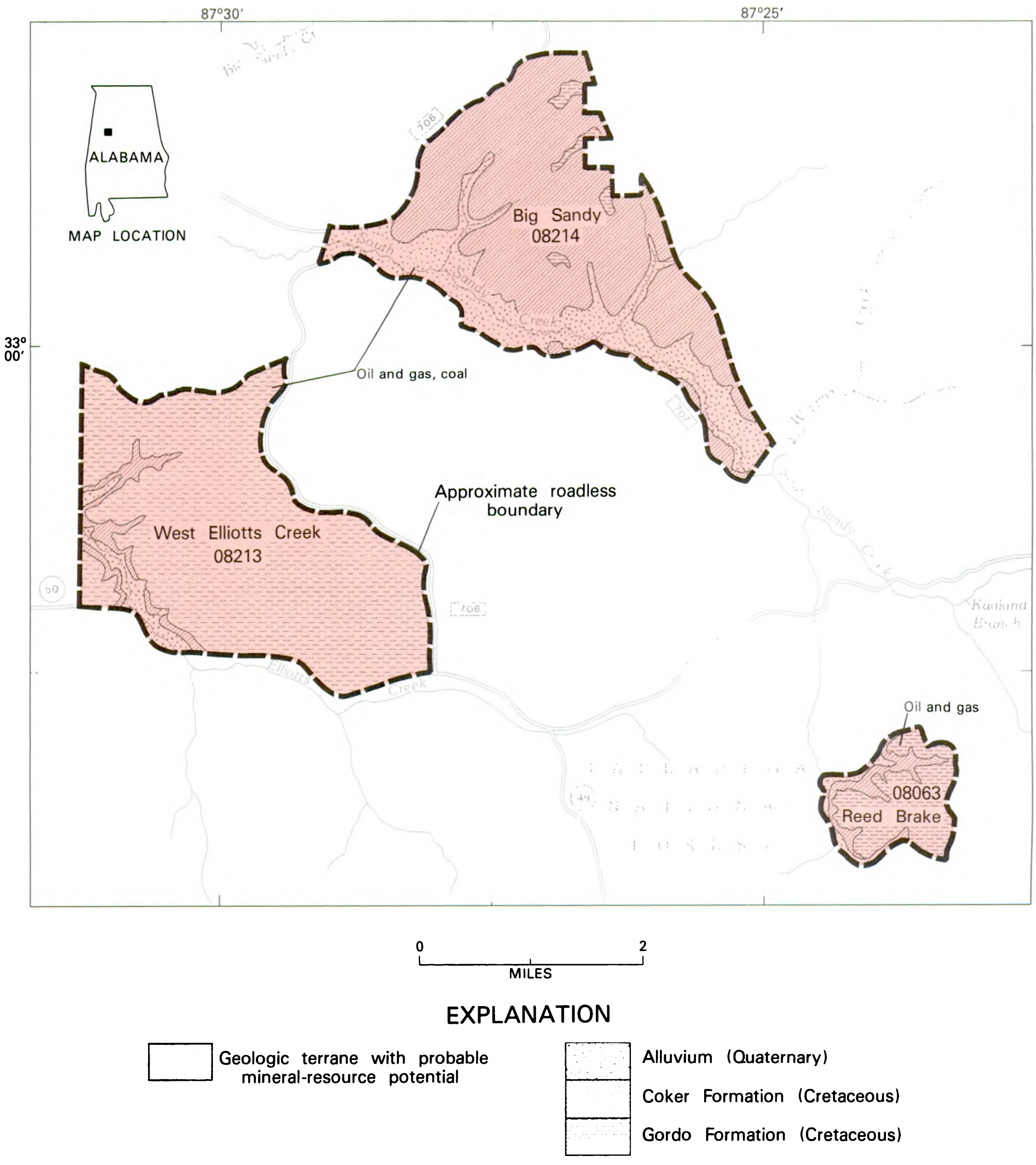

Figure 5.—Big Sandy, West Elliotts Creek, and Reed Brake Roadless Areas, Alabama.

County and has been mapped on the surface 5.5 mi northeast of this area.

Contours on top of the Pottsville Formation indicate the presence of this formation at depths ranging from less than 350 ft below the Big Sandy Roadless Area to about 750 ft below the West Elliotts Creek Roadless Area. Although coal has not been proven to exist beneath these areas, its presence is highly likely if the subsurface geology of the Pottsville Formation in this location is similar to that in exposures a few miles to the north. Regional structural trends of the Birmingham anticline and the Helena thrust fault northeast of the areas (Szabo and Patterson, 1983) suggest that the coal-bearing Pottsville Formation is absent under the Reed Brake Roadless Area.

The Big Sandy and West Elliotts Creek Roadless Areas have a probable resource potential for coal in the Pottsville Formation to depths of no more than 4000 ft. An average of 15,400 tons/acre has been used in estimating coal resources in central and northern Tuscaloosa County. On the assumption that coal is as abundant in the Pottsville Formation in the Big Sandy and West Elliotts Creek Roadless Areas as it is farther north, these two areas may contain approximately 100 million tons of probable deep coal resource potential.

Coal bed gas is presently produced in two coal degasification projects in the region of the three roadless areas, and natural gas has been found in two other gas fields (Thomas Sexton, oral commun., 1982). The producing Brookwood Degasification Coal Field is only about 15 mi northeast of the Big Sandy Roadless Area. The other producing coal bed gas field, the Oakgrove Field, is farther northeast. The two non-producing natural gas areas are the Wiley Dome and Lexington fields which are located about 35 mi north of the Big Sandy Roadless Area. The natural gas in both fields is in the Mississippian and Pennsylvanian Parkwood Formation (Frank Hinkle, oral commun., 1982).

The three roadless areas have probable resource potential for oil and gas, a conclusion based largely on industry activities in the National Forest and on geologic inferences. During the last seven years, numerous applications for oil and gas leases in the three roadless areas have been submitted to the U.S. Bureau of Land Management and several leases were in effect in May, 1981. Periodic seismic investigations along roads throughout the National Forest (B. W. Fenton, oral commun., 1980) also indicate continuing interest by oil and gas companies. However, little is known about possible hydrocarbon host rocks at depth in the areas. They seem as favorable for the occurrence of natural gas as in northern Tuscaloosa County, where the Wiley Dome and Lexington fields have been found. The Parkwood Formation, which contains gas in these two fields, probably is present at depths of no more than 5000 ft in the region; however, this likelihood is no more than an inference because no deep holes have been drilled near the roadless areas. Coal beds, thought to be present in the Pottsville Formation in the subsurface of two of the roadless areas, are even more likely to contain gas than the degasification fields to the north because of greater depth of burial. Porous clastic beds in the Pottsville Formation may also serve as traps for hydrocarbons, because containing seals are likely to have been provided by impermeable zones in the upper part of the formation. Such zones are known to be too impermeable to permit the flow of ground water.

In the three roadless areas plastic clay that may be suitable for use in structural clay products (Armstrong and Mory, 1982) occurs in two zones in the Gordo Formation and carbonaceous clay having bloating properties may be present in the Coker Formation. A clay zone at the base of the Gordo Formation is present in all three roadless areas. A zone near the middle of the formation is present in the West Elliotts Creek Roadless Area and is probably present in the Reed Brake Roadless Area. The clays are chiefly mixtures of kaolinite and quartz and contain minor amounts of chlorite and muscovite.

Current production of clay in the vicinity of the roadless areas is limited to two intermittently active pits. One of the pits is about 10 mi southeast of the Reed Brake Roadless Area. Plastic clay from this pit has been used in making terra cotta at a plant in Birmingham (B. W. Fenton, oral commun., 1979). The other pit is located 12 mi farther southeast. The clay from this pit is used in local pottery.

Preliminary ceramic evaluations indicate that clays in the roadless areas may be suitable for structural clay products (Armstrong and Mory, 1982). However, similar materials are abundant in the region (Patterson, and others, 1983). Clay and shale moved during coal stripping and discarded on waste dumps in Tuscaloosa and Bibb Counties are also a ceramic resource and would be more easily recovered than any of the clays from the three roadless areas.

The Tuscaloosa Group and the alluvium in the three roadless areas and surrounding region contain enormous resources of sand and gravel that have been used for road construction and maintenance. Most deposits in the Tuscaloosa Group are in tabular and lenticular units having an average thickness of about 10 ft. Thin stringers of sandstone, cemented with iron oxide, and clay zones occur in some deposits. Little is known about the alluvium of the flood plains along South Sandy and Elliotts Creeks, but considerable quantities of sand are present in both lowlands. A pit consisting of three small workings in the eastern part of West Elliotts Creek

Roadless Area is intermittently active and has been the only mining in the three areas in recent years.

The sand deposits in the three roadless areas are not shown on the map because of the large resources scattered throughout the region. The USFS has several inactive borrow pits outside the three roadless areas which are adequate for local needs. The city of Tuscaloosa, located about 10 mi north of the Big Sandy Roadless Area, is amply supplied with sand and gravel by extensive deposits in the Tuscaloosa Group and terraces along the Black Warrior River. Similar deposits occur along the Cahaba River, about 10 mi east of the roadless areas.

SUGGESTIONS FOR FURTHER STUDIES

Meaningful contributions to the energy resource potential of the three roadless areas would require new information on the rocks at depth, that are likely to contain coal and possibly oil and gas. Costly geophysical investigations and drilling would be required to obtain such information.

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SIPSEY WILDERNESS AND ADDITIONS, ALABAMA

By STANLEY P. SCHWEINFURTH,[1] U.S. GEOLOGICAL SURVEY, and

PETER C. MORY, U.S. BUREAU OF MINES

SUMMARY

On the basis of geologic, geochemical, and mineral surveys made in 1978–79, the Sipsey Wilderness and additions are deemed to have little promise for the occurrence of metallic mineral resources. Although limestone, shale, and sandstone resources that occur in the area are physically suitable for a variety of uses, similar materials are available outside the area closer to transportation routes and potential markets. A small amount of coal has been identified in the area, occurring as nonpersistent beds less than 28 in. thick. Areas underlain by beds less than 28 in. thick, despite their contained coal, are not shown on the map. Oil and (or) natural gas resources may be present if suitable structural traps exist in the subsurface. Therefore, the area has a probable oil and gas potential. Small amounts of asphaltic sandstone and limestone, commonly referred to as tar sands, may also occur in the subsurface.

CHARACTER AND SETTING

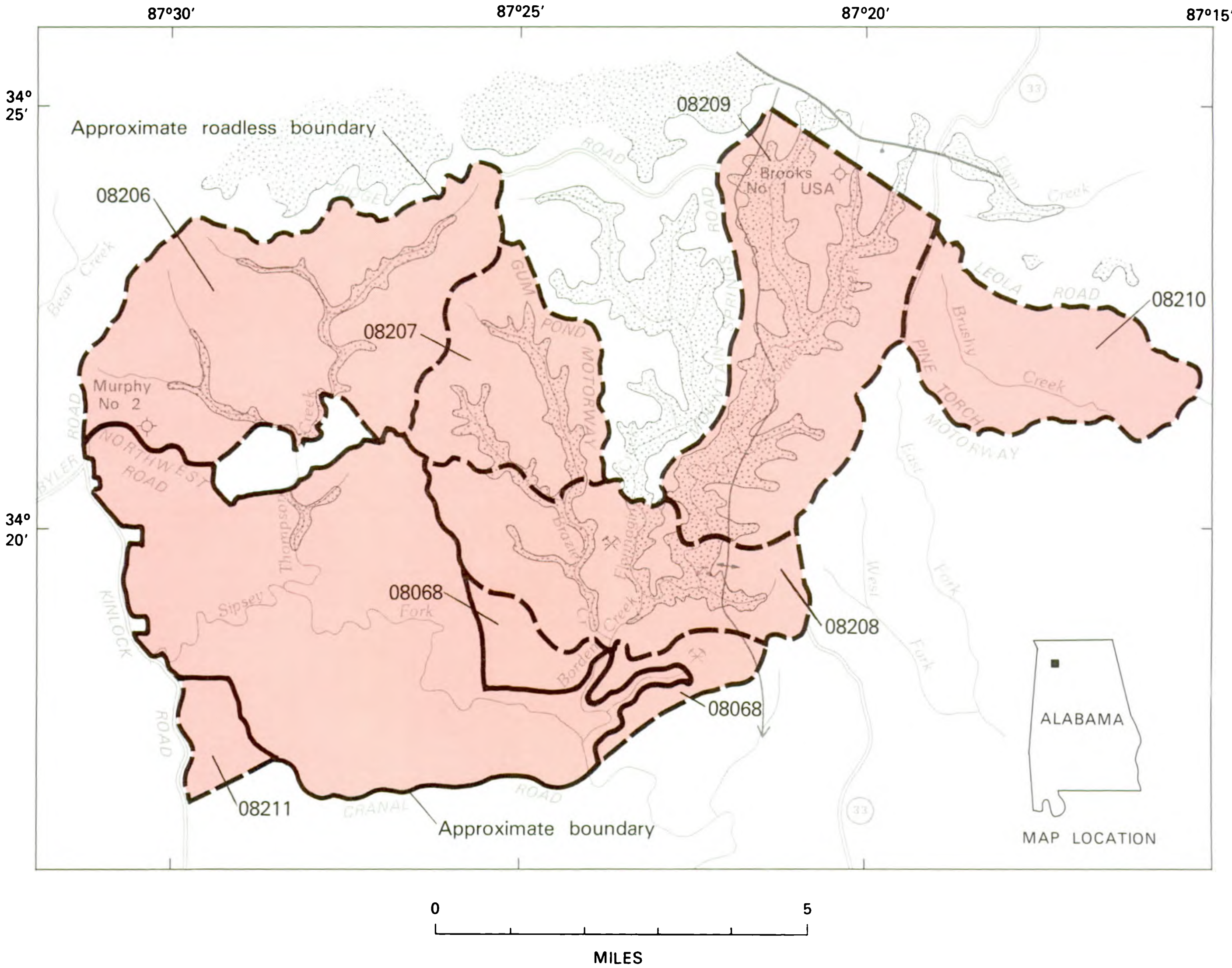
The combined Sipsey Wilderness and seven roadless areas, hereinafter called the study area, comprise about 66 sq mi in the William B. Bankhead National Forest, Lawrence and Winston Counties, Alabama. These tracts are about 14 mi south-southwest of Moulton, Alabama, the county seat of Lawrence County. The U.S. Government owns about 95 percent of the surface and mineral rights in the study area. A mineral survey was made in 1978–79 and the results were published by Schweinfurth and others (1982).

The study area lies in the Cumberland Plateau section of the Appalachian Plateaus physiographic province and is near the northern edge of the Warrior coal field. It is situated in the most rugged part of the north-central section of Alabama and is traversed by deeply incised stream valleys with high, rock-cliff walls which contain numerous rock shelters and caves, and an occasional natural bridge or stand of rock pinnacles. Altitudes of the plateau surface in the study area range from about 1050 ft along the northern boundary to about 880 ft along Cranal Road on the south. Topographic relief averages approximately 400 ft throughout the study area.

[1]With contributions from Robert B. Ross, Jr., and Paul T. Behum, USBM.

About 880 ft of Upper Mississippian to upper Lower Pennsylvanian sedimentary rocks crop out in the study area, and as much as 6800 ft of older Paleozoic sedimentary rocks may be present in the subsurface (Schweinfurth and others, 1981). The basal part of the exposed section consists of marine limestone assigned to the Bangor Limestone of Late Mississippian age. Overlying rocks of the Parkwood (Pennsylvanian) and the Pottsville (late Early Pennsylvanian) Formations consist of interbedded, coarse- to fine-grained, clastic continental and marine rocks. The Parkwood Formation crops out along valley walls and the Pottsville Formation forms the upland throughout the study area. The Bangor Limestone is separated from the overlying Parkwood Formation by an erosional unconformity, which may be angular in the eastern third of the study area. The Parkwood in turn is separated from the overlying Pottsville Formation by an erosional unconformity that is angular in the eastern third of the area. Deposits of locally derived colluvium mantle the valley walls. Alluvium, consisting of unconsolidated clay, silt, sand, gravel, and large boulders, lies along the valley floors.

The strata of the western part of the study area dip to the south at an average rate of about 55 ft/mi. The eastern part of the area is dominated by a low-relief, southward-plunging structural nose. The average plunge of the crest of this nose is about 40 ft/mi to



EXPLANATION

Geologic terrane with probable oil and gas potential

Dry oil and gas test-hole

Rocks of Pennsylvanian age

Rocks of Mississippian age

Contact

Fault--Bar and ball on downthrown side

Structural nose of anticline, showing direction of plunge--Approximately located

Abandoned coal adit

Abandoned quarry

Figure 6.—Sipsey Wilderness and Additions, Alabama.

the south. The nose is believed to be the result of at least two periods of local uplift during Early Pennsylvanian time followed by southward tilting in post-Pennsylvanian time. A large positive gravity anomaly and a large positive magnetic anomaly are associated with the structural nose. No faults were found in the study area, but evidence from nearby areas suggests that normal faults having throws of as much as 100 ft may exist within it.

MINERAL RESOURCES

Limestone is the major resource found in the Sipsey Wilderness and additions and a large tonnage has been quarried from the Bangor Limestone near the study area, although most quarries have been abandoned. Road-abrasion and polish tests indicate the limestone is suitable for road metal and paving aggregates. Because of its durability and lack of porosity, the limestone may also be suitable for dimension stone. The USFS has quarried the Bangor Limestone for road metal and for construction of bridge abutments but in recent years crushed stone has been trucked in from quarries outside the national forest. Chemical analyses of sampled beds indicate that they have a high calcium-carbonate content, and are low in silica and magnesium carbonate (Mory and others, 1981). However, limestone resources are not shown on the map because extensive deposits of Bangor Limestone occur north of the study area in the Moulton Valley where they are more favorably located relative to transportation routes and potential markets.

Large resources of clay, shale, and sandstone are present within the study area in the Parkwood and Pottsville Formations. Preliminary ceramic tests of clay and shale samples show that all samples were suitable for structural clay products such as building brick, floor brick, and tile. Five samples bloated during quick-fire tests and may indicate materials suitable for expanded lightweight aggregate. These commodities also are not shown on the map because similar materials are available outside the area closer to transportation routes and markets.

Thick beds of high-silica sandstone occur within the study area and some thinner beds of quartzose, feldspathic, and ferruginous sandstone also occur. Weakly cemented high-silica sandstone may be suitable for use as filter, furnace, molding, and abrasive (sand-blasting) sand, and low-grade glass sand. Other potential uses include construction sand, filler sand, and engine (traction) sand. Some dense, well-cemented sandstone may be suitable for rough building stone, or dimension stone. Access to the sandstone within the study area is poor and more accessible sandstone resources are widely distributed throughout northern Alabama.

As many as five thin, nonpersistent coal beds may be present in the Parkwood Formation in or near the study area. Of the five coal beds observed within the study area, only two beds are between 14 in. and 28 in. thick and contain demonstrated resources of coal; the remainder are less than 14 in. thick. Demonstrated coal resources are separately estimated for coal beds more than 28 in. thick and for coal in beds between 14 and 28 in. thick. Areas underlain by beds less than 28 in. but more than 14 in. thick, despite their contained coal, are not shown on the map. Analyses of weathered coal samples from one of the beds indicate that the bed has a high ash content and a low to high sulfur content. The demonstrated coal resources of the area underlain by the two beds are estimated to be 727,000 short tons. Both coal beds are exposed in relatively steep valley walls where they are overlain by a thick sequence (as much as 300 ft) of massive beds of sandstone and shale. Coal has been mined for local domestic and blacksmithing use but no attempt was made to quantify the amount of coal removed from the study area; past mining is considered negligible.

Heavy oil, dead oil, oil staining, and shows of natural gas have been reported from several rock units penetrated by tests drilled in or near the study area, but neither oil nor natural gas has been produced. The structural nose in the eastern part of the area does not show closure at the surface but it is associated with strong geophysical anomalies and may contain closure at depth. Normal faults which are present near and possibly within the study area could produce structural traps in the subsurface in conjunction with the structural nose. Normal faults alone may also produce structural traps in the regionally southward dipping strata lying to the east and west of the stuructural nose.

The structural nose has been tested by only one drill hole, the Brooks No. 1 U.S.A. (State permit No. 919), which was drilled to a total depth of 1815 ft in Upper Ordovician rocks. Oil shows were reported in the Bangor Limestone, Hartselle Sandstone, and Tuscumbia Limestone of Mississippian age. This test well did not penetrate the entire stratigraphic sequence reported to have had shows of oil and gas in other tests in northern Alabama. For example, a large show of natural gas was recorded in rocks of the Knox Group of Ordovician and Cambrian age penetrated in a test well (State permit No. 2284) about 8 mi southwest of the study area. The Knox is considered by Haley (1981) to have the best possibility for the discovery of oil or gas in the area, but it was not reached in the Brooks test well. One other test hole was drilled in the study area. The Murphy Oil Corp. test No. 2 (State permit No. 1587), was completed as a dry hole at a depth of 908 ft in the upper part of the Hartselle Sandstone. Slight shows of oil and asphalt were reported in the Hartselle. The Sipsey Wilderness and additions is assessed as having a probable oil and gas resource potential.

Limestone and sandstone beds of Mississippian age contain potentially valuable tar-sand deposits in northern Alabama. Asphaltic sandstone has been mined from outcrops of the Hartselle Sandstone in northern Lawrence County and used as road metal (Haley, 1981). However, the Hartselle does not crop out in the study area and the two tests drilled in the study area did not penetrate any major tar-sand impregnated intervals.

No metallic mineral deposits were identified in the study, and none have been reported in the literature. A geochemical survey of the area disclosed no major geochemical anomalies (Grosz, 1981).

SUGGESTIONS FOR FURTHER STUDIES

The available geologic, geochemical, and geophysical data indicate that there is little promise for the occurrence of metallic mineral resources in the study area. Oil and gas resources may underlie the area, but additional exploration, especially deep drilling, is necessary before the area can be fully evaluated.

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Location of areas studied.

ALASKA

Map No.	Name of Area
1	Chugach National Forest, study areas
2	Glacier Bay National Monument Wilderness study area
5	Granite Fiords Wilderness study area
4	Tracy Arm-Fords Terror Wilderness study area and vicinity
3	Western Chichagof and Yakobi Islands Wilderness study area

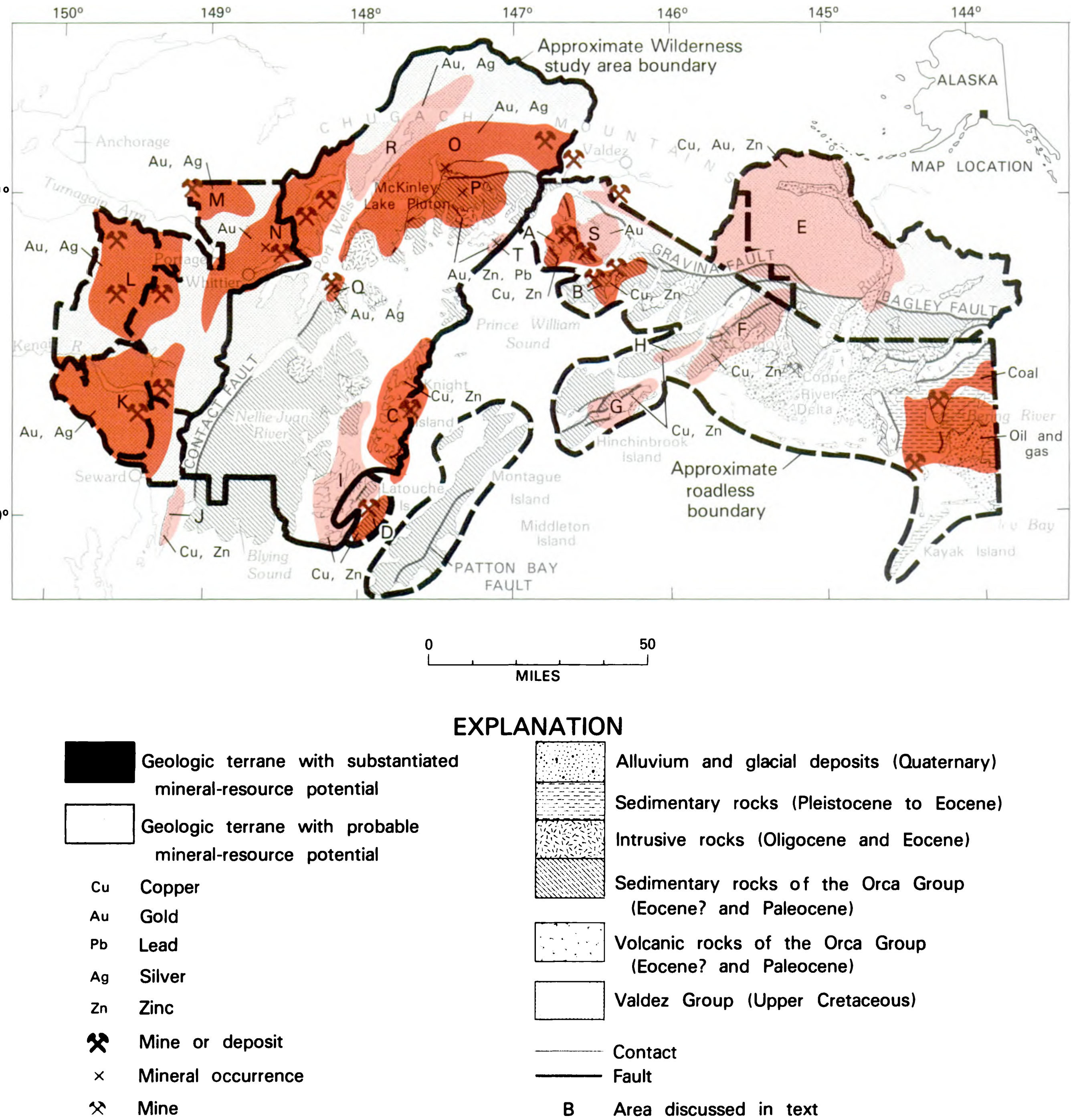

Figure 7.—Study areas within the Chugach National Forest, Alaska.

STUDY AREAS WITHIN THE CHUGACH NATIONAL FOREST, ALASKA

By STEVEN W. NELSON, U.S. GEOLOGICAL SURVEY, and

ULDIS JANSONS, U.S. BUREAU OF MINES

SUMMARY

A multidisciplinary mineral survey conducted from 1979-82 in the Chugach National Forest wilderness study lands, including roadless areas and the College Fiord-Nellie Juan Wilderness Study Area, has determined that there are areas with substantiated resource potential for gold, silver, copper, and zinc and areas with probable resource potential for all of the above metals as well as molybdenum, nickel, manganese, chrome, antimony, and lead. Areas in the southeast part of the national forest have substantiated potential for coal, oil, and gas resources.

CHARACTER AND SETTING

The Chugach National Forest, located in the Kenai-Chugach Mountains physiographic province of Alaska is an area of about 9000 sq mi. It is located 45 mi by road from Anchorage. The towns of Whittier and Cordova are within the forest boundary; Valdez lies north of the national forest.

Much of the region encompasses Prince William Sound, one of the largest embayments in the coast of Alaska. The area was extensively glaciated and glaciers are still present in the Chugach Mountains which attain an altitude of 13,250 ft within the forest.

The Chugach National Forest is underlain principally by two major geologic units, the Valdez Group (Upper Cretaceous) and the Orca Group (Paleocene to Eocene?). Both groups consist of metamorphosed graywacke, siltstone, and shale in deposits forming marine turbidites. They also include mafic complexes consisting of sheeted dikes, pillow basalt flows, and minor gabbro and ultramafic bodies. Sedimentary rocks younger than the Orca Group range from Eocene to Pleistocene in age. These rocks were deposited in a continental margin basin where marine regression and transgression took place during the middle Eocene and possibly during the early Miocene and are only exposed in the southeastern part of the forest.

Plutonic rocks were emplaced in the Eocene and Oligocene. Most of the plutons are granitic in composition, but an early phase of the Oligocene plutons ranges in composition from quartz diorite to gabbro.

Geochemical surveys were conducted to help identify the resource potential of the national forest (R. J. Goldfarb and Peter Folger, written commun. 1982; R. J. Goldfarb and others, written commun., 1982; Jansons, 1981). Stream-sediment, panned concentrate, rock, and mineral samples were collected and analyzed. Suites of elements present in anomalous concentrations were used to assist identification of areas with potential for the various types of mineral resources which occur within the national forest.

A gravity study shows a regional decrease in gravity from south to north and west, of about 130 milligals, which probably represents an approximate 12-mi increase in crustal thickness between the Continental Shelf and the Chugach Mountains. A major gravity feature that is well developed is an arcuate high that trends northward from Elrington Island, through Knight Island and apparently connects with an eastward trend from Glacier Island through Ellamar and further eastward. This gravity high roughly coincides with outcrops of the Orca Group mafic volcanic rocks, and indicates a thickness of as much as 6.5 mi for these rocks. Regional gravity data in this area is probably not useful for detailed analysis or detection of local mineralization.

The aeromagnetic survey data show a pair of regional gradients defined by contours almost paralleling the northern and western boundaries of the national forest and indicating a decreasing field strength to the north and west. Almost all of the other major features of the magnetic data seem to be associated with the distribution of the more magnetic mafic volcanic rocks. Most granitic plutons seem to have weak magnetic signatures and low susceptibilities. The Perry Island pluton has the strongest magnetic expression of these plutons and has several unique features including minor amounts of tungsten in associated quartz veins.

Placer gold was discovered on the Kenai and Russian Rivers in 1848. Placer mining began in the Hope area in about 1896 and continued into the early 1900's. Since 1980, 15–20 placer operations producing 1000–2500 oz gold/year were active during the 3- to 4-month mining season in the Kenai Peninsula area. Currently approximately 1860 placer claims are located within the Chugach National Forest. Lode gold has been mined at several places in the national forest. The first lode claims were located in 1898. Although production figures are incomplete, an estimated 264,400 oz of gold has been recovered from the national forest from both lode and placer sources.

Copper prospects have been developed in the area since 1897 and substantial production has come mainly from four mines and minor amounts from at least 17 other operations. Production from the national forest is estimated at nearly 206,400,000 lb of copper; silver and gold were also recovered from copper ores.

Coal was produced intermittently in the early 1900's from the southeastern part of the national forest. About 20,000 tons were extracted.

Petroleum exploration started in 1901, and oil was produced from the southeastern part of the national forest and refined at Katalla from 1904 to 1933. Production was nearly 154,000 barrels.

MINERAL RESOURCES

The principal areas of probable and substantiated resource potential for base and precious metals are made up of Valdez and Orca Group volcanic and sedimentary rocks. Although it has been commonly accepted that the Valdez and Orca Groups represent two different mineral provinces (Tysdal and Case, 1982), the Valdez Group characterized by gold mineralization and the Orca Group characterized by copper mineralization, the current study indicates that both kinds of mineralization occur in each group. Substantiated resource potential for base or precious metals occurs in 11 areas and 9 additional areas have probable resource potential for base or precious metals. Numerous mines with demonstrated resources are shown on the map.

Four areas have substantiated resource potential for copper-zinc sulfide deposits (areas A-D, on map) that are spatially related to mafic volcanic rocks. The base-metal sulfide deposits may represent sites of submarine thermal hot springs which provided both the sulfur and the metals by leaching from ocean floor sediments and underlying rocks. Six additional areas have probable potential for copper-zinc sulfide deposits (areas E-J). Additional resource potential for lead, nickel, chrome, gold, and silver would occur in these areas.

The geology of the gold mineralization is somewhat more complex. Gold in the Valdez Group is found in quartz veins that have been dated at 53 million years which cut sedimentary rocks, and quartz veins in 34-million-year-old plutons in the Port Wells district. Within the Valdez Group sedimentary rocks, the gold-bearing quartz veins occur along fractures and shears which crosscut regional structure and fabric. Seven areas of substantiated precious-metal resource potential (areas K-Q) and three areas of probable precious-metal potential (areas R-T) are in the Valdez Group rocks. In the Orca Group, gold mineralization is restricted to quartz veins cutting sedimentary rocks near the 51-million-year-old McKinley Lake pluton, quartz veins cutting greenstone on Culross Island, and on Bligh Island and Blue Fiord. These areas have a substantiated base- and precious-metal resource potential. Favorable conditions for gold mineralization were met both near granitic plutons of both Eocene and Oligocene age, and regionally where the rocks were subjected to low greenschist facies metamorphic conditions. Mineral-resource potential for copper, lead, zinc, molybdenum, arsenic, and antimony as byproducts occur in the areas of precious-metal resource potential.

Placer gold resources are principally confined to the Kenai Peninsula area on the west side of the national forest, although occurrences have been identified in almost all of the metal-bearing resource potential areas. These areas are not shown on the map because of problems of scale.

Extensive coal deposits occur in rocks in the Bering River area on the east side of the national forest. Although the extent of the field is great and structurally complex, large tonnages of minable coal appear to be present. The area is classified as one of substantiated coal resource potential; the coal rank includes bituminous, semianthracite, and anthracite.

The Katalla area, just south of the Bering River area, is one of substantiated potential for oil and gas. Although the production of the Katalla field over a 30-year period was relatively small, and the complex structure and lack of suitable reservoir rocks in the area suggest that major fields are unlikely. The past history of production and abundant surface evidence—including oil and gas seeps—may indicate that continued exploration is warranted.

SUGGESTIONS FOR FURTHER STUDY

Future study in the Chugach National Forest should focus on several aspects of the geology and mineral-resource occurrences to improve the understanding of the deposits. The determination of sedimentary facies associated with sedimentary hosted copper deposits would help to identify areas of greatest resource possibility. A study of stable isotopes in massive sulfide deposits is needed to better define genesis of the deposits. The study of the low-flow ground-water component of glacial melt would assist in the geochemical assessment of areas with extensive glacial cover. A study of stratigraphic units and sedimentary facies of the Orca Group would help to decipher controls for mineralization. An investigation of the relationship of metamorphic grade to the gold lode deposits and evaluation of zinc and barium geochemical anomalies found on Kayak Island and in the Don Miller Hills is needed to better assess resource potential. A study of textural and geometric relationships of sulfide minerals from deposits in shear zones and from unsheared areas will provide for a better understanding of the structural controls of sulfide mineralization. The study of the trace elements in sulfide minerals, and an attempt to establish timing of sulfide mineralization in sediment and volcanic hosted sulfide deposits is needed for a better understanding of the genesis and distribution of these resources.

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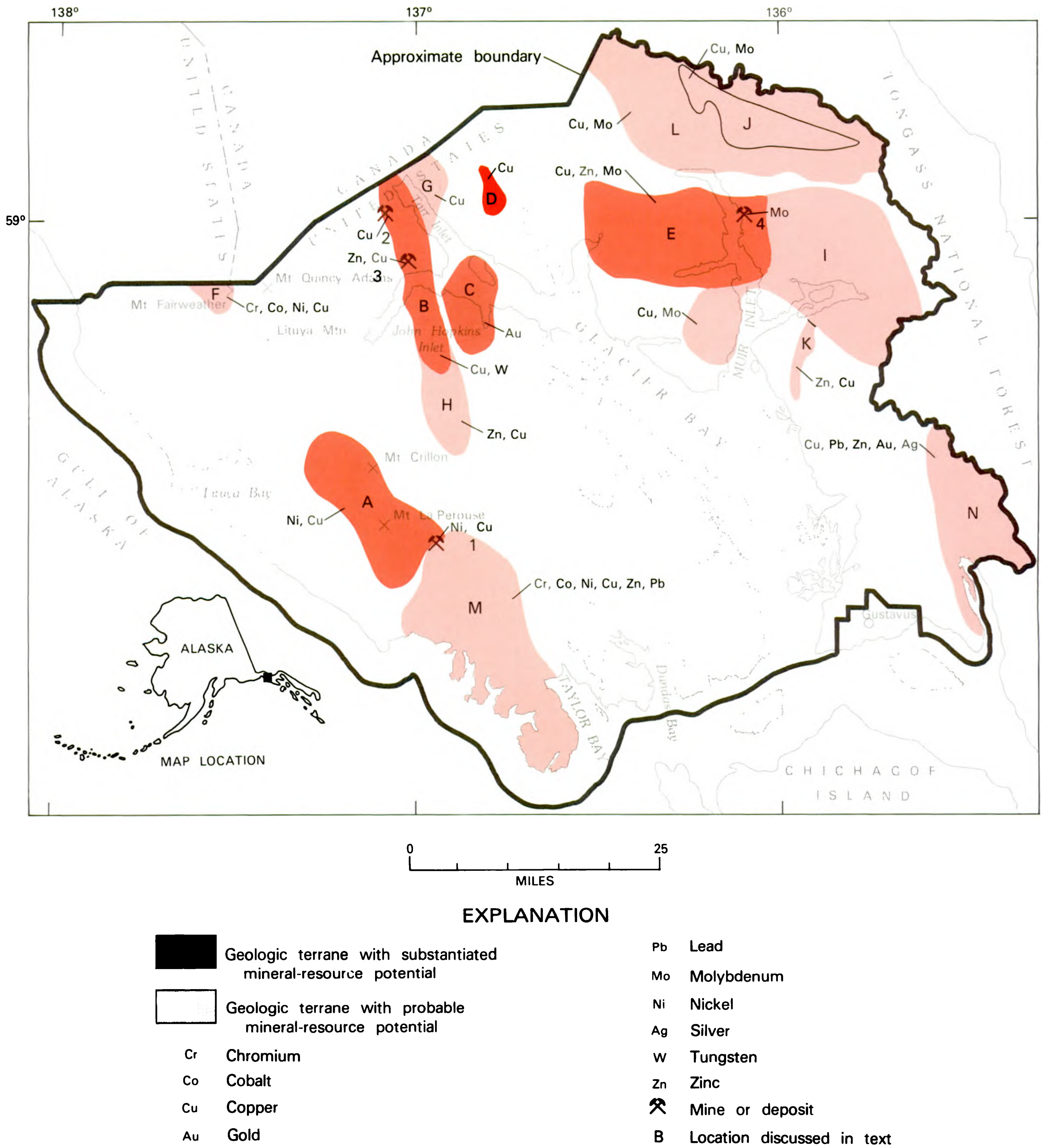

Figure 8.—Glacier Bay National Monument Wilderness study area, Alaska.

GLACIER BAY NATIONAL MONUMENT WILDERNESS STUDY AREA, ALASKA

By DAVID A. BREW, U.S. GEOLOGICAL SURVEY, and

ARTHUR L. KIMBALL, U.S. BUREAU OF MINES

SUMMARY

Glacier Bay National Monument is a highly scenic and highly mineralized area about 100 mi west of Juneau, Alaska. Four deposits with demonstrated resources of nickel, copper, zinc, and molybdenum have been identified within the monument and eleven areas of probable or substantiated mineral-resource potential have been identified, according to studies conducted in 1975-79. The monument is highly mineralized in comparison with most areas of similar size elsewhere in southeastern Alaska, and present estimates of mineral resources are considered conservative.

CHARACTER AND SETTING

The Glacier Bay National Monument is an area of about 4400 sq mi in the Pacific Border Ranges physiographic province, centered about 100 mi west-northwest of Juneau, Alaska. It was studied by the USGS and USBM and the results were published in 1978 (Brew and others, 1978).

The monument includes a variety of environments favorable for metalliferous mineral deposits and contains significant known magmatic segregation, porphyry-molybdenum, porphyry-copper, vein-gold, base-metal skarn, volcanogenic-base-metal, and beach-placer deposits. It also includes environments favorable for coal, oil and gas, geothermal energy, and industrial minerals, but none of these are likely to be present in significant amounts.

The USGS studies included reconnaissance geologic mapping, reconnaissance bedrock, and stream-sediment geochemical sampling, and field examination of a few of the mines, prospects, and metallic mineral occurrences studied in more detail by the USBM. Statistical analysis (Johnson, 1978) identified samples that contained anomalous amounts of one or more significant elements.

The USBM mining engineering studies included mining claim record search; on-site claim, mine, and prospect investigations; mapping and sampling of stained zones, altered zones, and geochemically anomalous sites; and evaluation and interpretation of private reports concerning mines and prospects.

About 1200 claims, most of them lode, have been recorded in the Haines and Juneau recording districts as being within the area studied. A search by the U.S. National Park Service determined that about 200 were active in 1977. Between 7000 and 8000 oz of gold were produced from the Reid Inlet gold district between 1938 and 1970, and about 4000 oz of gold and an unknown amount of platinum were produced from the Pacific Coast beach placers between 1890 and 1917.

Geologically, the monument is extremely complex, reflecting a long history of sedimentation, volcanism, intrusion, and deformation in part near the boundary between the North American continental crustal plate and the Pacific oceanic crustal plate. Layered sedimentary and volcanic rocks range from early Paleozoic age through Pleistocene, with apparent large gaps in the late Paleozoic and early and middle Mesozoic. Intrusive rocks range from Middle Jurassic age through Middle Tertiary, the major subdivisions being (1) foliated granitic rocks of mid-Cretaceous age, (2) locally foliated granitic rocks of Tertiary or Cretaceous age, (3) layered cumulus-type gabbro complexes of Tertiary age in the Fairweather Range, and (4) unfoliated granitic rocks of mid-Tertiary age.

MINERAL RESOURCES

Four deposits with important demonstrated mineral resources are known in the monument. They are, from west to east, (1) the Brady Glacier nickel-copper deposit in the Fairweather Range, (2) the Margerie Glacier copper deposit near Tarr Inlet, (3) the Orange Point zinc-copper deposit on Johns Hopkins Inlet, and (4) the Nunatak molybdenite deposit.

The Brady Glacier nickel-copper deposit (no. 1 on map) is a largely glacier covered magmatic-segregation sulfide occurrence in peridotite and gabbro at the base of a layered gabbro complex of unknown age in the Crillon-La Perouse area. The deposit is estimated to contain 90 million tons of demonstrated resources of 0.53 percent nickel, 0.33 percent copper, and resources of platinum group metals. An additional 90 million tons of resources of the same grade are also likely to be present.

The Margerie Glacier copper deposit (no. 2) is a fairly well exposed porphyry-copper occurrence in granitic rocks of probable Tertiary age. The deposit is estimated to contain 160 million tons of demonstrated resources of 0.2 percent copper, 0.008 oz gold/ton, 0.13 oz silver/ton, and 0.01 percent tungsten. Higher grade sulfide-bearing quartz veins occur within this large volume.

The Orange Point deposit (no. 3) is interpreted to be a volcanogenic zinc-copper sulfide occurrence. The host rocks are moderately well exposed metamorphosed andesites of late Paleozoic or Mesozoic age. The deposit is estimated to contain 270,000 tons of demonstrated resources of 2.7 percent copper, 5.2 percent zinc, 0.03 oz gold/ton, and 1.0 oz silver/ton, and an additional 530,000 tons of demonstrated resources of 0.4 percent copper, 0.3 percent zinc, 0.006 oz gold/ton, and 0.35 oz silver/ton.

The Nunatak molybdenum deposit (no. 4) is a porphyry-molybdenum occurrence in hornfels of original early to middle Paleozoic age and is probably related to nearby Tertiary granitic bodies. The well-exposed deposit is estimated to contain 145 million tons of demonstrated resources of 0.04 to 0.06 percent molybdenum and 0.02 percent copper accessible to surface mining, and an additional 9.1 million tons of demonstrated resources containing 0.06 percent molybdenum and 0.02 percent copper below sea level near shoreline. Within this volume is a potentially important higher grade section.

In addition to the four known deposits, five areas within the monument are considered to have substantiated mineral-resource potential: the Crillon-La Perouse nickel-copper area (A, on map), Margerie Glacier porphyry copper area (B), Reid Inlet gold area (C), Rendu Glacier copper area (D), and Muir Inlet copper, zinc, and molybdenum area (E).

Six areas considered to have probable mineral-resource potential are recognized within the monument. They are, from west to east, the Mount Fairweather chrome, cobalt, nickel, and copper area (F), Margerie Glacier northeastern extension copper area (G), Margerie Glacier southern extension zinc-copper area (H), Muir Inlet extension copper and molybdenum area (I), Casement Glacier porphyry copper and molybdenum area (J), and White Glacier zinc and copper (K) favorable areas.

Three other areas are also believed to have probable mineral-resource potential as they contain previously unknown geochemical and (or) geophysical anomalies that may indicate the existence of undiscovered resources. The anomalies which have not been field checked are porphyry copper and molybenum (L), chrome, cobalt, nickel, copper, lead, and zinc (M), and copper, lead, zinc, silver, and gold (N).

SUGGESTIONS FOR FURTHER STUDIES

There are a few areas in the northern part of the monument that have not yet been mapped in even reconnaissance fashion, a great many intrusive bodies of undetermined Jurassic or Cretaceous age that are critical to the definition of contrasting intrusive belts, and a major ancient suture zone; all of these may have had direct or indirect effects on the mineralization and more detailed studies would improve our understanding of the resource potential.

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GRANITE FIORDS WILDERNESS STUDY AREA, ALASKA

By HENRY C. BERG, U.S. GEOLOGICAL SURVEY, and

TOM L. PITTMAN, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys in 1972–73 and in 1975–78 of the Granite Fiords Wilderness study area revealed areas with probable and substantiated mineral-resource potential. In the northeastern sector, areas of probable and substantiated resource potential for gold, silver, and base metals in small, locally high grade vein and disseminated deposits occur in recrystallized Mesozoic volcanic, sedimentary, and intrusive rocks. In the central part, areas of probable resource potential for gold, silver, copper, and zinc in disseminated and locally massive sulfide deposits occur in undated pelitic paragneiss roof pendants. A molybdenite-bearing quartz vein has been prospected in western Granite Fiords, and molybdenum also occurs along with other metals in veins in the northeastern sector and in geochemical samples collected from areas where there is probable resource potential for low-grade porphyry molybdenum deposits in several Cenozoic plutons. No energy resource potential was identified in the course of this study.

CHARACTER AND SETTING

The Granite Fiords Wilderness study area is in southeastern Alaska, about 35 mi northeast of the town of Ketchikan. About 18 mi of the northern border is the International Boundary between Alaska and British Columbia. The area is entirely within the Tongass National Forest and encompasses about 1000 sq mi of remote, nearly virgin wilderness. There are no roads or well-developed trails in the study area. The Granite Fiords Wilderness study area was incorporated into Misty Fiords National Monument by the Alaska National Interest Lands Classification Act of 1981.

The part of the area that borders Behm Canal is accessible by boat. Elsewhere, access is by foot and helicopter, and by float-equipped airplanes that can land on several of the lakes. The northeastern part of the area can also be reached by glacier and cross-country trek from the head of an old, partly obliterated trail that leads from the village of Hyder to the eastern boundary of the study area.

The scenery in Granite Fiords is dominated by glacially sculpted features such as deep fiords and broad U-shaped valleys walled by sheer cliffs more than 3000 ft high. Most of the area was completely overridden by glacial ice, resulting in broad, rounded ridge crests. In the northern reaches, however, the mountains locally stood above the highest level of the ice and are characterized by matterhorns and knife-edged ridges, punctuated by spires and pinnacles. Small permanent snowfields and ice tongues dot the mountains throughout the study area but in the northern reaches, the land is still in the grip of glacial ice. There, only isolated spires and razor-backed ridges of bedrock penetrate the massive icefields and coalescing valley glaciers.

The average elevation of the rounded ridges is about 3000 ft. Along the deep fiords that indent the western part of the study area, these ridges rise directly from sea level, resulting in spectacular halfdomes and buttresses closely resembling those in Yosemite Valley, California. The highest peaks in Granite Fiords are along and near the northern boundary. At 7499 ft, Mount John Jay on the International Boundary is the highest, and at least half a dozen other nearby peaks exceed 6000 ft.

The climate is characterized by heavy precipitation, probably equivalent to more than 100 in. of rainfall per year. Vegetation consists of dense, nearly impenetrable rain forest at low elevations, and brush, moss, and lichen at higher levels. Significant forest cover is restricted to the area near Behm Canal and along the major river valleys.

Granite Fiords Wilderness study area lies mainly within the Coast Range batholithic complex, a terrane mainly of Mesozoic or Cenozoic plutonic rocks and of

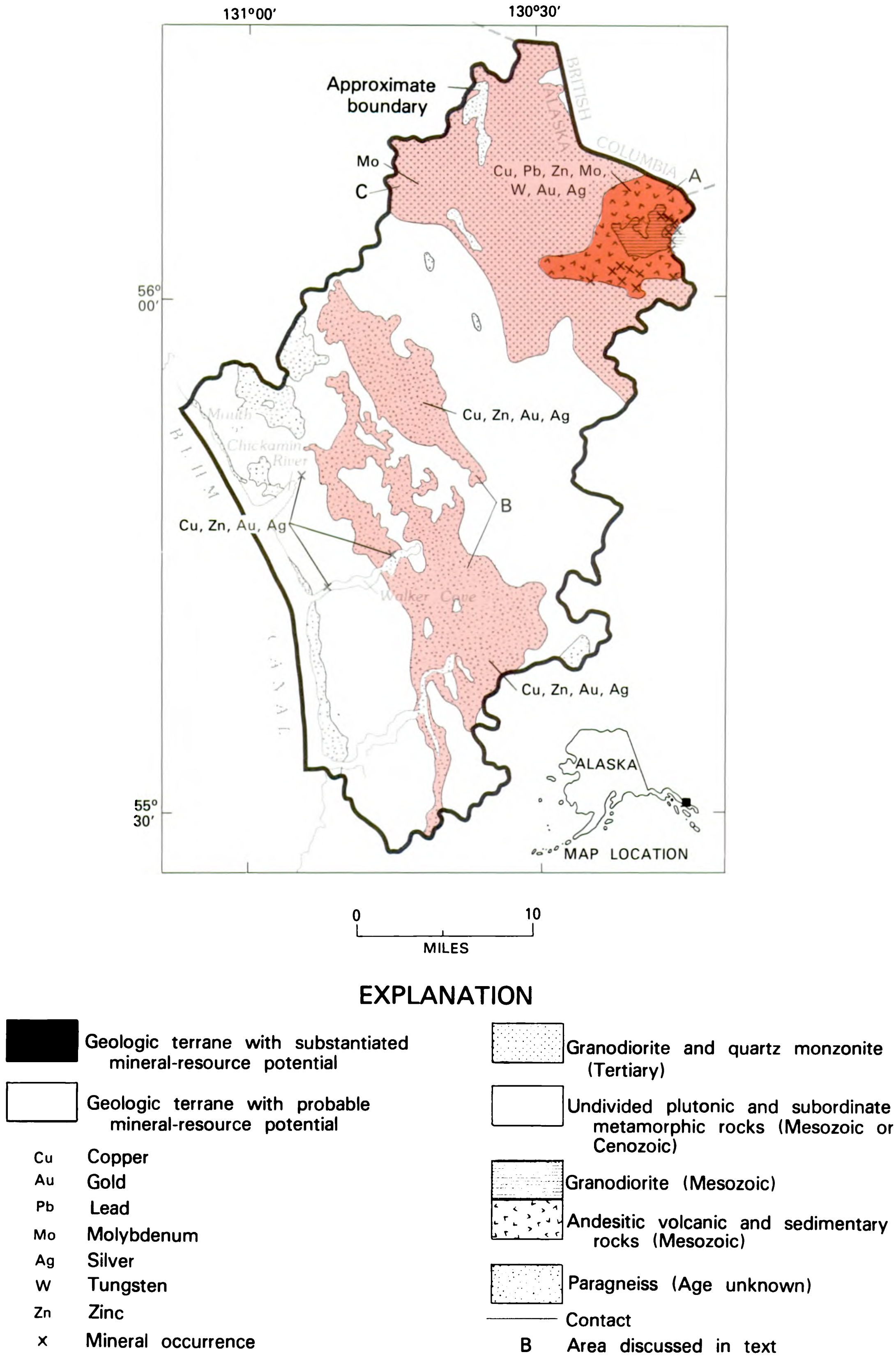

Figure 9.—Granite Fiords Wilderness study area, Alaska.

high-grade metamorphic rocks of unknown age. Other rocks in the study area include recrystallized Mesozoic andesitic volcanic rocks, detrital sedimentary rocks, and granodiorite that crop out near the northeastern boundary and Quaternary lava flows that underlie small areas near the southwestern boundary.

The mineral resources of the Granite Fiords Wilderness study area were surveyed in 1972–73 (Berg and others, 1977) and in 1975–78 (Berg and others, 1978). Two-thirds of the batholithic complex in the Granite Fiords study area is of plutonic rocks—chiefly quartz diorite, granodiorite, and quartz monzonite—that range in structure from strongly gneissoid to massive and nonfoliated. The plutons are progressively more silicic and massive northeastward across the batholith. The remaining third of the complex consists of banded gneiss derived mainly from sedimentary rocks (paragneiss) and minor amphibolite that originally was intermediate to mafic igneous rocks. In some places, the paragneiss grades imperceptibly into the adjacent granitic plutons; in others it occurs in striking, sometimes even bizarre patterns of angular, elongate, and swirled inclusions of dark rock in the lighter granite. The paragneiss is regionally metamorphosed in the amphibolite facies throughout the study area.

MINERAL RESOURCES

Studies by the USGS included reconnaissance geologic mapping, geochemical sampling of rocks and stream sediments, and study of geologic relationships of some of the prospects and mineral occurrences. The mineral-resource evaluation also utilized a reconnaissance aeromagnetic survey by a commercial vendor under contract to the USGS.

Mining engineering studies by the USBM included mining claim records search, on-site claim and prospect investigations, and mapping and sampling of altered zones and geochemically anomalous rock sample sites.

The previously known mineral resources in the Granite Fiords area consist of metalliferous bedrock deposits containing small amounts of gold, silver, molybdenum, copper, lead, and zinc. No new deposits were found during the investigation, but the anomalous amounts of gold, silver, molybdenum, copper, lead, and zinc that occur in the geochemical samples suggest that metalliferous resources may exist.

Nineteen vein-type and disseminated mineral occurrences are known to have been prospected within the boundaries of the study area. Sixteen of them are in the remote northeastern part of Granite Fiords. The other three are near tidewater: one near the mouth of the Chickamin River and two at Walker Cove. Most of these occurrences were originally staked in the early 1900's; about half a dozen were being prospected in 1972. Except for a 1-ton test shipment in 1925 from the northeastern sector, there is no record of any mineral production.

The occurrences in the northeastern part of the Granite Fiords area are sulfide-bearing quartz-fissure veins and stringer lodes, massive sulfide stringers, or disseminated sulfide deposits. Their sulfide minerals include arsenopyrite, chalcopyrite, galena, molybdenite, pyrite, pyrrhotite, sphalerite, and tetrahedrite. The occurrences are mainly in recrystallized Mesozoic bedded and intrusive rocks that have been intruded by Cenozoic quartz monzonite and granodiorite. The information obtained during this investigation suggests that any mines that may be developed in the northeastern part of the study area probably would be underground operations mining less than 500 tons per day from veins or aggregates of veins.

The occurrence near the mouth of the Chickamin River is in quartz diorite and consists of a quartz vein that contains pyrite and a little molybdenite. The principal occurrence at Walker Cove is a 75 ft-wide zone of iron-stained paragneiss containing disseminated pyrite and chalcopyrite. Samples from this occurrence gave results of 0.3 to 1.5 percent copper as well as small amounts of zinc, gold, and silver. Similar types of deposits may occur elsewhere in the paragneiss unit.

Analysis of geochemical samples showed that the only valuable metals present in greater than background amounts are gold, silver, molybdenum, copper, lead, and zinc. However, most anomalous values were not much higher than background amounts, and only about 25 percent of them were as much as two or three times background. Most samples contained only 1 metal in anomalously high amounts, and only 7 contained 3 or more metals.

The distribution of known mines, prospects, and mineral occurrences and of anomalous geochemical samples show three principal areas with potential for metallic mineral resources: (1) The area in the northeastern part of the study area underlain by recrystallized Mesozoic bedded and intrusive rocks has substantiated potential for small, locally high grade vein-type deposits containing gold, silver, copper, lead, zinc, molybdenum, and tungsten (area A on map). (2) The area of undated paragneiss in the west-central part of the study area has probable potential for low-grade disseminated and massive sulfide deposits containing gold, silver, copper, and zinc (area B on map). (3) The areas of Cenozoic granodiorite, quartz monzonite, and granite plutons in the eastern part of the study area have probable potential for large low-grade porphyry molybdenum deposits (area C on map); these plutons also occur sporadically elsewhere in the study area. A major prophyry molybdenum deposit currently (1982) under development about 10 mi south of the study area is in a mid-Cenozoic granite porphyry stock similar to those found in area C.

SUGGESTIONS FOR FURTHER STUDIES

Although the Granite Fiords Wilderness study area contains no productive mines or extensively explored prospects, there are two major mineral deposits close to its borders. The Granduc copper mine in British Columbia is about 1 mi from the northeastern extremity of the study area, and the Quartz Hill porphyry molybdenum deposit is about 10 miles south of the southern boundary. Our reconnaissance investigations suggest that additional detailed geochemical, geophysical, or geological mapping studies, combined with drilling or other physical exploration might reveal comparable mineral deposits within the boundaries of Granite Fiords.

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TRACY ARM-FORDS TERROR WILDERNESS STUDY AREA AND VICINITY, ALASKA

By DAVID A. BREW, U.S. GEOLOGICAL SURVEY, and

A. L. KIMBALL, U.S. BUREAU OF MINES

SUMMARY

The spectacularly scenic Tracy Arm-Fords Terror Wilderness study area lies on the southwest flank of the Coast Range about 45 mi southeast of Juneau, Alaska. A mineral-resource survey of the area in 1972–1975 identified two areas with substantiated mineral-resource potential: the Sumdum Glacier mineral belt with gold, copper, and zinc potential; and the Endicott Peninsula area with zinc, silver, and gold potential. The Sumdum Glacier belt is estimated to contain between 3 and 15 mineral deposits and there are 5 known mining areas in the Endicott Peninsula.

CHARACTER AND SETTING

The study area consists of about 1250 sq mi on the southwest side of the Coast Range in southeastern Alaska; it is about 45 mi southeast of Juneau, Alaska. An additional 550 sq mi between the study area and the International Boundary with Canada and in part contiguous with the southwest boundary of the wilderness study area, was evaluated because of its importance to the mineral-resource assessment of the area. The information presented here is abstracted from Brew and others (1977) and from a revised version of that same report (Brew and others, 1983).

The area is one of spectacular scenery, with fiords, forests, glacier-covered peaks to 8095 ft high, tidewater glaciers, icebergs, and some broad river valleys.

Studies by the USGS in 1972–1975 included reconnaissance geochemical sampling of stream sediments and rocks; and study of geologic relationships of some of the mines, prospects, and mineral occurrences. The mineral-resource evaluation also utilized an aeromagnetic survey of the area. Mining engineering studies by the USBM included mining-claim records search; onsite claim, mine, and prospect investigations; and mapping and sampling of stained zones, altered zones, and geochemically anomalous sites.

About 670 claims, approximately 90 percent of them lode, are recorded in the area studied. Seventy percent of these were within the wilderness study area. Approximately 24,000 oz of gold and probably a similar quantity of silver were produced from the Sumdum Chief lode property at the turn of the century.

Geologically, the area spans most of the Coast Range plutonic-metamorphic complex (an informal term). The Coast Range complex is bounded on the west by a long foliated tonalite sill of probable early Tertiary age; to its northeast lies the main part of the complex, consisting of a broad terrane of complexly deformed amphibolite-facies gneiss, marble, and some schist of uncertain, but probably original late Paleozoic and (or) Mesozoic age. Near the International Boundary with Canada, this terrane is intruded by a series of generally unfoliated granodiorite bodies of mid-Tertiary age which are locally associated with migmatite zones. To the west of the sill, the rocks consist of low-grade metanorphics which are locally intruded by granite and other rocks.

MINERAL RESOURCES

Almost all of the mineralization within the wilderness study area occurs in the western metamorphic belt, parallel and adjacent to the western side of the Coast Range batholithic complex (an informal term). Little significant mineralization appears to be present within the batholithic complex.

The western metamorphic belt has been recognized as having mineral-resource potential since the early 1900's when most of the occurrences investigated were located. The present study has identified two areas within this belt in the study area with substantiated resource potential for gold, copper, zinc, and silver; these are, in the order of decreasing importance, the Sumdum Glacier mineral belt and the Endicott Peninsula area.

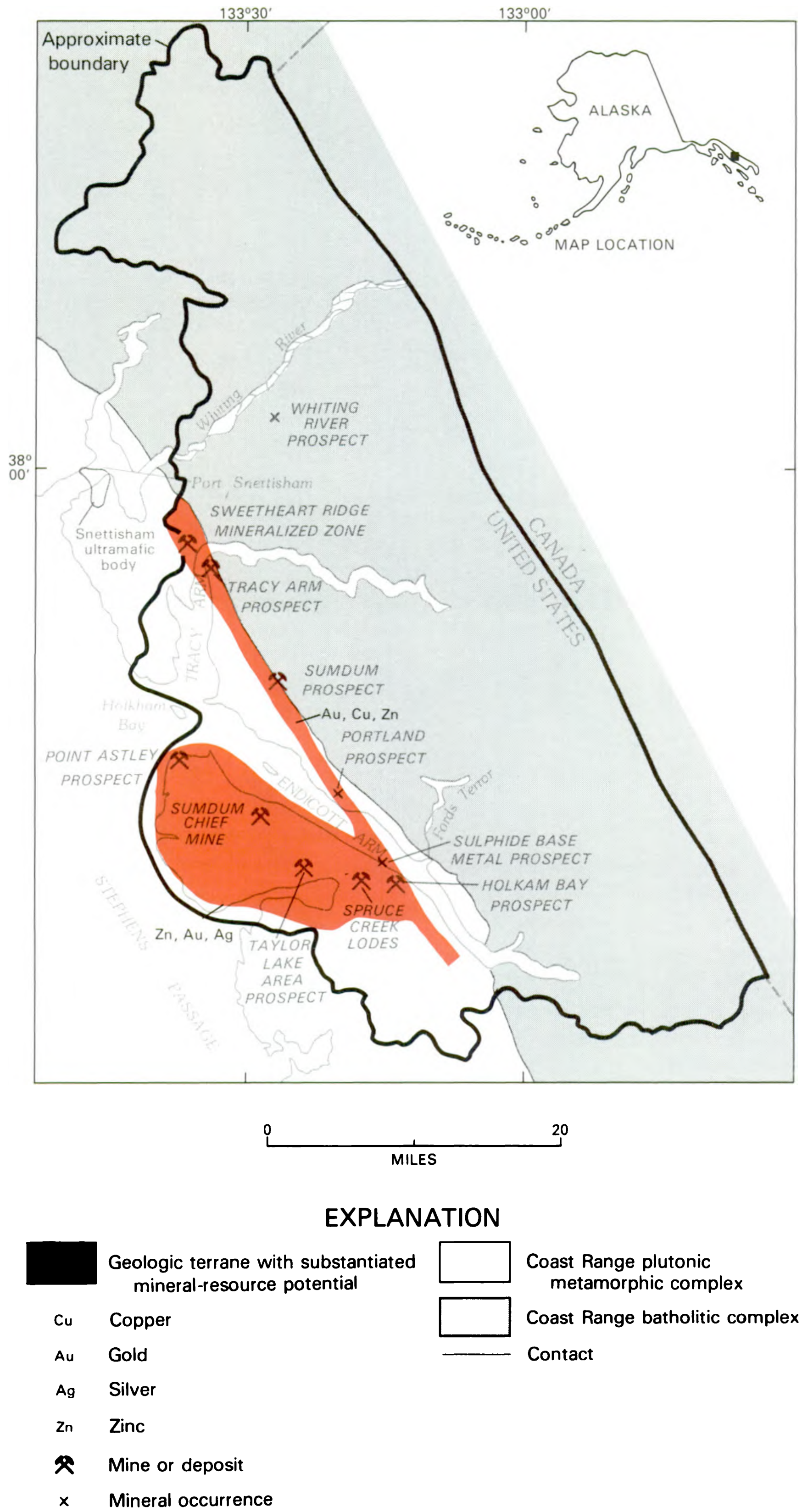

Figure 10.—Tracy Arm-Fords Terror Wilderness study area and vicinity, Alaska.

The Sumdum Glacier mineral belt extends for about 32 mi along the southwest side of the Coast Range batholithic complex and contains three known important mineralized areas: the Tracy Arm zinc-copper prospect, the Sumdum copper-zinc prospect, and the newly discovered Sweetheart Ridge gold-copper occurrence. The deposits in the belt consist of pyrrhotite, chalcopyrite, sphalerite, pyrite, galena, and some gold in lenses and pods parallel to the foliation or disseminated in the metamorphic rocks.

These three deposits have demonstrated resources and warrant further exploration. The Tracy Arm zinc-copper deposit is estimated to contain 187,000 tons of rock averaging 3.42 percent zinc, 1.42 percent copper, 0.43 oz silver/ton, and 0.008 oz gold/ton. The Sumdum copper-zinc prospect is estimated to contain 26.7 million tons of rock averaging 0.57 percent copper, 0.37 percent zinc, and 0.30 oz silver/ton. A 147-ft-long portion of the Sweetheart Ridge mineralized zone is estimated to contain 7300 tons of rock per 100 ft of depth that average 0.23 oz gold/ton and 0.7 percent copper.

The entire Sumdum Glacier mineral belt is considered favorable ground for the occurrence of mineral deposits and the available information is used to suggest, therefore, that the number of deposits that may occur is somewhere between 3 and 15. The minimum number represents the deposits described above; the additional 12 could include some of the poorly known or unexplored prospects or mineral occurrences already known in the belt.

The Endicott Peninsula area has been prospected since before 1869 and several occurrences have long been known: the Point Astley zinc-silver deposit, the Sumdum Chief gold mine, the Taylor Lake area prospects, the Holkam Bay gold prospect, and the Spruce Creek area gold lodes and placers. The deposits in the area are largely either sulfide minerals in lenses and stringers along the foliation in phyllite or disseminated through it, or gold-bearing quartz veins in shaly limestone, limy slate, or phyllite. The area, as a whole, is poorly exposed because of extensive timber and brush.

The one known significant deposit in the area consisted of gold-bearing quartz veins in shaly limestone at the Sumdum Chief gold mine. The Sumdum Chief deposit was mined before 1905; it produced about 24,000 oz of gold from ore that contained about 0.4 oz gold/ton. The other prospects and mines had very little or no production. The Taylor Lake occurrences are geologically similar to the Sumdum Chief. The Point Astley zinc-silver prospect has not been thoroughly explored. The deposit appears to be extremely irregular and the lateral and vertical continuity of the mineralized zones are not known. The gold mines and prospects near Spruce Creek occur mainly along quartz stringers in broad altered zones, and all appear to have low gold contents that only rarely exceed 0.25 oz gold/ton. The Holkam Bay prospect is similar and had some small production.

The area was studied for radioactive minerals, oil, gas, coal, and industrial mineral deposits as well as geothermal energy, but there is little promise for the occurrence of these resources.

SUGGESTIONS FOR FURTHER STUDY

Since release of the report by Brew and others (1977), several exploration companies have been active in the Sumdum Glacier mineral belt, but further work, particularly in the southern part of the belt, would be of significant help in refining the evaluation of that area. Relatively little activity has occurred in the Endicott Peninsula area; intense geochemical and geophysical work would remove many of the present uncertainties and probably would refine the present limit of the favorable areas.

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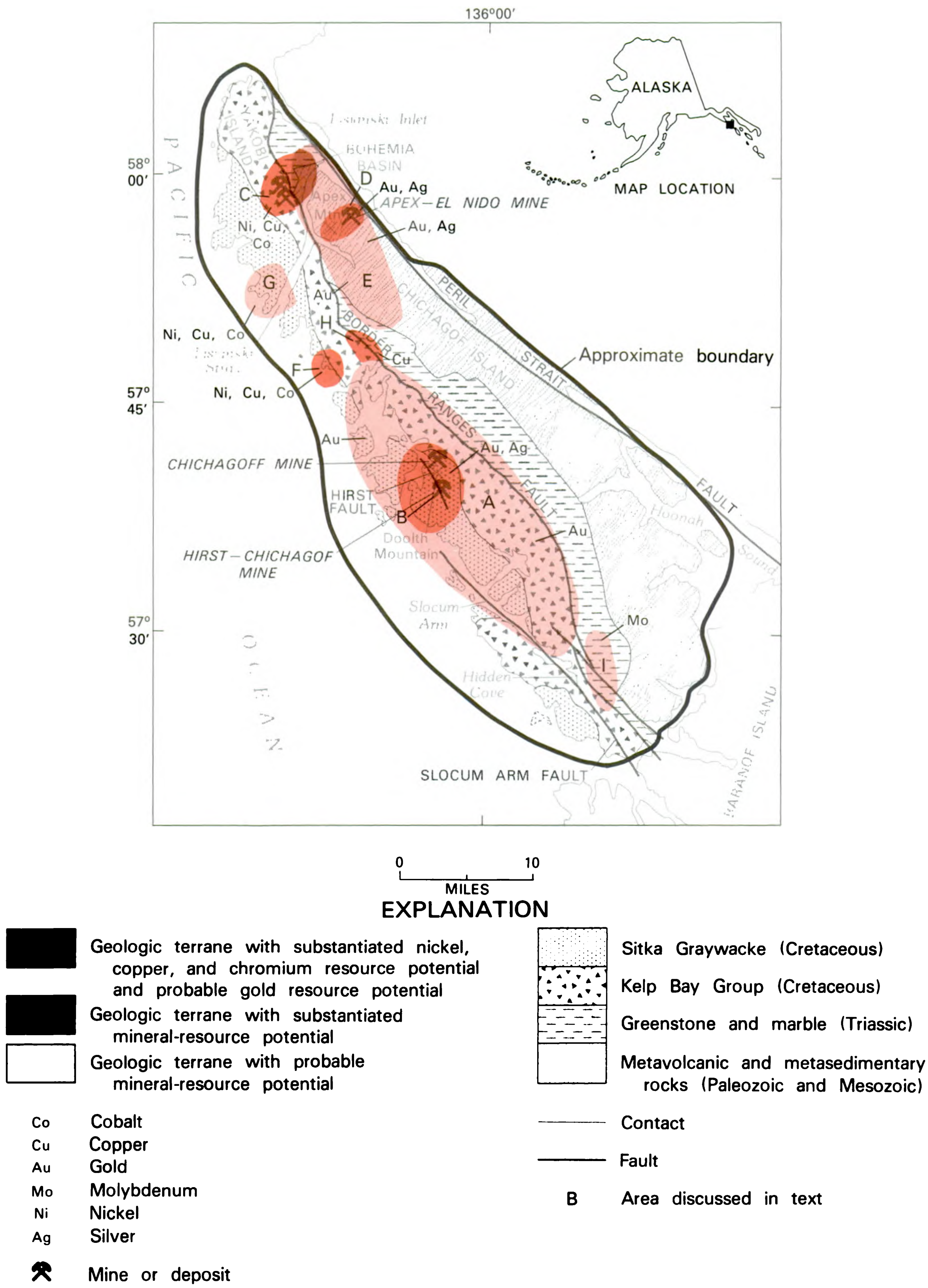

Figure 11.—Western Chichagof and Yakobi Islands Wilderness study area, Alaska.

WESTERN CHICHAGOF AND YAKOBI ISLANDS WILDERNESS STUDY AREA, ALASKA

By BRUCE R. JOHNSON, U.S. GEOLOGICAL SURVEY, and

ARTHUR L. KIMBALL, U.S. BUREAU OF MINES

SUMMARY

On the basis of mineral-resource studies by the USGS and USBM in 1980 of the Western Chichagof and Yakobi Islands Wilderness study area, southeastern Alaska, five areas of substantiated mineral-resource potential and four areas of probable mineral-resource potential have been delineated. No energy resource potential was identified in this study.

CHARACTER AND SETTING

Western Chichagof and Yakobi Islands are part of the Alexander Archipelago of southeastern Alaska. The wilderness study area is within the Tongass National Forest, is approximately 60 mi long and as much as 20 mi wide, and has an area of 633 sq mi. Topography is moderately rugged with high peaks and ridges at about 3000 ft separated by river valleys and lakes at or near sea level. The southwestern coastline is particularly irregular, consisting of myriad small islands, peninsulas, fiords, and reefs.

The sedimentary and metamorphic rocks of western Chichagof and Yakobi Islands can be divided into four roughly linear northwest-trending stratigraphic belts which are progressively younger toward the southwest (Johnson and Karl, 1982). The oldest rocks form a discontinuous belt along Hoonah Sound and Lisianski Inlet of metamorphosed sedimentary and volcanic rocks. The second belt of rocks, to the southwest, is composed of the Triassic(?) Goon Dip Greenstone and Whitestripe Marble. These two belts have been intruded by Jurassic and Cretaceous diorite, quartz diorite, and tonalite plutons that exhibit a general northwest foliation.

A major fault, the Border Ranges fault, forms the boundary between the belts described above and two younger belts to the southwest. The Cretaceous Kelp Bay Group, the third belt, immediately southwest of the Border Ranges fault consists of a complex assemblage of metasedimentary and metavolcanic rocks. The fourth and youngest belt, the Cretaceous Sitka Graywacke, is southwest of the Kelp Bay Group and in fault contact with it. All of the belts have been intruded by Tertiary(?) plutonic rocks following movement on the Border Ranges fault.

MINERAL RESOURCES

The Western Chichagof and Yakobi Islands Wilderness study area lies within the Sitka recording district and the Chichagof mining district. The following descriptions of mineral resources are abstracted from Johnson and others (1982). Detailed descriptions of the mines, prospects, and occurrences within the study area, as well as details of the individual resource calculations are given in Kimball (1982) and Still and Weir (1981).

The older rocks of the northeastern belts and the Kelp Bay Group and younger rocks to the southwest are cut by small, felsic to intermediate stocks and dikes. The dikes, which are believed to be related to Tertiary(?) plutonism (Loney and others, 1975), tend to be most abundant near localities of known mineralization. Many gold-bearing veins occur near bends in fault surfaces or at intersections of main faults and lesser splits. The ore zones containing the veins tend to be tabular, dip steeply, and are commonly a few feet thick and a few hundred feet long. The mineralogy of the gold-bearing veins is relatively constant throughout the study area. Quartz veins carry from 0.5 to 3 percent pyrite, and smaller amounts of arsenopyrite, galena, sphalerite, chalcopyrite, and gold, with local occurrences of tetrahedrite and scheelite.

Gold occurrences in an area of probable resource potential along the west coast of Chichagof Island (A, on map), include nearly all the production in the Chichagof mining district. The occurrences are in weakly metamorphosed sedimentary and volcanic host rocks of the Kelp Bay Group and the structurally overlying Sitka Graywacke. The host rocks are cut by numerous strike-slip and thrust(?) faults and mineralization in the form of hydrothermal gold-quartz veins commonly occurs along northwesterly striking, steeply dipping shear zones within graywacke, schist, and marble. Numerous precious-metal prospects occur within area A and several small mines have produced small amounts of gold and silver. There is a probable resource potential for additional occurrences of gold along faults in this area. Area A surrounds a center of mining activity and production at Doolth Mountain (B). This area has substantiated gold and silver resource potential and contains the Chichagoff and Hirst-Chichagof mines, which have demonstrated resources of 316,000 oz gold and 88,000 oz silver, almost all of the gold resources of the study area.

The Chichagoff mine is located along the Chichagof fault, which has a traceable strike length of at least 12 mi. The mine opened in 1905 and closed in 1942 with a recorded production of 660,000 oz of gold and 200,000 oz of silver from over 600,000 tons of ore. The mine and adjacent mineralized area consists of 29 patented claims and ranks as the third largest lode-gold producer in Alaska. Mining reached a depth of 2700 ft below sea level, and underground workings explore the fault for 4800 ft in a horizontal direction and 4300 ft vertically. Twenty-three percent of the area explored by underground workings was mined. Almost all mine workings are currently inaccessible.

The Hirst-Chichagof mine is along the Hirst fault which is parallel to and approximately 0.8 mi southwest of the Chichagof fault. The property was staked in 1905 and operated from 1922 to 1943. The structure is explored along 5000 ft of strike, as much as 2200 ft vertically and mining reached a depth of 1800 ft below sea level. It produced 131,000 oz of gold and 33,000 oz of silver from over 140,000 tons of ore. Old records indicate that less than ten percent of the area explored by underground workings was mined. Almost all the old workings are currently inaccessible. The mine and adjacent mineralized area are partially covered by 12 patented claims.

The Lisianski Gold area of probable gold and silver resource potential (area E) is characterized by gold-quartz occurrences along northeast-striking faults, fractures, and shear zones in diorite, amphibolite, greenstone, and schist within the belt of Mesozoic or older metamorphic rocks. Area E includes five properties that produced about 18,000 oz of gold and 2,500 oz of silver and twelve others with reported gold occurrences. Based on gold production area D is an area of substantiated gold and silver resource potential which contains a number of gold occurrences (130 recorded claims), including the Apex-El Nido mine, and is the most important portion of the Lisianski Gold area (E).

The Apex and El Nido gold-bearing quartz veins were discovered in 1919 and 1920, respectively, and produced about 17,000 oz of gold and 2400 oz of silver in the periods 1924–28, 1934–35, and 1937–39. Currently, there are 41 unpatented lode and 3 placer claims, mostly on the northeast side of Apex Mountain. The deposits consist of steeply dipping, gold-bearing quartz veins, 1 to 4 ft thick, along faults in diorite and amphibolite. Sporadically distributed scheelite ($CaWO_4$) also occurs in the veins.

Nickel-copper-cobalt deposits occur in 3 areas having resource potential in the wilderness study area (two substantiated and one probable). The deposits are massive sulfide magmatic segregations in noritic and gabbro-noritic facies of composite Tertiary(?) stocks that are generally potassium poor and vary widely from tonalite to norite. The stocks intrude Cretaceous metavolcanic and metasedimentary rock of the Kelp Bay Group and turbidites of the Sitka Graywacke. Contact metamorphic halos surround the stocks. The deposits consist generally of pentlandite, chalcopyrite, and pyrrhotite in either massive or disseminated bodies. The massive sulfide bodies are podlike, small, and difficult to explore or delineate without extensive drilling.

Bohemia Basin is an area of substantiated nickel-copper-cobalt resource potential (area C), on Yakobi Island. It is the largest of the three known nickel-copper-cobalt areas and 980 mining claims have been recorded since 1920, of which 265 are unpatented active claims and 9 are patented claims. Extensive surface exploration and more than 50,000 ft of diamond drilling have partially delineated three mineralized bodies. The two largest bodies in this area are reported to contain at least 20,100,000 tons of demonstrated resources averaging 0.31 percent nickel, 0.18 percent copper, and 0.04 percent cobalt (Inspiration Development Company, press release, April 3, 1978).

Similar magmatic segregations are known in an area of substantiated nickel-copper-cobalt resource potential in mafic rocks 15 mi to the southeast, on Chichagof Island near Mirror Harbor (area F). These occurrences have been known since 1911 and 330 claims have been recorded, with 114 claims presently current. Exploration, including diamond drilling, has been conducted during the past several seasons in this area and although tonnage estimates are not available, seven diamond drill holes have intercepts of nickel, copper, and cobalt similar in grade to Bohemia Basin. The Squid Bay-Lost Cove area of probable nickel-copper-cobalt resource potential (area G) is about 8 mi south of

Bohemia Basin on Yakobi Island and northwestern Chichagof Island. Host rocks at this locality are similar to the Mirror Harbor occurrences, but USBM samples from this area contain low copper values, with minor nickel and cobalt.

Ninety claims have been recorded near Mt. Baker, an area of substantiated copper resource potential (area H). The largest known concentration of copper is in a northwesterly striking vertical zone in greenstone 350 to 400 ft long. Several trenches (now sloughed), a shallow shaft, and a crosscut have been opened. Sample analyses from a trench at the southeastern end of the zone show 2.0 percent copper across a 13 ft width, and from a shallow shaft at the northwest end of the zone show 7.5 percent copper across a 2 ft width. Minor gold and silver values are also present.

The Slocum Arm Molybdenum area (I) is 1.5 mi east of Hidden Cove, at the southern end of Slocum Arm. Ten claims are currently active. Molybdenum mineralization occurs in small quartz veins, dikes, and country rock across an area 0.75 mi wide by 1.5 mi long near a dioritic intrusion. The area has probable molybdenum resource potential.

SUGGESTIONS FOR FURTHER STUDIES

Current knowledge of the detailed geology of the study area is confined to areas adjacent to the well-known mineral deposits such as at Doolth Mountain and at Bohemia Basin. The remainder of the study area is well mineralized, but the extent of mineralization is inadequately known. Detailed geologic and geochemical studies of the lesser known areas such as Squid Bay-Lost Cove, Mt. Baker, and Slocum Arm would provide a more complete resource assessment.

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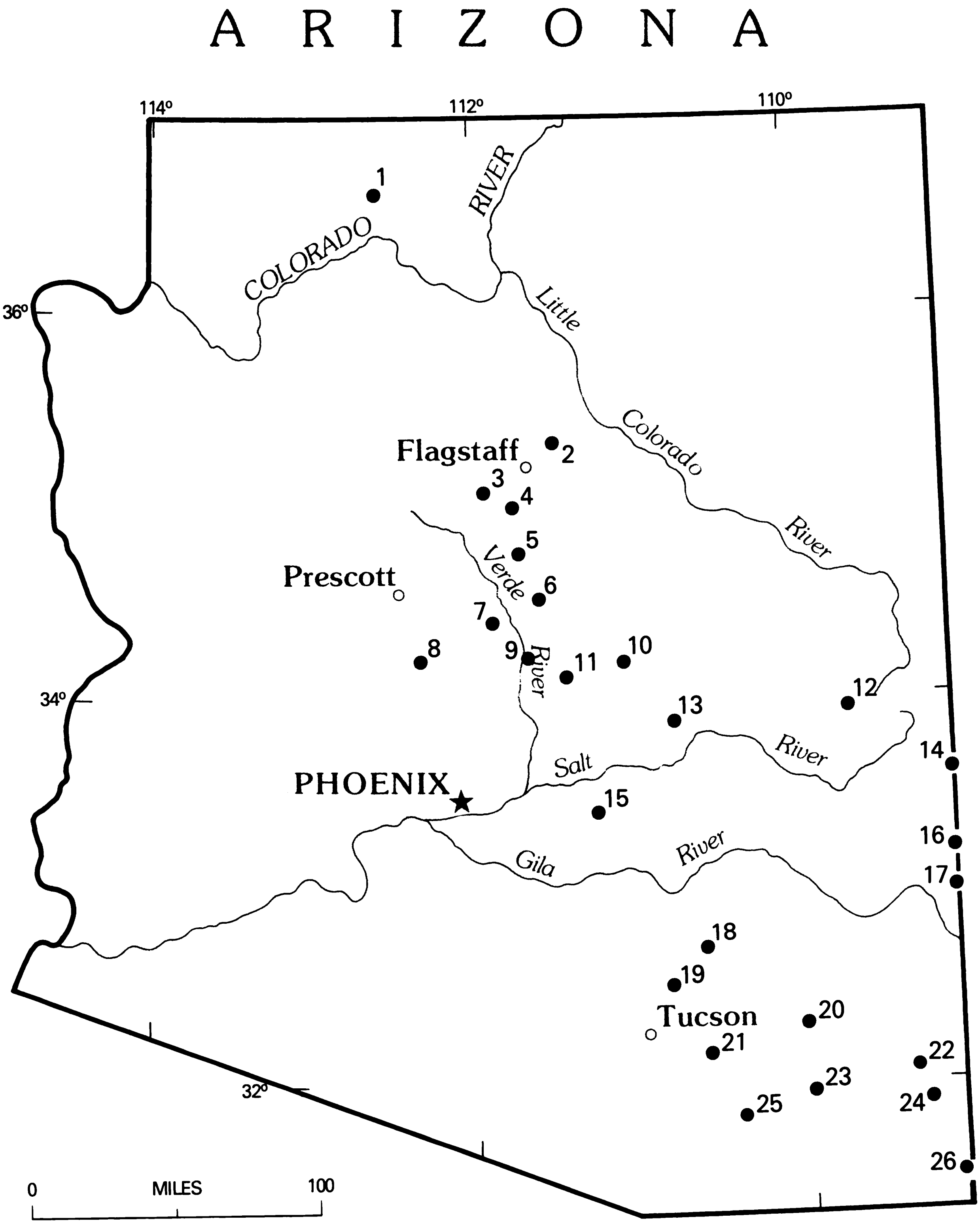

Location of areas studied.

ARIZONA

Map No.	Name of Area
7	Arnold Mesa Roadless Area
14	Blue Range Wilderness, Arizona and New Mexico
26	Bunk Robinson Peak and Whitmire Canyon Roadless Areas, New Mexico and Arizona—See New Mexico
24	Chiricahua Wilderness
23	Dragoon Mountains Roadless Area
9	Fossil Springs Roadless Area
18	Galiuro Wilderness and contiguous roadless areas
10	Hells Gate Roadless Area
17	Hells Hole Roadless Area, Arizona and New Mexico
1	Kanab Creek Roadless Area
16	Lower San Francisco Wilderness study area and contiguous roadless areas, Arizona and New Mexico
11	Mazatzal Wilderness and contiguous roadless areas
12	Mount Baldy Wilderness
22	North End Roadless Area
8	Pine Mountain Wilderness
19	Pusch Ridge Wilderness
4	Rattlesnake Roadless Area
21	Rincon Wilderness Study Area
13	Sierra Ancha Wilderness
2	Strawberry Crater Roadless Areas
15	Superstition Wilderness
3	Sycamore Canyon Primitive Area
6	West Clear Creek Roadless Area
5	Wet Beaver Roadless Area
25	Whetstone Roadless Area
20	Winchester Roadless Area

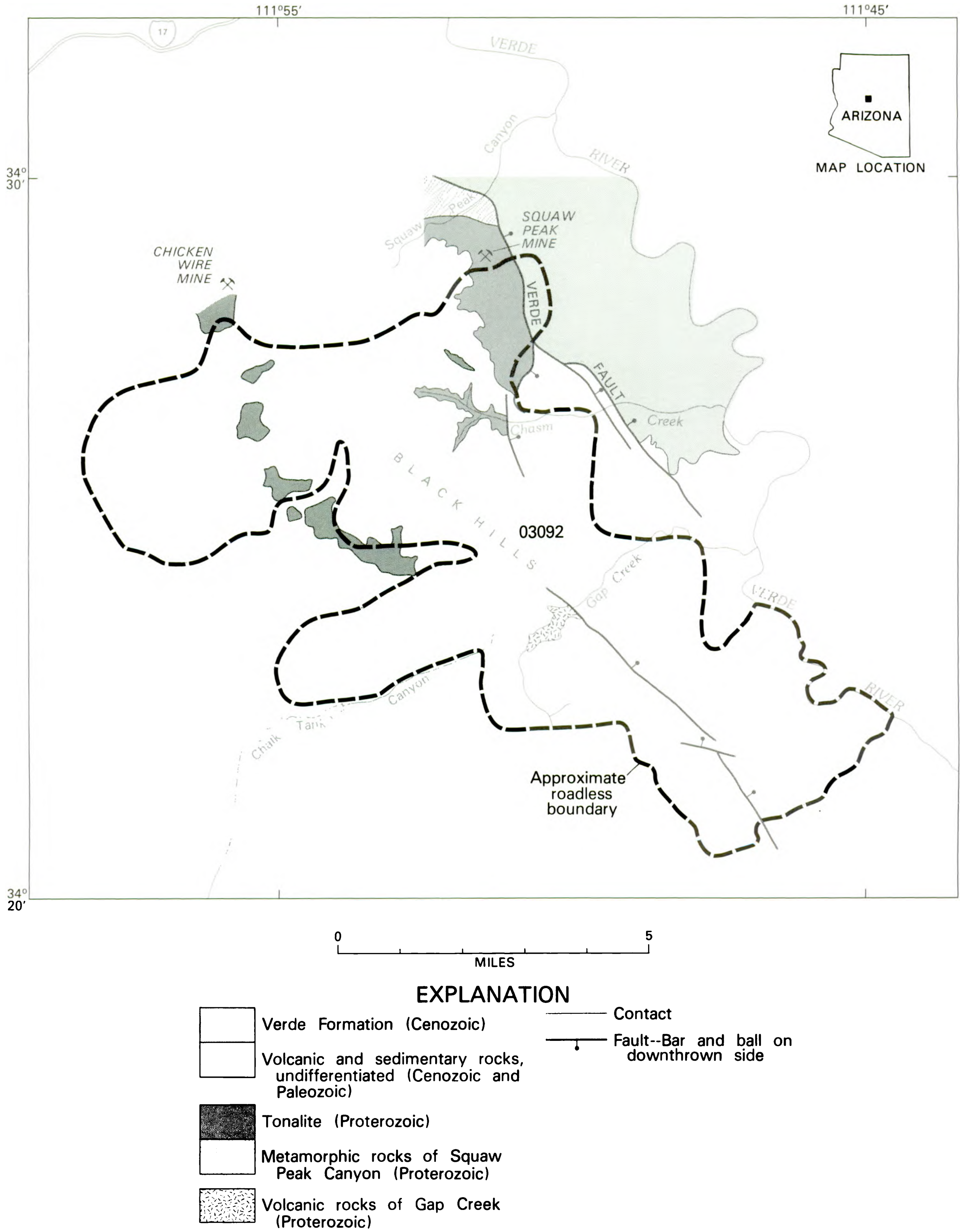

Figure 12.—Arnold Mesa Roadless Area, Arizona.

ARNOLD MESA ROADLESS AREA, ARIZONA

By EDWARD W. WOLFE, U.S. GEOLOGICAL SURVEY, and

ROBERT A. MCCOLLY, U.S. BUREAU OF MINES

SUMMARY

Geologic, geochemical, and aeromagnetic investigations and a survey of mines and prospects in 1980 in the Arnold Mesa Roadless Area, Arizona, provide little evidence for the occurrence of mineral or energy resources. Buried Proterozoic basement rocks are possible hosts for porphyry-type copper and massive sulfide deposits but the thick cover of Paleozoic sedimentary rocks and upper Cenozoic volcanic rocks precluded assessment of this possibility. Chemistry and temperature of spring and well waters suggest that a geothermal resource may exist near the eastern margin of the roadless area, but the anomaly has not been tested by drilling and this resource remains unverified. No other energy resources were identified.

CHARACTER AND SETTING

The Arnold Mesa Roadless Area comprises about 44 sq mi in and along the flanks of the Black Hills south of Camp Verde, Arizona. The crest and southwest flank of the Black Hills within the roadless area are moderately dissected rolling uplands. The northeast flank, which is steep terrain that forms the western wall of the Verde River Valley, has a total relief within the roadless area of almost 4000 ft and is deeply incised by canyons such as those of Gap and Chasm Creeks.

The roadless area is within the transition zone between the Colorado Plateaus and the Basin and Range Province. The zone is underlain by Precambrian rocks and gently dipping Paleozoic strata that are similar to Precambrian and Paleozoic rocks in the southern part of the Colorado Plateau in the Grand Canyon.

Proterozoic rocks just north of the roadless area, in the vicinity of Squaw Peak Canyon, include foliated mafic and, locally, intermediate volcanic rocks of greenschist facies that are intruded by a Proterozoic pluton composed mainly of tonalite. The tonalite is locally exposed in the northern and central parts of the roadless area. In the southern part of the roadless area, Proterozoic rocks exposed along Gap Creek, in Chalk Tank Canyon, and locally along the Verde River are dominantly relatively unmetamorphosed dacite and rhyolite with subordinate mafic volcanic or volcaniclastic rocks.

Gently dipping Paleozoic dolomite and limestone with subordinate sandstone and siltstone rest unconformably on the Proterozoic rocks. These strata, Cambrian to Pennsylvanian or Permian in age, have an aggregate maximum thickness of 730 to 910 ft, but they pinch out locally between the Proterozoic tonalite and the upper Cenozoic Hickey Formation.

The transition zone in central Arizona was the locus of voluminous eruptions of basaltic lava and pyroclastic deposits that rest on the eroded surface of the Paleozoic and Precambrian rocks. Dacitic to rhyolitic lava flows and pyroclastic deposits, also of late Miocene age, occur locally within the roadless area.

Northwest-trending linear basins of late Cenozoic age characterize the transition zone and indicate extension and basin subsidence. The roadless area includes the southernmost part of one of these basins, the 30 mi-long Verde basin alined approximately along the Verde River, that contains late Cenozoic basin-fill deposits more than 3100-ft thick (Nations, 1974) of the Verde Formation.

The Verde basin and its sedimentary fill are bounded on the southwest by the Verde fault, which, in the northern part of the roadless area, is a conspicuous, single, steep, normal fault. Near Chasm Creek, however, the single fault splays southward into several high-angle faults that can be traced only a short distance southeast of Chasm Creek. Another fault system, similar to the Verde fault in trend and sense of movement but offset en echelon from it, extends from the upper part of Gap Creek to the southern boundary of the roadless area.

MINERAL RESOURCES

Prospecting and claim staking have occurred intermittently from about the mid-1800's to the present. No mine production is known from within the roadless area and at the time of field examination, no mining or exploration work was occurring within the roadless area.

At the Squaw Peak mine, just north of the Arnold Mesa Roadless Area, the Proterozoic tonalite pluton is the host for a porphyry-type copper deposit (Roe, 1976). The Squaw Peak mine is not currently active, and the only recorded production was from 1944 to 1946. During that period, 1000 tons of ore produced 5.4 tons of 98.82 percent molybdenite (MoS_2) and 36 tons of concentrate averaging 22.85 percent copper, 1.92 oz silver/ton, and 0.016 oz gold/ton (Hill, 1949). Roe has shown that the deposit does not extend into the roadless area, and no outcrop evidence of similar occurrences exists in the roadless area. There is a small possibility that similar porphyry-type mineral deposits may occur in the subsurface throughout the roadless area; however, overlying Paleozoic sedimentary and Cenozoic volcanic rocks as much as 1500 ft thick cover any such porphyry-type copper deposits.

A minor amount of gold with an estimated value of a few hundred to a few thousand dollars has been produced north of the roadless area at the Chicken Wire gold mine from brecciated tonalite adjacent to quartz veins. Although quartz veins do occur in the roadless area, they are relatively scarce in the outcrop areas of tonalite and no resource potential for the occurrence of small vein- or fracture-related deposits of silver or gold was identified.

The Proterozoic volcanic rocks of Gap Creek underlie the southern part of the roadless area. They are broadly like the host rocks for the massive sulfide deposit of Jerome, Arizona (Anderson and Creasey, 1958; Donnelly and Hahn, 1981), and there may be a possibility for the occurrence of similar ores of copper, silver, and gold. The unit is largely buried by younger sedimentary and volcanic rocks as much as 2500 ft thick and because direct evidence of a massive sulfide deposit has not been found. However, this does not preclude the occurrence of massive sulfide deposits under the cover of younger rocks within the volcanic rocks of Gap Creek. Therefore, the possibility exists for such deposits in the southern part of the roadless area, but due to the lack of conclusive data, no resource potential was identified.

Rock suitable for crushing into aggregate occurs throughout the roadless area, and tonalite has been quarried locally for use in flood-control construction on the Verde River. However, deposits of potential aggregate material outside the roadless area are more accessible and closer to markets. No potential was identified for the occurrence of resources in the Paleozoic and Cenozoic rocks that cover most of the roadless area.

Evidence gathered by Ross and Farrar (1980) indicates that ground water near the eastern boundary of the roadless area has been in contact with reservoir rocks of elevated temperature. The sampled springs and wells all lie within and east of the Verde fault zone and its projection to the southeast. Their modestly elevated temperatures suggest a possible geothermal resource, but this resource remains untested.

The results of geologic, geochemical, and aeromagnetic investigations and a survey of mines and prospects (McColly and Korzeb, 1981) in 1980 indicate little likelihood that the Arnold Mesa Roadless Area has occurrences of metallic mineral resources in porphyry copper-type settings, but a greater likelihood in the area for massive sulfide-type deposits (Wolfe and others, 1983).

SUGGESTIONS FOR FURTHER STUDIES

Additional detailed examination and geochemical sampling of the exposed Proterozoic rocks represent the most direct approach to identifying geochemical patterns that might offer further evidence on the presence or absence of mineral deposits. Geophysical studies and, ultimately, drilling are the most likely techniques for additional evaluation of the weak geothermal anomaly.

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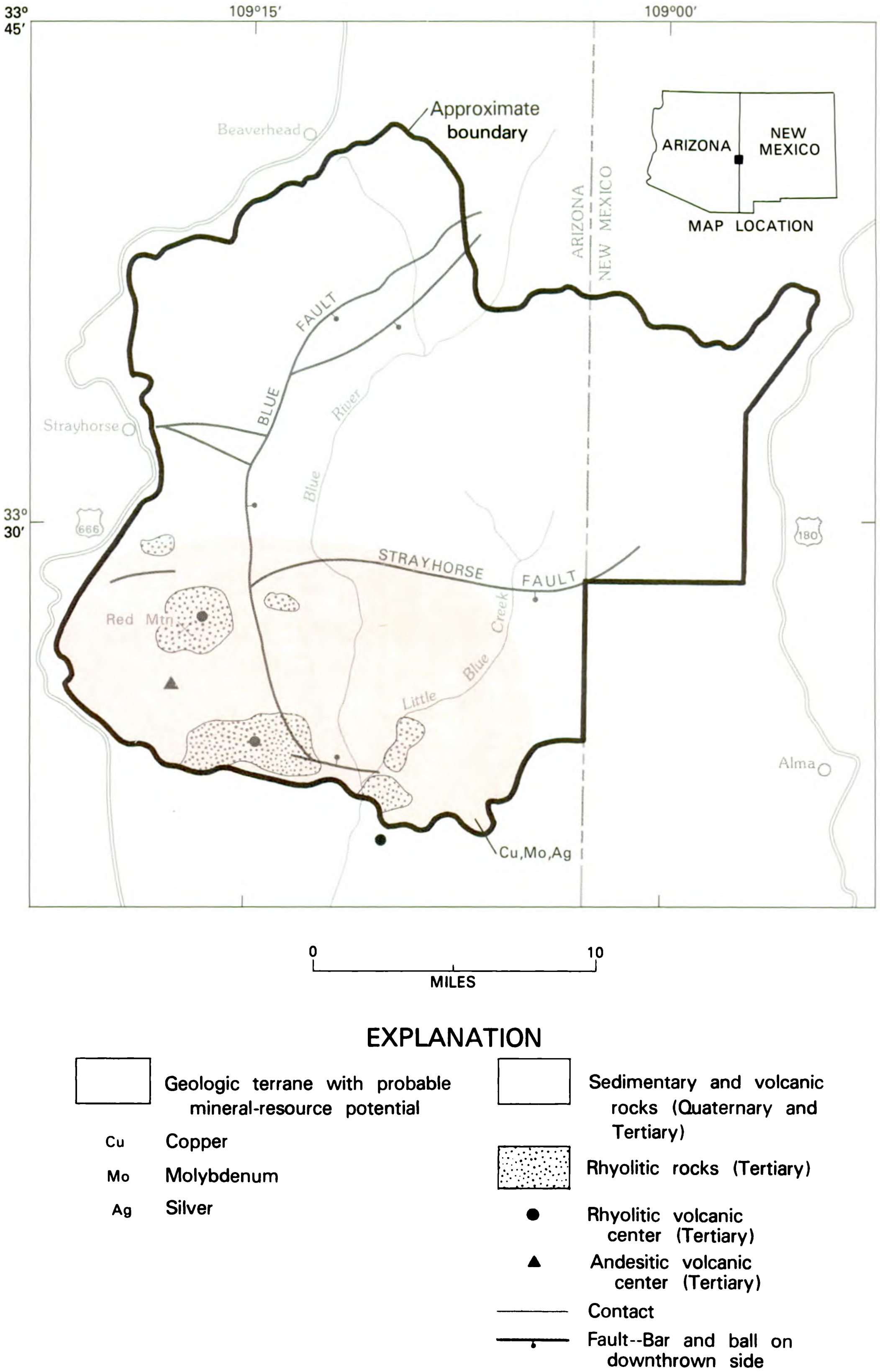

Figure 13.—Blue Range Wilderness, Arizona and New Mexico.

BLUE RANGE WILDERNESS, ARIZONA AND NEW MEXICO

By JAMES C. RATTE, U.S. GEOLOGICAL SURVEY, and

R. G. RAABE, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Blue Range Wilderness was completed in 1969 and it was determined that a probable resource potential for molybdenum, copper, and silver is present in volcanic rocks of middle Tertiary age in the southern and southwestern parts of the area. There is also a likelihood for the occurrence of base-metal resources (including porphyry copper deposits) of Laramide age beneath the middle Tertiary volcanic rocks that cover the area, but data are insufficient to assess the resource potential.

CHARACTER AND SETTING

The Blue Range Wilderness comprises about 380 sq mi, about 35 sq mi of which are in Catron County, New Mexico and the remainder of which are in Greenlee County, Arizona. The wilderness is part of an irregular mountainous region that is bisected north to south by the Blue River. Altitudes range from 4500 ft to about 9400 ft, giving a maximum relief of nearly 5000 ft in the canyon of the Blue River.

A mineral-resource appraisal of the area that is now the Blue Range Wilderness (formerly the Blue Range Primitive Area) was completed by the U.S. Geological Survey and U.S. Bureau of Mines, and published by the USGS and USBM in 1969, (Ratté and others, 1969); the significance of an aeromagnetic anomaly in the southwestern part of the wilderness was described by Eaton and Ratté (1969). Although there have been no further studies in the Blue Range by either the USGS or the USBM, considerable work in adjacent areas by both agencies now provides a better understanding of the regional setting as it pertains to mineral resources, and additional data have been obtained from exploratory drilling of mineral-resource targets within the wilderness by private industry.

The Blue Range Wilderness is near the western edge of the Mogollon-Datil volcanic field of middle Tertiary age, which covers a large part of southwestern New Mexico and adjoining parts of Arizona. This volcanic field constitutes the mountainous transition zone between the Colorado Plateau and the Basin and Range physiographic and structural provinces. The rocks in the wilderness are all volcanic in origin except for stream-deposited conglomerate that has buried the volcanic rocks over about 25 percent of the wilderness.

A number of eruptive and intrusive centers for the volcanic rocks are present, particularly in the southwestern part and near the southern border of the wilderness. Red Mountain is a rhyolitic eruptive center that is superimposed upon a much larger andesitic volcano, the likely center of which is a few miles south of Red Mountain, as indicated by a swarm of andesitic to quartz latitic dikes and a positive magnetic anomaly. Other silicic eruptive centers occur both west and east of the Blue River in the southern part of the wilderness. These silicic centers and the andesite center have local areas of intensely argillized and silicified rocks that contain disseminated pyrite and minor fracture coatings of secondary copper minerals. The rhyolite of Red Mountain has been altered locally by solfataric action, which produces brightly colored iron-stained outcrops, and minor fluorite was seen in some rhyolite breccia. Elsewhere in the wilderness, the rocks consist mainly of laharic and mudflow breccias derived from the andesitic volcano, and of thick, younger lava flows of basalt and basaltic andesite. Rhyolitic ash-flow tuffs, prevalent mainly in the northeastern part of the area, are the distal outflow sheets from eruptive sources in the Mogollon Mountains, east of the wilderness.

Pre-Tertiary rocks are nowhere exposed at the surface within the wilderness, but their presence or absence in the subsurface is critical to an assessment of the potential for ore deposits beneath the volcanic rocks. Exploratory drilling by private mining companies in the wilderness since 1969 has shown that below the Tertiary volcanic rocks, the Mesozoic(?) and Paleozoic rocks, which are 600 to 800 ft thick, overlie Precambrian rocks at depths of as little as 2300 ft beneath the surface.

The Blue Range Wilderness is along a major north-northeast-trending zone of faults that may mark a deep-seated regional fracture system. Thus, most faults that cut the rocks in this area have north to northeast trends like the Blue Fault. There are also strong west to northwest faults like the Strayhorse fault.

Rock and stream-sediment samples were collected within the wilderness and chemically analyzed. Anomalously high metal values for molybdenum, copper, and silver were found largely in samples of altered rocks around the volcanic centers or in stream sediments adjacent to them.

There is no record of mineral or petroleum production, nor of patented mining claims, within the Blue Range Wilderness. Several groups of unpatented claims, totalling at least 600, are present in the southwestern part of the wilderness and along its southern boundary, and these have been sites of active mineral exploration, both before and since 1969. At least eight deep exploration core holes totalling about 25,000 ft have been drilled within or adjacent to the wilderness since 1969 by private mining companies.

Major copper deposits at Morenci, Arizona, which have produced more than 3 million tons of copper, occur at the southwest end of the north-northeast-trending structural zone, about 20 mi south of the Blue Range Wilderness. Other nearby metal mining districts, in rocks similar to those in the Blue Range, include Mogollon and Steeple Rock, New Mexico, which have produced modest amounts of silver, gold, and copper.

MINERAL RESOURCES

The mineral-resource potential of the Blue Range Wilderness consists of the following: (1) An area of probable resource potential for molybdenum, silver, and copper deposits is associated with middle Tertiary volcanic centers of andesite to high-silica rhyolite compositions in the southern part of the wilderness. The resource potential in these rocks is supported by geologic and geophysical evidence of intrusive activity and intensely altered and weakly mineralized rocks at several volcanic centers. (2) The wilderness also has a likelihood for the occurrence of base-metal veins or porphyry copper deposits of Laramide age (Late Cretaceous-early Tertiary) beneath the middle Tertiary volcanic rocks that cover this area, but data are insufficient to assess the resource potential. Major copper deposits of the same age occur in the area adjacent to the wilderness, particularly at Morenci, Arizona. It is reasonable to expect that the pre-middle Tertiary geologic terrane beneath the wilderness is similar to that near Morenci, and therefore, could include Laramide intrusive rocks and copper deposits.

That the Blue Range Wilderness is located on the same north-northeast-trending structural zone as the Laramide ore deposits at Morenci could be favorable evidence for the emplacement of intrusives or ore deposits of either Laramide or mid-Tertiary age. This has been a factor in exploration in the wilderness by several major mining companies since the USGS-USBM mineral-resource appraisal in 1969.

The results of private exploration, which has included a total of about 25,000 ft of deep-core drilling, are not adequate to assess the mineral-resource potential of the area. Mineralized and altered rocks were encountered in some drill holes in both middle Tertiary volcanic rocks and pre-Tertiary rocks (best assays for 10-ft intervals were 0.56 percent copper and 0.19 oz silver/ton). Although the companies who have drilled in the wilderness have discontinued their projects there, drilling to date has not been sufficient to determine the presence or absence of significant mineral resources.

SUGGESTIONS FOR FURTHER STUDIES

Improved techniques for interpreting geophysical data collected over complex volcanic terranes should be applied in an effort to identify Laramide intrusives beneath the middle Tertiary rocks. Additional geologic studies of the major faults and volcanic centers might enhance mineral-deposit target definition in the middle Tertiary rocks.

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CHIRICAHUA WILDERNESS, ARIZONA

By HARALD DREWES,[1] U.S. GEOLOGICAL SURVEY, and

FRANK E. WILLIAMS, U.S. BUREAU OF MINES

SUMMARY

Based on the results of geologic, geophysical, geochemical, and mines and prospect studies in 1972, the Chiricahua Wilderness in southeasternmost Arizona was assessed to have three small areas of probable resource potential for silver, gold, and molybdenum. The remainder of the area has little promise for the occurrence of energy and mineral resources. Samples from the areas with probable resource potential are enriched in silver, gold, and molybdenum probably associated with widely scattered quartz veinlets. Other kinds of mineral deposits like those in nearby mining camps, that conceivably could be present in the area, would be covered by several thousand feet of volcanic rocks younger than mineralized rocks of the region.

CHARACTER AND SETTING

The Chiricahua Wilderness covers an area of about 28 sq mi in the central, high part of the Chiricahua Mountains in extreme southeastern Arizona. The area lies in Cochise County about midway between Douglas and Willcox, Arizona, and Lordsburg, New Mexico; it is about 10 mi south of the Chiricahua National Monument, 6 mi southwest of the village of Portal, Arizona, and lies entirely within the Coronado National Forest.

The wilderness is centered around Chiricahua Peak, almost 9800 ft high, and has a local relief of 3000 ft. The area is forested and has fairly abundant, if somewhat intermittent, stream water as a result of a yearly precipitation of about 20 in. Access to the area is by means of roads up the canyons from the highways in the intermontane valleys east and west of the mountains, and from roads that cross the mountains at Onion Saddle and between Tex and Rucker Canyons that serve recreation areas. Trails are abundant within the wilderness.

Mining history of the region around the study area began in 1881, when claims that later became the Hill top mine, 6 mi north of the area, were first placed. Early production came from lead oxides near the surface, largely in Paleozoic host limestone. The California (Chiricahua) mining district, which covers most of the range of mountains contains 4100 unpatented claims, all outside the study area, and only 12 claims within 2 mi of it. Recorded production from 1902, when the Hilltop mine was developed, to 1950 amounted to 28,700 tons of ore and concentrates valued at about $1.1 million. This ore yielded 290 oz gold, 117,000 oz silver, 4035 tons lead, 582 tons zinc, and 176 tons copper, with most of the production coming from the Hilltop mine.

The wilderness is underlain mostly by mid-Tertiary volcanic and plutonic rocks and by some Cretaceous sedimentary and volcanic rocks (Sabins, 1957; Drewes, 1981a). These rocks overlie a sequence of Paleozoic rocks, mainly limestone, like those at the Hilltop mine.

Most of the Cretaceous rocks are the Bisbee Formation (in places known as the Bisbee Group), estimated to be at least 2500 ft thick. The Bisbee is mainly a medium- to dark-gray shale and siltstone that has interbedded sandstone, limestone, and conglomerate (Drewes and Williams, 1973).

In the northern and northeastern part of the study area dacitic lava, volcanic breccia, and conglomerate and sandstone derived from dacitic material unconformably overlie the Bisbee Formation. The probable age of these dacitic rocks is Late Cretaceous-early Tertiary.

Most of the wilderness is underlain by rhyolite and latite in a volcanic pile at least 3000 ft thick. These rocks include much welded tuff, some unwelded tuff and tuff breccia, and lava flows. Monzonite which is mostly a brownish-gray rock with abundant coarse crystals, intrudes these volcanic rocks and locally was effusive upon them, apparently forming shallow laccoliths and

[1]With contributions from G. P. Eaton, USGS.

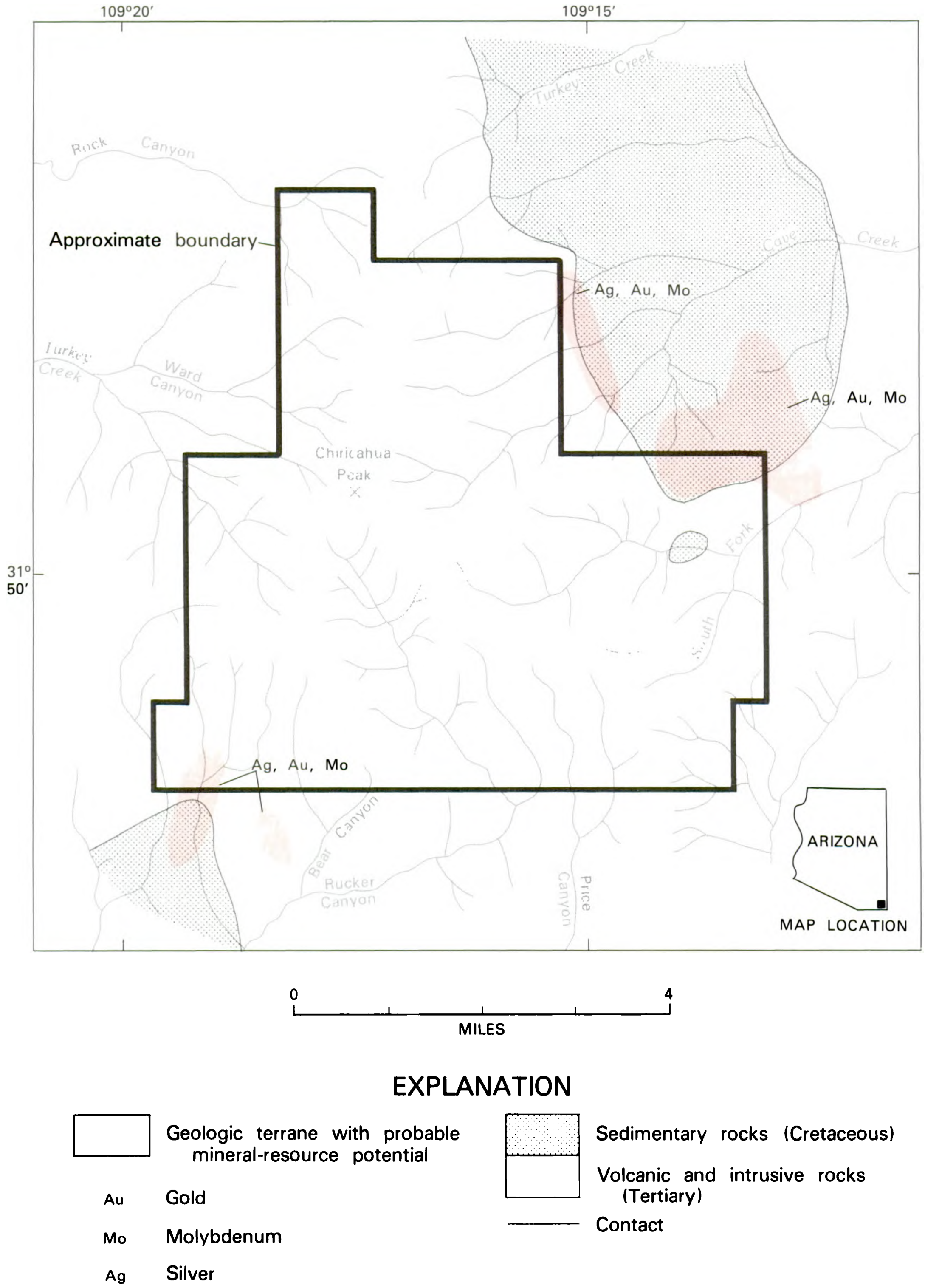

Figure 14.—Chiricahua Wilderness, Arizona.

some extrusive domes. The rhyolite tuff and welded tuffs make the spectacular and colorful yellowish-brown cliffs along the canyons on the east side of the range. Several of these volcanic units in nearby parts of the Chiricahua Mountains are dated at 25 to 28 million years, or early Miocene-late Oligocene.

Quartz veinlets are scattered in west- to northwest-trending steeply inclined fractures in the monzonite of the northeastern and southwestern parts of the study area. Mostly the veinlets are less than 2 in. thick; to the southwest, one is about 2 ft thick. Although almost entirely quartz, the vein material, based on laboratory study, contains small amounts of silver, gold, molybdenum, and other metals (Drewes and Williams, 1973, p. A24–A33).

Several rhyolite and andesite dikes cut the volcanic and sedimentary rocks of the study area, but appear unrelated to the sparse mineralization.

The rocks of the wilderness are cut by a few normal faults. These trend northerly, dip steeply or are vertical, and have large displacement. The older rocks of nearby areas are typically more severely faulted and are locally folded; presumably such structural features also occur in the subvolcanic rocks of the wilderness. Marjaniemi (1968) proposed that the central part of the Chiricahua Mountains is underlain by a large subcircular area of volcanic collapse, or a caldera; this has not been confirmed, however, it would place potential subvolcanic mineral targets far below the reach of modern exploration and development methods.

MINERAL RESOURCES

The results of the combined geologic, geophysical, geochemical, and mining-history investigations indicate that the Chiricahua Wilderness is largely unmineralized. Weak silver, gold, and molybdenum mineralization occurs in a few small areas mainly near the northeast and southwest borders of the area.

The observed areas of probable mineral-resource potential are associated with rocks that contain quartz veinlets or oxidized or leached areas. A large quartz vein was explored and 12 tons of ore was shipped in 1945 from a mine 3 mi from the wilderness; the mineral content and value of the ore is unknown. An area of leached rock near the northeast corner of the study area was also explored by drilling, but, again the results are unknown.

Possible mineralization of Cretaceous and Paleozoic rocks beneath the volcanic pile is highly speculative and would be difficult to explore. Although in nearby areas these older rocks are more abundantly mineralized than are the Tertiary volcanic rocks, the estimated overlying thickness of 3000 ft of the volcanic rocks in the wilderness is so large that underlying mineral deposits would be difficult to locate.

Potential resources of industrial materials were not recognized in the study area; most rock types within the area with any possible industrial material also occur outside of it in far more accessible situations.

Petroleum and natural gas have not been produced in nearby parts of Arizona and New Mexico. The nearest wildcat well (Portal Drilling Company, Portal No. 1) was drilled to a depth of 5353 ft, bottoming in Tertiary volcanics (Pierce and others, 1970, p. 193).

From these observations and this evaluation, the wilderness has very little promise for the occurrence of energy resources.

SUGGESTIONS FOR FURTHER STUDIES

Some of the rhyolite ash-flow tuff sheets of the northern Chiricahua Mountains are believed to have come from a volcanic center in the high, central part of the mountains, and contain anomalous concentrations of tin. Although tin is not typically a resource from such rocks, further study on tin occurrences in this and other areas in the region would be desirable.

Petroleum and gas exploration has increased in southeastern Arizona in recent years, with the recognition that an overthrust belt in the region (Drewes, 1981b) may provide a deep-drilling target, even through a thick volcanic cover. The results of deep seismic studies, which are used to spot specific targets, would be valuable to assess the possibility for oil and gas resources.

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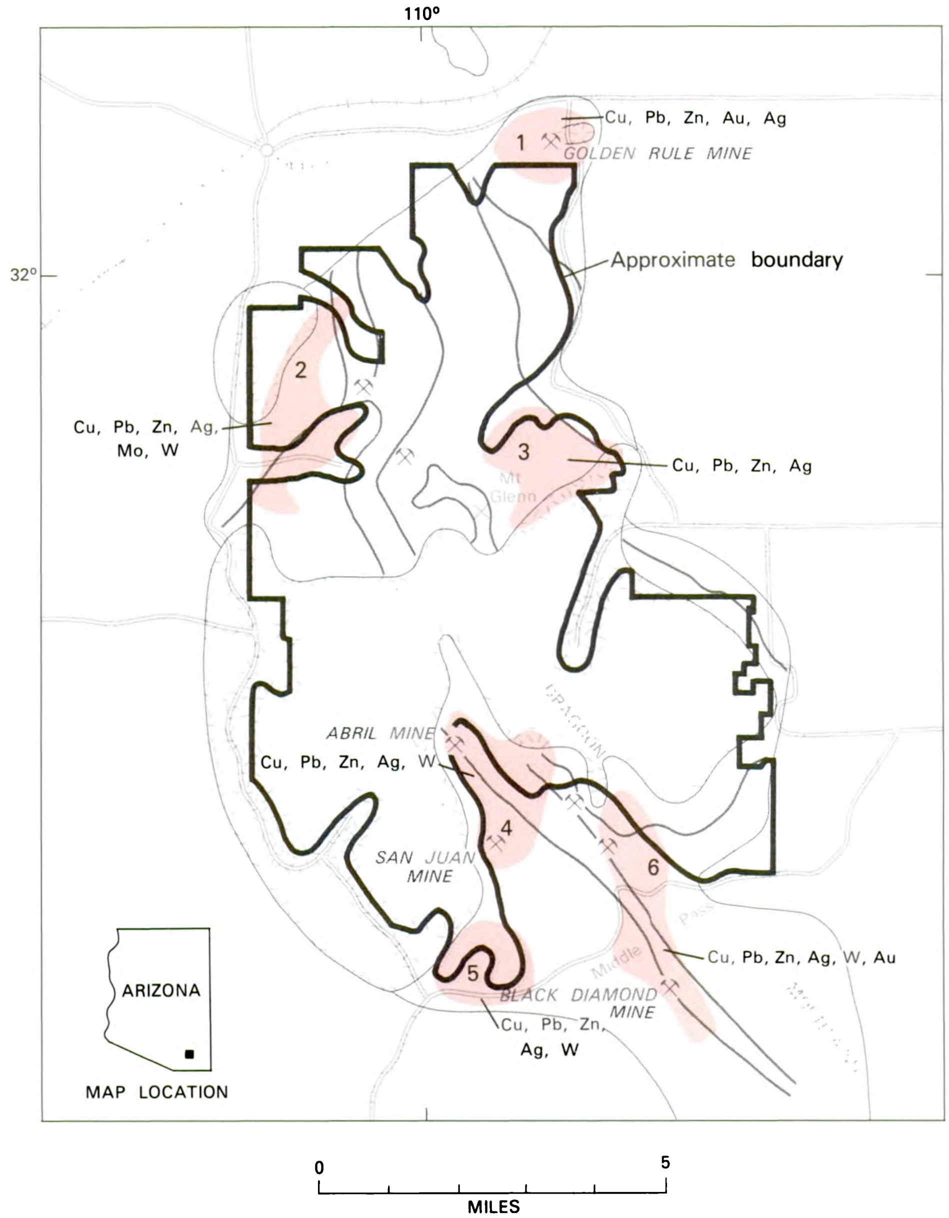

EXPLANATION

Geologic terrane with probable mineral-resource potential

Cu Copper
Au Gold
Pb Lead
Mo Molybdenum
Ag Silver
W Tungsten
Zn Zinc
Mine

Alluvium on gravel (Quaternary)

Stocks, mainly granite (Tertiary)

Sedimentary and metasedimentary rocks (Mesozoic, Paleozoic, and Precambrian)

Contact

Fault

2 Location discussed in text

Figure 15.—Dragoon Mountains Roadless Area, Arizona.

DRAGOON MOUNTAINS ROADLESS AREA, ARIZONA

By HARALD DREWES,[1] U.S. GEOLOGICAL SURVEY, and

T. J. KREIDLER, U.S. BUREAU OF MINES

SUMMARY

The mineral and hydrocarbon resource potential of the Dragoon Mountains Roadless Area was assessed in 1980–82 and six areas of probable mineral-resource potential were identified. The area may contain metamorphic skarn-type mineralization of copper, lead, molybdenum, and zinc, and some of these may contain silver and gold. More remotely, the area could also contain stockwork molybdenum mineralization and replacement or vein-type mineralization of beryllium, fluorite, thorium, tin, and tungsten. Rock products exist within the area and are discussed due to the proximity of a railroad, but similar materials occur outside the area. There is little promise for the occurrence of energy resources.

CHARACTER AND SETTING

The Dragoon Mountains Roadless Area lies in the northern end of the Dragoon Mountains near the center of Cochise County in southeastern Arizona. It covers an area of about 52 sq mi, lying between the village of Dragoon to the north and the county road through Middle Pass to the south, and between the San Pedro River valley to the west and Sulfur Springs valley to the east.

The area is rugged and is in the Coronado National Forest. Scrubby forests cover the high terrain and grass, shrubs, and cactus cover the lower country. Surface water is scarce, with springs few and watercourses ephemeral. Access is by ranch or USFS roads from the highways in the adjacent valleys, and some of these roads extend well into the roadless area.

Base and precious metals were mined from several sites in and near the roadless area. These deposits are from skarn-type alteration of mixed limestone and shale near granite. Most production probably was lead, zinc, and silver; a little gold and tungsten may have been produced. Production records for the patented claims and mines in and near the study area show that the total value of production was about $2 million. In one canyon, marble has been quarried.

The roadless area is underlain by a wide variety of rocks that are stongly faulted and intruded by several stocks and many dikes (Drewes and Meyer, 1983). A Precambrian basement is made up of schist, arkose, quartzite, sedimentary breccia, metavolcanic rock, and amphibolite, all intruded by granodiorite stocks. These are unconformably overlain by Paleozoic and Mesozoic sedimentary sequences. The Paleozoic rocks are mainly limestone but include some clastic rocks both near the base and top; the Mesozoic sequence is largely of clastic rocks.

The basement rocks and sedimentary sequences are intruded by igneous rocks. A small Oligocene stock lies along the northwest flank of the mountains. The large Miocene to Oligocene Stronghold Granite, a stock, lies in the center of the mountains and extends beyond their west flank. Tertiary or Cretaceous plugs occur near the Golden Rule mine in the northeastern tip of the range. Most dikes in the area are also Miocene, and typically trend northwest across stock and host rock alike. Quaternary gravel deposits lap against the flanks of the range and west of the Stronghold stock they lie upon a pediment.

The Dragoon Mountains are abundantly faulted. Many faults are steep northwest- or north-trending stuctures; others are gently inclined. Many of the faults are thrust faults formed under compressive deformation. A few tight folds or truncated folds occur with the thrust faults. Nearly all of these structural features are cut by the stocks and thus were available as conduits for fluids dispersing from the stocks and plugs, some of which probably carried metals.

[1]With contributions from K. C. Watts, Jr., and D. P. Klein, USGS.

MINERAL RESOURCES

Six areas have probable mineral-resource potential based on observations of geology, geochemistry and geophysics (Drewes and others, 1983).

Area 1 is around the Golden Rule mine, largely outside the northeast corner of the roadless area. The area is underlain by metamorphosed Paleozoic rocks, including the Abrigo and Martin Formations, intruded by the Tertiary rhyolite porphyry plugs. Mining records and analyses of mineralized rock on the dump show the presence of base metals, silver, and gold. Aeromagnetic and gravity anomalies, along with surface observations, suggest the concealed presence of a stock and of a strong northeast-trending fault at the northern flank of the range. The metamorphosed and locally mineralized formations dip southwest and are cut by the northeast-trending fault, as well as by bedding-plain thrust faults. These data suggest that area 1 has a probable resource potential for mineralization similar to that found at the mine, most likely down-dip in the Abrigo and Martin Formations, along the fault, or beneath the gravels north of the range. This implied mineralization would be vein or skarn-type contact deposits like those at the surface.

Area 2 is along the northwest flank of the Dragoon Mountains largely along the southeast wall of the Oligocene stock, where its roof is projected outward at a low angle. The site also extends south along a zone of steep faults and to an upwarped and up faulted, mineralized structural feature. Small mines and prospects lie along steeply inclined to vertical faults along which there are slivers of metamorphosed Paleozoic limestone. Geochemical anomalies appear to be more widespread than the known mineralization. A geophysical anomaly at the stock has a configuration suggesting that body has a shoulder to the southeast, where pods of aplite appear along the fault zone with the limestone slivers. These observations indicate that additional base metal and silver mineralization may exist, most likely along fault zones and in formations typically altered to skarn minerals. There is also a probable resource potential for stockwork molybdenum deposits or tungsten deposits.

At area 3, on the northeast side of the Stronghold stock, a probable mineral-resource potential is inferred because the Abrigo and Martin Formations, and other units of the Paleozoic sequence dip gently northeastward over a shoulder of the stock. The area has some prospects and small mines, containing concentrations of base metals and silver. Area 3 also has favorable geochemical anomalies and a magnetic anomaly penetrating the area from the northeast. We feel there is a probable resource potential in area 3 for small skarn-type deposits of base metals and silver down dip along the favored formations, and perhaps also some enrichment along intersections of faults and dikes at higher stratigraphic levels in the northern half of the area.

Area 4 lies largely outside the roadless area along a prong of sedimentary and metamorphic rocks between two lobes of the Stronghold stock. The Abril and San Juan mines lie in this area, along with many prospects. These mines are on skarn-type replacement deposits in faulted Paleozoic limestone along faults and near the stock. The mines are on a north-trending linear magnetic anomaly. A base metals-tungsten-silver geochemical anomaly trends northwest along the faulted sedimentary and metamorphic rocks, and a thorium-tin-beryllium geochemical anomaly trends northeast across the area, largely following the stock itself. These studies suggest that area 4 has a probable resource potential for additional deposits of base metals and silver, and perhaps also of other metals in vein or replacement deposits. While most of the site is outside the Dragoon Mountains Roadless Area, some zones of faulted metamorphic and sedimentary rock near the stock may extend into the roadless area.

Area 5 covers some of the southwestern part of the roadless area, along a gently outward dipping wall of the Stonghold stock which intrudes the Abrigo and Martin Formations. Skarn-type mineralization appears in scattered prospects near the contact, with enrichment in base metals, silver, and tungsten. The linear magnetic anomaly of area 4 extends across the eastern part of area 5, too. Area 5 has a probable resource potential for occurrences of lead and silver enrichment where the favored host rocks are expected to lie at moderate depth. While the deposits may be small, the area is accessible and would thus be easier to explore than most parts of the other areas of probable mineral-resource potential.

Area 6 is almost entirely south of the roadless area, lying along a zone of northwest-trending faults mostly in Paleozoic and Mesozoic rocks. The Black Diamond mine, south of Middle Pass, is in this belt near the point at which the present study ends. The north end of this area is close to a gently south dipping part of the Stronghold stock. With the exception of this northern end and some slices of limestone along fault zones, the rocks are unaltered. Part of the area coincides with a magnetic anomaly. Geochemical anomalies for silver and tungsten occur in most of the area, and for gold in the southern part of the area. These data indicate that there is a probable resource potential for occurrences of small deposits of base metals, silver, gold, and perhaps tungsten, in replacement bodies in fault slices of limestone or along heavily fractured ground near the larger faults.

Several industrial rock products occur in the roadless area. Marble for use as crushed rock or as flux may be obtained in several zones in the southern end of the roadless area, with the most promising marble in the Escabrosa and Horquilla Limestones of the Paleozoic sequence. The Horquilla Limestone may also be suitable for use in cement production, as it is near Tucson. A quartzitic variety of Pinal Schist of the basement rocks, near the mouth of Fourr Canyon may prove suitable for flux in copper smelters. Although in each of these instances the rock products are close to a railroad, other areas outside the roadless area also contain an abundance of these commodities.

Conditions for the accumulation of petroleum and natural gas are believed to be negligible. The roadless area does lie in the proposed southern extension of the overthrust belt in which exploration for possible deep targets has been in progress for a few years. The local accumulation through thrust faulting of a thick pile of sedimentary rocks not withstanding, the entrapment conditions near so many young (mid-Tertiary) stocks, plugs, and dikes are probably poor.

SUGGESTIONS FOR FURTHER STUDIES

Further study of several of the areas indicated as having probable mineral-resource potential and of areas containing industrial rock products may be desirable. Extending this study for base metals and silver would probably involve more closely spaced geochemical sampling of alluvium and altered rock chips along fractures in those parts of areas 1, 3, and 5 overlying down-dip extensions of suitable host rocks of mineralization, and a similar check along faults of areas 2, 3, 4, and 6. More detailed geophysical work may also help to indicate the configuration of shoulders or cupolas of concealed parts of stocks.

The simplest single extension of this study would be to check the key rock types like the Horquilla Formation or the metamorphosed northern part of the area for suitability in use for lime rock or cement production.

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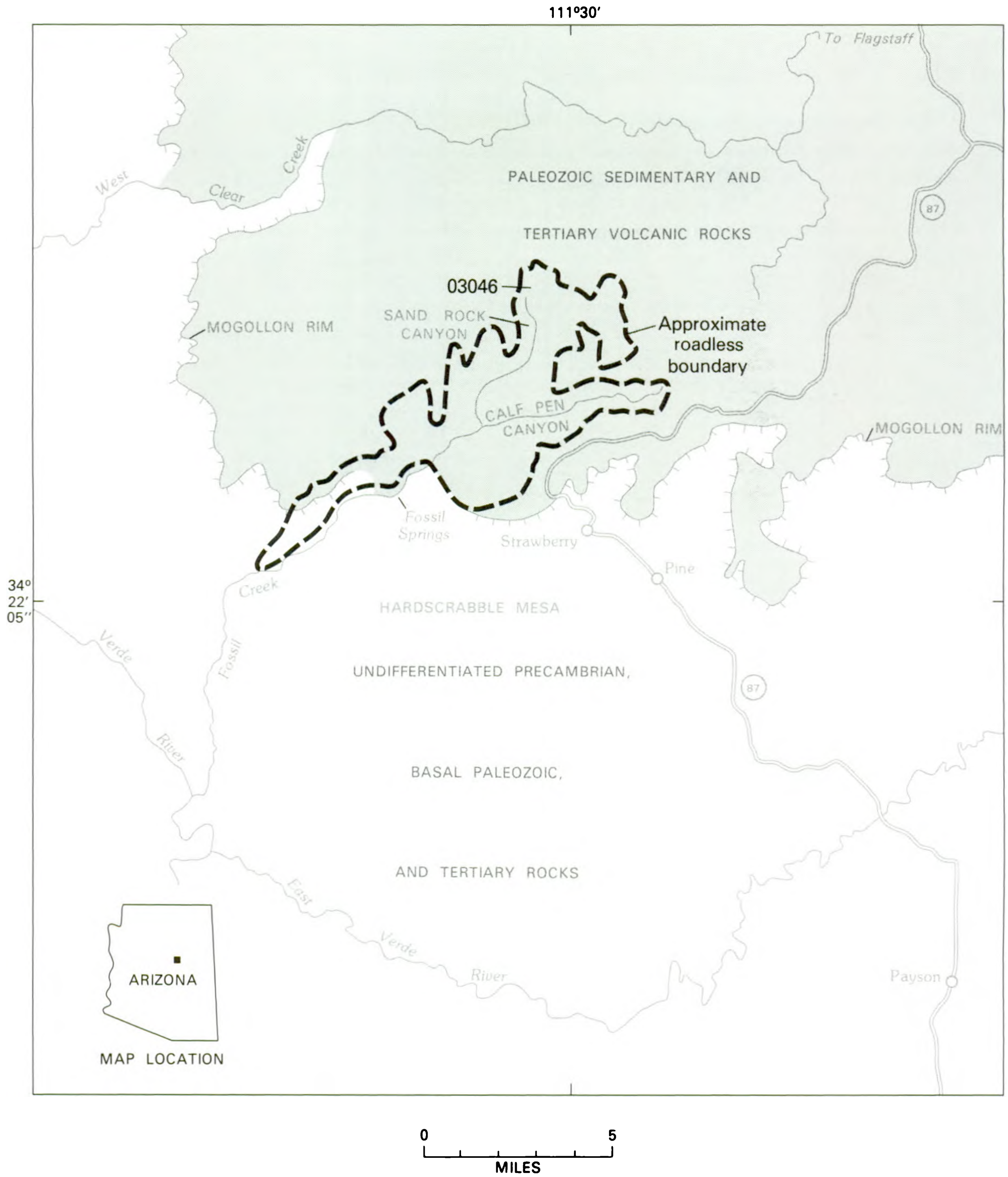

Figure 16.—Fossil Springs Roadless Area, Arizona.

FOSSIL SPRINGS ROADLESS AREA, ARIZONA

By L. S. BEARD,[1] U.S. GEOLOGICAL SURVEY, and

C. E. ELLIS, U.S. BUREAU OF MINES

SUMMARY

Based on field studies conducted by the USGS and the USBM during 1980–81, the Fossil Springs Roadless Area in central Arizona is concluded to have little promise for the occurrence of mineral or energy resources. Rocks in the Supai Formation (Pennsylvanian-Permian) near the central part of the roadless area contain widespread but spotty copper mineralization and trace amounts of uranium. Analyses obtained during the study define geochemical anomalies in two portions of the area that remain unexplained. The suites of anomalous metals suggest the possibility of hydrothermal veins and the presence of ultramafic rocks; neither were found in the field. Construction materials present within the roadless area—chiefly basalt, sandstone, limestone, and dolomite—are readily available in abundance and more accessible in adjacent areas. The presence of oil and gas is unlikely; the only producing wells in Arizona are in formations not present in the Fossil Springs Roadless Area.

CHARACTER AND SETTING

The Fossil Springs Roadless Area includes about 22 sq mi of plateau and canyons in the Coconino National Forest in Yavapai, Gila, and Coconino Counties, Arizona. The roadless area lies near the Mogollon Rim, southern boundary of the Colorado Plateau, which in this vicinity is characterized by steep-walled canyons cut into a high tableland of relatively flat lying Paleozoic sedimentary rocks veneered locally with Tertiary volcanic rocks.

Paleozoic and Cenozoic rocks present in the Fossil Springs Roadless Area have a cumulative thickness of about 3000 ft. The bulk of the outcrops in the canyon walls in the northeastern part of the area consist of sandstone, siltstone, shale, and minor limestone of the Supai Formation (Pennsylvanian and Permian) and crossbedded sandstone of the Coconino Sandstone (Permian). To the northwest, the plateau is covered by Tertiary volcanic rocks, a few tens to a few hundred feet thick. South of Fossil Springs the volcanic rocks, chiefly dark gray basalts and yellowish-gray basaltic and dacitic tuffs, thicken abruptly to more than 2000 ft against an ancestral Mogollon Rim (Twenter, 1962) cut into the Paleozoic section by prevolcanism erosion. Preserved locally beneath the volcanics are Tertiary gravel deposits containing clasts of lower Paleozoic and Precambrian lithologies. A K-Ar age of 10.16±0.22 million years for a basalt flow about 1250 ft above the floor of the canyon gives a minimum age of formation of the ancestral Mogollon Rim and subsequent deposition of the gravels (Pierce and others, 1979). A unique feature of the area is a deposit of travertine (Pleistocene and Holocene) that forms a conspicuous bench above Fossil Springs. Thin sheets of colluvium and masses of landslide blocks obscure much of the outcrop throughout the roadless area.

The prevailing dip of the Paleozoic strata is low toward the north or northeast. This homoclinal structure is broken into several fault blocks in which the strata dip westerly or southerly. All the faults in the roadless area are high-angle normal faults that have displacements commonly ranging from about 50 to 400 ft. The Tertiary volcanic rocks, which rest unconformably on the Paleozoic strata, are flat lying in the northern part of area, but south of Fossil Springs they dip gently southwestward. Most of the faults that cut Paleozoic strata seem to displace the volcanic rocks also, but with less displacement. The buried ancestral Mogollon rim appears to be in part structurally controlled, but this is difficult to prove because of poor exposures. Few of the

[1]With contributions from G. W. Weir, USGS.

faults can be traced in the volcanics away from the canyon rims because of the lack of lithologic contrasts on the plateau top.

MINERAL RESOURCES

An aeromagnetic map of the Fossil Springs Roadless Area (Davis and Weir, 1983) shows variations in total magnetic intensity of the area related to magnetic property contrasts in the volcanic rocks and to magnetic contrasts between the basalts and the sedimentary rocks. There are no magnetic lows that might represent zones of alteration in which metallic mineral deposits may occur, nor of magnetic highs that would indicate any large masses of high magnetic susceptibility, other than basalt.

Geochemical analyses obtained on samples of stream sediments, pan concentrates of stream sediments, bedrock, and mineralized rock from the copper-uranium occurrences define complex geochemical anomalies that as yet cannot be geologically accounted for. Panned concentrate samples containing anomalous levels of chromium, cobalt, and nickel normally associated with ultramafic rocks were found in the central part of the area, about 1 mi upstream from Fossil Springs. In the upper reaches of Calf Pen Canyon, large barium and beryllium anomalies in the pan concentrates suggest possible hydrothermal vein deposits. Neither ultramafic rocks nor vein systems were observed in the field. The source of these anomalies is not known. The chromium, cobalt, and nickel anomalies are perhaps related to either a thin mafic dike or flow or to mineralization along a fault zone; neither was observed in the field. The barium and beryllium anomalies might be related to barite veins; although none are known in the roadless area, occurrences have been reported to the south along Tertiary fault zones (C. M. Conway, oral commun. 1982). The anomalies do not seem to indicate the occurrence of mineral resources.

The Fossil Springs Roadless Area does not lie within an organized mining district. Four bulldozer cuts originally made during coal prospecting and later utilized for copper and uranium exploration in Permian rocks are included in a block of claims located in 1962 and 1969 in the central part of the roadless area. The prospects were inactive in 1980 and early 1981. Quarries in Paleozoic sandstone and Tertiary basalt near the borders of the roadless area were also inactive in 1980 and early 1981.

Copper-uranium occurrences are found within a discontinous zone, a few tens of feet thick, in the lower third of the Supai Formation about 400 ft above the base of the formation. This zone is characterized by lenses of limestone-pebble conglomerate, sandstone, and carbonaceous shale, interstratified with lesser amounts of siltstone, shale, and sandstone. Radioactivity due to the uranium occurrences is generally confined to coaly layers within carbonaceous shale and most of the copper minerals also occur in the carbonaceous shale or in gray sandstone and conglomerate interlayered with carbonaceous shale. Mineralization is sporadic and not concentrated; the sparsely mineralized rock occupies only a small part of the zone and is commonly only a few inches to a few feet thick and extends a few feet to several tens of feet along the outcrop. This minor mineralization is not assessed as being a resource and no resource potential for the area was identified.

Flagstone has been quarried from two small workings in the Coconino Sandstone near the southeast edge of the area. Basalt quarried from three small workings on the southeast and south edges of the area was probably used locally as road material. Both of these commodities are in abundance outside the area. No energy resource potential was identified in this study.

SUGGESTIONS FOR FURTHER STUDY

Although there is little promise for the occurrence of mineral resources in the Fossil Springs Roadless Area, studies to identify the source of the geochemical anomalies could have valuable implications for regional studies and mineral exploration in the surrounding area. Anomalies of this type are unexpected in terms of what is presently known of the geology of the area; of particular interest is that ultramafic bodies are not known to occur in this region.

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GALIURO WILDERNESS AND CONTIGUOUS ROADLESS AREAS, ARIZONA

By S. C. CREASEY,[1] U.S. GEOLOGICAL SURVEY, and

J. E. JINKS, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Galiuro Wilderness and contiguous roadless areas in southeastern Arizona during 1972 identified one area of substantiated and four areas of probable resource potential for base and precious metals. It is possible, however, that the dominant, Oligocene and Miocene Galiuro Volcanics, which cap most of the Galiuro Range, conceal other mineral occurrences within underlying, older rocks. No energy resources were identified in this study.

CHARACTER AND SETTING

The Galiuro Wilderness and contiguous roadless areas, to be referred to as the study area, are in the Coronado National Forest, in southeastern Arizona, about 50 mi northeast of Tucson. The study area lies entirely within the Galiuro Range, one of the large northwest-trending mountain ranges that form the Basin and Range province in southern Arizona. The range is bounded on the west by the San Pedro valley and on the east by the Aravaipa valley. In the study area, the range consists of two ridges separated by two medial valleys and a low pass. These deeply incised valleys, Rattlesnake and Redfield, are developed parallel to the lengths of the ranges, in contrast to most of the other streams in the area, which flow at high angles to the range fronts. The Galiuro Wilderness covers an area of about 96 sq mi, and lies at altitudes ranging from about 4000 to 7650 ft; it forms a broad U-shaped area that opens to the north, and the area within the limb of the "U", essentially the floor of Rattlesnake valley, is excluded from the wilderness. The roadless areas surrounding the Galiuro Wilderness include most of the area lying between the boundary of the wilderness and the boundary of the Coronado National Forest.

The Galiuro Range is a tilted fault block bounded on the west by a west-dipping high-angle normal fault. A parallel west-dipping normal fault extends about three-quarters of the way through the central part of the study area from the south boundary. Movement along these and other normal faults produced a gentle eastward dip in the Galiuro Volcanics, the sequence of volcanic rocks that covers most of the Galiuro Wilderness. Mineralizing solutions carried small amounts of base and precious metals along the central fault, which was at least partly active during accumulation of the Galiuro Volcanics. These volcanic rocks, Oligocene and Miocene in age, conceal older rocks that include Precambrian schists, granites, and quartzites, Paleozoic quartzites, and Upper Cretaceous and (or) lower Tertiary volcanic rocks and granitic stocks. The mineral potential of study area lies primarily in the possibility that the Galiuro Volcanics conceal mineral occurrences within the underlying older rocks.

Historically, two mining districts lie near the study area, Copper Creek (Bunker Hill) and Rattlesnake. The Copper Creek district is centered around the mines in Copper Creek just to the northwest of the study area, and the Rattlesnake district is in the approximate geographic center of the wilderness, where the boundary of the wilderness has been drawn to exclude known mines. Copper and gold production data on the two mining districts show that the Copper Creek district was the most significant, producing 1354 oz of gold, whereas the Rattlesnake district yielded only 163 oz of gold.

The mineral appraisal of the Galiuro Wilderness and contiguous roadless areas consisted of geologic, geochemical, and geophysical studies and examination of mines and prospects (Creasey and others, 1981). The USGS geochemical studies consisted of sampling and analysis of minus-80 mesh stream sediments, altered bedrock, and rocks from prospect pits; the geophysical study consisted of an aeromagnetic survey made to help separate the areas favorable for mineral deposits from the unfavorable areas. Mine and prospect evaluation made by the USBM consisted of locating, mapping, and systematically sampling all claims, mines, and prospects.

[1]Abstracted from a report by Creasey and others (1981) by Susan Tufts, with contributions from W. J. Keith, USGS.

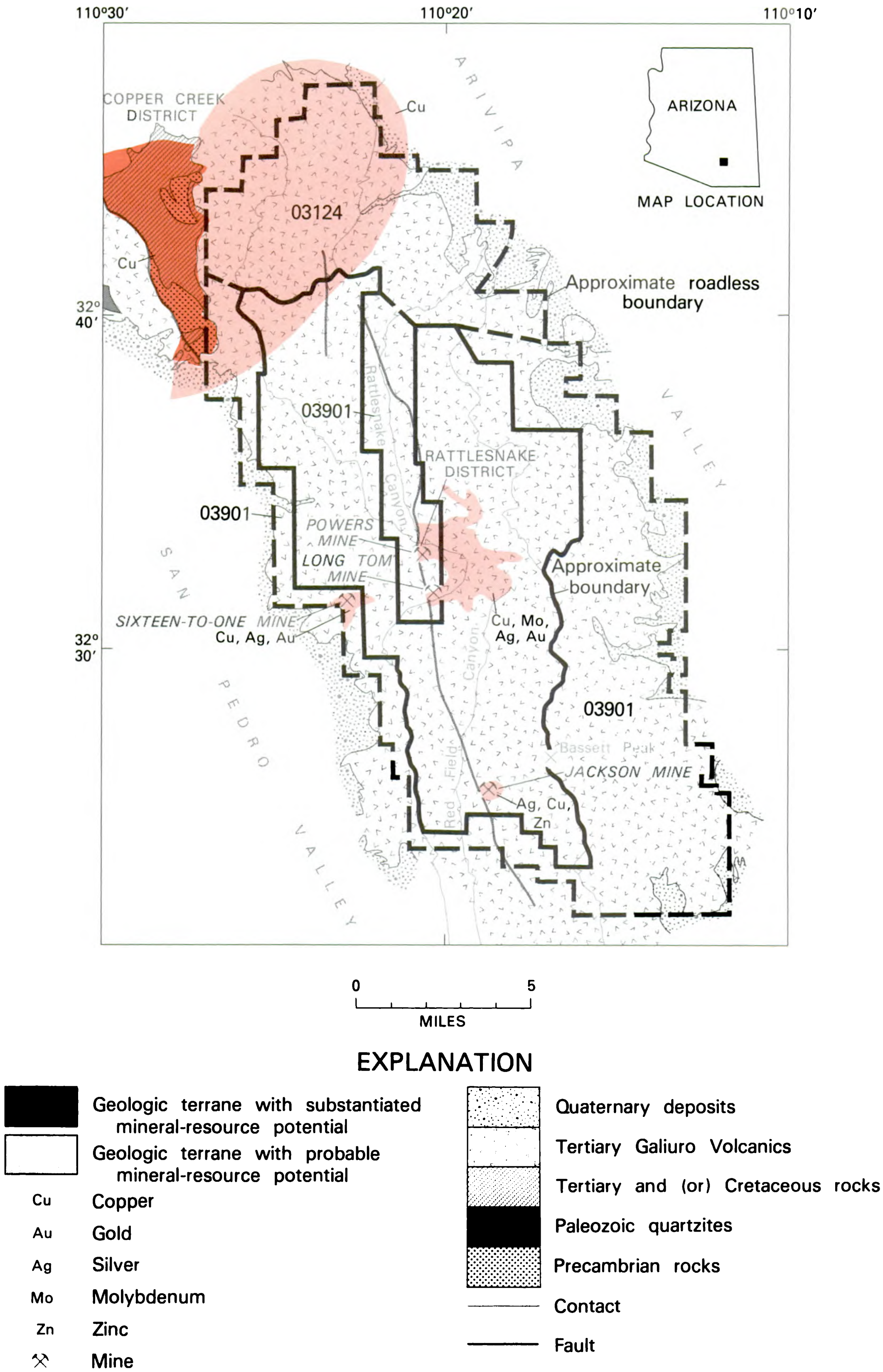

Figure 17.—Galiuro Wilderness and contiguous roadless areas, Arizona.

MINERAL RESOURCES

The mineral potential of the Galiuro Wilderness and contiguous roadless areas is difficult to assess. The study area lies within the Arizona copper province, one of the world's most productive, but the main surface rock units in the wilderness are younger than the deposits of the copper province and, therefore, conceal the older rocks that could be the hosts for significant copper deposits. Some indication of the copper potential in these older rocks is given by the occurrence of copper deposits in the Copper Creek district, adjacent to the northwest corner of the wilderness, and by geologic and geochemical studies of the older rocks in that same area. These studies revealed a large area of altered rock containing anomalous quantities of copper. This area of copper-bearing older rocks has a substantiated copper resource potential. These altered and mineralized older rocks no doubt extend eastward beneath the younger volcanic rocks in the adjoining corner of the study area, where they could be potential hosts for copper deposits. Based on these observations the northwest corner of the study area is assessed as having a probable copper resource potential. However, the extent of these older rocks beneath the volcanic cover is not known; the surface geology is not diagnostic and, although some drilling has been done, the drill logs are not available for study.

Within the study area, altered (pyritic and argillic) volcanic rocks occur in two areas and along the major north-trending fault that extends almost throughout the length of the study area. Clear signs of near-surface occurrences were not observed, although anomalies for several metals occur within these altered areas. Whether these near-surface metal anomalies indicate mineral deposits at depth in the older rocks beneath the volcanic rocks cannot be evaluated from data obtained from this study, but the areas are considered to have a probable resource potential for copper, zinc, molybdenum, silver, and gold.

Altered rocks in the area between the Rattlesnake and Redfield Canyons contain anomalously high amounts of molybdenum and silver and could be interpreted to indicate copper and molybdenum at depth in the older rocks. Estimates of the depth from the surface to the older rocks in this area range from 800 to 2400 ft. Sampling in the area around the Sixteen-to-One mine on the west side of the wilderness and Jackson mines in the southern part of the wilderness indicates that anomalous amounts of metals are present. However, there are no indications of mineral resources in the rocks exposed at the surface, and the possibility of mineral occurrences at depth is conjectural. Geochemical sampling in the southeastern corner of the study area indicates base- and precious-metal anomalies in stream-sediments, but the origin of these metals is unknown. Neither surface outcrops of altered rocks nor prospects indicate mineralization and no resource potential was identified. Based upon the geochemical studies, it is unlikely that any large near-surface deposits of base metals, such as zinc, or molybdenum, tungsten, and tin, were overlooked during this study. The same assurance does not exist for the precious-metal deposits of silver and gold, because they form deposits at low concentrations relative to base-metal deposits and are harder to detect by sampling. However, careful prospecting over the past century has not revealed such deposits.

Examination of claims, mines, and prospects by the USBM did not reveal demonstrated mineral resources. The alteration and mineralization associated with the Copper Creek district may extend under the northwest corner of the study area. However, this can be determined only by drilling or by sinking shafts in that area.

There is near-surface gold in altered volcanic rocks containing pyrite around the divide between Rattlesnake and Redfield Canyons, which includes the Powers and Long Tom mines. However, this low-grade material occurs in small, disconnected pockets along faults and only a probable resource potential for gold has been identified.

The Sixteen-to-One mine area, outside the wilderness, but inside the contiguous roadless area is in a pyritized area that has small pockets of gold mineralization along fractures and faults and the area is judged to have a probable gold resource potential in the volcanic rocks at the surface. It is not likely that widespread copper mineralization occurs at depth in the older rocks, because of the small size of the pyritized area at the surface.

The altered and mineralized areas around the Jackson mine and the prospects to the southeast are closely associated with the fault that runs through the central part of the study area. The exposed alteration zone along the fault is narrow and the metal content low. Whether or not this fault zone contains deposits at depth where the fault cuts older rocks is conjectural, but the possibility exists and the area has a probable resource potential. Other metal anomalies along the fault appear to be isolated and do not indicate a resource potential.

An aeromagnetic survey of the study area revealed a high magnetic intensity in the northwestern part of the area and several discontinuous high-gradient anomalies over the eastern part of the area. Although most of the major anomalies are associated with the volcanic rocks on the upper slopes and crests of the mountains, the host rocks in mining localities probably are expressed in the magnetic pattern. For example, the higher intensity in the northwestern part of the area may represent an extension of the rocks that contain copper deposits in the Copper Creek mining district. None of the anomalies has sufficient amplitude to indicate large deposits of highly magnetic ore minerals lying at shallow depths in the study area.

Limestone, quartz sand, sand, and gravel, all occur in the study area, but all are found in abundance outside the area. The Galiuro Volcanics have resources of construction stone and pumice, as well as vitrophyre and obsidian, some of which might be perlitic in the commerical sense of expanding on heating. However, the study area is far from potential markets and without access roads. The volcanic rocks in the study area are too old and too thin to retain enough heat for geothermal energy and the area has no known occurrences of uranium. The geologic setting is not favorable for the occurrence of fossil fuels.

SUGGESTIONS FOR FURTHER STUDIES

Further sampling should be undertaken to confirm or disprove some of the apparent metal anomalies found during the reconnaissance sampling. In addition, drilling would be necessary, particularly in the northwestern corner of the study area, to determine whether the older rocks underlying the Galiuro Volcanics contain ore deposits.

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HELLS GATE ROADLESS AREA, ARIZONA

By CLAY M. CONWAY, U.S. GEOLOGICAL SURVEY, and

ROBERT A. MCCOLLY, U.S. BUREAU OF MINES

SUMMARY

Although no mineral-resource potential was identified in the Hells Gate Roadless Area during mineral surveys in 1981, the area is largely underlain by a regionally extensive Proterozoic granite-rhyolite complex which is tin-bearing. The geologic setting precludes the occurrence of fossil fuel resources and no other energy resources were identified.

CHARACTER AND SETTING

The Hells Gate Roadless Area comprises approximately 49 sq mi in the northern part of the Tonto National Forest in Gila County, Arizona. The area is roughly a 4 by 15 mi strip along a deeply incised segment of upper Tonto Creek. Altitudes range from 3000 ft in the lower gorge to 6000 ft in hills above the upper gorge. Vegetation is light to moderately heavy. Intermediate to higher altitudes are forested with pinion pine, alligator juniper, and several oak varieties with stands of yellow pine above 5000 ft. Succulents, cactus, and chapparal are common at lower altitudes.

The Hells Gate Roadless Area lies in the central mountain belt of Arizona at the base of the Mogollon Rim which is the physiographic margin of the Colorado Plateau. Geologically the area is a slightly structurally disrupted and erosionally stripped margin of the Colorado Plateau. Paleozoic and Middle Proterozoic sedimentary rocks, exposed nearby, have been entirely removed by erosion from the roadless area, exposing folded, faulted, and metamorphosed Early Proterozoic volcanic, plutonic, and sedimentary rocks (Gastil, 1958; Conway, 1976). These 1.7 billion year old rocks are locally blanketed with upper Tertiary lacustrine sand and gravel deposits.

About 90 percent of the exposed Proterozoic rocks in the roadless area are intrusive and extrusive rhyolite, granophyre, and granite, all of essentially the same composition. They formed as subaerial and hypabyssal parts of a great volcanic complex. This complex is overlain by quartzite which constitutes most of the remaining rocks exposed in the area. The granite-rhyolite complex is stratigraphically underlain by and intruded into a thick section of variable sedimentary and volcanic rocks immediately southeast of the roadless area. Geologic and geochemical studies have shown that the rhyolite, and particularly the granophyre and granite, have certain characteristics common to tin-bearing granites.

MINERAL RESOURCES

Little mining activity has occurred within 20 mi of the roadless area. For a short period in the late 1800's, there was small-scale gold mining in quartz veins in diorite 3–10 mi west of the roadless area. A few small mines have operated intermittently in the volcanic and clastic strata underlying the extrusive rhyolite south and east of the roadless area for gold, silver, copper, beryllium, and barite, but there has been very little production. There are no mines or claims of record in the roadless area; only a few barren prospect pits have been found.

The absence of past mining in the roadless area, very few prospects and claim records, and the absence of geologic, geochemical or geophysical evidence for specific sites of mineralization, indicate that there is little promise for the occurrence of mineral resources in the Hells Gate Roadless Area. However, the area is largely underlain by felsic igneous rocks, part of a regionally extensive suite (Tonto Basin, Mazatzal Mountains), which has petrographic and chemical characteristics indicating a possibility of tin mineralization. Widespread tin values in analyses of sediments and concentrates and the tin oxide, cassiterite, occur in the nearby Mazatzal Wilderness (Wrucke and others, 1983) and in the Hells Gate Roadless Area. Associated with the anomalous tin are high niobium, tantalum, yttrium, and beryllium.

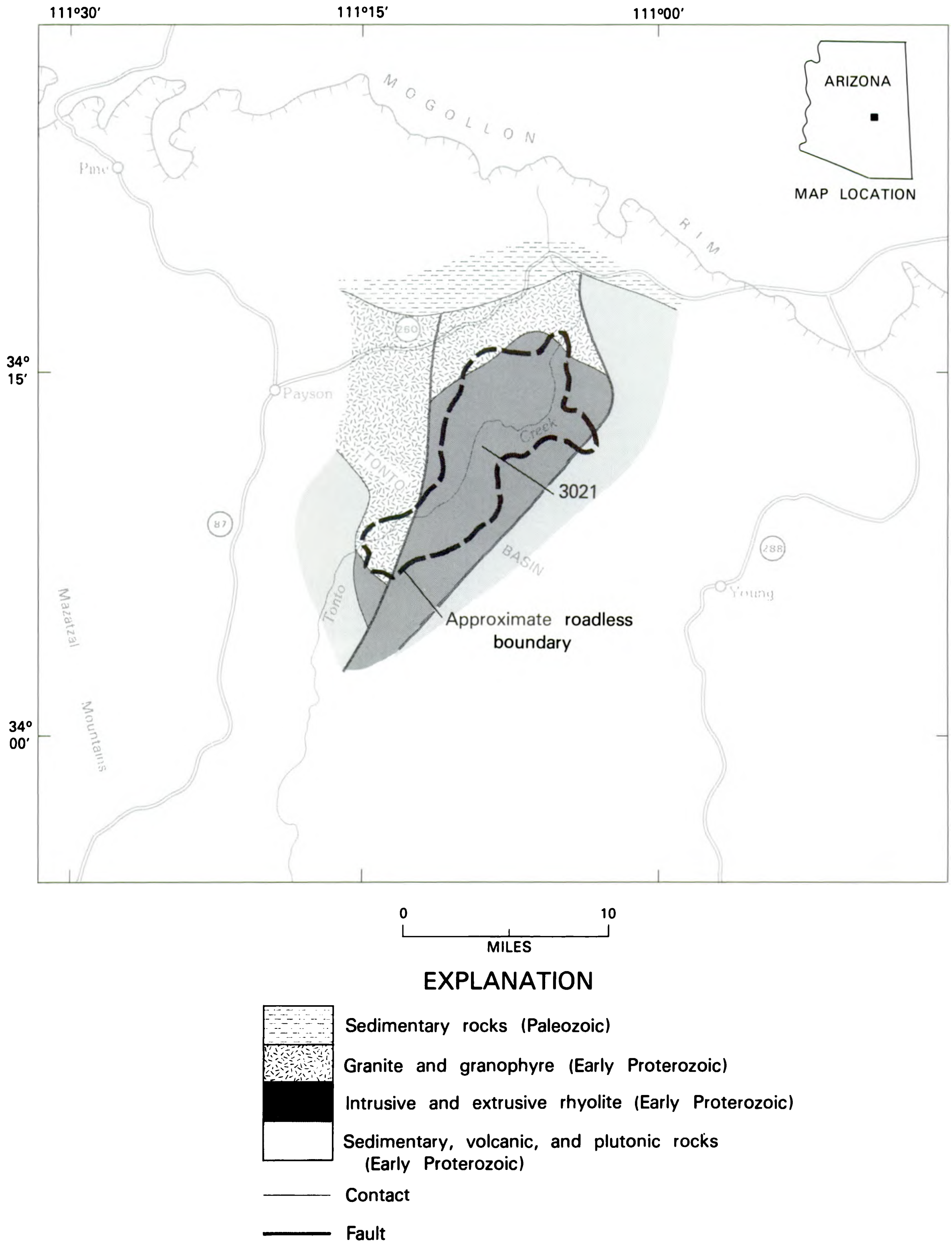

Figure 18.—Hells Gate Roadless Area, Arizona.

Upper parts of the granite and the overlying granophyre, which have the greatest possibility for tin, crop out along the northwest margin of the roadless area and dip beneath it. Most of this zone is outside the Hells Gate Roadless Area.

There are small occurrences of barite along Miocene faults that extend into the roadless area, but barite veins in the region are sparce and no barite was observed while mapping the faults in the roadless area.

SUGGESTIONS FOR FURTHER STUDIES

The potential for tin and associated metals in the Hells Gate Roadless Area and the region cannot be fully evaluated at this point. The granophyre and the upper part of the granite pluton along the northwestern margin of the area should be further explored.

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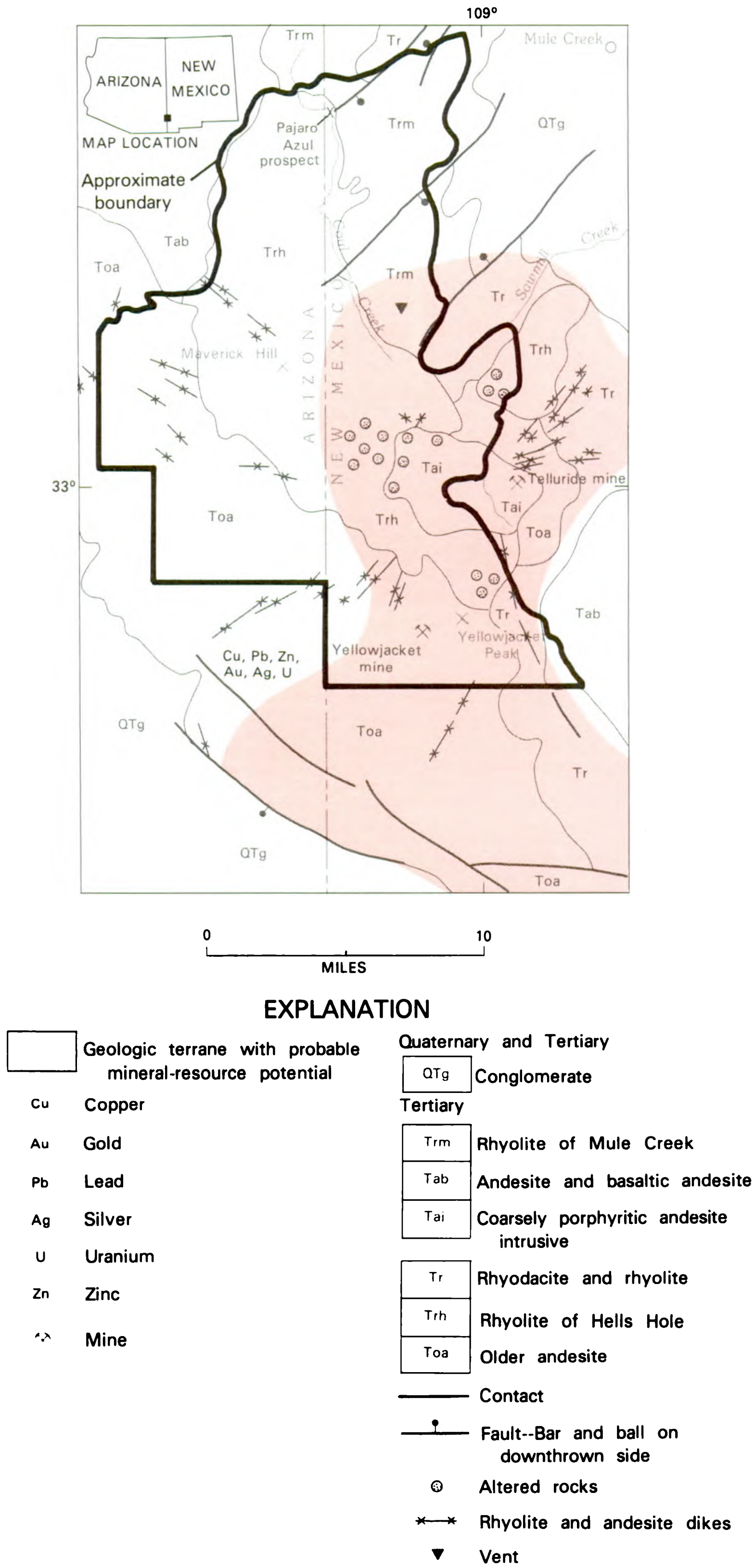

Figure 19.—Hells Hole Roadless Area, Arizona and New Mexico.

HELLS HOLE ROADLESS AREA, ARIZONA AND NEW MEXICO

By JAMES C. RATTÉ,[1] U.S. GEOLOGICAL SURVEY, and

JOHN P. BRIGGS, U.S. BUREAU OF MINES

SUMMARY

The Hells Hole Roadless Area was studied in 1979 and the southeast part was determined to have a probable mineral-resource potential for the discovery of base- or precious-metal deposits related to igneous intrusions of middle to late Tertiary age. There also is a probable resource potential for porphyry copper mineralization of Laramide age beneath the Tertiary volcanic rocks that cover the area. There is little promise for the occurrence of energy resources in the area.

CHARACTER AND SETTING

The Hells Hole Roadless Area encompasses about 50 sq mi along the Arizona-New Mexico State line 3 mi southwest of Mule Creek, New Mexico and 24 mi east of Clifton and Morenci, Arizona. New Mexico and Arizona Highway 78 is the northern boundary of the roadless area.

The area is part of a northwest-trending mountainous region that merges with the Big Lue Mountains northwest of Arizona Highway 78. Altitudes in the area range from less than 5000 ft along the southwest flanks of the mountains to 7488 ft on Maverick Hill along the range crest. The range is cut by steep-walled canyons that drain north or northwestward to the San Francisco River or southwestward to the Gila River.

Geologically the area is in the southwestern part of the Mogollon-Datil volcanic field of middle to late Tertiary age, which covers part of the transition zone between the Basin and Range and Colorado Plateau structural provinces. The study area is toward the northwest end of a fault-bounded, mountainous block that is about 70 mi long and 25 mi wide. No pre-Tertiary rocks are exposed in the study area. The nearest basement rocks to the mapped area crop out 5–6 mi to the west, where lower Paleozoic quartzite and limestone overlie Precambrian granitic, gabbroic, and metasedimentary rocks (J. E. Cunningham, written commun., 1980). A more complete section of Paleozoic rocks is exposed a few miles farther west in the Clifton-Morenci area (Lindgren, 1905). About 12 mi southeast of the mapped area, Mesozoic rocks unconformably overlie Precambrian granitic rocks without any intervening Paleozoic rocks.

Major porphyry copper deposits are being mined at Morenci, Arizona, 24 mi west, and at Tyrone, New Mexico, 50 mi southeast of the study area. These large, disseminated copper deposits occur in quartz monzonite intrusives of early Tertiary age, which are overlapped by mid-Tertiary volcanic rocks; similar deposits could underlie mid-Tertiary volcanic rocks in the intervening area between these deposits, including Hells Hole Roadless Area (Ratté and others, 1982).

The Hells Hole Roadless Area does not lie within an organized mining district. There are no patented mining claims within the area nor has there been any recorded production from within its boundaries. Actual mining has been limited to two small workings. One is located on the west flank of Yellowjacket Peak, where secondary copper minerals occur in a narrow shear zone at the Yellowjacket prospect; the other is at the Telluride mine on upper Sawmill Creek, where a narrow zone of discontinuous quartz veins is exposed in the stream bed. The only other prospect is the Pajaro Azul (Bluebird) uranium prospect on Coal Creek in the northeastern part of the area, where a siliceous, cemented fault zone, which cuts rhyolite breccia, is anomalously radioactive. Approximately 850 unpatented mining claims have been located within or adjacent to the mapped area (80 percent or more outside the study area), of which 650 were in compliance with federal recordation requirements in 1980. A strip of claims connecting the Telluride mine and Yellowjacket Peak represents recent base- and precious-metal exploration efforts within the study area.

The southern portion of the study area adjoins the Steeple Rock (Mayflower, Twin Peaks) mining district. Production from the district totals about $7 million in silver, gold, and minor amounts of base metals and

[1]With contributions from D. C. Hedlund, R. A. Martin, and J. R. Hassemer, USGS.

fluorite. A characteristic, northwest-trending, fault-fissure vein system extends into the northern part of the district, south of the study area. A current base- and precious-metal exploration program is centered on a tract south of the western half of the study area and, on the New Mexico side, a similar program is being conducted. No recent production has been recorded from this northern portion of the Steeple Rock district; past production includes 1115 oz gold, 3640 oz silver, and 1965 lbs copper.

MINERAL RESOURCES

A probable mineral-resource potential for base- or precious-metal deposits within the Hells Hole Roadless Area is based on the following: (1) A favorable geologic environment has been determined by geologic mapping (Ratté and Hedlund, 1982) and by geophysical interpretations (Martin, 1981). (2) Evidence of mineralization is provided by present and past mining activity in areas adjacent to the Hells Hole Roadless Area and by anomalously high elemental concentrations in geochemical samples taken in the area. Stream-sediment concentrates, veins, and hydrothermally altered rocks were sampled within the mapped area (Hassemer and others, 1981).

The favorable geologic environment consists of a middle Tertiary volcanic center and a subjacent shallow stock or small batholith of silicic to intermediate composition that is believed to underlie most of the study area. Volcanism and intrusive activity were sustained over an interval of about 10 million years during which time the magma, or magmas, evolved from andesite through rhyodacite and low-silica rhyolite to high-silica rhyolite. Ore deposit models indicate that this geologic environment is most conducive to the formation of stockwork molybdenum deposits, and epithermal precious-metal deposits of the fissure-vein type like those that occur in the nearby Steeple Rock mining district. The geologic setting is generally favorable for the occurrence of porphyry copper deposits; however, such deposits almost invariably are early Tertiary or Late Cretaceous in age in this region. Because of the proximity of major porphyry copper deposits at Morenci, Arizona, and Tyrone, New Mexico, the possibility exists that a similar deposit is buried beneath mid-Tertiary volcanic rocks within the roadless area. A tin porphyry system is also possible in this geologic environment (Sillitoe and others, 1975), and although it would be a unique and unlikely occurrence in this region, the strategic importance of tin makes even the possibility of a tin porphyry system noteworthy.

Panned concentrates from stream-sediment samples show anomalously high amounts of beryllium and niobium over the volcanic center, particularly from areas draining outcrops of the rhyolite of Hells Hole and near the vent for the rhyolite of Mule Creek. Anomalously high amounts of tin, boron, barium, and tungsten, although more dispersed, are also most common over or peripheral to the volcanic center. Anomalously high amounts of silver, copper, molybdenum, lead, zinc, bismuth, antimony, and arsenic, on the other hand, are concentrated both over and around the volcanic center and along the northwest fracture zone south of the roadless area. Samples of altered and mineralized rocks associated with the volcanic center contain significant values for beryllium, niobium, tin, barium, molybdenum, silver, and copper. Selected samples of altered and mineralized rocks from the northwest fracture zone are enriched in silver, copper, molybdenum, zinc, lead, and barium; one sample from the Twin Peaks mine contained gold. Fluorite is common in the concentrate samples in the northwest fracture zone, but was not seen in concentrates that might be associated with the rhyolites of the volcanic center within the Hells Hole Roadless Area.

Niobium in the minerals pseudobrookite and ilmenite (Hassemer and others, 1981) forms as much as 1 1/2 percent of the magnetic fraction of the gravel in some drainages across the major rhyolite outcrops, but there is little likelihood of sufficient volume or grade for economic niobium placer deposits.

The silicic volcanic rocks, particularly the high-silica rhyolite of Mule Creek, are suitable source rocks for uranium-bearing solutions. A single prospect in the northwestern part of the roadless area (Pajaro Azul) has revealed a uranium occurrence, formed most likely by the movement of uranium-bearing ground water along a fracture zone in rhyolite. No evidence of other occurrences of this type, nor evidence for other types of uranium deposits was found within the mapped area.

As a result of this study, there is little promise for the discovery of oil, gas, energy resources, or any other mineral resources within the Hells Hole Roadless Area.

SUGGESTIONS FOR FURTHER STUDIES

Additional geochemical and petrological studies of the rocks of the Hells Hole volcanic center and modeling of geophysical anomalies are necessary to adequately appraise the mineral-resource potential of the area.

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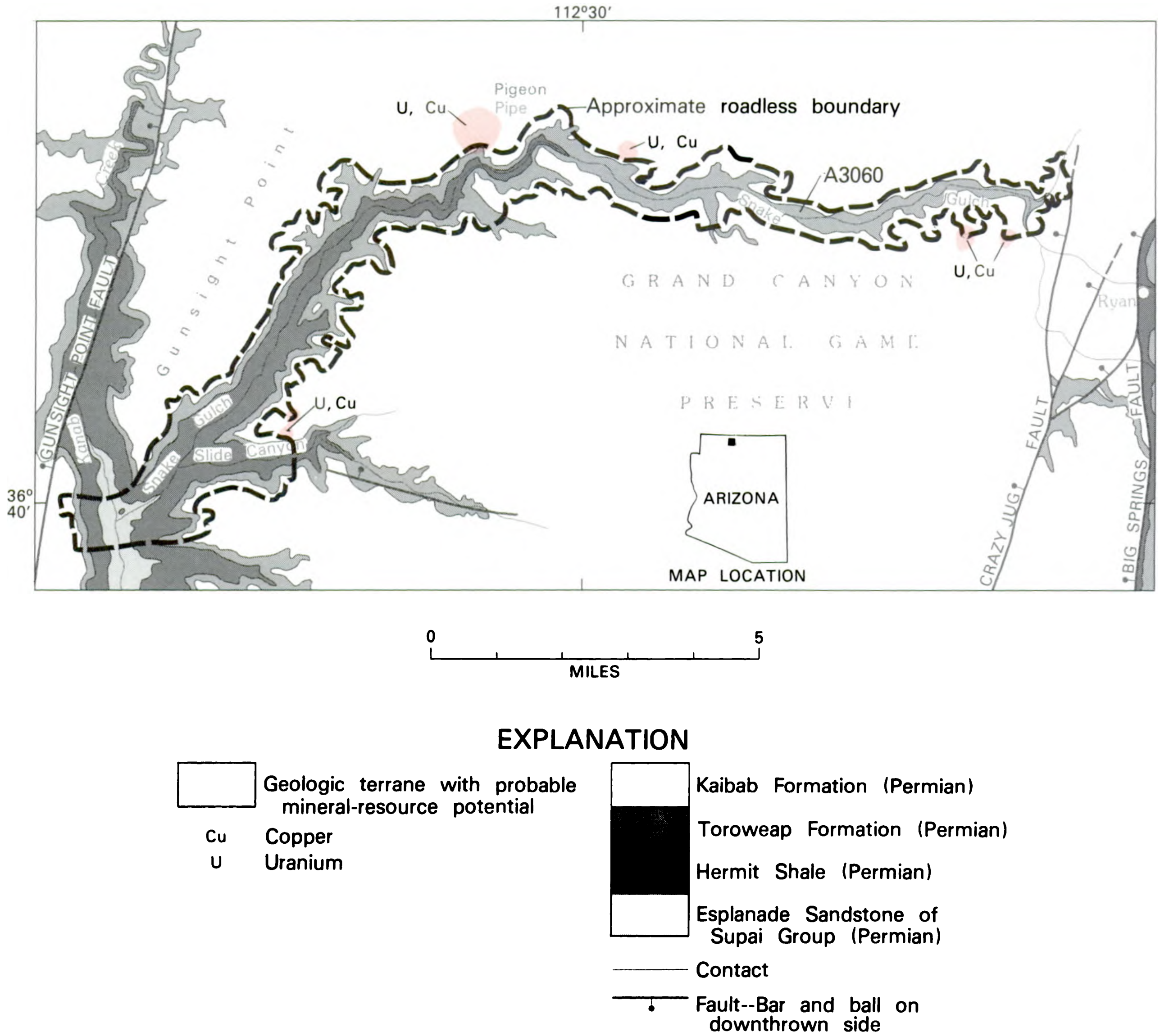

Figure 20.—Kanab Creek Roadless Area, Arizona.

KANAB CREEK ROADLESS AREA, ARIZONA

By GEORGE H. BILLINGSLEY,[1] U.S. GEOLOGICAL SURVEY, and

CLARENCE E. ELLIS, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey in 1982, the Kanab Creek Roadless Area in north-central Arizona has a probable mineral-resource potential for uranium and copper in four small areas around five collapse structures. Gypsum is abundant in layers along the canyon rim of Snake Gulch, but it is a fairly common mineral in the region outside the roadless area. There is little promise for the occurrence of fossil fuels in the area.

CHARACTER AND SETTING

The Kanab Creek Roadless Area encompasses about 14 sq mi within the Colorado Plateau Province and is about 18 mi north of the Grand Canyon, Arizona. It is contiguous with the Kanab Canyon Wilderness on the west and south sides and lies within the Grand Canyon Game Preserve of the Kaibab National Forest. The rugged canyon area is over 1500 ft deep at its deepest point, and crosses Kanab Canyon in its westernmost part. Altitudes in the roadless area range from 3720 ft to 6200 ft.

The nearest settlements in the region are Fredonia, 15 mi to the north, and Jacob Lake, 9 mi to the east; both towns are in Arizona and connected by State Highway 89A. The roadless area can only be reached by a few unmarked, unimproved jeep and hiking trails.

The rocks of the Kanab Creek Roadless Area consist of horizontal beds of sandstone, shale, and limestone, of Early Permian age. The rock units exposed include (in ascending order), the Esplanade Sandstone, Hermit Shale, Toroweap Formation (Seligman, Brady Canyon, and Woods Ranch Members), and the Kaibab Formation (Fossil Mountain and Harrisburg Members). The Triassic Moenkopi Formation is exposed 15 mi to the north.

The upper 160 ft of the Esplanade Sandstone is exposed at the mouth of Snake Gulch and consists mainly of a dark-reddish-brown mudstone and siltstone capped with a resistant reddish-brown to white massive ledge-forming sandstone. An erosional surface with relief of about 20 ft marks the unconformity between the Esplanade and Hermit Shale. The slope-forming Hermit Shale, (which is about 575 ft thick), consists of alternating bright-red-brown shaly mudstone and siltstone interbedded with pale-red-brown ledge-forming massive beds of sandstone. The contact with the overlying Coconino Sandstone, which is absent in the Kanab Creek Roadless Area, but exposed about 3 mi to the east-southeast, is a level surface with large tension cracks in the underlying Hermit Shale that are filled in with Coconino Sandstone. The Coconino Sandstone is a cross-laminated white sandstone only 14 ft thick in the upper 6 mi of Snake Gulch (outside of the roadless area) and nonexistent elsewhere. Reworked white Coconino Sandstone and red shale and sandstone of the Hermit form the interbedded layers of the basal Seligman Member of the Toroweap Formation. The Seligman Member, which is about 30 ft thick, forms a continuous cliff with the overlying Brady Canyon Member, which has a thickness of approximately 210 ft. The fossiliferous gray limestone beds of the Brady Canyon grade upward into slope-forming pale-red and gray shale and siltstone of the Woods Ranch Member of the Toroweap, which is about 160 ft thick. Thick layers of massive gypsum occur throughout the Woods Ranch Member. An erosional unconformity with as much relief as 10 ft marks the boundary between the Toroweap and the Kaibab. The basal unit of the Kaibab is a yellowish-gray fossiliferous cherty limestone representing the Fossil Mountain Member, which is about 280 ft thick. An arbitrary boundary is drawn at a gradational contact between the cliff-forming Fossil Mountain Member and the overlying slope-forming Harrisburg Member. The Harrisburg, which is about 200 ft thick, is a series of

[1]With contributions from Jack Antweiler, USGS.

alternating gray and pale-red shale and siltstone interbedded with gray limestone and gypsifereous siltstone. The Harrisburg forms the semiresistant plateau surface around the Kanab Creek Roadless Area and has variable thicknesses because of recent erosion. Unconsolidated Quaternary deposits are scattered on the slopes of the canyon as colluvium, and elsewhere as flood-plain deposits, alluvial-valley deposits, alluvial fans, and a few travertine deposits.

A few normal north-south trending faults occur at the east end and southeast of the Kanab Creek Roadless Area with a maximum throw of 1200 ft. One large fault, the Gunsight Point fault, occurs in Kanab Canyon just west of Snake Gulch. The sedimentary rocks of Snake Gulch dip very slightly from east to west, with a regional dip of 1°. Collapse structures are scattered at random on the Plateau surface on both sides of the canyon. The collapsed structures are recognized by gently dipping strata from 1° to 10° towards a central point in the center of a circular-shaped area. The collapsed areas vary in diameter from about 50 ft to 0.75 mi, and are commonly brecciated to the depth of Mississippian strata to form breccia pipes. Uranium often occurs in these structures.

MINERAL RESOURCES

The nearest known mineral deposits to the roadless area, until recently, were the copper deposits of the Jacob Lake-Warm Springs district, 4 mi east of Snake Gulch (Tainter, 1947). These are ribbon-like bodies of azurite and malachite at the intersection of vertical joints in beds of cherty sandy limestone of the Kaibab Limestone. Copper occurrences such as these could exist near the rims of Snake Gulch, but no copper minerals were observed within the Kanab Creek Roadless Area.

The presence of uranium resources and several uranium prospects related to collapse structures in a contiguous area of similar geology indicate a probable mineral-resource potential for uranium adjacent to parts of the Kanab Creek Roadless Area. Collapse structures (breccia pipes) are near the Snake Gulch canyon on lands of the U.S. Bureau of Land Management and the Kaibab National Forest. A deposit of uranium in a collapse structure (Pigeon Pipe) occurs on the north rim of Snake Gulch and an area of probable uranium resource potential extends a small distance into the roadless area. Three small areas of probable potential around four other collapse structures extend into the area. Elsewhere, the Snake Gulch canyon has a little promise for the occurrence of mineral deposits except for layers of gypsum that occur in the Woods Ranch Member of the Toroweap Formation along the rim of the canyon. Mineral prospects are rare or nonexistent, and no significant anomalies were found in geochemical samples collected within the roadless area.

The deep Paleozoic rocks could be favorable for oil and gas in this area. However, the nearest drill hole, about 12 mi northwest of the Kanab Creek Roadless Area, penetrated Cambrian strata, and was dry.

SUGGESTIONS FOR FURTHER STUDIES

It is unlikely that further study of the Kanab Creek Roadless Area would reveal evidence for mineral resources at the surface, but studies of collapse structures in surrounding adjacent areas might reveal significant mineralization at depth, such as the recent discovery of the uranium ore body at depth in the Pigeon Pipe.

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LOWER SAN FRANCISCO WILDERNESS STUDY AREA AND CONTIGUOUS ROADLESS AREAS, ARIZONA AND NEW MEXICO

By JAMES C. RATTÉ,[1] U.S. GEOLOGICAL SURVEY, and

MICHAEL E. LANE, U.S. BUREAU OF MINES

SUMMARY

The Lower San Francisco Wilderness study area and contiguous roadless areas were examined for mineral potential in 1980–81 and found to have an area of probable mineral-resource potential for base- or precious-metal deposits in middle to upper Tertiary volcanic rocks. The entire area has a largely unassessable potential for base-metal deposits related to igneous intrusives of Laramide age, like those in the nearby Morenci mining district, Arizona. The contiguous roadless area has an area of probable mineral-resource potential for molybdenum or copper deposits related to intrusive igneous rocks in the core of a dacitic volcano of Oligocene age. An area in the west part of the study area has a probable geothermal-resource potential.

CHARACTER AND SETTING

The Lower San Franciso study area consists of about 40 sq mi, in a strip between 1 and 6 mi wide, along a 20–30 mi stretch of the San Francisco River in Arizona and New Mexico. The wilderness study area is almost equally divided between the two states, but the contiguous roadless area is entirely in New Mexico. Within the study area, the San Francisco River has cut a spectacular steep-walled canyon nearly 2000 ft deep. The area was studied in 1980–81 and the results were published in 1982 (Ratté and others, 1982).

Clifton and Morenci, Arizona, are the closest towns down river about 10 mi west of the study area, and Glenwood, New Mexico, is about 5 mi upriver. Elevations in the study area range from about 3800 ft, at the mouth of the Blue River at the west end of the area, to about 4500 ft at the east end, and 6600 ft on the north rim of the San Francisco River canyon.

The study area is within the transition zone between the relatively stable Colorado Plateau and the more tectonically active Basin and Range structural and physiographic provinces. The transition zone was the site of intense faulting and igneous activity during Laramide time (Late Cretaceous to early Tertiary), and large volumes of basaltic to rhyolitic volcanic rocks were erupted along the transition zone in middle Tertiary time. The study area is entirely covered now by middle Tertiary and younger volcanic rocks or stream-deposited sedimentary rocks, but lower Tertiary and pre-Tertiary rocks may underlie parts of the study area at 1000 ft or less below the level of the San Francisco River. In fact, middle Tertiary volcanic rocks overlie Paleozoic sedimentary rocks and Precambrian granite only a few miles south of the study area.

The rocks within the study area are cut by 3 sets of high-angle normal faults that trend north-northeast, northwest, and west-northwest. Displacements on the faults of each set range from a few tens of feet to hundreds of feet. The other major structures in the study area are all constructional volcanic features, mainly eruptive centers, such as andesitic and basaltic cinder cones, a small stratovolcano, and rhyolite vents, plugs and breccia pipes.

Mining activity within the study area has been practically nil, and there were no active mining claims within the area in 1980. However, since completion of a minerals survey in 1981, sizeable blocks of claims have been filed in the New Mexico part of the study area in Goat Basin, and southeast of Goat Basin on the north side of the San Franciso River.

[1]With contributions by J. R. Hassemer and R. A. Martin, USGS.

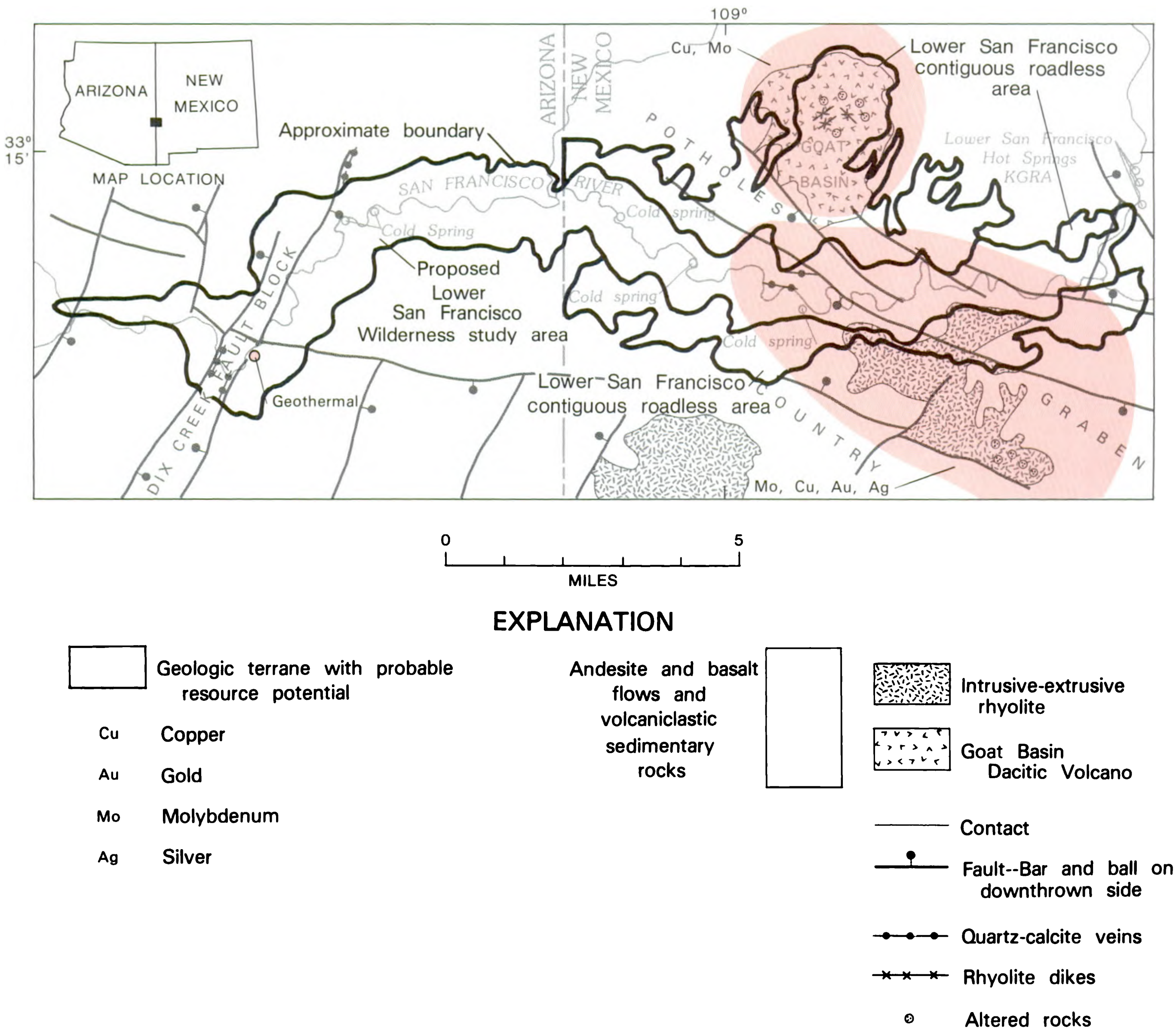

Figure 21.—Lower San Francisco Wilderness study area and contiguous roadless areas, Arizona and New Mexico.

MINERAL RESOURCES

Any ore deposits discovered in the study area are most likely to be of Laramide or middle Tertiary age. Laramide time is when most of the important copper deposits of the southwestern United States were formed, including the deposits at the Morenci and Metcalf mines, less than 15 mi southwest of the western end of the study area, which have produced more than 3 million tons of copper. Some subvolcanic intrusive centers of middle Tertiary age in the vicinity of the study area, as at Steeple Rock and Mogollon, New Mexico, have deposits of silver, gold, copper, and fluorite.

Within the study area, the greatest incentive to mineral exploration is the possibility of discovering a porphyry copper deposit related to a Laramide intrusive buried beneath the middle Tertiary volcanic cover. The probability of such a blind intrusive occurring within the 40 sq mi area of the Lower San Francisco Wilderness study area and contiguous roadless area, and the further probability of its being mineralized sufficiently to form an ore deposit, is largely unassessable by the methods used in this mineral survey.

The best exploration target for ore deposits of mid-Tertiary age is the Goat Basin volcano, north of the San Francisco River and entirely within the contiguous roadless area. The volcano is a stratified volcanic cone 2–3 mi in diameter; it consists of explosive breccia, lava flows, and minor tuff of hornblende dacite and pyroxene andesite, 26–28 million years old. Its flanks are largely buried by younger andesite lava flows, but its center (Goat Basin) is eroded to a depth of 1200–1400 ft below the exhumed rim. A negative aeromagnetic anomaly of about 100 gammas, which is centered over the volcano, and the presence of small rhyolite dikes and altered and weakly mineralized rocks in the center of the volcano indicate a subvolcanic silicic intrusive at a depth of a few hundred to a few thousand feet beneath the volcano, and such an intrusive might be mineralized. Geochemical samples of silicified and pyritized rhyolite show molybdenum and copper. A probable molybdenum-copper resource potential exists in this area.

Weak signs of mineralized rocks also occur in the form of quartz and calcite veins peripheral to 18–21 million year old (Miocene) rhyolite eruptive centers, and as silicified and argillized rocks within rhyolite south of Goat Basin, along and south of the San Francisco River. The rhyolite centers are exposed mainly along a narrow downdropped block, the west-northwest trending Potholes Country graben, which is expressed as an aeromagnetic low similar to and merging with the aeromagnetic low over the Goat Basin volcano. The magnetic pattern thus indicates the possibility that the 18–21 million year old rhyolite extends beneath the volcano and is connected to the rhyolite dikes at its center.

The 18–21 million year old rhyolites are high-silica rhyolites (greater than 77 percent SiO_2) and are chemically similar to rhyolites that are commonly associated with molybdenum-tin-tungsten mineral deposits. Samples of altered and mineralized rocks along individual quartz-calcite veins, and in siliceous or other altered zones within the rhyolite, commonly have very weak metal concentrations of silver, gold, copper, lead, antimony, tungsten, and manganese. Silicified zones in similar rhyolite in prospects in adjacent areas are highly anomalous in silver and gold. Panned concentrates from stream sediments in the vicinity of the rhyolite also show weakly anomalous abundances of molybdenum, tin, niobium, and thorium. This area has a probable resource potential for molybdenum, copper, gold, and silver.

The Dix Creek north-northeast-trending fault block in the western part of the study area contains quartz-calcite veins along the faults on both sides of the block, and the fault block has been interpreted to have a possible large volume silicic intrusive at considerable depth beneath the surface. Samples from the veins lack metal values except for manganese in calcite, silver, gold, and copper in quartz at the north end of the fault block, just north of the wilderness study area. It is unlikely that this structure is related to significant mineral resources.

A probable potential for geothermal resources is present in the Lower San Francisco Wilderness study area according to a study by the University of Arizona for the U.S. Department of Energy (Witcher, 1979). The wilderness study area encloses a stretch of the San Francisco River that is between two known geothermal resource areas (KGRA's) as classified by the USGS (Muffler, 1979; Hatton, 1981). A KGRA is defined by the USGS as an area which has the necessary geothermal potential to justify spending money for development. Several springs along the river between the KGRA's, and within the wilderness study area, have surface temperatures that are above the average temperature of other springs and the river water. One of the springs with above average temperature (26°C) has a calculated temperature at depth of 126°C. It also has chemical characteristics similar to the water of the nearby KGRA's, being a sodium-chloride water high in silica and lithium (Witcher, 1979, tables 1, 2). The spring occurs along the eastern fault of the Dix Creek fault block, which is also cut by a west-northwest fault in this area. Thus, the setting of this geothermal spring is consistent with an origin for the heated water by deep circulation of ground water through fractured rocks, the water rising to the surface again along a major fault zone.

In summary, there is a probable, though largely unassessable (without deep drilling), resource potential for a porphyry copper deposit beneath the middle Tertiary volcanic cover. Areas of probable mineral-resource potential exist for a molybdenum-copper deposit in the middle Tertiary volcanic rocks beneath the Goat Basin volcano, and for minor precious-metal deposits in rocks related to intrusive and extrusive rhyolite centers of Miocene age. Springs along the San Francisco River in the west part of the study area indicate a probable geothermal-resource potential.

SUGGESTIONS FOR FURTHER STUDIES

Additional geologic and geophysical studies are needed to assess the position and character of the post-Laramide surface beneath the middle Tertiary volcanic rocks, and to characterize geophysical anomalies that might represent hidden Laramide-age intrusive bodies. Mathematical modelling of the aeromagnetic anomalies associated with the Goat Basin volcano and Miocene rhyolite eruptive centers, and additional geochemical sampling in those areas are needed to better assess their mineral-resource potential.

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MAZATZAL WILDERNESS AND CONTIGUOUS ROADLESS AREAS, ARIZONA

By CHESTER T. WRUCKE,[1] U.S. GEOLOGICAL SURVEY, and

CLARENCE E. ELLIS, U.S. BUREAU OF MINES

SUMMARY

A mineral survey conducted in 1979 and 1980 by the USGS and USBM has shown that the Mazatzal Wilderness has demonstrated resources of silver, gold, lead, and mercury, small areas of substantiated mineral-resource potential for silver and copper, and areas of probable resource potential for resources of silver, copper, lead, mercury, and molybdenum. Gold, silver, and copper resources occur in small deposits in the north-central, eastern, and southern parts of the wilderness. A small demonstrated mercury resource is located at the Sunflower mine near the southeastern corner of the wilderness adjacent to the well-known Sunflower mining district. Molybdenum mineralization found during this study in the Tangle Creek area west of the Verde River may extend eastward into the roadless area and the wilderness. Tin occurrences not previously known in the Mazatzal region were found in the central part of the wilderness, and uranium was found near Horseshoe Reservoir, but there is little promise for the occurrence of tin and uranium resources. No potential for fossil fuel resources was identified in this study.

CHARACTER AND SETTING

The Mazatzal Wilderness comprises 320 sq mi, and the contiguous roadless areas comprise an additional 130 sq mi, in the mountainous region of central Arizona. The dominant physiographic feature is the northern part of the Mazatzal Mountains. This part of the mountains rises steeply from an altitude of about 3500 ft in the valley east of the mountains to 7903 ft at Mazatzal Peak. To the west, the range slopes steeply from the forested crest, then more gently on the lower flanks to the desert lowlands at altitudes of about 2500 ft along the Verde River. Mountainous terrane on the west side of the Verde River is in the roadless area bordering the wilderness. The spectacular escarpment of the Mogollon Rim, marking the southern border of the Colorado Plateau, is a few miles north of the wilderness. It rises above mesas that extend southward into the wilderness and are separated from the Mazatzal Mountains by the deep canyon of the East Verde River, a tributary of the Verde River. The nearest town is Payson, 8 mi east of the wilderness.

[1]With contributions from Sherman P. Marsh, Clay M. Conway, Dolores M. Wilson (Kulik), and Calvin K. Moss, USGS.

Much of the Mazatzal Mountains, the canyon of the East Verde River, and the mountains west of the Verde River are underlain by a variety of Proterozoic stratified rocks that form several tilted, structurally fragmented, layered sequences that, if stacked together, would have a total stratigraphic thickness of about 55,000 ft. These rocks are little altered despite their antiquity even though some were invaded by a large mass of Proterozoic granite. The ancient layered rocks retain many features indicative of their origin as sedimentary and volcanic rocks. Overlying the Proterozoic rocks are much younger Paleozoic sedimentary strata that were deposited in shallow seas and today are extensively exposed as flat-lying beds along the Mogollon Rim. These rocks have been eroded from most of the wilderness and roadless areas but occur as cappings on a few ridges and as isolated exposures. Erosion of these and the older rocks has taken place over a long span of geologic time but was accelerated about 15 million years ago, after the beginning of faulting that broke central and southern Arizona into mountain blocks and intervening basins. Volcanic rocks that were erupted during the faulting partly buried all older rocks. These volcanic rocks and the sedimentary deposits that accumulated with them

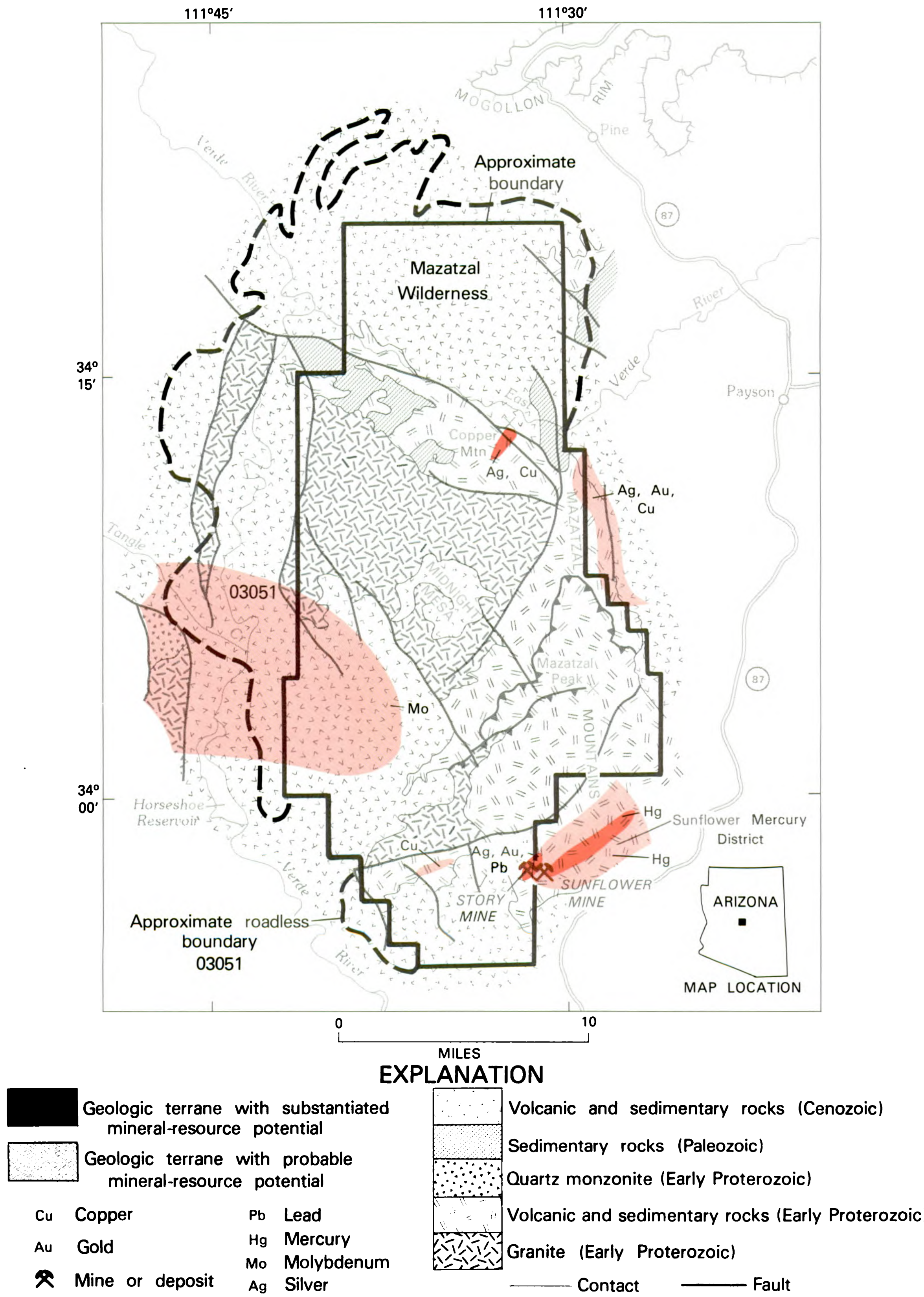

Figure 22.—Mazatzal Wilderness and contiguous roadless areas, Arizona.

are widely exposed in the wilderness. They, too, have been faulted repeatedly in the last few million years during the evolution of the present mountains and valleys.

A mineral-resource study in 1979 and 1980 included geologic mapping, geochemical sampling and evaluation, geophysical studies (compilation and interpretation of gravity and aeromagnetic data), and an examination of mines, claims, and prospects in the area.

MINERAL RESOURCES

Metallic mineral occurrences are widespread in and around the Mazatzal Wilderness. Within the wilderness are occurrences of silver, gold, copper, mercury, and (or) tin, and the roadless area along the west side of the wilderness has indications of uranium and molybdenum (Wrucke and others, 1982). Despite these abundant occurrences and their wide distribution, there is little promise for the occurrence of mineral deposits in much of the area.

Silver and gold occur in Proterozoic metamorphic and granitic rocks in and around the wilderness. The most favorable area for silver and gold in the wilderness is at and near the Storey mine. The vein deposits that have been mined are estimated to have demonstrated resources of 78,000 tons of additional mineralized rock, containing 1.9 oz silver/ton, 0.06 oz gold/ton, and 3.9 percent lead. A geologically similar area occurs 0.5 mi north and northeast of the Storey mine and has a probable potential for gold, silver, and lead. An area of silver-gold-copper veins immediately east of the wilderness, north of Mazatzal Peak, has a probable mineral-resource potential. Copper was produced in the 1880's from the silver-gold veins. The northern and southern ends of this area extend into the wilderness but chances are small that these veins extend a significant distance into the wilderness. The Copper Mountain area has a substantiated resource potential for silver and copper based on assay and geochemical data and the fact that 485 oz of silver and 33.5 tons of copper ore were produced from the deposit in 1967. Silver also occurs in small sulfide veins in the Proterozoic granite north of Midnight Mesa, but no resource potential was identified.

An occurrence of copper is in an area 3 mi west of the Storey mine southwest of Mazatzal Peak. Here bedded gossans suggest the possibility of massive sulfide mineralization. No evidence of a massive sulfide body was found by geophysical techniques above the maximum search depth of 400 ft. However, this area also has locally abundant copper minerals in veins and has a probable resource potential for copper.

The Sunflower mercury district, located in metamorphosed Proterozoic sedimentary and volcanic rocks east of the southern end of the wilderness, has produced about 95 percent of the mercury recovered in Arizona. However, the total production from the district has been small, amounting to 3973 flasks of mercury (Beckman and Kerns, 1965). The mercury distribution in the district trends southwestward and extends into the wilderness at the southwestern end of the district. A demonstrated mercury resource estimated at a few hundred flasks of mercury occurs within the wilderness as an extension of the Sunflower mine. Farther inside the wilderness, evidence of mercury mineralization has not been found at the surface.

Indications of porphyry molybdenum deposits were found during this study by geochemical sampling in granitic rock (Proterozoic quartz monzonite) exposed in the Tangle Creek area west of the wilderness. Although a traverse through the area revealed no obvious indications of molybdenum minerals, the data support a probable potential for a porphyry-type molybdenum resource. Interpretation of gravity and aeromagnetic data indicate that the granitic body may be of modest size and extend eastward into the roadless area, and possibly also into the wilderness beneath younger rocks. Exploration would be required to determine the distribution and grade of mineralized rock.

Tin was identified in the Proterozoic granite during this study in the central part of the wilderness. Tin had not previously been reported as occurring in central Arizona. High concentrations of tin were found in alteration zones of a kind associated with tin deposits in many parts of the world. However, available data offer little promise that the granite contains tin resources.

Uranium occurrences exist in Cenozoic sedimentary rocks outside the wilderness near Horseshoe Reservoir, and barely inside the roadless area and the wilderness northeast of the reservoir. The concentration of uranium in these rocks is low and there is little promise for the occurrence of uranium resources in the area.

SUGGESTIONS FOR FURTHER STUDIES

The broad features and many details of the geology and mineral resources of the Mazatzal Wilderness and contiguous roadless areas are known as a result of this study. However, the area contains tin-bearing rocks not previously reported in central Arizona and a possibly significant molybdenum deposit, neither of which is well understood. Detailed study of the Proterozoic granitic and metamorphic rocks that contain the tin and molybdenum mineralization may reveal further evidence of a potential for the occurrence of deposits of these commodities in and around the Mazatzal Wilderness. Further study of the Proterozoic metamorphic rocks also may provide information on their potential for massive sulfide deposits of the kind known in similar rocks in northwestern Arizona.

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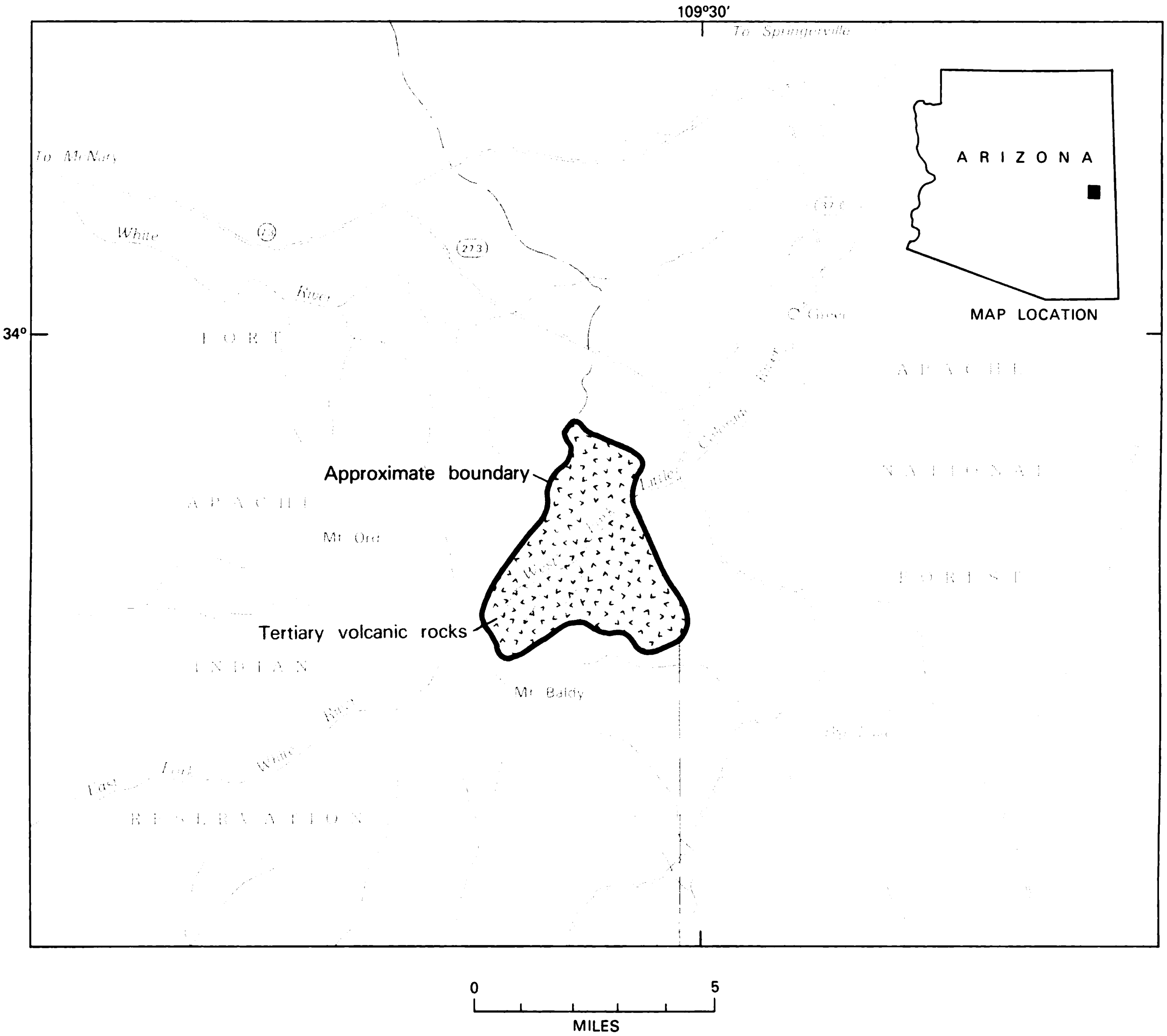

Figure 23.—Mount Baldy Wilderness, Arizona.

MOUNT BALDY WILDERNESS, ARIZONA

By TOMMY L. FINNELL,[1] U.S. GEOLOGICAL SURVEY, and

JOHN H. SOULÉ, U.S. BUREAU OF MINES

SUMMARY

The Mount Baldy Wilderness, Arizona, was surveyed for mineral resources in 1966 and was judged to have little or no promise for the occurrence of mineral resources. No mineral deposits, mining claims, or concentrations of trace metals were recognized within the area during the investigations of the USGS or the USBM. No oil test holes have been drilled within the area; holes drilled about 35 mi north of the area were not productive.

CHARACTER AND SETTING

The Mount Baldy Wilderness occupies about 11.5 sq mi in the White Mountains of east-central Arizona, about 140 mi east-northeast of Phoenix. The wilderness is very near the highest part of the White Mountains; elevations range from about 9200 ft to 11,400 ft above sea level. Baldy Peak, the highest point in the White Mountains, is about a ¼ mi south of the wilderness and has an elevation of 11,403 ft.

The wilderness is underlain by about 3500 ft of young (less than 26 million years old) volcanic flows and as much as 450 ft of glacial drift (Finnell and others, 1967). The volcanic rocks are mainly intermediate (dacite to rhyolite) porphyry, basalt, and basaltic scoria and tuff. The geologic structure of the rocks exposed in the wilderness is simple. The older basalt flows are steeply tilted locally, the intermediate flows above them slope gently to the northwest, north, east, and southeast, and the glacial deposits and younger basalts are flat lying.

MINERAL RESOURCES

The wilderness lacks significant faults of the kind that contains veins of gold and silver ore at Mogollon, New Mexico, about 53 mi to the southeast. Concentrations of visible ore minerals were not found, and a geochemical survey of the wilderness showed the metal content of all samples to be so low that the possibility of discovering mineral resources in the area is remote.

A small cinder cone in the north part of the wilderness might be suitable for road metal, but many cinder cones east and north of the area are much larger and more easily reached. Sedimentary rocks that yield oil, gas, coal, uranium, and bleaching clay elsewhere in eastern Arizona either are absent from or are present only at great depth beneath the Mount Baldy Wilderness. The Coconino Sandstone (Permian), a potential reservoir for petroleum and natural gas, may be present at depth beneath the wilderness, but the existence of structural traps is highly conjectural. Thin coal beds may be present in sedimentary rocks at depths of 3000 ft or more beneath the wilderness, but exploitation for thin coal at such depths is considered to be unlikely. Rocks of the type that yields bleaching clay are not found in the wilderness. Small deposits of uranium are in the Chinle Formation (Triassic) about 40 mi north-northwest of the area, but regional geologic relationships indicate that the Chinle Formation does not underlie the Mount Baldy Wilderness. Similarly, other uranium-bearing formations of the Colorado Plateau do not lie beneath the area.

SUGGESTIONS FOR FURTHER STUDIES

Further study of the Mount Baldy Wilderness would seem warranted only in the event that economic deposits of minerals or petroleum are found in nearby areas.

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[1]With contributions by C. Gilbert Bowles, USGS.

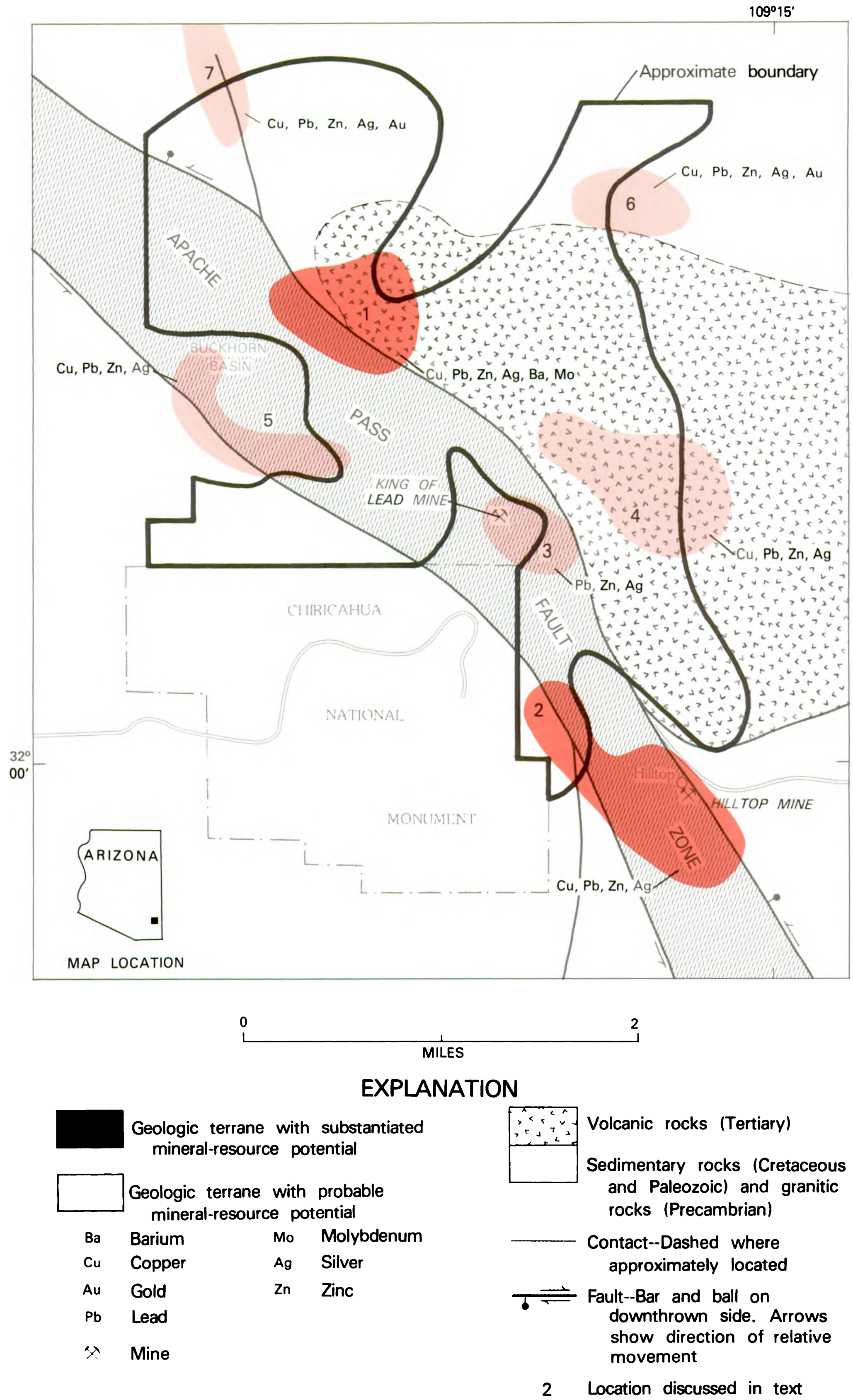

Figure 24.—North End Roadless Area, Arizona.

NORTH END ROADLESS AREA, ARIZONA

By HARALD DREWES,[1] U.S. GEOLOGICAL SURVEY, and

P. R. BIGSBY, U.S. BUREAU OF MINES

SUMMARY

Studies conducted in 1978–79 in the North End Roadless Area indicate probable or substantiated metallic mineral-resource potential in about one-fifth of the area. The area has potential for disseminated or stockwork-type molybdenum mineralization, copper-lead-zinc-silver veins, lead-zinc-silver limestone replacement deposits, and tungsten-bearing contact metamorphic skarn deposits. The area also contains cement rock and marble dimension stone, but has only slight promise for the occurrence of petroleum and natural gas.

CHARACTER AND SETTING

The North End Roadless Area covers about 40 sq mi of the northern end of the Chiricahua Mountains near the southeastern corner of Arizona. It lies adjacent to the north and east sides of the Chiricahua National Monument and is about midway between the towns of Portal and Bowie, in the Coronado National Forest.

The roadless area covers moderately high terrain that is partly forested. Access to the area is by means of roads up the larger canyons from county roads or State highways in the intermontane valleys east and west of the mountains. A few trails facilitate access to the interior of the area.

The North End Roadless Area is underlain by a wide variety of sedimentary, volcanic, and plutonic rocks, some of which are strongly faulted (Sabins, 1957; Drewes, 1981, 1982, 1983). Precambrian schist and granodiorite plutons are the oldest rocks of the area, forming a basement for four sequences of overlying sedimentary and volcanic rocks. The lowest of these is mainly a limestone sequence, about 8100 ft thick and of Paleozoic age. Next is a shale and sandstone sequence, about 6500 ft thick and of Mesozoic age. The third is a rhyolite and andesite volcanic sequence of Tertiary age; it is about 6500 ft thick near a major volcanic center in the eastern part of the area, but it thins rapidly and is absent over much of the area. The capping sequence, of Tertiary and Quaternary gravel, is thin in most of the area but is at least 6000 ft thick beneath the San Simon Valley east of the roadless area.

The faults cutting these rocks are the key features that guided the emplacement of Tertiary granitic plutons, influenced the distribution of metamorphism, and probably controlled mineralization. The Apache Pass fault zone trends diagonally northwest to southeast through the area, forming a belt of broken rock 0.5 to 1 mi wide. This fault zone is almost vertical and has been active at various times between the Precambrian and late Tertiary. A zone of thrust faults trends west across the northern part of the area, and is also related to the Apache Pass fault zone. The thrust faults dip moderately at the surface, but presumably flatten at depth, and are offset by some of the latest movement on the Apache Pass fault zone. These faults and the broken rock near them have helped granitic magma of Tertiary age and mineralizing fluids move upward from deep sources into the Paleozoic and Mesozoic rocks. Near the intrusive rocks the Paleozoic and Mesozoic rocks are metamorphosed, and locally contain lead, silver, zinc, and copper mineralization.

Mining began in 1881 in the vicinity of the roadless area with the early development of claims that later became the Hilltop mine, 1 mi south of the area. Scattered prospects and a few patented claims lie within, or just outside the roadless area. During the time of the study, there was sporadic development work at the King of Lead mine and nearby claims lying in an area between the Chiricahua National Monument and the roadless area. Base metals and silver ore have been produced from the Hilltop mine (about $1.1 million production between 1902 and 1950) and a small amount of similar ore was probably produced from the King of Lead mine and from mines in the Buckhorn Basin about 0.5 mi west of the roadless area.

[1]With contributions from C. L. Forn, K. C. Moss, and K. C. Watts, Jr., USGS.

MINERAL RESOURCES

Seven areas of probable and substantiated mineral potential were identified in this study. These areas are discussed in order of their decreasing significance (although a few successive sites are of nearly equal significance), based on their known or inferred geologic, geophysical, and geochemical features.

Although area 1 contains only a few small prospects it is regarded as having substantiated mineral-resource potential. It lies along the Apache Pass fault zone and is, in part, underlain by metamorphosed Paleozoic limestone, two Tertiary rhyolitic plugs, and a Tertiary granodiorite stock. Volcanic rocks in the northeastern part of the area are extensively pyritized and oxidized. Chip samples from prospects and outcrops show the presence of copper, lead, zinc, molybdenum, barium, and silver mineralization. Geochemical anomalies in stream-sediment samples from area 1 suggest a possible focus of mineralization many hundreds to a few thousand feet below the center of the area (Watts and others, 1983). Three types of mineralization could occur in area 1; vein or replacement deposits of lead, zinc, and silver in the sedimentary rocks, skarn contact deposits near the granodiorite stock, and copper or molybdenum porphyry-type mineralization at moderate depth.

Area 2 contains the Hilltop mine and numerous prospects (Drewes and others, 1983), and extends to the southeast beyond the North End Roadless Area. It also lies along the Apache Pass fault zone and is underlain by Mesozoic and Paleozoic sedimentary rocks, a small stock and rhyolitic plugs north of Hilltop, and a large stock on its southern side. Sampling in the area gave data showing anomalous concentrations of base metals and silver. From aeromagnetic data, we infer that the crest of the large stock plunges gently northwest beneath Hilltop. A mineralized zone like that at the Hilltop mine is inferred to plunge to the northwest, extending below part of the study area, defining a zone of substantiated resource potential for base metals and silver.

Area 3 has a probable resource potential for small lead-zinc-silver replacement or vein mineralization at moderate depths like that at the King of Lead mine (Drewes and others, 1983). This area also lies along, or within, the Apache Pass fault zone, and it is underlain by Mesozoic and Paleozoic sedimentary rocks and some small plugs and dikes (Sabins, 1957; Drewes, 1982, 1983). There is less observed mineralization than at areas 1 and 2 and anomalous concentrations of copper and molybdenum are more widely scattered. Aeromagnetic data (Moss, 1983) shows positive anomalies suggestive of the presence of small buried stocks, which may provide a favorable environment for mineralization.

Area 4 lies northeast of the Apache Pass fault zone and is underlain by Tertiary volcanic rocks cut by some breccia pipes and normal faults. The area contains almost no signs of prospecting. Mineralized carbonate reefs along the faults contain high values for lead, barium, molybdenum, and silver. Aeromagnetic data shows the possible presence of a stock beneath the eastern end of area 4. These signs are viewed as indicating probable resource potential for base metals and silver beneath the volcanic cover, possibly in veins along faults.

Area 5 lies largely outside the roadless area and, also follows a strand of the Apache Pass fault zone. The area is underlain by Mesozoic and Paleozoic rocks that are intruded by a stock and by plugs and dikes. Observations of mineralization at the surface and of geochemical and geophysical features are suggestive of a probable resource potential for small replacement, vein, or contact metamorphic mineralization containing base and precious metals.

Area 6 also has a probable mineral-resource potential for base and precious metals but lies largely outside the roadless area. The area is underlain by the same kind of sedimentary rocks as the other sites but its thrust-faulted terrane has only a few plugs and dikes. The area contains geochemical anomalies and a few small mines. Aeromagnetic data suggests that area 6 is above the south flank of an eastward-plunging stock. The area is favorable for blind vein or replacement mineralization at accessible depths, and may also contain deeper contact mineralization.

Area 7 has probable resource potential for base and precious metals, though evidence is weaker than for the other areas. It is underlain mainly by Mesozoic and Paleozoic sedimentary rocks intruded by Tertiary stocks and dikes. Some Precambrian granite is in the northern part of the area. These rocks are cut by a strand of the Apache Pass fault zone and by a splay fault branching from the zone. Scattered prospects occur in area 7, and some of them contain copper, lead, zinc, arsenic, antimony, and silver. Geochemical samples of the alluvium suggest the possible presence of concealed mineralization near the boundary of the study area. Aeromagnetic data suggests that a stock exposed west of the site has a crest that plunges gently northeastward below this possibly mineralized ground.

Marble and lime rock occur in the area and other commodities—silica rock, sand and gravel, and graphite—are present or have been reported present in or near the roadless area. All these products are more accessible and abundant at and near old quarries or outcrops outside the roadless area.

The North End Roadless Area lies within the overthrust belt (Drewes, 1980, 1981) and has become an area of interest for petroleum and natural gas resources.

While rocks deep in the subsurface could contain traps for these fluids, the abundant steep faults and stocks in the roadless area suggest that such fluids would not likely be preserved.

SUGGESTIONS FOR FURTHER STUDIES

The abundance of areas deemed favorable for mineralization suggest the area warrants further study.

The part of area 1 with disseminated sulfides warrants a more detailed geologic and geochemical investigation, and possibly studies using ground geophysical techniques. A more precise modeling of subsurface extensions of stocks and plugs at this site may also be desirable. A study of the alteration minerals in the volcanic terrane would also be useful.

In several other areas where known or projected mineralization is associated with faults (areas 1, 2, 4, 5, and perhaps 7), a more detailed geochemical sampling program examining mineralized rock and alteration along fractures might determine areas of movement of hydrothermal solutions.

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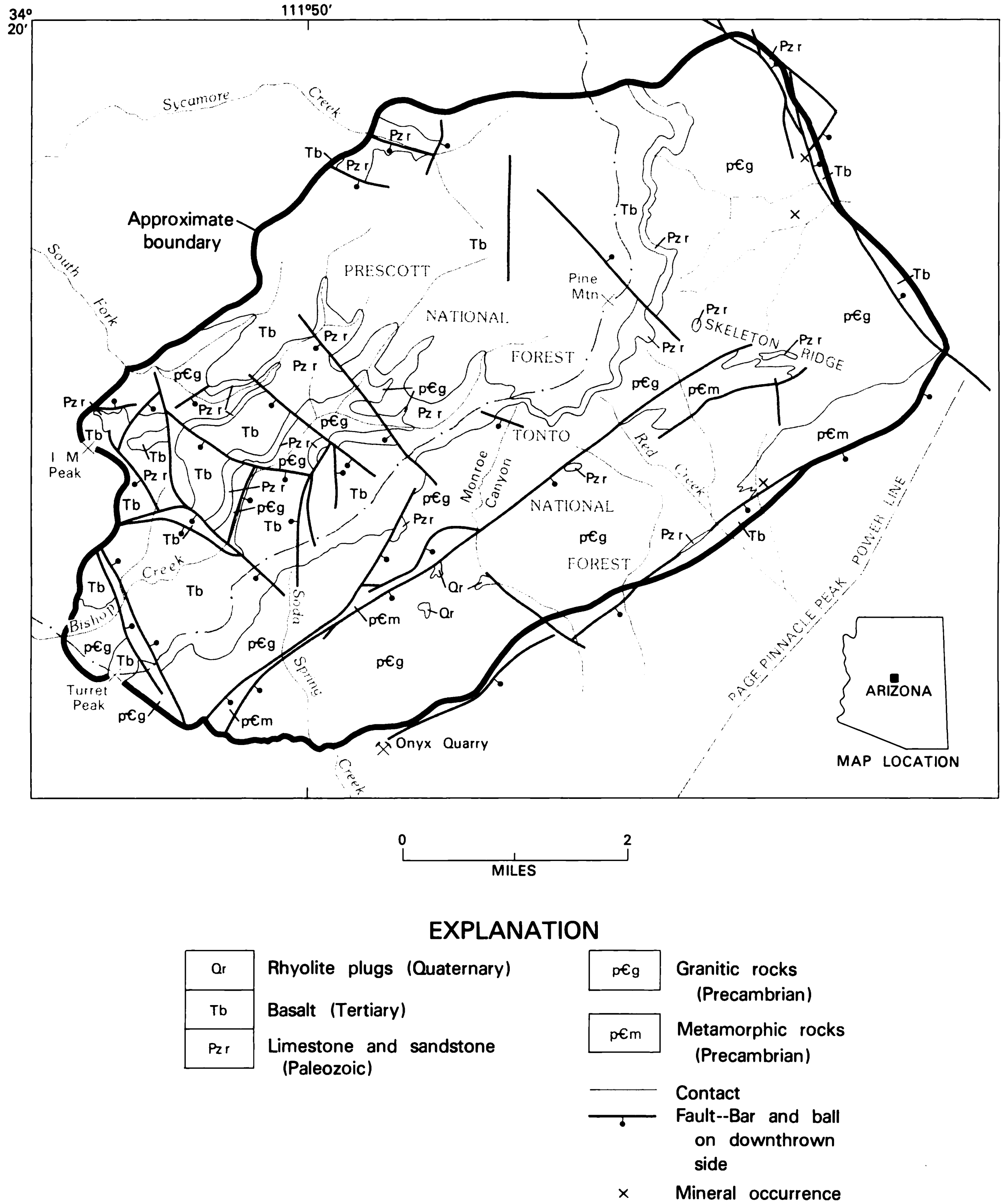

Figure 25.—Pine Mountain Wilderness, Arizona.

PINE MOUNTAIN WILDERNESS, ARIZONA

By FRANK C. CANNEY,[1] U.S. GEOLOGICAL SURVEY, and

FRANK E. WILLIAMS, U.S. BUREAU OF MINES

SUMMARY

A geologic study and geochemical survey were made of the Pine Mountain Wilderness in 1966. Only slight traces of mineralization of no apparent significance were found and the results of the geochemical survey were negative. The presence of important near-surface mineral deposits in the area is considered unlikely. No evidence of nonmetallic or energy resources was identified during the course of this study.

CHARACTER AND SETTING

The Pine Mountain Wilderness comprises an area of about 31 sq mi in southeastern Yavapai County near the center of Arizona. The wilderness is between the Black Canyon Highway (Arizona State Route 69 and Interstate Highway 17) and the Verde River. It is about 40 mi east-southeast of Prescott, the county seat of Yavapai County, and about 20 mi south of Camp Verde. The northwestern part of the area is in the Prescott National Forest, and the southeastern part is in the Tonto National Forest. The Pine Mountain Primitive Area was studied in 1966 (Canney and others, 1967). Because the boundaries of the proposed wilderness were known in 1966, all the additional tracts of land outside the existing primitive area proposed for inclusion in the wilderness were also examined. The Pine Mountain Wilderness was formally established in 1973.

The Pine Mountain Wilderness is characterized by rather diverse types of topography and vegetation, but in general it is rugged and mountainous. It forms the southeast end of the Black Hills, a northwest-trending range that bounds Verde Valley on the southwest, and extends northwestward to the famous Verde mining district. The wilderness is divided into two parts roughly equal in size but different in character. The part west and northwest of the Prescott-Tonto National Forest boundary is generally mesalike because of the nearly horizontal attitude of the Tertiary lava flows and moderately deep canyons have been cut into it by Bishop and Sycamore Creeks. Within the Prescott National Forest area a good network of horse and foot trails permits relatively easy access to much of the area. The part of the wilderness southeast and east of the Prescott-Tonto National Forest boundary is extremely rugged and is dissected by many moderately deep canyons. In the Tonto National Forest area travel is generally difficult owing to complete lack of trails and the vegetative cover is often so dense that to travel any distance is an extremely difficult, painful, and time-consuming operation.

Altitudes in the wilderness range from 6814 ft on Pine Mountain to slightly less than 4000 ft at several points on the southeast border. Turret Peak (alt. 5840 ft) and 1 M Peak (alt. 5998 ft) are prominent and easily recognizable landmarks on the southwest edge of the area. The vegetation is extremely varied, both in type and amount, as would be expected from the rather large differences in altitude between various parts of the area. It ranges from plant communities composed of various species of shrubs and cacti characteristic of the Sonoran Desert to relatively open stands of ponderosa pine.

The rocks in the Pine Mountain Wilderness vary greatly both in age and type. The Tonto National Forest section is underlain principally by very old (Precambrian) rocks, mostly granites and closely related types, although there are small areas of highly metamorphosed volcanic and sedimentary rocks. The metamorphic rocks are also well exposed in the deeper canyons in the Prescott National Forest section. Overlying Precambrian rocks, principally in the western part of the wilderness (Prescott National Forest section), are nearly flat-lying strata of sandstone and limestone of early to middle Paleozoic age (about 350–550 million years old). These sedimentary rocks are covered nearly everywhere by basalt lava flows of Tertiary age, so are generally exposed only in the walls of the deeper canyons in the western part of the wilderness and in the east-facing cliffs along the Pine Mountain escarpment.

[1]With contributions by William L. Lehmbeck, USGS.

The Paleozoic rocks are missing from large areas in the southwestern part of the wilderness; presumably they were eroded before the advent of volcanic activity, for basalt flows rest directly on the old igneous rocks in those areas. The basalt flows that are widespread in the wilderness, and compose much of the exposed bedrock in the Prescott National Forest area, were deposited during an episode of extensive volcanic activity that occurred in north-central Arizona only a few million years ago.

Strong tectonic forces elevated the Black Hills at least 3000 ft a few million years ago. Vigorous stream erosion since that time has shaped the landscape of the Pine Mountain Wilderness that we see today. The rocks in the wilderness responded to the stresses during the period of Cenozoic deformation principally by simple uplift and minor tilting; no folds have been recognized, and the principal structural features are vertical to high-angle faults.

MINERAL RESOURCES

The 1966 mineral survey (Canney and others, 1967) found no evidence of any significant near-surface mineral deposits in the Pine Mountain Wilderness. This was not unexpected, because much prospecting has been done during the past 75–100 years in this part of Arizona in the hopes of finding large and rich deposits of gold, silver, copper, and zinc like those mined in the Verde mining district, 30–40 mi to the northwest. Certainly any surface indications of important mineralization would have been detected by these early prospectors. And considering how thoroughly this area must have been prospected, diggings are surprisingly scarce; only three prospects were noted during the 1966 survey.

Precambrian massive sulfide deposits and Precambrian fissure veins are the principal types of ore deposits in the Black Hills and in the Bradshaw Mountains to the southwest. Although most of the important known Precambrian ore deposits are found in a belt extending south and southwest of the Verde district, the geology of the wilderness is permissive for the occurrence of such deposits, because Precambrian igneous and metamorphic rocks are exposed in more than 50 percent of the area.

Very few mineral claims have apparently been staked in the wilderness. In 1966, only the Frances Young group of 18 claims were believed to be in the wilderness, but fragmentary and incomplete land records prevented finding their precise location. Since the 1966 survey, additional claims were staked in 1972, 1979, and 1981 according to the USFS, but they have no record or knowledge of any physical exploration on these claims.

Geochemical prospecting, using active-stream sediments and heavy-mineral concentrates, was the principal method employed to evaluate the mineral potential of the area. No anomalies that might be considered indicative of the presence of near-surface metallic mineral deposits were found.

Iron-stained zones, bleached areas, quartz-jasper stringers and veins, minor shear zones, and other miscellaneous types of altered rock are common in the metamorphic rocks of the wilderness. These occurrences were examined, and samples were collected for analyses from many of them. Only insignificant traces of metallic minerals were revealed by the analytical data and field studies. The presence of significant near-surface mineral deposits in the area therefore is considered unlikely.

No nonmetallic or energy resources were identified in the wilderness in the course of this study.

SUGGESTIONS FOR FURTHER STUDIES

Additional studies do not appear warranted at this time. Ore deposits, if present, are probably of the massive sulfide type, and buried deeply beneath the ground surface, beyond the range of the various geochemical and geophysical techniques used in routine exploration. Some of the newer geophysical methods might possibly be capable of detecting such hidden ore bodies if not buried too deeply, but this would require blanketing the entire wilderness with expensive surveys; such techniques are usually used in limited areas where it is possible to define restricted target areas by other means, for example geochemical surveys, and such target areas were not defined by the 1966 study. Future development of a geochemical method that could detect mineralization beneath a cover of younger barren rocks would, of course, be ample justification for conducting such a survey in the wilderness, especially the western part (Prescott National Forest section) where the Precambrian rocks are nearly everywhere covered by much younger sedimentary and volcanic rocks.

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PUSCH RIDGE WILDERNESS, ARIZONA

By MARGARET E. HINKLE, U.S. GEOLOGICAL SURVEY, and

GEORGE S. RYAN, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey in 1979 by the USGS and USBM, the Pusch Ridge Wilderness, located at the northern boundary of the city of Tucson, Arizona, offers little or no promise for the occurrence of energy resources. Only one area contains a probable potential for small, isolated contact-metamorphic deposits containing copper, molybdenum, tungsten, lead, and zinc. This area is located around the southwestern end of Pusch Ridge, adjacent to a residential area.

CHARACTER AND SETTING

The Pusch Ridge Wilderness covers approximately 88 sq mi of the Coronado National Forest on the southwest side of the Santa Catalina Mountains in Pima County, Arizona. The wilderness abuts the northern edge of the city of Tucson, about 8 mi from the center of Tucson. Other borders of the wilderness are, roughly, the Cañada del Oro and U.S. Highway 89 to the west, Cargodera Canyon to the north, and the Mount Lemmon Highway to the east. Access to the area is easily accomplished except on the north side. The terrain has rugged, steep canyons, sharp ridges, and pinnacle-type peaks. Altitudes range from about 2800 ft at the valley floor in the Sonoran desert environment, to 9160 ft in the coniferous forest environment at the summit of Mount Lemmon.

A mineral survey was made of the Pusch Ridge Wilderness in the fall of 1979 and the area was evaluated for its mineral potential by analysis of geochemical samples by the USGS, and by examination of mines, prospects, and mineralized areas by the USBM. The results were published in 1982 (Hinkle and Ryan, 1982).

The Pusch Ridge Wilderness is located in the southern Basin and Range province of the Western United States, where subparallel mountain ranges are separated by broad alluvial valleys. The Santa Catalina Mountains are part of a zone of metamorphic rocks that form mountain ranges in Arizona extending from the Rincon Mountains northwest through the Santa Catalina Mountains to the Picacho Mountains.

The part of the zone of metamorphic rocks in which the Pusch Ridge Wilderness is located consists primarily of a Tertiary granitic and Proterozoic gneissic complex that is locally deformed and intruded by pegmatitic dikes and sills. Although identification of some of the rock units within the complex and opinions concerning the ages and origins of these similar appearing rocks have been and remain controversial, the rocks within the wilderness were apparently originally made up of Tertiary age granitic rocks that were intruded into Proterozoic granites (Banks, 1980; Keith and others, 1980). Both rock types have been widely converted to gneisses whose foliation forms a broad arch trending westerly across the wilderness. This part of the mountain range is bounded on the south by the Catalina fault zone, which juxtaposes gneissic rocks with middle Tertiary sedimentary rocks that lie just south of the wilderness.

The old Pontatoc mine is located in this fault zone just outside of the wilderness boundary. The Pontatoc mine contained copper mineralization, minor molybdenite, and trace amounts of silver. The mine has not operated since 1918 and the workings are now within a residential area. Additional scattered old prospect pits and adits occur within the Catalina fault zone; all of these small faults and fractures which have been explored contained localized concentrations of copper and associated metals.

Along the western border of the Santa Catalina Mountains the Pirate fault has juxtaposed Pliocene and Miocene(?) gravel and conglomerate against the Tertiary granitic and Proterozoic gneissic complex. The Pirate fault has a large displacement. Many fractures parallel the Pirate fault in the adjacent rocks of the complex. The fractures acted as localizing channels for pods and lenses of pegmatite rocks which intruded the granitic and gneissic rocks. An area of fractured and cemented rocks exists where the Pirate fault crosses

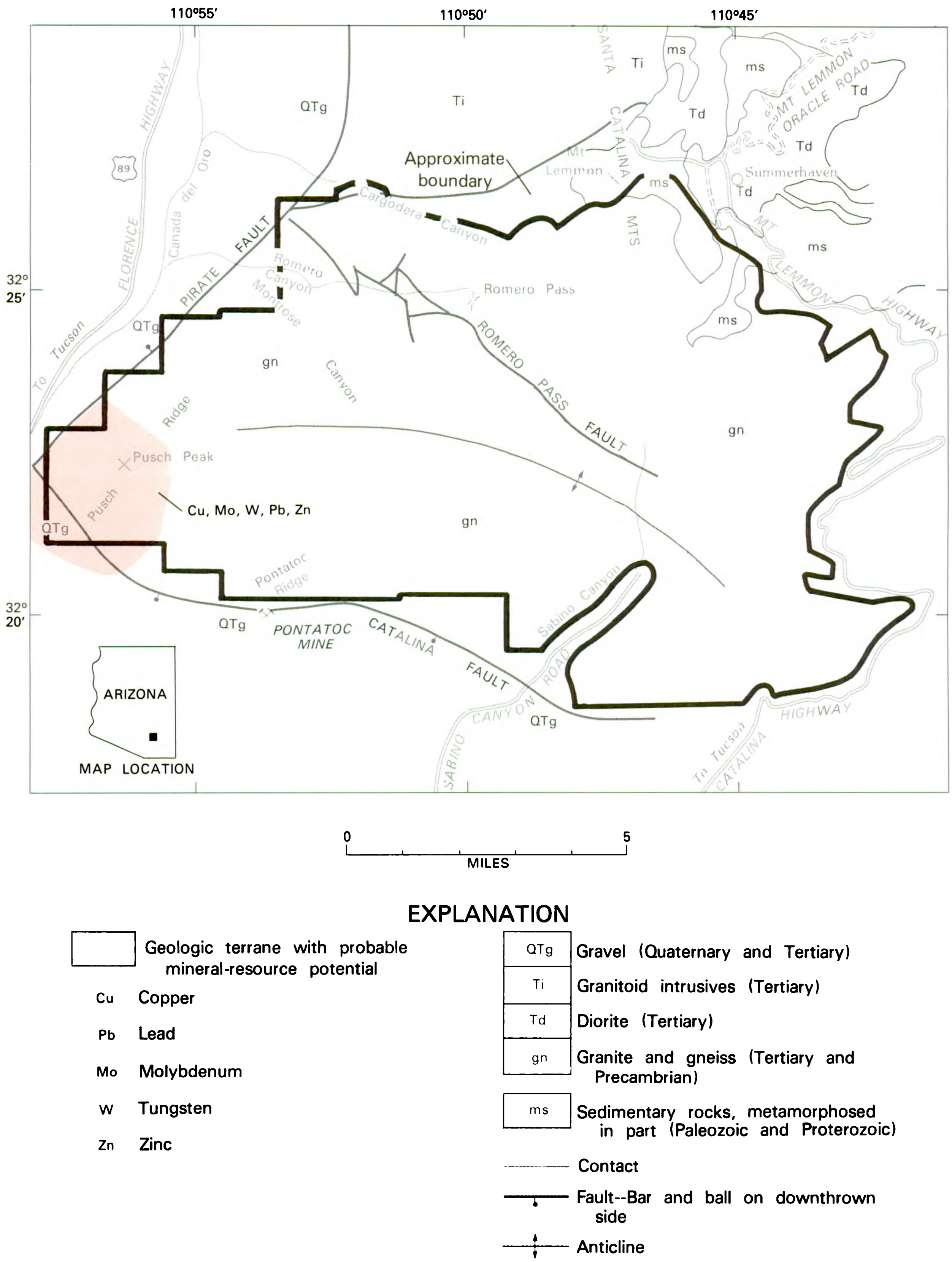

Figure 26.—Pusch Ridge Wilderness, Arizona.

Cargodera Canyon, and the granitic and gneissic rocks contain abundant inclusions of metamorphosed sedimentary rocks; a few old prospects occur in this area.

The Romero Pass fault is a zone of fractured igneous rocks with intrusions of pegmatitic rocks that extends from Romero Pass westward approximately N. 60° W. and intersects the Pirate fault. A large mass of fractured and cemented rock occurs in the area of intersection. The eastward extension of the Romero Pass fault zone coincides with the series of valleys and streams extending southeast. Although a few outcroppings of copper-stained quartz and other rocks occur within the Romero Pass fault zone, no prospect pits were seen.

MINERAL RESOURCES

Although located within a highly mineralized region of Arizona, the Pusch Ridge Wilderness has very little history of mineral activity and no mineral production. The Pontatoc mine, just south of the wilderness yielded a small production of copper from the Catalina fault zone; the Oracle Ridge mining district (Old Hat district) about 3 mi northeast of the wilderness yielded a moderate copper production from Paleozoic carbonate rocks in contact with intrusive diorite. Though related metamorphosed carbonate rocks occur to a minor extent in the northeast part of the wilderness, the mineralizing diorite is missing. The central part of the wilderness seems characterized by barren gneissic granites; the periphery, chiefly along the Catalina and Pirate fault zones, has scattered claims and prospects. Most of the prospecting activity within the wilderness has been along and near these fault zones in veins stained with secondary copper or in pegmatite dikes, or in fractured areas that appeared to be favorable to mineral concentration. No resultant mineral production has come from these prospecting activities. Other than the aforementioned occurrences, the Pusch Ridge Wilderness apparently lacks appropriate geologic environments favorable for the occurrence of mineral resources.

Nevertheless, the geochemical survey of the USGS and assays of samples from prospects by the USBM indicate that the Pusch Ridge Wilderness has anomalously high concentrations of copper, lead, zinc, tin, tungsten, and molybdenum in four broad geographic areas: (1) south and southeast of the Mount Lemmon Highway, primarily between the Palisade Ranger Station and Molino Basin, (2) along most of the length of the Pirate fault on the west side of the wilderness, and adjacent areas east of the fault, (3) scattered sites along the Catalina fault on the south side of the wilderness, and (4) at the intersection of the Pirate and Catalina faults at the southwestern end of the Pusch Ridge. West of the Mount Lemmon Highway, the anomalous metal values were not considered as indicating a resource potential as they could be the result of contamination by ore minerals washed down the drainages from isolated, small, mineral deposits east of the wilderness. Along the Pirate and Catalina faults there is little promise for the occurrence of mineral resources because the distribution of samples containing anomalous metal concentrations was discontinuous and erratic. The area near the intersection of the Pirate and Catalina faults, both of which have scattered areas that contain anomalously high amounts of metals and mineralized prospects, was determined to have probable mineral-resource potential. If mineral deposits exist in this area, they are probably small, discontinuous fracture-controlled deposits with copper, molybdenum, tungsten, lead, and zinc minerals.

No additional areas with promise for mineral resources were found during the USGS-USBM investigation of the Pusch Ridge Wilderness. No evidence for energy resources was identified in the course of this study.

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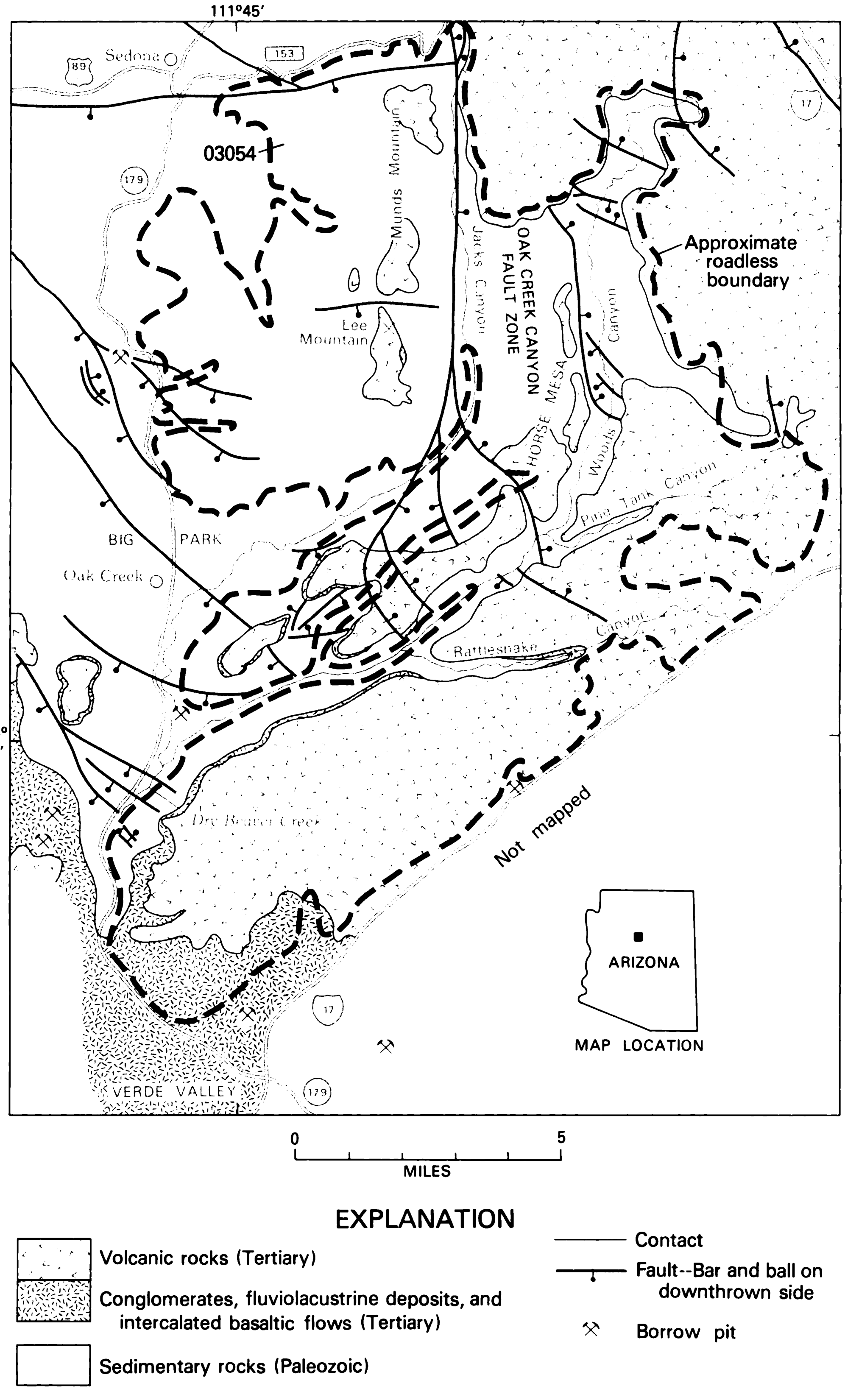

Figure 27.—Rattlesnake Roadless Area, Arizona.

RATTLESNAKE ROADLESS AREA, ARIZONA

By THOR N. V. KARLSTROM,[1] U.S. GEOLOGICAL SURVEY, and

ROBERT MCCOLLY, U.S. BUREAU OF MINES

SUMMARY

There is little promise for the occurrence of mineral or energy resources in the Rattlesnake Roadless Area, Arizona, as judged from field studies by the USGS and USBM in 1982. Significant concentrations of minerals within the roadless area are not indicated by geologic mapping, geochemical sampling, or aeromagnetic studies. Basalt, volcanic cinders, sand and gravel, and sandstone that may be suitable for construction materials occur in the area, but are more readily accessible outside the roadless area boundary.

CHARACTER AND SETTING

The Rattlesnake Roadless Area is an area of about 110 sq mi located in Yavapai and Coconino Counties, central Arizona. Sedona and Oak Creek, the nearest population centers, are located, respectively, at the northwest corner and along the western margin of the roadless area.

The roadless area boundary mainly follows the rims of steep-walled canyons cut into the Mogollon Rim of the Colorado Plateaus by Dry Beaver Creek and its main tributaries in Jacks, Pine Tank, and Rattlesnake Canyons. The area is skirted by Interstate Highway 17 to the east and southeast, by State Highway 179 to the southwest and west, and by Schnebly Hill Road (USFS road 153) to the north. The canyon mouths mark the edge of the Mogollon Rim where its gently westward dipping surface falls off abruptly to the Verde Valley, a structural basin in the Arizona transition zone floored with a thick sequence of deeply dissected lake deposits. The maximum altitude in the roadless area is 6834 ft on the eroded plateau surface; the lowest altitude, 3480 ft, is on Dry Beaver Creek where it flows into Verde Valley.

The canyon walls in the area expose multicolored sedimentary rocks of Pennsylvanian to Early Permian age as much as 2500 ft thick, unconformably overlain by basaltic rocks and associated gravels and fluviolacustrine deposits of Tertiary age as much as 500 ft thick. The exposed Paleozoic rocks include (from bottom to top): distinctive reddish siltstone and sandstone of the lower, middle, and upper units of the Supai Formation (525 ft), including in the upper unit the gray to greenish-gray limestone of the Fort Apache Limestone(?) Member of the Supai Formation (about 25 ft); a transition zone of alternating red and gray siltstone and sandstone (550 ft); the grayish thick-bedded, primarily eolian crossbedded sandstone of the Coconino Formation (600 ft); the grayish thin- to medium-bedded sandstone of the Toroweap Formation (350 ft); and erosional remnants of the lower part of the grayish to buff limestone and dolomite of the Kaibab Formation (less than 300 ft). Subsurface data indicate that the exposed sedimentary rocks are underlain by Cambrian to Pennsylvanian sandstone, siltstone, and limestone more than 1000 ft thick that lie unconformably above metamorphosed and intruded basement rocks of Precambrian age (Earl Huggins, oral. commun., 1983).

The volcanic rocks mantling the Plateau surface are mainly alkali olivine basalt flows that locally overlie Tertiary gravels and that were fed by dikes or plugs which cut underlying rocks as young as late Tertiary in age. Radiometric dating of basaltic flows in the region (Damon and others, 1974; Peirce and others, 1979) indicates that volcanic activity was concentrated mainly in Miocene and Pliocene time. The volcanic rocks directly overlie either eroded Paleozoic strata or Tertiary conglomerates. At lower altitudes, interbedded conglomerates and lacustrine deposits are intercalated with basalt flows that record late volcanic eruptions contemporaneous with marginal lacustrine deposition in Lake Verde during Pliocene time (Nations and others, 1981). Within the roadless area, Lake Verde at its maximum extent rose to about the present 5000 ft level.

[1]With contributions from George H. Billingsley, USGS.

During dissection after the lake retreated, a series of Quaternary fluvial gravels were deposited in the roadless area. Locally, as many as five aggradational epicycles are recorded by terrace gravels and alluvial fans that graded to successively higher levels above present stream grade.

The nearly flat lying Paleozoic and Cenozoic rocks in the roadless area are cut by a system of near-vertical curving normal faults that trend northwest, north-south, and east-west. Traced southward through the area, the northwest-trending and north-south-trending faults tend to decrease in displacement and to split into a series of curving faults that define both horsts and grabens. This progressive decrease in displacement and bifurcation into secondary faults suggest that the roadless area lies near the margin of a structural subprovince. Downward displacements on bounding faults have occurred around the Munds Mountain-Lee Mountain upland. A magnetic high coincides with the differentially elevated crustal block, which indicates that the block is probably intruded at depth by an igneous body of high magnetic susceptibility (Martin, 1983). Faulted basalt flows on Horse Mesa, which have a potassium-argon age of 6.4 million years (Peirce and others, 1979), suggest latest fault movement along the north-south-trending Oak Creek Canyon fault zone in late Miocene or later time.

MINERAL RESOURCES

Based on geologic mapping, geochemical sampling and analysis (Gerstel and others, 1983), aeromagnetic data (Martin, 1983), and a review of County and Federal land records, the roadless area is evaluated as having little promise for the occurrence of mineral-resource potential. Significant mineral concentrations were not observed nor previously reported from the roadless area. Field observations and geochemical sampling along steep-dipping faults and intrusive contacts, and the available subsurface information do not suggest extensive mineralization at depth. Concentrations of heavy minerals that would suggest potential placer deposits or buried upstream source bodies were not detected in outcrop nor indicated by geochemical sampling of the fluvial and fluviolacustrine deposits in the roadless area. The basaltic flows, cinders, and sand and gravel can be used for road metal, concrete aggregate, riprap, or cinder block, and some of the sandstone exposed in canyon walls might provide usable building stone and flagstone. Similar construction materials, however, are more readily accessible and closer to markets outside the roadless area boundaries.

SUGGESTIONS FOR FURTHER STUDIES

Further mapping and sampling in the roadless area offer little promise for establishing any significant mineral-resource potential.

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RINCON WILDERNESS STUDY AREA, ARIZONA

By CHARLES H. THORMAN, U.S. GEOLOGICAL SURVEY, and

MICHAEL E. LANE, U.S. BUREAU OF MINES

SUMMARY

On the basis of geologic and geochemical investigations by the USGS and examination of mineralized prospects by the USBM, in 1977, the Rincon Wilderness Study Area has little promise for the occurrence of mineral or energy resources. A few prospects and small exploratory mines in four widely separated areas exist, but no record of mineral production was found. Geochemical anomalies in these four areas are weak and no resource potential was identified.

CHARACTER AND SETTING

The Rincon Wilderness Study Area includes about 98 sq mi of the Coronado National Forest in the Rincon Mountains east of Tucson, Arizona. The area is horseshoe-shaped, encompassing the Saguaro National Monument on its north, east, and south sides. Mica Mountain (8666 ft) and Rincon Peak (8482 ft), the highest peaks in the Rincon Mountains, are about 1 mi inside the Monument. Much of the study area lies on the rugged flanks of the mountains, but it extends to less rugged terrain to the south, along Happy valley to the east, and into the Redington Pass area, the broad saddle between the Rincon and Santa Catalina Mountains to the north. The Rincon Mountains lie within the Basin and Range province, about 100 mi south of the Colorado Plateau province. North- to northwest-trending mountains and valleys typify this part of the Basin and Range province.

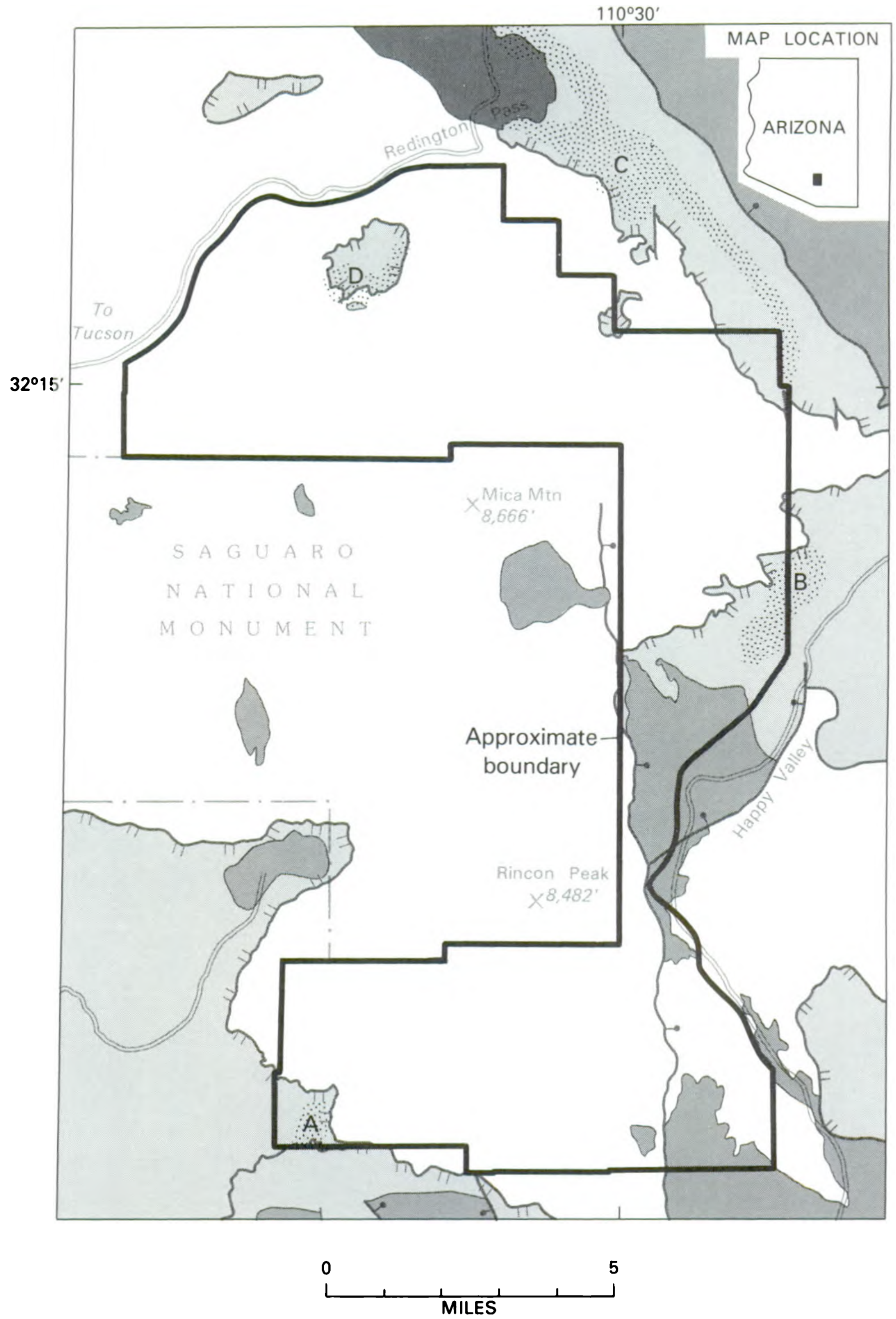
The geology of the Rincon Mountains is complex. Rocks range in age from about 1.8 billion years old (Precambrian) to about 0.5 million years old (Cenozoic). The core of the Rincon Mountains, which includes most of the Saguaro National Monument as well as parts of the wilderness study area, is underlain by igneous and metamorphic rocks chiefly of Precambrian and Tertiary ages, hereafter referred to as the core rocks. Most of the study area, which flanks the mountains, is underlain by a terrain of sedimentary, metamorphic, and igenous rocks of Precambrian through mid-Tertiary age, hereafter referred to as the cover rocks. Separating the cover and core rocks is the Santa Catalina fault which dips gently away from the center of the mountains. Development of the Santa Catalina fault is interpreted to have begun in late Mesozoic-early Tertiary time when the cover rocks were pushed northeastward over the core rocks.

In mid-Tertiary time, the present form of the Rincon Mountains was attained as the result of doming of the core area. This caused the cover rocks to slide off the high part of the dome reactivating the Santa Catalina fault, an already established zone of weakness. Subsequent erosion has left the cover rocks exposed primarily on the flanks of the mountains. The cover rocks are cut by many low- and high-angle faults due to the two periods of deformation, late Mesozoic-early Tertiary and mid-Tertiary. Mountain ranges in the southwestern United States having many of the same geologic features as the Rincon Mountains are generally referred to as metamorphic core complexes.

Valley-fill gravel deposits were deposited in the basin areas surrounding the Rincon Mountains uplift from about 15 million years ago until the present. Locally these valley deposits are faulted against the cover rocks, along high-angle faults.

MINERAL RESOURCES

There is little promise for the occurrence of mineral or energy resources in the Rincon Wilderness Study Area. Geochemical investigations during the study included the collecting and analyses of stream-sediment and rock samples. Anomalous amounts of beryllium, copper, manganese, molybdenum, lead, and silver were detected in some stream-sediment samples, but because most of these samples are interspersed with samples containing only background values they are not considered indicative of significant mineralization. In four small areas, however, samples containing anomalous values



EXPLANATION

Core unit of metamorphic and intrusive granitic rocks

Cover unit of sedimentary, igneous, and metamorphic rocks

Valley-fill gravel deposit

Pluton Youtcy Ranch (Tertiary)

A Mineralized areas discussed in text

Contact

Fault--Bar and ball on downthrown side

Santa Catalina Fault

Figure 28.—Rincon Wilderness Study Area, Arizona.

are clustered. Analyses of rock samples confirmed that the sources for the anomalous metal values were weakly mineralized zones that had already been examined by prospectors, as evidenced by numerous small diggings (areas A-D, on map). In each instance the mineralized rocks occur along or very near to the Santa Catalina fault or one of the smaller faults related to it. As a result of this study it was concluded that the anomalous geochemical samples are not considered as indicating mineral-resource potential.

Mountain ranges in the southwestern United States referred to as metamorphic core complexes, such as the Rincon Mountains, differ geologically from areas known to contain mining districts. No metamorphic core complexes are known to have large metallic ore deposits.

The known areas of anomalous concentrations of metals in the Rincon Mountains are small and the concentration of metals weak and erratic. The surface signs of mineralization are largley restricted to four locales in which some prospects exist: east of Colossal Cave, southwest of the Rincon Mountains (area A); north of Happy Valley, east of the mountains (area B); between Roble and Youtcy Canyons, northeast of the mountains (area C); and near Italian Trap, north of the mountains (area D). Very little primary sulfide mineralization is present, and signs of alteration are restricted to narrow zones along faults and fractures. The geochemical anomalies are weak; sites at which anomalous values of copper, molybdenum, or silver were obtained are mainly controlled by faults.

Nonmetallic mineral resources occur in deposits that are small and remote. Sand and gravel deposits in the main drainages are similar to larger deposits that occur closer to nearby highways and cities. Limestone and marble present in some of the metamorphic rocks are too impure and too broken for use as dimension stone. Use of this marble as decorative rock is limited by the distance to available markets. Limestone suitable for making cement is not likely to be found in large quantities within the Rincon Wilderness Study Area. Closely spaced fractures in the granitic rocks make them of little value for building stone.

The likelihood for occurrences of energy resources in the study area is remote. The abundant granitic rocks of the core area and the intense faulting of the cover rocks leave the study area with a completely unfavorable situation for oil and gas accumulations, and a history of later thermal activity in the study area further reduces the chances for the preservation of such accumulations. The kinds of rocks in which coal deposits could occur are not known in the Rincon Mountains. Although uranium mineralization occurs 1–2 mi northeast of the study area, such mineralization is unlikely within the study area. Known deposits occur along or close to low-angle faults that strike and dip away from the study area. No geothermal potential was identified in the study area and no hot springs or evidence of ancient hot springs occur in the Rincon Mountains. The youngest volcanic rocks are too old to be viewed as signs of available heat at shallow depths.

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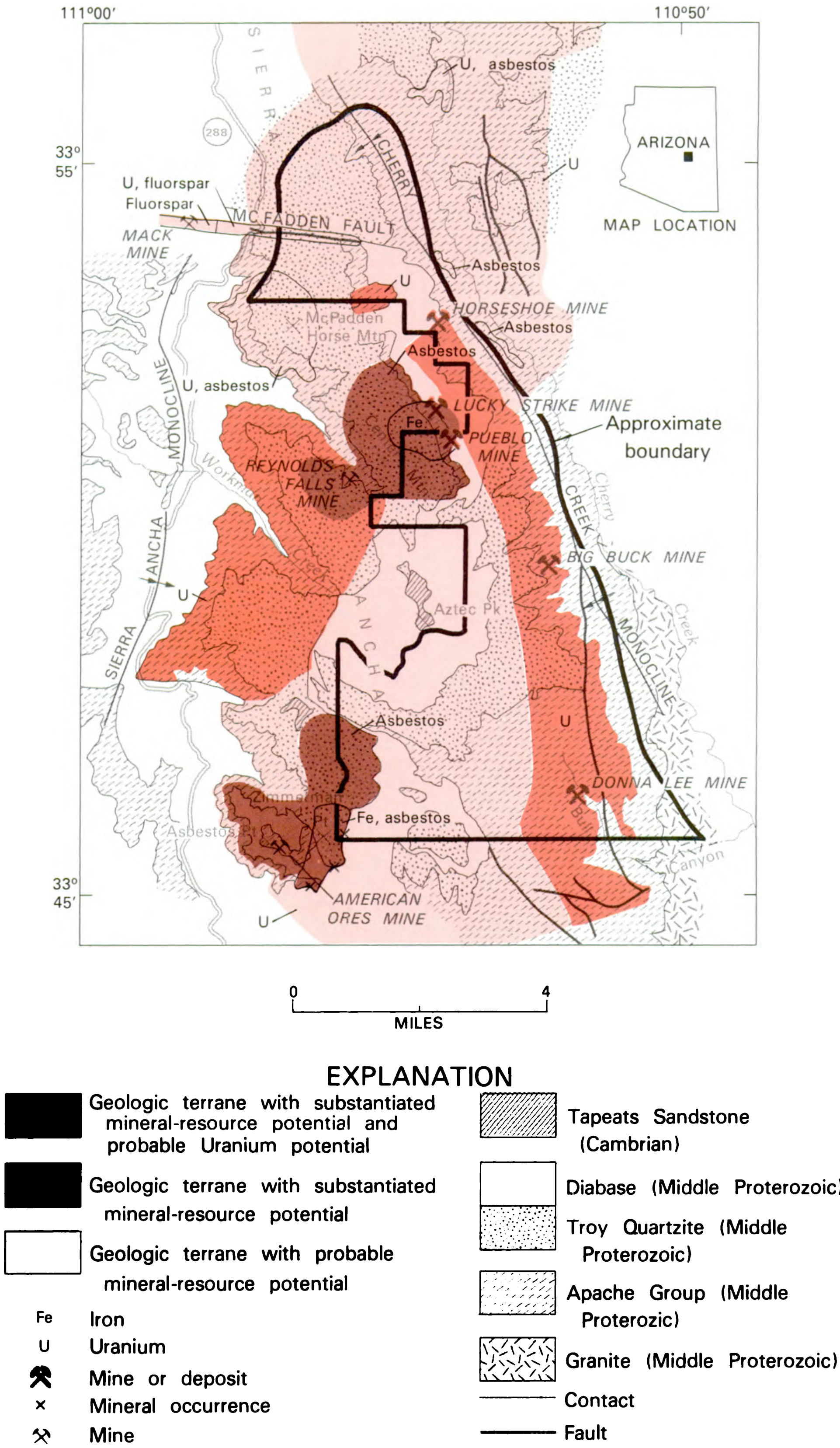

Figure 29.—Sierra Ancha Wilderness, Arizona.

SIERRA ANCHA WILDERNESS, ARIZONA

By CHESTER T. WRUCKE,[1] U.S. GEOLOGICAL SURVEY, and

THOMAS D. LIGHT, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys conducted in 1978 show that the Sierra Ancha Wilderness has demonstrated resources of uranium, asbestos, and iron; probable and substantiated resource potential for uranium, asbestos, and iron; and a probable resource potential for fluorspar. Uranium resources occur in vein and strata-bound deposits in siltstone that underlies much of the wilderness. Deposits of long-staple chrysotile asbestos are likely in parts of the wilderness adjacent to known areas of asbestos production. Magnetite deposits in the wilderness form a small iron resource. A fluorite resource may exist in the northern part of the wilderness east of a notable flourite deposit that is located in a comparable geologic setting 1.4 mi west of the wilderness boundary. No fossil fuel resources were identified in this study.

CHARACTER AND SETTING

The Sierra Ancha Wilderness occupies an area of about 33 sq mi in the mountain region of central Arizona, about 75 mi northeast of Phoenix. The wilderness is located in the Sierra Ancha, a northerly trending mountain range that has a flat-topped crest along much of its length, and cliffs, steep slopes, and broad benches on its flanks. Higher parts of the range are thickly forested and rise to altitudes of 7000 to 7700 ft above the deeply dissected regions to the east and west. Most of the wilderness is situated on the eastern side of the Sierra Ancha, where the range descends precipitously to altitudes of 3000 to 4000 ft along Cherry Creek, located immediately east of the wilderness boundary. State Highway 288 traverses the Sierra Ancha region from the north and south, 0.2 to 3 mi west of the wilderness.

The wilderness and surrounding areas are underlain principally by a layered sequence of sedimentary and igneous rocks of Middle Proterozoic age (Bergquist and others, 1981). These rocks rest unconformably on Middle Proterozoic granites that form the basement throughout most of the region. The oldest of the Middle Proterozoic stratified sequences is the Apache Group, about 1300 ft in thickness, which comprises in ascending order the Pioneer Formation, the Dripping Spring Quartzite, the Mescal Limestone, and an unnamed basalt. The Troy Quartzite, which is the youngest Proterozoic sedimentary formation, rests unconformably on the Apache Group and is about 1000 ft thick.

Diabase, 1150 million years old, intruded the Apache Group and the Troy Quartzite mostly as sills. Dikes are numerous but insignificant in volume. Sills are individually as thick as 1200 ft and aggregate about half the volume of the host strata. Where diabase was emplaced in the Mescal, the original dolomite of the formation was converted almost completely to limestone. In the noncarbonate formations, a narrow selvage of hornfels was commonly formed adjacent to thick sills.

The Tapeats Sandstone of Cambrian age occurs as erosional remnants on the Proterozoic rocks at two localities on the crest of the Sierra Ancha. The sandstone is the youngest geologic unit in the vicinity of the wilderness, other than Cenozoic gravels and a few Quaternary landslide deposits.

The subhorizontal attitude of most strata in the wilderness reflects the location of the Sierra Ancha in the Colorado Plateau structural province. However, the stratified rocks locally record significant disruption, largely from the effects of inflation by the diabase and the uplift of some blocks more than others. The Cherry Creek monocline east of the wilderness and the Sierra Ancha monocline to the west represent deformation

[1]With contributions from James K. Otton, Andrew F. Shride, Joel R. Bergquist, Paul K. Theobald, James S. Duval, and Dolores M. Kulik (Wilson), USGS.

before and during emplacement of the diabase. Additional displacements occurred along a few faults during Cenozoic time.

MINERAL RESOURCES

The Sierra Ancha Wilderness contains resources of uranium, asbestos, iron, and possibly fluorspar. Field studies in the wilderness were conducted by the USBM and the USGS in 1978 (Otton and others, 1981).

Uranium was discovered in the Sierra Ancha region in 1950, and in the period 1953–60 a total of 2185 tons of ore averaging 0.24 percent U_3O_8 was produced from 14 mines. Most of the production was from the Red Bluff area, 2.5 mi southwest of the wilderness (outside of the area studied), and from the Workman Creek area west of the wilderness. Three uranium mines, the Big Buck, Donna Lee, and Horseshoe, have had production and are located in the wilderness; they accounted for 291 tons of ore averaging 0.14 percent U_3O_8. As of 1979, exploration was being continued in several localities.

Uranium deposits in the Sierra Ancha region occur in carbonaceous siltstone in the upper member of the Dripping Spring Quartzite. This rock underlies nearly all of the wilderness. Most of the uranium occurs as uraninite in near-vertical veins and disseminated along favorable stratigraphic zones laterally adjacent to the veins. The most extensive uranium deposits overlie diabase sills or are located near major dikes of diabase.

Most of the wilderness has resource potential for uranium, and several areas in or adjacent to the wilderness have demonstrated uranium resources in areas of substantiated resource potential. Demonstrated resources with an average grade of 0.05–0.1 percent U_3O_8 include 4 to 8 million lbs U_3O_8 along both sides of Workman Creek within 2.5 mi of the wilderness, 2 to 6 million lbs U_3O_8 at the Donna Lee mine along Bull Canyon inside the wilderness, and 1 to 5 million lbs U_3O_8 at the Big Buck mine in the wilderness about 2.5 mi east-northeast of Aztec Peak. Areas underlain by the Dripping Spring Quartzite contiguous to these localities, and the area centered about 1.5 mi east-northeast of McFadden Horse Mountain, have substantiated uranium resource potential. Uranium deposits in these areas probably range in grade from 0.01 to 0.3 percent U_3O_8 and in size from 100,000 to 2.0 million lbs U_3O_8. An area of probable resource potential underlies the central part of the wilderness, where specific geologic sites for uranium are difficult to identify because of the great depth of burial of the Dripping Spring Quartzite.

Asbestos, in the form of long fiber, low-iron chrysotile, has been produced in the Sierra Ancha region since 1913. As much as 50 to 85 percent of the fibers in these deposits are textile length (more than 1/8 in.). The only asbestos production in the wilderness has been from the Pueblo mine, which probably produced several tens of tons of fiber, as did the Lucky Strike just north of the Pueblo mine but outside the wilderness. The Reynolds Falls mine, just west of the wilderness, furnished several hundred tons of asbestos, and a few thousand tons of fiber were produced from the American Ores mine, located 1 mi west of the southwest corner of the wilderness. An area of substantiated asbestos resource potential borders a large-scale discordant diabase-Mescal Limestone contact beneath Center Mountain. If this contact is characterized by numerous steps or other irregularities over broad areas, a few deposits with contents of 200 to 10,000 tons of long-staple asbestos would be likely. If irregularities are widely spaced and of short lateral extent at this or other discordant contacts, many separate occurrences of 10 to 50 tons, and exceptionally as much as 200 tons, can be expected. A number of small areas of probable asbestos resource potential exist in the Sierra Ancha Wilderness, and one area of substantiated resource potential occurs in the area around Asbestos Point.

Iron occurs in a few small deposits in the wilderness and adjacent areas. A magnetite-bearing horizon on the southern and eastern flank of Zimmerman Point has about 15 million tons of demonstrated resources averaging 26.5 percent iron in an area of substantiated iron potential (Cerro de Pasco Corp., written commun., 1979). Magnetite beds at the Pueblo and Lucky Strike asbestos mines have been estimated by Colorado Fuel and Iron, Inc. to contain about 6 million tons of demonstrated resources averaging 40–60 percent iron (B. B. Kyle, oral commun., 1978). Although these deposits and others suggested by magnetic anomalies occur in areas of substantiated iron resource potential, they are regarded as having little promise for the recovery of iron.

Fluorspar mined during the period 1976–78 from the Mack mine on the McFadden fault, about 1.4 mi west of the wilderness, totalled approximately 30,000 tons of ore that averaged between 60 and 90 percent CaF_2. A probable resource potential for fluorspar exists along the McFadden fault in the wilderness. Scattered occurrences of copper and anomalous concentrations of barite, lead, bismuth, tin, tungsten, and molybdenum found in concentrates from stream sediment in the Sierra Ancha are not associated with known resources (Tripp and others, 1980).

Hydrothermal alteration and contact metasomatism associated with the diabase were important in the development of most of the known mineral deposits in the Sierra Ancha. The genetic relationship of diabase and uranium mineralization is suggested by (1) proximity of diabase to uranium deposits, (2) similar ages of uraninite in veins and zircons in diabase, and (3) high temperatures of formation for the deposits. Syngenetic uranium in the carbonaceous siltstone in the upper member of the Dripping Spring Quartzite was mobilized and redeposited in fractures by hydrothermal fluids driven by heat from the diabase. The asbestos deposits formed where the Mescal Limestone was subjected to karstification and silicification prior to deposition of the Troy Quartzite and was subsequently serpentinized by heat and fluids from the diabase. Deposition of asbestos occurred generally within 25 ft above or below a diabase sill in veins developed where small-scale thrust and bedding-plane faults opened near discordant steps as diabase shouldered aside the adjacent sedimentary strata. The relationship of iron deposits to diabase is evident from magnetite stockworks formed by pyrometasomatic replacement of carbonate rock adjacent to sills and by the partial to complete conversion of sedimentary hematite in the Apache Group to magnetite by contact metamorphism during diabase intrusion.

The origin of the fluorspar deposits is uncertain. They occupy the McFadden fault, which formed during emplacement of the diabase.

SUGGESTIONS FOR FURTHER STUDY

The general geology and mineral resources of the Sierra Ancha Wilderness are moderately well known. However, careful investigations of the structural geology and stratigraphy in areas where discordant diabase intrusions transect favorable strata would provide information useful for making projections of possible concealed uranium and asbestos resources, some of which could be substantial. Additional geochemical and geophysical surveys may be helpful in defining the sources of the anomalous concentrations of barite, lead, bismuth, tin, tungsten, and molybdenum observed in the wilderness.

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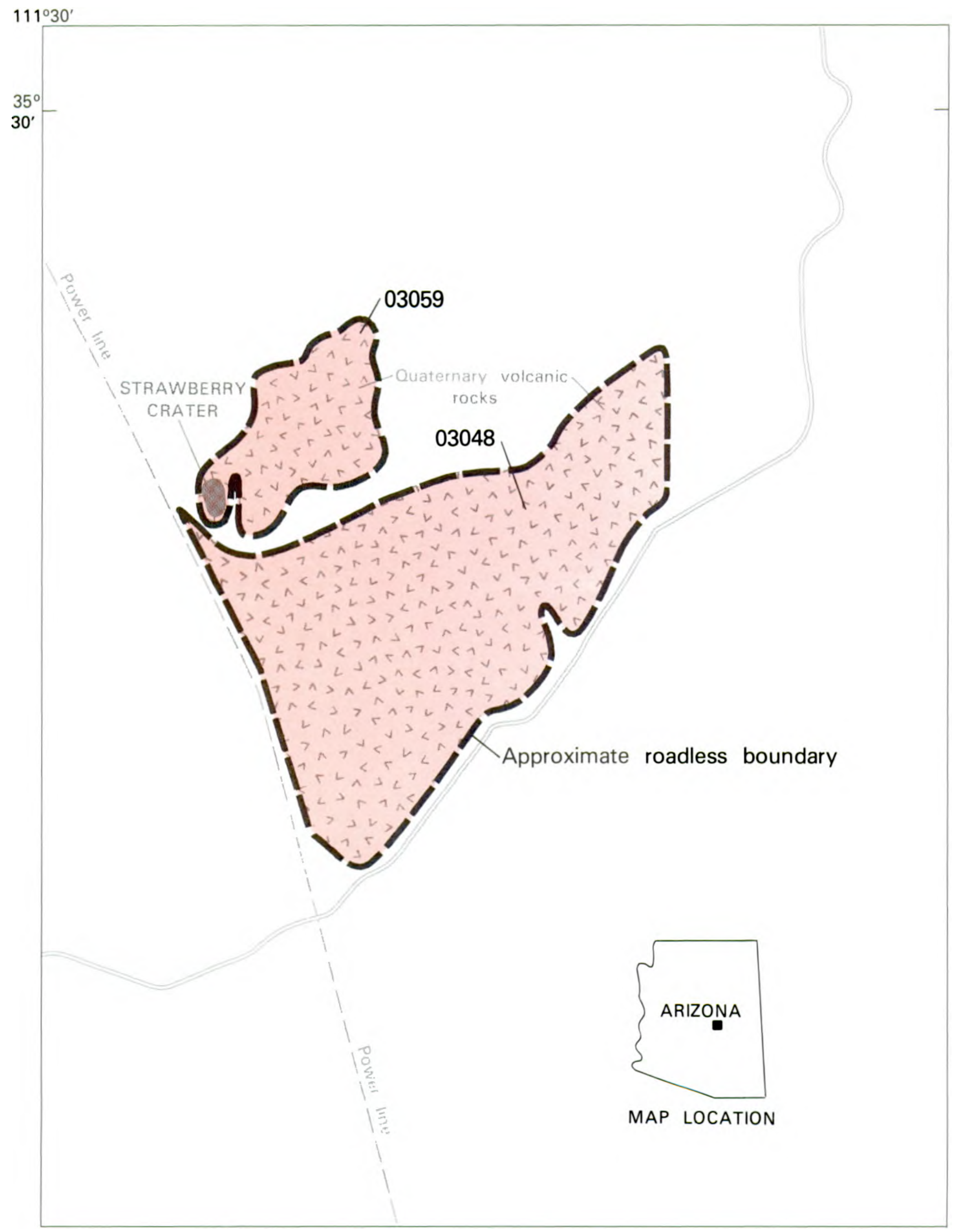

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EXPLANATION

Geologic terrane with probable geothermal resource potential

Figure 30.—Strawberry Crater Roadless Areas, Arizona.

STRAWBERRY CRATER ROADLESS AREAS, ARIZONA

By EDWARD W. WOLFE, U.S. GEOLOGICAL SURVEY, and

THOMAS D. LIGHT, U.S. BUREAU OF MINES

SUMMARY

The results of a mineral survey conducted in 1980 in the Strawberry Crater Roadless Areas, Arizona, indicate little promise for the occurrence of metallic mineral or fossil fuel resources in the area. The area contains deposits of cinder, useful for the production of aggregate block, and for deposits of decorative stone; however, similar deposits occur in great abundance throughout the San Francisco volcanic field outside the roadless areas. There is a possibility that the Strawberry Crater Roadless Areas may overlie part of a crustal magma chamber or still warm pluton related to the San Francisco Mountain stratovolcano or to basaltic vents of late Pleistocene or Holocene age. Such a magma chamber or pluton beneath the Strawberry Crater Roadless Areas might be an energy source from which a hot-, dry-rock geothermal energy system could be developed, and a probable geothermal resource potential is therefore assigned to these areas.

CHARACTER AND SETTING

The Strawberry Crater Roadless Areas are located in Coconino County, Arizona, approximately 20 mi northeast of Flagstaff, Arizona. Together the two roadless areas encompass 15.5 sq mi in the northeastern portion of the Coconino National Forest. The Strawberry Crater Roadless Areas are accessible from U.S. Highway 89 by several interconnecting USFS roads.

The eastern San Francisco volcanic field was previously studied by Moore and Wolfe (1976). The area, in the southern part of the Colorado Plateau, is underlain by largely basaltic Quaternary lavas and cinder cones that overlie nearly horizontal Permian Kaibab Limestone or Triassic siltstone or sandstone of the Moenkopi Formation. Holocene basaltic cinders from the eruption of Sunset Crater mantle much of the area. Locally, basaltic ash has been reworked to form small dunes. Tree-ring dating (Smiley, 1958) indicates that the lavas and cinders of the Sunset Crater eruptions are less than 1000 years old.

The Strawberry Crater flow consists of blocky basaltic andesite dated at less than 100,000 years old (Damon and others, 1974). The cone, built largely of agglutinated basaltic andesite spatter, was breached by the flow. Subsequently a small dacite vitrophyre plug was emplaced within the breached cone. In addition to resting on older Quaternary basalt, Strawberry Crater and its lava flow overlie the east edge of the rhyodacite of Deadman Mesa, which erupted from the O'Leary Peak silicic center and has been dated at about 0.17 m.y. (million years) old (P. E. Damon and M. Shafiqullah, unpub. data, 1980).

There has been no mining in the Strawberry Crater Roadless Areas, and exploration and mining activity in the general vicinity of Strawberry Crater have been limited to cinder and pozzolan deposits. Cinder deposits within 5 mi of the roadless areas were being mined in 1980. No other commodities are known to occur in the areas.

MINERAL RESOURCES

All rocks exposed in the Strawberry Crater Roadless Areas are relatively unaltered; there is no evidence of mineralization. Semiquantitative spectrographic analyses of samples of flow and pyroclastic units give values appropriate for unaltered basaltic rocks (Wolfe and Hahn, 1982) and show no indication of concealed metallic mineral resources.

The Strawberry Crater Roadless Areas contain deposits of cinder suitable for the production of aggregate block and deposits of decorative stone; similar deposits occur in great abundance throughout the San Francisco volcanic field outside the roadless areas.

The Strawberry Crater Roadless Areas are within a region of the San Franciso volcanic field that has probable resource potential for geothermal energy. The youngest volcanic vents of the San Francisco field are in the general vicinity of Strawberry Crater. These include Sunset Crater, which is less than 1000 years old, the rhyolite of Sugarloaf (K-Ar age is approximately 0.22 m.y.), and the dacitic to rhyolitic O'Leary Peak center (K-Ar ages of approximately 0.17 and 0.24 m.y.) (K-Ar ages from Damon and others, 1974, and P. E. Damon and M. Shatiqullah, unpub. data, 1980). Strawberry Crater itself erupted less than 0.1 m.y. ago (Damon and others, 1974). Strawberry Crater, O'Leary Peak, Sugarloaf, and the exposed conduit system for the San Francisco Mountain stratovolcano, which erupted largely between 1.0 and 0.4 m.y. ago, form an alinement that coincides closely with a distinct linear aeromagnetic low (Sauck and Sumner, 1970); a common volcano-tectonic control for these vents is suggested (Wolfe and Hoover, 1982). If an intrusive complex related to these alined vents and to the coincident aeromagnetic low contains residual magmatic heat or is partly molten, it may comprise a potential source of geothermal energy. Stauber (1982) suggested that one of several possible explanations for low compressional wave velocity approximately 6.5 to 22 mi below San Francisco Mountain would be the presence of partly molten rock. In addition, magnetotelluric soundings show local anomalously low resistivities at depth near Sunset and Strawberry Craters (Ware and O'Donnell, 1980). Possibly these anomalies reflect locally high lower crustal temperatures.

SUGGESTIONS FOR FURTHER STUDIES

Additional geophysical studies to elucidate the electrical and magnetic characteristics of the crust beneath the eastern part of the San Francisco volcanic field would contribute to evaluation of geothermal resources. The most definitive information, however, will be obtained only when and if holes suitable for heat-flow studies are drilled into the Precambrian basement.

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SUPERSTITION WILDERNESS, ARIZONA

By DONALD W. PETERSON,[1] U.S. GEOLOGICAL SURVEY, and

JIMMIE E. JINKS, U.S. BUREAU OF MINES

SUMMARY

On the basis of geologic studies and mineral evaluations made between 1973 and 1977, most of the Superstition Wilderness and adjoining areas are judged to have little promise for occurrence of mineral resources. However, two areas in an east-trending zone near the southern margin of the area, marked by spotty occurrences of mineralized rock, prospect pits, and a band of geochemical anomalies that coincides with alined magnetic anomalies, are considered to have probable mineral-resource potential. This zone lies within about 6 mi of two productive mines in Arizona's great copper belt, and the trend of the zone is parallel to many of the significant mineralized structures of this belt. A small isolated uranium anomaly was found in the northeastern part of the wilderness, but no evidence of other energy resources, such as petroleum, coal, or geothermal, was found.

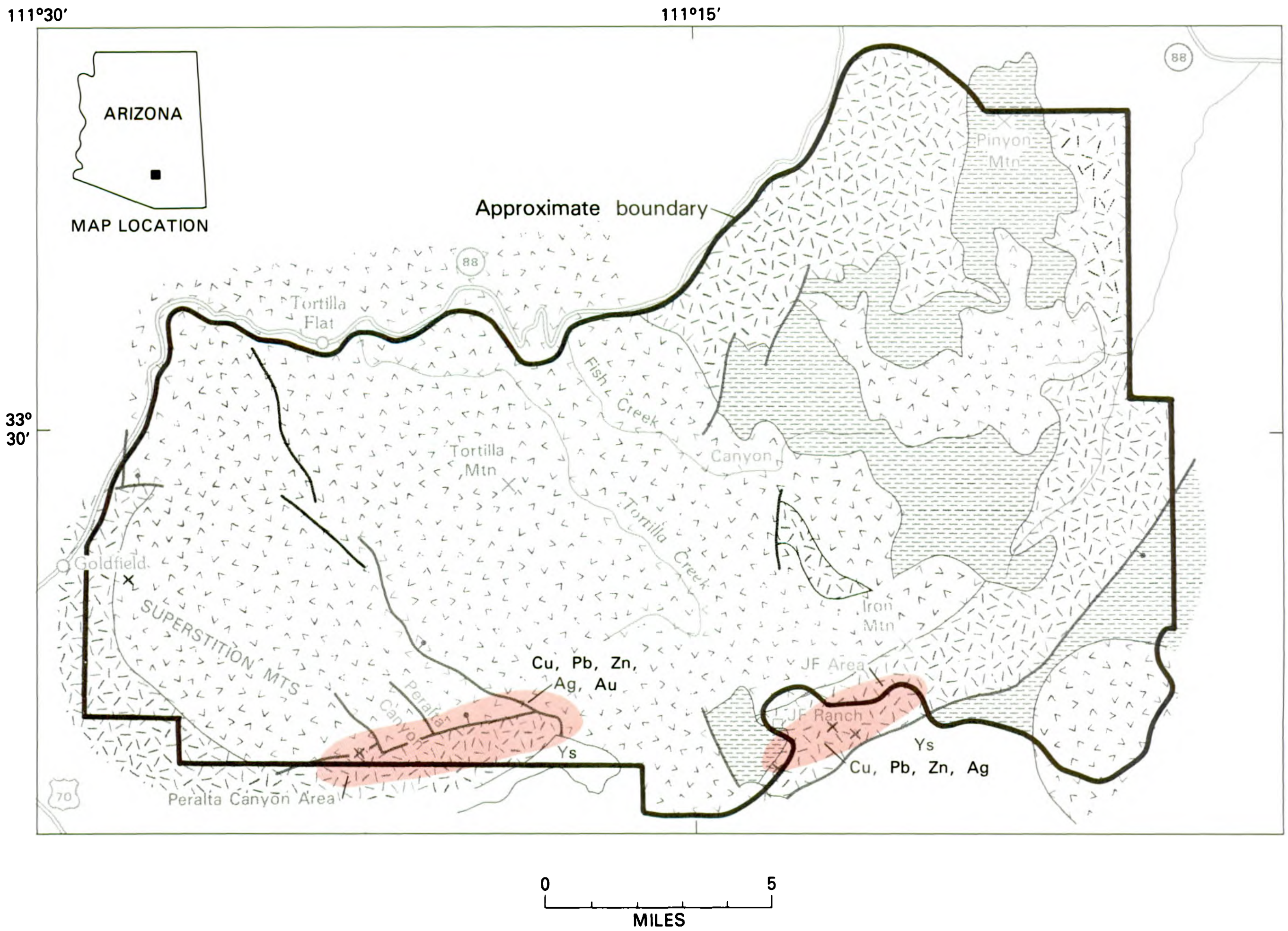
CHARACTER AND SETTING

The Superstition Wilderness in south-central Arizona includes about 194 sq mi; an additional contiguous area of about 50 sq mi was included in the study for a total of about 244 sq mi. The Superstition Mountains rise as a spectacular range front above the adjacent desert to the south and west and provide a scenic treat to travelers on U.S. Highway 70. Arizona State road 88 skirts the northern boundary of the wilderness and offers hints of the ruggedly dissected landscape that makes up the interior of the wilderness. Altitudes range from 1660 to 6266 ft; local relief between canyon bottoms and ridge tops ranges from a few hundred to a thousand feet, and the relief between the desert and the summit of the Superstition Mountains is 3500 ft.

The wilderness is in a region of highly diverse rock types and complex geologic structure. Rocks range in age from Middle Proterozoic to Quaternary and include metamorphic, sedimentary, and both intrusive and extrusive igneous rocks. The geology of the eastern half of the wilderness differs distinctly from that of the western half. The eastern half includes mainly Proterozoic rocks of different types that have been pervasively faulted. The rocks include schist and granite of Proterozoic age unconformably overlain by Middle Proterozoic sedimentary rocks (sandstone, quartzite, shale, conglomerate, and limestone), all intruded by massive sills and dikes of diabase. These, in turn, are unconformably overlain by isolated remnants of Paleozoic sedimentary rocks. The Proterozoic and Paleozoic rocks have been extensively faulted on an intricate scale chiefly by discontinuous high-angle normal faults of various orientations. Fault blocks have been tilted in diverse directions; the attitude of strata within individual fault blocks is relatively uniform, whereas attitudes vary widely from one block to another. These rocks are locally overlain by volcanic rocks of Tertiary age.

The western half of the wilderness consists chiefly of Tertiary volcanic rocks of many different types. The most abundant are thick deposits of ash-flow tuff; these are overlain, underlain, and intruded by rhyolitic, dacitic, and basaltic lavas. The volcanic rocks were erupted from many different vents that lie within or near the wilderness, and, as is characteristic of volcanic source areas, the rocks are locally highly contorted and bear complex relationships with one another. The roots of one or more collapsed calderas that are the source of the voluminous ash-flow tuff may lie within the wilderness. Spectacular canyons have been cut into the volcanic rocks, and in some places erosion has carved intricate and fantastic forms for which the Superstition Mountains are famous.

[1]With contributions from D. L. Gaskill, M. L. Sorensen, W. E. Yeend, W. R. Miller, J. M. Motooka, J. C. Wynn, K. L. Stark, N. H. Suneson, and G. D. Johnpeer, USGS, and F. E. Williams, H. C. Meeves, L. S. Griffiths, and J.A.T. Fallin, USBM.



EXPLANATION

▭	Geologic terrane with probable mineral-resource potential
Cu	Copper
Au	Gold
Pb	Lead
Ag	Silver
Zn	Zinc
×	Mineral occurrence

	Volcanic rocks (Tertiary)
	Sedimentary rocks (Paleozoic and Proterozoic)
	Granite (Proterozoic)
Ys	Schist (Proterozoic)
	Contact
	Fault--Bar and ball on downthrown side

Figure 31.—Superstition Wilderness, Arizona.

The USBM, at intervals from 1973 to 1977, examined mining claims, prospects, and the few accessible mine workings showing evidence of mineralization. The USGS, at intervals from 1975 to 1977, carried out reconnaissance geologic mapping and geochemical sampling for analyses. Aeromagnetic mapping and a gravity survey were also carried out. Analytical results were compiled by Motooka and others (1978), and gravity results by Wynn and Manydeeds (1978).

MINERAL RESOURCES

The southern and eastern boundaries of the area studied are within 6 mi of large copper mines; the mines of the Globe, Miami, and Superior areas, which have had copper and precious-metal production exceeding $2 billion, lie within 20 mi of the wilderness. In spite of this proximity and intensive prospecting throughout terrane that resembles the geology around the major mineral deposits, little mining activity has resulted within and adjacent to the wilderness.

Legal records reveal that no mining claims have been patented or mineral leases effected within the wilderness or the adjoining areas. Notices of claims filed through the years indicate a low level of prospecting activity during recent years, and most claims have not been maintained.

Abundant pits, shafts, and adits dot an east-west zone along the southern margin of the wilderness. Material found on dumps shows that the workings encountered appreciable mineralized ground, particularly in two areas designated here as the JF area (SE part of wilderness) and the Peralta Canyon area (SW part of wilderness). Valid claims have been maintained in the areas and although almost all workings are inaccessible and could not be examined both areas have a probable mineral-resource potential. In the JF area, hydrothermal alteration and copper, lead, zinc, and silver mineralization are found in both schist and granite in an elongate zone extending from about 1.5 mi south of the JF Ranch for about 4 mi in an east-northeast direction toward Iron Mountain; the vaguely defined zone is as much as 1.5 mi wide and lies both within and outside the wilderness.

In the Peralta Canyon area, mineralized ground in an east-northeast trending zone from 1 mi west of the mouth of Peralta Canyon eastward for about 4 mi has been explored by several small operations. Alteration and mineralization of base and precious metals occur both in Proterozoic granite and Tertiary volcanic rocks, and they are associated, at least in part, with an east-northeast trending range-front fault. A few claims are maintained, but no recent exploration activity is known.

A small amount of mineralization evidently occurs along a siliceous vein in a mine near the western margin of the wilderness, about 2 mi southeast of the community of Goldfield. The workings are inaccessible.

An important control of ore deposits in the Globe-Miami mining district (6–20 mi east of the wilderness) is postulated to be the east-northeast trending contact between Proterozoic schist and granite (Peterson, 1962). Granitic stocks of Late Cretaceous or early Tertiary age intruded this ancient zone of weakness, carrying mineralizing fluids that solidified to form the important ore deposits. A reconnaissance of the geology of the area undertaken as part of this study showed that the contact between the ancient schist and granite extends westward across the southern part of the wilderness. A band of geochemical anomalies with high values of copper, lead, zinc, silver, and other metals extends across the southern part of the wilderness and straddles the ancient contact. An east-west series of magnetic low anomalies is also alined roughly along the contact. No large intrusive bodies of younger Cretaceous or Tertiary age were found in proximity to the contact, although a north-trending dike swarm has intruded schist just north of the contact in an area just west of Iron Mountain (JF area). These dikes could be outliers of a larger concealed intrusive body. The possibilities are intriguing because of the alteration and mineralization in the JF area. Owing to these combined factors, the two areas along the southern margin of the wilderness are designated as having probable mineral-resource potential.

Another possibility for undiscovered minerals would be a deposit concealed beneath the Tertiary volcanic rocks. The only hint of such a deposit is a tongue-like geochemical anomaly extending north-northwest from the Peralta Canyon area and no resource potential is identified.

Anomalously high values of uranium and thorium were detected in a number of rock and stream-sediment samples near the northeastern corner of the wilderness (Peterson and Jinks, 1983).

Although the Superstition Mountains are well known for legends of lost gold, the general geologic environment holds little promise for an important gold deposit that could have been found using the techniques of 19th century prospecting. The Lost Dutchman mine can likely be relegated to the store of folk tales that extend and embellish historical reality.

SUGGESTIONS FOR FURTHER STUDIES

Most of the wilderness holds little promise for identification of mineral resources. The areas indicated as having probable mineral-resource potential will need detailed geologic mapping and exploration to determine the feasibility of realizing this potential.

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SYCAMORE CANYON PRIMITIVE AREA, ARIZONA

By LYMAN C. HUFF, U.S. GEOLOGICAL SURVEY, and

R. C. RAABE, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey made by the USGS and USBM in 1965, the Sycamore Canyon Primitive Area has little promise for the occurrence of mineral commodities.

CHARACTER AND SETTING

The Sycamore Canyon Primitive Area, which occupies about 74 sq mi, lies about 24 mi southwest of Flagstaff, Arizona. The margin of this primitive area corresponds to the rim of deeply eroded Sycamore Canyon. To the southeast, beyond the canyon rim, lies an upland within the Coconino National Forest. To the northwest, also beyond the canyon rim, lies a similar upland within the Kaibab National Forest. These uplands near the head of the canyon have an elevation of about 6700 ft above sea level. In its lowest part, where Sycamore Creek leaves the primitive area at its southern end, the area has an elevation of 3600 ft. Through much of the area the canyon is more than 1700 ft deep.

The rocks in Sycamore Canyon consist almost entirely of flat-lying sedimentary rocks of Paleozoic age. Many of the formations that crop out in the Grand Canyon National Park also crop out in Sycamore Canyon and form similar beautiful cliffs.

The Paleozoic sedimentary rocks include thick formations of limestone, siltstone, and sandstone. Above these is a thin layer of mudstone and sandstone of early Mesozoic age, which is in turn overlain locally by gravel and basalt flows of Tertiary and Quaternary age. The alluvial sand and gravel deposits along the narrow flood plain of Sycamore Creek are also of Quaternary age. The basaltic igneous rocks present are located mostly near the head of the canyon. They are flows and dikes peripheral to the volcanic complex centering around San Francisco Mountain to the north.

Access to Sycamore Canyon is limited to hiking trails which wind down from the canyon rim to the narrow lowland along Sycamore Creek. Vistas are similar to that along the Kaibab Trail at Grand Canyon but on a smaller scale. Kelsey Spring and other springs in the northern part of the canyon provide fresh water near good camping sites. During late summer much of the flow of Sycamore Creek is underground and good sources of water in the lower part of the canyon are difficult to find.

MINERAL RESOURCES

No evidence of mineral deposits was discovered in this area. The sedimentary beds are cut by numerous small faults but none of these are mineralized. The rocks are well exposed so that if any mineral deposits were located in the area they would almost certainly be noticed.

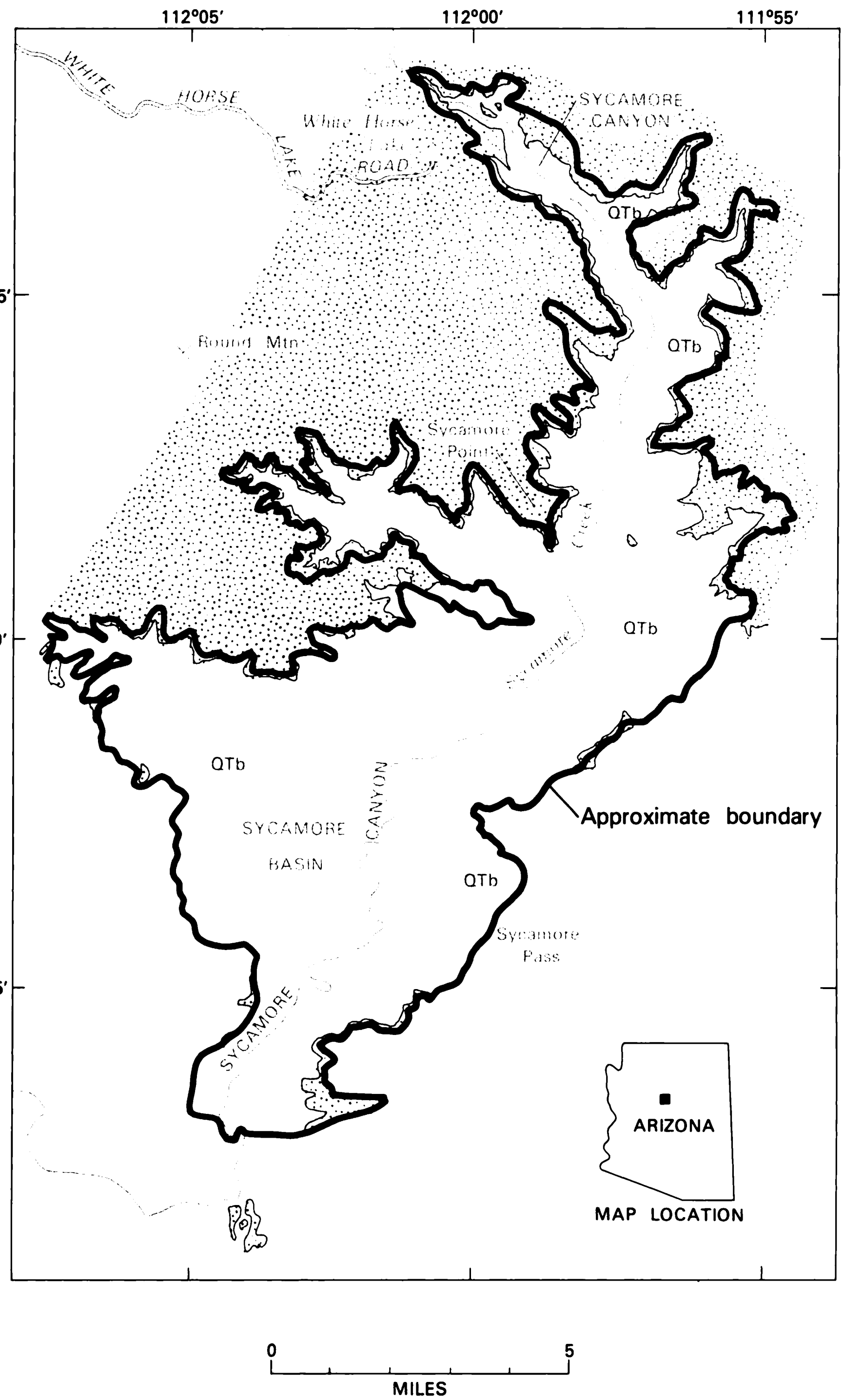
The only mining claims located in the area are near the southern end where two partners excavated the clay fill in a cave close to Sycamore Creek in the belief that that is where the renegade Apache Indian Geronimo buried treasure. This cave, which is limestone, and its clay filling were examined carefully and concluded to be entirely natural.

To help evaluate the area for mineral resources, sediment samples were collected along Sycamore Creek and its tributaries. These were analyzed for traces of the ore metals without finding any local concentrations. In addition, a scintillometer was used to test rocks in the area without finding any abnormal radioactivity.

No oil wells have been drilled in the area and it is unlikely that any drilled would be successful. Geologic structures favorable for accumulating oil are lacking and geologic mapping indicates that Precambrian crystalline rocks unsuitable for oil underlie the area at relatively shallow depth.

SUGGESTIONS FOR FURTHER STUDIES

Further study of this primitive area offers little promise for the discovery of any hidden mineral deposits.



EXPLANATION

Basalts (Quaternary and Tertiary)

QTb Sedimentary rocks (Mesozoic and Paleozoic)

Contact

Figure 32.—Sycamore Canyon Primitive Area, Arizona.

REFERENCE

Huff, L. C., Santos, Elmer, and Raabe, R. G., 1966, Mineral resources of the Sycamore Canyon Primitive Area, Arizona: U.S. Geological Survey Bulletin 1230-F, 19 p.

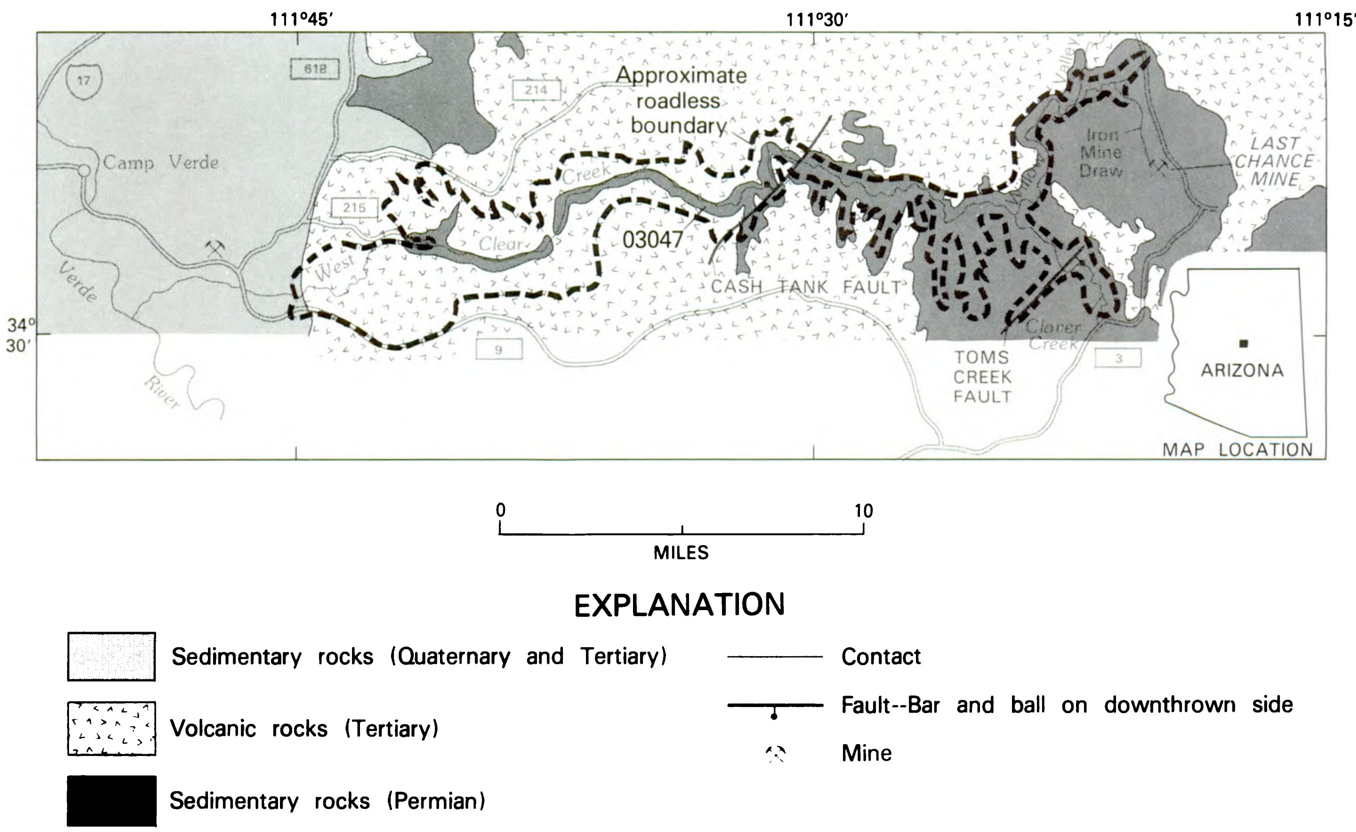


Figure 33.—West Clear Creek Roadless Area, Arizona.

WEST CLEAR CREEK ROADLESS AREA, ARIZONA

By GEORGE E. ULRICH, U.S. GEOLOGICAL SURVEY, and

ALAN M. BIELSKI, U.S. BUREAU OF MINES

SUMMARY

Results of USGS geologic, geochemical, and aeromagnetic studies and USBM review of mineral records and prospect examination for the West Clear Creek Roadless Area, Arizona, indicate that there is little likelihood of the occurrence of mineral or energy resources. No concentrations of minerals were identified within the boundary of the area. A small manganese deposit occurs 1-3 mi east of the area but does not extend into the area. Slightly anomalous values for certain trace metals were found in samples taken within the area, but do not indicate the presence of metallic resources. Gypsum, basaltic cinders, and sandstone occur in the area, but similar materials are available and have been quarried outside the area where they are much more readily accessible.

CHARACTER AND SETTING

The West Clear Creek Roadless Area includes approximately 53 sq mi in Yavapai and Coconino Counties in central Arizona, about 70 mi north of Phoenix. The area lies on the southwestern margin of the Colorado Plateau and includes part of the Verde valley, one of several northwest-linear basins in the Arizona transition zone separating the Basin and Range and Colorado Plateaus physiographic provinces. Interstate 17 connecting Phoenix and Flagstaff crosses Verde Valley 10 mi west of the roadless area and affords a view of the west-facing escarpment of the plateau margin notched by the prominent canyon of West Clear Creek.

The roadless area boundary closely follows the rim of the steep-walled canyon of West Clear Creek and its tributaries. The perennial stream within the canyon drops 3000 ft over a distance of 36 mi from its head at the juncture of Willow and Clover Creeks to its confluence with the Verde River. Together with its tributaries, it drains an area of about 240 sq mi. The maximum altitude of the area, approximately 7000 ft above sea level, occurs at the eastern end, on the top of the plateau. The topographic relief increases about 100 ft at the eastern end, to a maximum of 1800 ft toward the west as the canyon deepens across the Plateau margin. The relief decreases abruptly at the western boundary where West Clear Creek flows onto the broad open floor of the Verde River valley.

Paleozoic and Mesozoic rocks are exposed in the precipitous walls of the canyon and include upper Paleozoic sedimentary strata having a cumulative thickness of about 1700 ft and remnants of Triassic rocks in the northeastern corner of the roadless area. The Paleozoic formations, in ascending order, are the impressive "red rocks" of the Supai Formation (650 ft of siltstone, sandstone, and minor limestone), the light-gray crossbedded Coconino Sandstone (700 ft), and the ledgy limestones of the Kaibab Formation (as much as 350 ft). In the middle part of the canyon, west of the Cash Tank fault, these rocks were deeply eroded more than 10 million years ago, creating an old valley at least 1300 ft deep which crossed the direction of the modern westerly course of West Clear Creek. This paleovalley was partly filled by as much as 300 ft of coarse conglomerate chiefly derived from the valley walls. Beginning about 11 million years ago (Pierce and others, 1979), extensive volcanic eruptions, primarily basaltic, produced pyroclastic deposits and lava flows that filled and overtopped the remaining space within the old valley, reaching a maximum thickness of about 1500 ft. Basin-filling sediments of the Tertiary Verde Formation were deposited in the western part of the roadless area during and following the volcanic activity. After deposition of the Verde Formation had ceased, extensive erosion by the present river system began; it has cut as much as 1500 ft into the plateau.

The structural setting is one of gentle westward dips in the sedimentary rocks and steeply dipping normal faults. Most of the faults trend north to northwest, but two of them, the Cash Tank and Toms Creek faults, are unusual in that they strike northeasterly and can be traced for more than 3 mi. The Cash Tank fault is also notable for its large throw, 240–360 ft, and is reflected in both the gravity and aeromagnetic data. The Toms Creek fault parallels the aeromagnetic contours in the area and lies on a trend which, if extended to the northeast, would coincide with the breccia zone described by Jones and Ransome (1920) in the Long Valley manganese district.

MINERAL RESOURCES

On the basis of geologic mapping, geochemical sampling, an aeromagnetic survey, and review of the county and federal land records, the roadless area is considered to have little likelihood for the occurrence of hidden mineral resources. No metallic mineral occurrences are known within the area.

Mineralized areas, mining claims, and mining activities are limited to the Long Valley manganese district 1–3 mi east of the roadless area. The Last Chance mine near the head of Iron Mine Draw, is within the Long Valley district but mineralization does not appear to extend into the roadless area.

The Verde Formation occurs at the western extremity of the roadless area and is quarried for gypsum about 2 mi west of the area; however, this formation does not contain evaporite deposits within the roadless area. Basalt and basaltic cinder deposits along the canyon rim have uses for road metal, concrete aggregate, riprap, and cinder blocks, and the Coconino Sandstone exposed in the canyon can be used as building- and flagstone but similar construction materials are more readily available outside the area.

SUGGESTIONS FOR FURTHER STUDIES

Further study of the roadless area offers little promise for the identification of hidden mineral deposits.

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WET BEAVER ROADLESS AREA, ARIZONA

By GEORGE E. ULRICH,[1] U.S. GEOLOGICAL SURVEY, and

ALAN M. BIELSKI, U.S. BUREAU OF MINES

SUMMARY

On the basis of field studies by the USGS and the USBM in 1982 there is little promise for the occurrence of mineral or energy resources in the Wet Beaver Roadless Area, Arizona. No significant concentrations of metals were indicated by geochemical sampling or aeromagnetic data within the area. Basaltic cinders and sandstone have been quarried for construction materials near the area but are readily available and more accessible outside the precipitous canyons of Wet Beaver Creek and its tributaries.

CHARACTER AND SETTING

The Wet Beaver Roadless Area includes 15.4 sq. mi of the Coconino National Forest in Coconino and Yavapai Counties, central Arizona, about 85 mi north of Phoenix. Montezumas Castle National Monument is 4 mi southwest of the area's western boundary. The roadless area lies on the southwestern margin of the Colorado Plateau and near the eastern margin of the Verde valley, one of several linear basins in the Arizona Transition Zone that separates the Basin-and-Range and Colorado Plateaus physiographic provinces. Interstate 17 connecting Phoenix and Flagstaff crosses Verde valley 2 mi northwest of the roadless area, and access to the area is easiest from the Sedona interchange to the USFS Ranger Station from which only foot traffic is allowed into the roadless area. Two well-marked trails climb from Wet Beaver Creek onto the basalt-capped surface of the Mogollon Rim within 2 mi of the Ranger Station.

The roadless area boundary closely follows the rim of the steep-walled canyon of Wet Beaver Creek and its tributaries cut into the gently westward sloping surface of the Colorado Plateau. The perennial stream within the canyon drops 2100 ft over a distance of 13 mi from its head at the juncture of Brady and Jacks Canyons in the east to the intersection with Casner Canyon on the western edge of the roadless area. Wet Beaver Creek continues another 12 mi on the broad floor of Verde valley before it joins the Verde River near Camp Verde. Together with its tributaries, Wet Beaver Creek drains an area of 101 sq mi above the western boundary of the roadless area. Perennial springs below Hog Hill discharge 1200 to 1500 gallons of water per minute into Wet Beaver Creek (Twenter and Metzger, 1963). The maximum altitude within the roadless area, just east of Hog Hill, is 6470 ft. The lowest point, at 4000 ft, is the stream bed of Wet Beaver Creek near the western boundary. Topographic relief within the roadless area ranges from 1200 ft near the mouth of the canyon at Casner Butte, to approximately 150 ft at the eastern boundary.

The rocks exposed by the downcutting of Wet Beaver Creek include, in ascending order, the spectacular red sandstones and siltstones of the upper Supai Formation, (550 ft) in the western part of the canyon, the light-gray and yellowish-gray crossbedded Toroweap and Coconino Sandstones, undivided, (600 ft) exposed in most of the canyon, and the gray ledgy limestones and dolomites of the Kaibab Formation (280 ft) in the eastern part. These sedimentary rocks, all of Early Permian age, are unconformably overlain by 300 to 1500 ft of Tertiary basaltic rocks and are intruded by basaltic dikes and at least one basaltic plug. The unconformity truncates increasingly older rocks from east to west and is commonly marked by a thin conglomerate or gravel with clasts of the Permian rocks described above.

The structural setting is one of variable local dips and a gentle regional dip to the east within the sedimentary rocks. Normal faults offset volcanic and sedimentary units, dip steeply, and strike mainly northwest or north. Blocks of Permian strata between faults are generally upthrown on the west and tilted downward toward the east. The net displacement for all faults mapped within the main canyon is approximately 1300 ft down to the

[1]With contributions from J. Suzanne Bywaters, USGS.

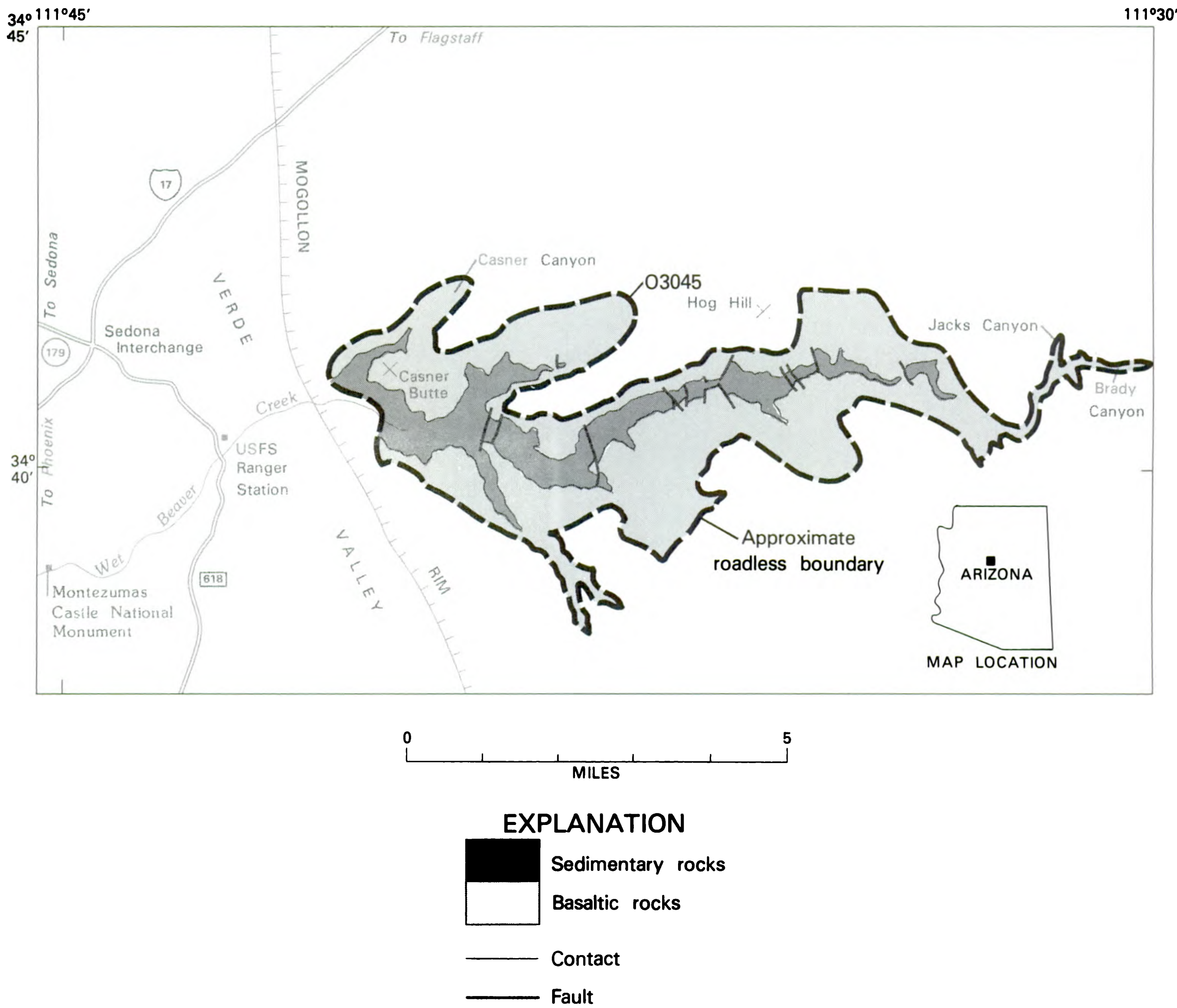

Figure 34.—Wet Beaver Roadless Area, Arizona.

west. The density of faults increases locally near areas of basaltic vent deposits.

MINERAL RESOURCES

On the basis of geologic mapping, geochemical sampling, an aeromagnetic survey, and review of the county and federal land records, the roadless area is considered to have little promise for the occurrence of mineral resources. There are no known mineral occurrences within the roadless area. Basalt and basaltic cinder deposits along the canyon rim have a potential for road metal, concrete aggregate, riprap, and cinder blocks, and the Coconino Sandstone exposed in the canyon may be used as building and flagstone but similar construction materials are more readily available outside the roadless area. No energy resources were identified in the study.

SUGGESTIONS FOR FURTHER STUDIES

Further study of the roadless area offers little promise for the identification of hidden mineral deposits.

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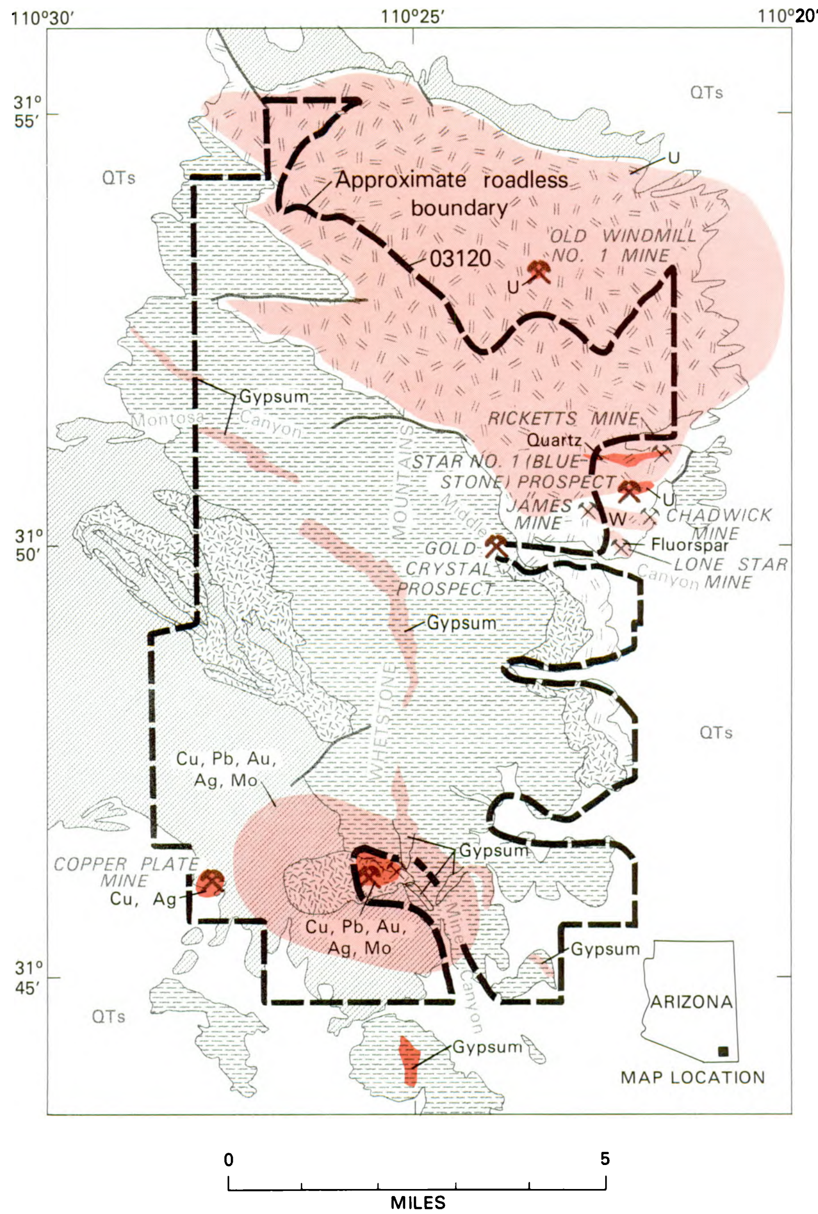

EXPLANATION

Geologic terrane with substantiated mineral-resource potential	QTs — Quaternary and Tertiary sedimentary rocks
Geologic terrane with probable mineral-resource potential	Cretaceous granitic rocks
Cu Copper — Ag Silver	Cretaceous sedimentary rocks
Au Gold — W Tungsten	Paleozoic sedimentary rocks
Pb Lead — U Uranium	Proterozoic granitic rocks and schist
Mo Molybdenum	Contact
Mine or deposit	Fault

Figure 35.—Whetstone Roadless Area, Arizona.

WHETSTONE ROADLESS AREA, ARIZONA

By CHESTER T. WRUCKE,[1] U.S. GEOLOGICAL SURVEY, and

ROBERT A. MCCOLLY, U.S. BUREAU OF MINES

SUMMARY

A mineral survey conducted by the USGS and the USBM in 1981 has shown that areas in and adjacent to the Whetstone Roadless Area have a substantiated resource potential for copper, lead, gold, silver, and quartz, and a probable mineral-resource potential for copper, silver, lead, gold, molybdenum, tungsten, uranium, and gypsum. Copper and silver occur in a small vein deposit in the southwestern part of the roadless area. Copper, lead, silver, gold, and molybdenum are known in veins associated with a porphyry copper deposit in a reentrant near the southern border of the roadless area. Vein deposits of tungsten and uranium are possible in the northeast part of the roadless area near areas of known production of these commodities. Demonstrated resources of quartz for smelter flux extend into the roadless area from the Ricketts mine. Areas of probable potential for gypsum resources also occur within the roadless area. No potential for fossil fuel resources was identified in the study.

CHARACTER AND SETTING

The Whetstone Roadless Area comprises about 57 sq mi in the Basin and Range province of southeastern Arizona, about 40 mi southeast of Tucson and 25 mi north of the border with Mexico. The principal physiographic feature of the roadless area is a prominent north-northeast-trending ridge about 9 mi long that forms the crest of the Whetstone Mountains and culminates in several peaks about 7100 to 7700 ft in altitude, no one of which stands out significantly compared to the others. Some lower slopes and many of the higher areas in the mountains expose well-defined layered rock sequences, a few of which, especially near the ridge crest, form bold exposures many hundreds of feet in length, giving an impression of bedrock structure of marked simplicity and continuity. This is the general appearance of the range from the vicinity of Benson, the nearest town, which is situated about 6 mi northeast of the roadless area.

Bedrock in the roadless area and surrounding parts of the Whetstone Mountains consists of Proterozoic igneous and metamorphic rocks and an overlying stratigraphic succession of Paleozoic and Mesozoic strata. The Paleozoic and Mesozoic rocks have been intruded by Mesozoic granitic masses. Published geologic maps of the area are by Creasey (1967) and Hayes and Raup (1968).

The oldest rocks in the area are muscovite-biotite-quartz schist of Early Proterozoic age and quartz monzonite and alaskite of Middle Proterozoic age. The metamorphic rocks formed from shales and silty shales that were regionally metamorphosed near the end of the Early Proterozoic Era and intruded by quartz monzonite about 1400–1450 million years ago. Alaskite that also intruded the schist may be genetically related to the quartz monzonite.

Resting unconformably on the Proterozoic rocks are sedimentary deposits that range in age from Cambrian to Permian. Middle Cambrian sandstone and quartzite recorded the beginning of Paleozoic sedimentation in southeastern Arizona, and represent deposition by advancing seas that beveled the Proterozoic basement. The overlying limestones and dolomites were deposited from the Late Cambrian into the Late Pennsylvanian in an open marine environment, whereas carbonate strata of Late Pennsylvanian to Late Permian age originated under tidal, supratidal, and marine conditions. Gypsum beds of Late Permian age record a supratidal environment. The Paleozoic rocks aggregate about 8000 ft in thickness.

[1]With contributions from David C. Scott, USBM, and R. Scott Werschky, Viki Bankey, M. Dean Kleinkopf, Mortimer H. Staatz, and Augustus K. Armstrong, USGS.

Sandstone, shale, limestone, and conglomerate of Late Cretaceous age were deposited on an unconformity of great local relief that had been carved into the Paleozoic rocks. Deposition of the Mesozoic strata was marine and nonmarine in a prograding delta near the margin of a shallow sea that advanced northwestward into southeastern Arizona from Mexico. The Cretaceous stratified succession is about 8800 ft thick.

The youngest Mesozoic rocks in the roadless area are granodiorite in sills and a small stock, and intrusive rhyodacite in irregular sill-like masses. These bodies were emplaced into the Paleozoic and Mesozoic strata about 74 million years ago. They are the youngest rocks in the Whetstone Mountains, other than a Tertiary(?) dike near the south end of the range, and Cenozoic gravels that crop out mainly around the base of the mountains.

The principal structural feature of the Whetstone Mountains is a southwest-dipping homocline of Paleozoic and Mesozoic strata. Steep faults and thrust faults in these rocks generally have displacements of a few hundred feet or less and do not significantly disturb the homoclinal pattern of the strata. The homocline and faults probably represent deformation mainly during the Laramide orogeny of Late Cretaceous and Early Tertiary age. Additional deformation probably occurred during Basin and Range faulting in the Neogene.

MINERAL RESOURCES

The Whetstone Roadless Area has a substantiated resource potential for copper, gold, silver, and quartz and a probable resource potential for lead, copper, silver, gold, molybdenum, tungsten, uranium, and gypsum. Fluorite and mercury occur in or near the area but no resource potential was identified (Wrucke and others, 1983; McColly and Scott, 1982). Mining activity in the Whetstone Mountains dates from the 1870s, but no mines have yielded ore since the 1960's.

Copper ore containing minor amounts of silver was mined from a vein deposit in quartz-rich sandstone at the Copper Plate mine in the 1950's, and the mine contains demonstrated resources of 2000–4000 tons of low-grade copper and occurs in an area of substantiated mineral-resource potential.

Copper also is known in Mine Canyon just outside the roadless area. The copper occurs in a porphyry-type deposit in granodiorite and in vein and replacement sulfide deposits in granodiorite and skarn at nearby mines. The area of the porphyry deposit as well as the vein deposits has substantiated mineral-resource potential, based on demonstrated resources of 32 million tons of 0.28 percent copper and 0.01 percent molybdenum (DeRuyter, 1957). Records dating from 1918 show that mines in the vein deposits have produced at least 136,048 lbs of copper, 900,000 lbs of lead, and small amounts of silver and gold. A probable mineral-resource potential for copper, lead, silver, gold, and molybdenum exists around the area of substantiated resource potential. This determination is based on the assumption that copper mineralization extends beyond the area explored by drilling and mining, and on geophysical evidence that the granodiorite widens at depth.

Quartz was produced for smelter flux during the 1950's from the Ricketts mine, located outside the roadless area, north of Middle Canyon. Demonstrated resources of 5000–6000 tons for each vertical foot of quartz exist in that part of the quartz body that extends for a distance of 800 ft westward into the roadless area and is shown on the map as an area of substantiated quartz resource potential.

Tungsten has been mined sporadically since about 1900 from an area 1 mi north of Middle Canyon. Most of the production was from veins at the Chadwick mine outside the roadless area, although the James mine within the roadless area has recorded production. All of the ore-grade deposits were exhausted prior to 1960, and there is little promise of additional deposits near the surface. A probable resource potential for tungsten in this area is based on the possibility that tungsten veins occur at depth.

High-grade fluorspar has been produced at the Lone Star mine, on the north side of Middle Canyon. Although the mine is about 1000 ft outside the roadless area the fluorite vein system might extend into the roadless area at depth. The mine is believed to have been the largest single producer of fluorspar in Arizona. Although the workings are now inaccessible, a probable mineral-resource potential for fluorite is assigned to this area.

Uranium deposits occur in veins in Proterozoic quartz monzonite and alaskite on the northeastern flank of the Whetstone Mountains. High scintillometer readings, chemical values for uranium, and the production of uranium at the Old Windmill No. 1 mine in Cottonwood Canyon indicate that additional resources exist at the mine. Demonstrated resources of 47 tons of uranium-bearing rock containing as much as 0.094 percent uranium occur at the Star No. 1 (Bluestone) prospect north of Middle Canyon. However, the concentration of uranium in the mine areas and elsewhere is spotty. The northern part of the Whetstone Mountains has a probable resource potential for uranium.

Gypsum occurs in Permian sedimentary rocks near the south end of the Whetstone Mountains, outside the roadless area, and these same Permian rocks occur within the roadless area, indicating a probable resource potential for gypsum.

A gold deposit at the Gold Crystal prospect in Middle

Canyon outside, but within a few hundred feet of the roadless area has about 3000 tons of demonstrated low-grade gold resources to a depth of 100 ft, and a small area of substantiated resource potential extends into the roadless area.

Mercury (as cinnabar) was found in heavy-mineral concentrates during sampling in the vicinity of Middle Canyon and Montosa Canyon. The mercury shows no clear relationship to any of the known mineral resources in the area. No mercury resource potential was identified.

Most of the known mineral deposits in the Whetstone Mountains were formed by hydrothermal processes that can be related to igneous events. The copper deposits in the southern and western parts of the mountains are best developed in and adjacent to Cretaceous granodiorite, leaving little doubt of a genetic tie between these deposits and the Cretaceous intrusive rocks. A genetic relationship between the uranium, tungsten, and fluorite veins and the Proterozoic quartz monzonite and alaskite is suggested by the close spatial association of the mineral deposits to these igneous rocks. Moreover, the trace-element suite uranium, fluorine, tungsten, beryllium, niobium, and yttrium is in both the host igneous rocks and the vein deposits. This relationship is consistent with a model for mineralization in which the uranium, tungsten, and beryllium were carried in solution as fluoride complexes during a late phase of the igneous event. The quartz body located between the quartz monzonite and alaskite probably is of Proterozoic age, whereas the mercury mineralization most likely was Cretaceous or younger.

SUGGESTIONS FOR FURTHER STUDY

The geology of the Whetstone Mountains is known in some detail, but the mineral deposits are understood only in a general way as a result of this investigation. Detailed study of the Proterozoic rocks would lead to a better understanding of the fluorite, tungsten, and uranium mineralization and enhance the possibility for finding additional occurrences of these commodities. Study of the Cretaceous igneous rocks would aid in understanding the copper mineralization. Detailed geochemical sampling and geologic mapping could provide information on the source and setting of the mercury occurrences.

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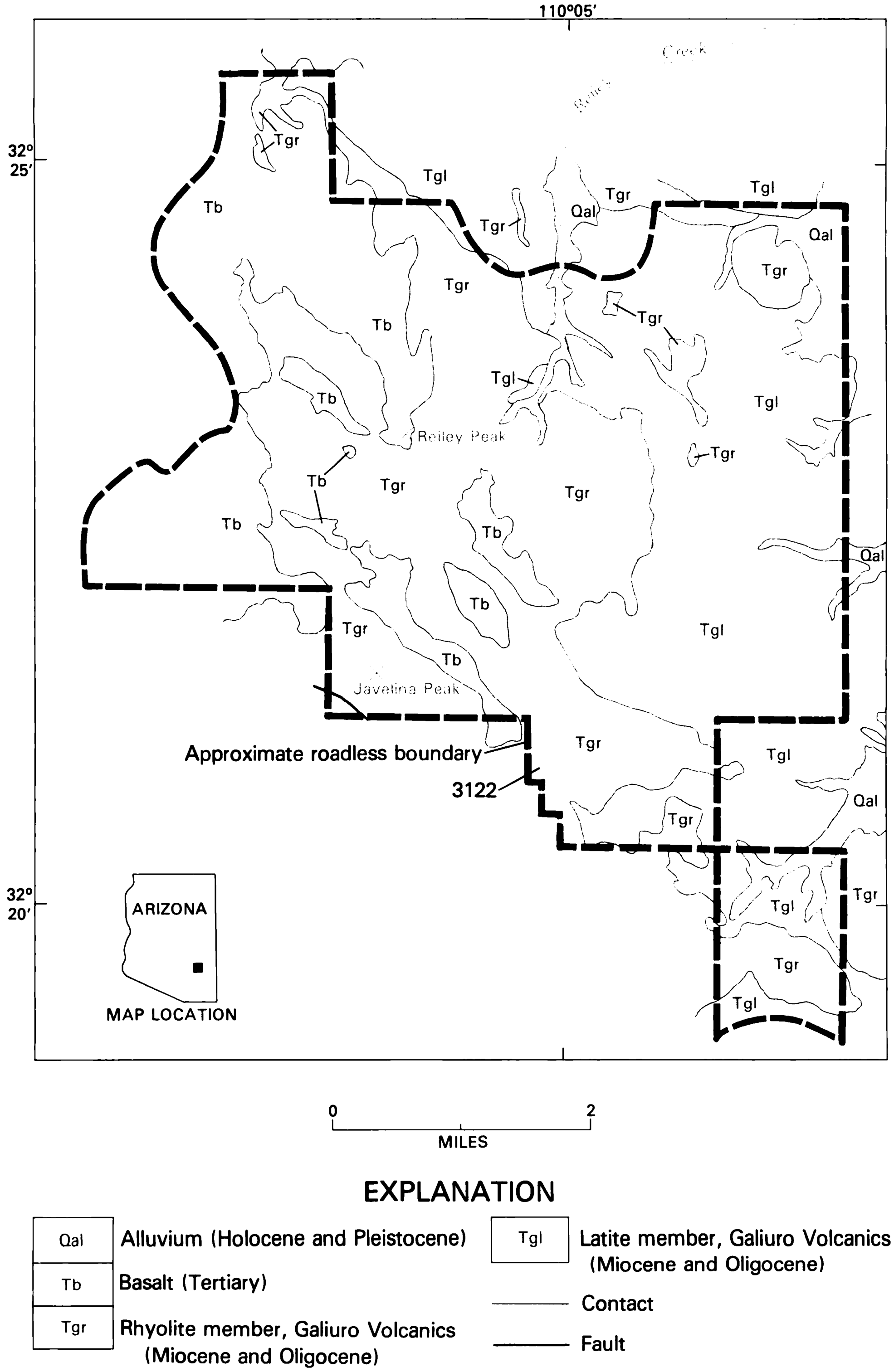

Figure 36.—Winchester Roadless Area, Arizona.

WINCHESTER ROADLESS AREA, ARIZONA

By WILLIAM J. KEITH,[1] U.S. GEOLOGICAL SURVEY, and

TERRY J. KREIDLER, U.S. BUREAU OF MINES

SUMMARY

Results of geologic, geochemical, geophysical, and mining activity and production surveys in the Winchester Roadless Area in 1981 indicate little promise for the occurrence of metallic and nonmetallic or energy resources in the area. Volcanic rocks cover the area to a thickness of 1000 to 2000 ft and possibly more, thus preventing inspection and evaluation of the underlying rock.

CHARACTER AND SETTING

The Winchester Roadless Area, located in northwestern Cochise County, Arizona, consists of 22 sq mi of Coronado National Forest in the Winchester Mountains. The area lies approximately 15 mi northwest of Willcox, Arizona. Access to the boundary of the roadless area by county and ranch roads (with permission from the owners) is good on all but the west side, where roads generally end more than 1 mi from the boundary. Within the area the terrain is steep and rugged, with many vertical cliffs. Altitudes in the area range from about 5000 ft on the eastern flank of the mountains to 7631 ft at the summit of Reiley Peak. Heavy growth of manzanita inhibits accessibility at higher altitudes. Intermittent streams have incised steep-walled canyons into the volcanic rocks.

This study consisted of (1) field checking and modification of the existing geologic maps of the area (Creasey and others, 1961, 1981), (2) field examination of all mines, prospects, and mineralized areas in and adjacent to the Winchester Roadless Area, (3) sampling of bedrock and stream sediments from drainage basins for geochemical analysis; and (4) examination and interpretation of available aeromagnetic and gravity data. The results have been published by Keith and others (1982).

Rocks of the Winchester Roadless Area consist of a sequence approximately 1000 to 2000 ft thick of silicic ash-flow tuffs and lava flows capped by basaltic lava flows. The silicic volcanic rocks are assigned to the Galiuro Volcanics (Cooper and Silver, 1964). The Galiuro Volcanics is divided into four members, two of which occur in the Winchester Roadless Area. The lower or latite member consists of undifferentiated lava flows and tuffs that range from latite to rhyolite in composition. This member is limited to the central and eastern parts of the area and dips approximately 30° northwest. The upper or rhyolite member consists of rhyolitic lava flows, dikes, and ash-flow tuffs. The rhyolite member is found in the central and western parts of the area and appears to thicken to the west. The Galiuro Volcanics, considered to be of Oligocene and Miocene age (Creasey and Krieger, 1978) is capped by younger basalt which consists of black vesicular lava flows and is confined to the central and western parts of the roadless area.

MINERAL RESOURCES

Twenty-eight sample sites were selected as representative of the drainage basins in and around the Winchester Roadless Area. The sites were sampled for rock, stream sediment, and panned concentrates. Samples were analyzed for 31 elements by six-step semiquantitative emission spectrography and for two additional elements (zinc and gold) using atomic absorption or colorimetry. The results of the analyses indicate a generally high concentration of lanthanum, niobium, lead, and tin in the panned concentrates. The lanthanum and niobium occur in zircon, sphene, and other minerals that weather out of the Galiuro Volcanics and have no significance for the assessment of resource potential. The tin and lead anomalies, which are from drainage basins near the boundary of the roadless area, are probably related to human contamination in areas where springs have been developed and where there has been a large amount of human traffic (hunters, picnickers, or ranchers).

Geophysical data (gravity, magnetic, and audiomagnetotelluric) indicate no significant features that

[1]With contributions from Ronny A. Martin, USGS.

can be confidently interpreted as being directly related to mineral deposits. The Galiuro Volcanics have generally lower magnetic susceptibilities than the overlying basalt. A magnetic high along the southern border of the roadless area possibly reflects an underlying extension of the Precambrian intrusive rocks exposed to the south that have high magnetic susceptibility but are not known to be mineralized. A broad magnetic low in the northwest corner of the roadless area probably reflects a thin basaltic cover over a thick section of rocks with low magnetic susceptibility (probably an extension of the Galiuro Volcanics). Therefore, these magnetic anomalies do not in themselves indicate the presence of significant mineralization. Reconnaissance gravity data show a broad gravity low over the central roadless area, which probably indicates the area where ash-flow tuffs and lava flows are at their maximum thickness. Resistivity contrasts between audiomagnetotelluric soundings just south of the roadless area suggest the possibility of a northwest-trending fault along the west face of the Winchester Mountains. Low resistivities at depth for two soundings and an entire low-resistivity section for another sounding plus low magnetic intensity suggest that the rocks may have been altered along the postulated fault, although there is no surface evidence of mineralization.

The Winchester mining district lies approximately 3 to 4 mi south of the southern boundary of the roadless area. The district was originally worked for silver in the 1870's, but has had little or no activity since the 1920's (Keith, 1973). Gold mineralization southeast of the roadless area occurs in a sliver of Paleozoic limestone in fault contact with Precambrian granite but geologic evidence indicates that this feature does not extend into the roadless area at the surface. Geophysical data suggests that it may extend into the roadless area in the subsurface, buried under a thick pile of Tertiary volcanic rocks.

A search of the Cochise County records revealed that no mining claims have been located in or near the roadless area. The only prospect in the roadless area was a small pit near the center of sec. 17, T. 12 S., R. 22 E. No mineralization was evident in the pit, which had been dug into volcanic rock.

Pan concentrates of stream-sediment samples in or near the Winchester Roadless Area assayed no significant gold and silver values.

Geologic, geochemical, geophysical, and mines and prospects surveys of the Winchester Roadless Area indicate that there is little promise for the occurrence of any metallic or nonmetallic resources.

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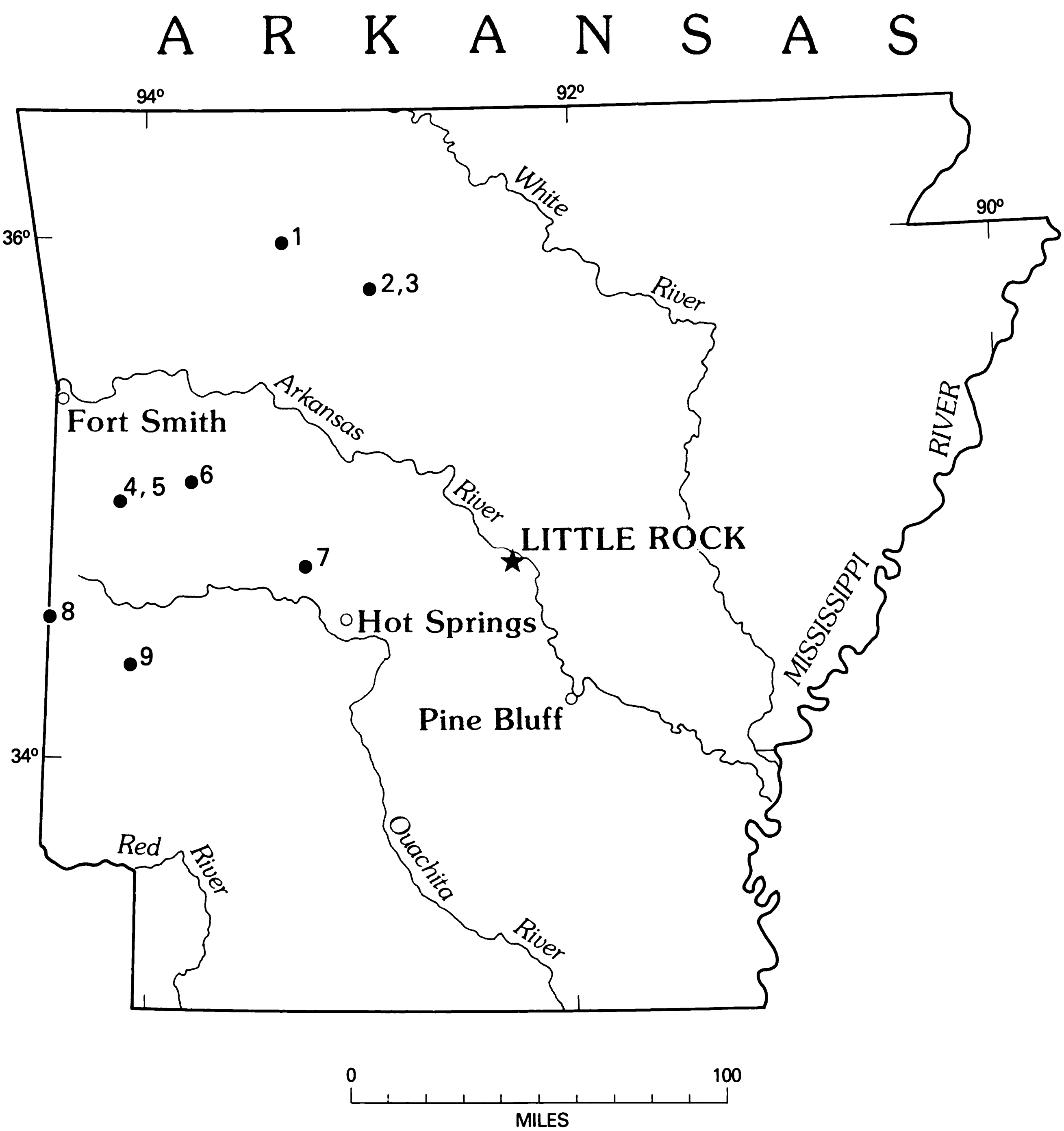

Location of areas studied.

ARKANSAS

Map No.	Name of Area
4	Bell Star East and West Roadless Areas
5	Belle Starr Cave Wilderness Study Area
8	Black Fork Mountain Roadless Area, Arkansas and Oklahoma
9	Caney Creek Wilderness
6	Dry Creek Wilderness Study Area
7	Little Blakely Roadless Area
2	Richland Creek Roadless Area
3	Richland Creek Wilderness Study Area
1	Upper Buffalo Wilderness and Buffalo Addition Roadless Area

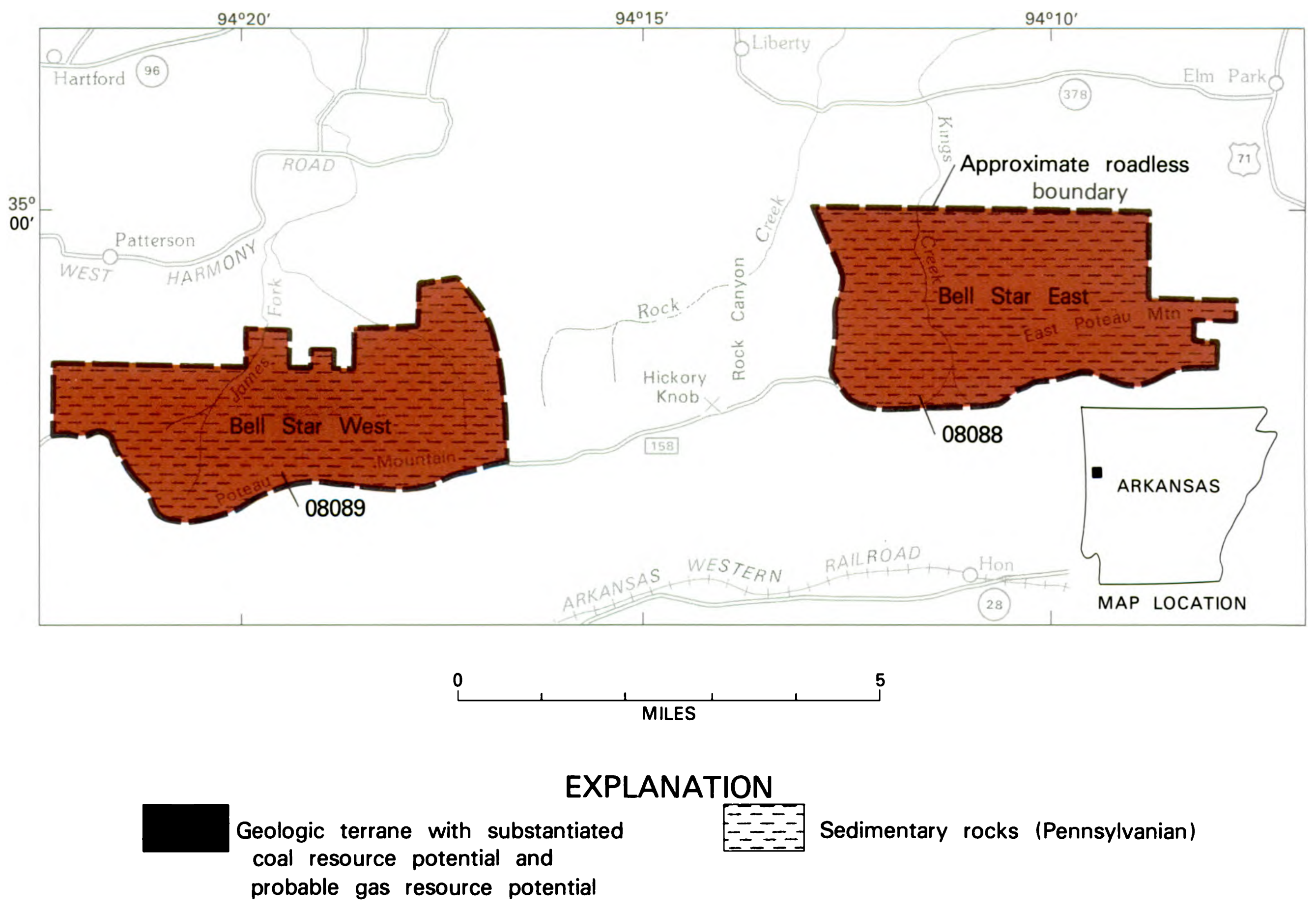

Figure 37.—Bell Star East and West Roadless Areas, Arkansas.

BELL STAR EAST AND WEST ROADLESS AREAS, ARKANSAS

By MARY H. MILLER, U.S. GEOLOGICAL SURVEY, and

LYLE E. HARRIS, U.S. BUREAU OF MINES

SUMMARY

On the basis of mineral and geologic surveys in 1981–82, it was concluded that Bell Star East and West Roadless Areas, Arkansas, have inferred resources of coal in areas of substantiated coal resource potential from the Lower Hartshorne coal bed at depths of 2000 to 4000 ft below the surface. These areas also have a probable potential for natural gas from the Atoka and Hall Formations at depths as much as 6000 ft below the surface. No metallic mineral resources were identified in the roadless areas.

CHARACTER AND SETTING

Bell Star East and West Roadless Areas cover about 18 sq mi in the Ouachita National Forest, Sebastian and Scott Counties, Arkansas. Access to the areas is by USFS Road 158 and by primitive, privately owned dirt roads that cut across private land.

Bell Star East and West Roadless Areas occupy the center and part of the north flank of the east-west trending Poteau syncline (Reinemund and Danilchik, 1957). The Pennsylvanian Savanna and McAlester Formations are exposed in the roadless areas, and the Pennsylvanian Atoka Formation and Hartshorne Sandstone are exposed on the outer flanks of the syncline (Haley, 1966; Haley and Hendricks, 1968).

MINERAL RESOURCES

There are no mines within the roadless areas; one coal prospect was found near West Creek in Bell Star West Roadless Area. Coal has been produced from the Lower Hartshorne coal bed in the McAlester Formation about 2.25 mi north and about 1 mi south of the roadless areas. This coal bed, which underlies the roadless areas at depths of 2000 to 4000 ft, contains 47.5 million short tons of inferred coal resources (Reinemund and Danilchik, 1957; Haley and others, 1980; Harris, 1981) and the roadless areas are classified as having substantiated coal resource potential. The Lower Hartshorne coal bed in the roadless areas also could contain coal bed gas (Harris, 1981) although no coal bed gas resources were identified.

Natural gas has been produced from the Mansfield field about 3 mi north of the roadless areas, and minor quantities from the Waldron syncline, about 4.5 mi southeast of the roadless areas. These wells produce from the Pennsylvanian Atoka Formation at depths as much as 6000 ft (Haley and others, 1980; W. M. Caplan, oral commun., 1982). There is a probable potential for natural gas in the roadless areas.

The Savanna and McAlester Formations contain stone, sand, and gravel useful to the construction industry, but these materials occur in abundance outside the roadless areas.

SUGGESTIONS FOR FURTHER STUDY

Drilling to determine thickness and continuity of the Lower Hartshorne coal bed would be necessary to completely evaluate the resource potential for coal in the roadless areas.

The potential for natural gas in the Atoka Formation within the roadless areas can be proved or disproved only by exploratory drilling.

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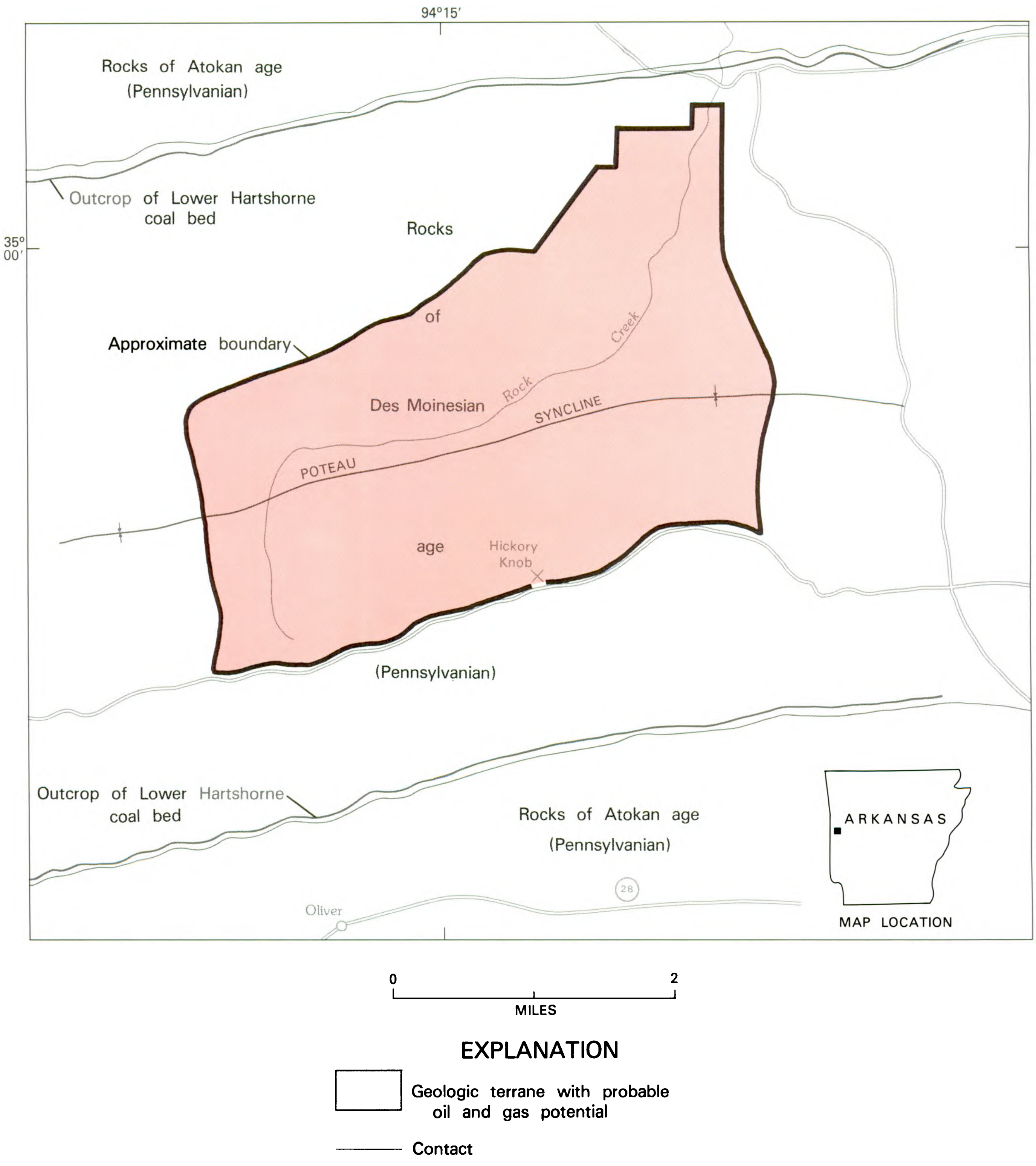

Figure 38.—Belle Starr Cave Wilderness Study Area, Arkansas.

BELLE STARR CAVE WILDERNESS STUDY AREA, ARKANSAS

By BOYD R. HALEY, U.S. GEOLOGICAL SURVEY, and

RAYMOND B. STROUD, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Belle Starr Cave Wilderness Study Area conducted in 1977 concluded that there is little promise for the occurrence of metallic mineral resources in the area. There is a probable resource potential for small quantities of natural gas. A coal bed that underlies the area contains demonstrated coal resources of about 22.5 million tons in a bed that averages less than 28 in. thick. Despite its contained coal, this area is not shown as having a coal resource potential.

CHARACTER AND SETTING

The Belle Starr Cave Wilderness Study Area covers an area of about 9.4 sq mi in parts of Sebastian and Scott Counties, west-central Arkansas. Rock Creek is an intermittent stream that has its headwaters in the southwestern part of the area and flows northeastward in a valley that, at its maximum, is about 1100 ft deep and 2 mi wide. The forest-covered valley walls are a series of slopes underlain by shale, and some bluffs as much as 40 ft high formed by the more resistant sandstone.

The rocks in the study area are sedimentary and are gently folded into the Poteau Syncline. They consist of shale, sandstone, and siltstone, a few thin coal beds of limited extent, and one coal bed (Lower Hartshorne) of wide extent. All of the rocks at the surface are part of the Des Moinesian Series of Middle Pennsylvanian age.

MINERAL RESOURCES

The Lower Hartshorne coal bed extends under the study area and has been mined at the surface and in the subsurface north and south of the study area. Assuming an average thickness of the coal at 2 ft (it may be more), there is a demonstrated resource of 22.6 million short tons of coal under the Belle Starr Cave Wilderness Study Area. Demonstrated coal resources are estimated separately for beds more than 28 in. thick and for beds less than 28 in. thick. Beds more than 28 in. thick are considered as areas of substantiated coal resource potential, but because the Lower Hartshorne coal bed more than likely averages less than 28 in. thick, no coal resource potential is shown on the map.

Natural gas was discovered in 1902 about 3 mi north of the study area. Wells drilled since that date have produced gas from sandstone reservoirs of Atokan age to depths of about 6000 ft. The southern limit of that gas field (Mansfield) has not been established by dry holes, and shows of gas have been reported from wells drilled through similar Atokan rocks about 7 mi southeast of the study area. Because these Atokan age rocks are present at depth underneath the study area, the area has been assessed to have a probable resource potential for small volumes of gas.

Some of the sandstone in the area could be used as flagstone or aggregate and some of the shale could be used in the brick industry. Stone of equal quality is present elsewhere in west-central Arkansas.

There is little promise for the occurrence of metallic mineral resources according to the data derived from geochemical studies of outcropping rocks and stream sediments (Haley and others, 1980).

REFERENCE

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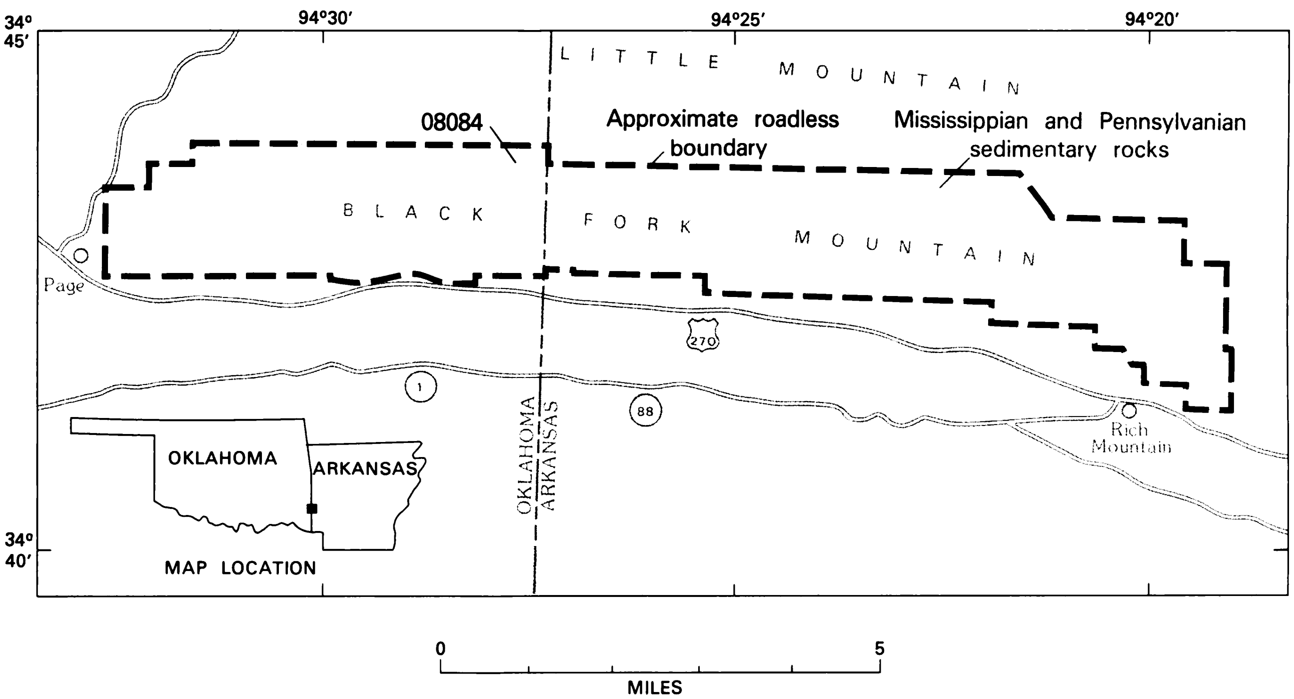

Figure 39.—Black Fork Mountain Roadless Area, Arkansas and Oklahoma.

BLACK FORK MOUNTAIN ROADLESS AREA, ARKANSAS AND OKLAHOMA

By MARY H. MILLER,[1] U.S. GEOLOGICAL SURVEY

SUMMARY

On the basis of a mineral survey in 1982, the Black Fork Mountain Roadless Area has little promise for the occurrence of metallic mineral resources. Stone and sand and gravel suitable for construction purposes occur in the Jackfork Sandstone and the Stanley Shale which also occur outside the roadless area. Although the potential for gas and oil is unknown and no resource potential was identified, some investigators believe that there is a possibility for the occurrence of gas and oil in the roadless area.

CHARACTER AND SETTING

Black Fork Mountain Roadless Area covers about 21 sq mi in the Ouachita National Forest in Polk County, Arkansas and LeFlore County, Oklahoma. Access to the area is principally via U.S. Highway 270 and USFS roads.

The north flank of Eagle Gap syncline makes up Black Fork Mountain. The area is bounded on the north and south by high-angle thrust faults, and the stratigraphic displacement may be as much as 25,000 ft (Seely, 1963). Formations exposed in the roadless area are the Pennsylvanian Atoka Formation, the Pennsylvanian and Mississippian Jackfork Sandstone, and the Mississippian Stanley Shale (Seely, 1963).

MINERAL RESOURCES

Between 1900 and 1918, impsonite, a nearly infusible asphaltic pyrobitumin with a high-fixed carbon content, was mined from a deposit near Page, Oklahoma for its vanadium content (Ham, 1956). Although this material is present in the roadless area in fissures and along a bedding plane in the Jackfork Sandstone, no resource potential was identified.

Good-quality rock for construction purposes occurs in the Jackfork and Stanley Formations throughout the roadless area.

Most of the area is leased for gas and oil, and although no oil and gas potential was identified, some investigators believe there is a possibility for the occurrence of gas and oil in this area from rocks of Arbuckle (Cambrian and Ordovician) age or younger (C. G. Stone, oral commun., 1983).

SUGGESTIONS FOR FURTHER STUDY

Deep exploratory drilling to determine the gas and oil potential seems desirable.

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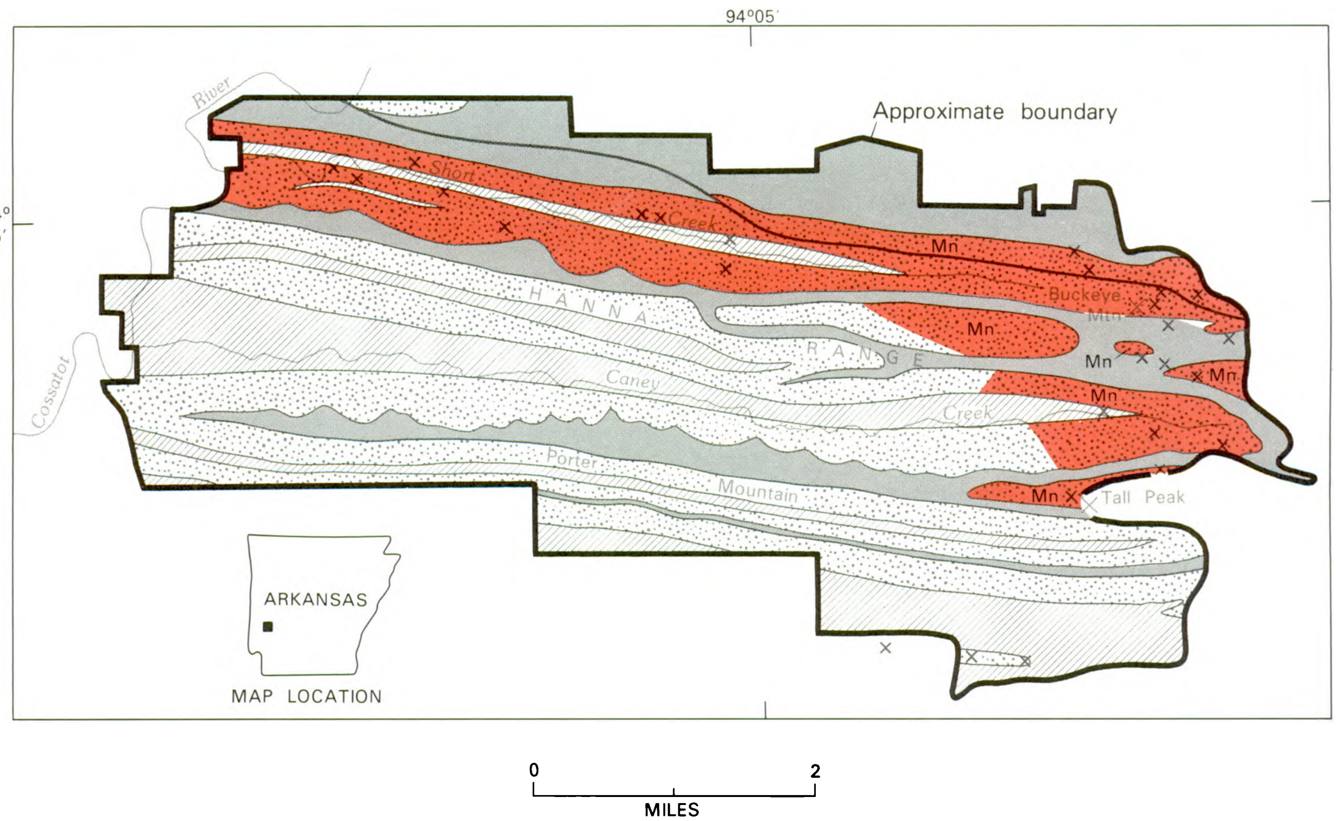
Seely, D. R., 1963, Structure and stratigraphy of the Rich Mountain area, Oklahoma and Arkansas: Oklahoma Geological Survey Bulletin 101, 173 p.

[1]With contributions by Marjorie C. Smith, USGS.



EXPLANATION

Geologic terrane with substantiated mineral-resource potential

Mn — Manganese

× — Mineral occurrence

Stanley Shale (Mississippian)

Arkansas Novaculite (Mississippian and Devonian)

Formations older than Arkansas Novaculite (Paleozoic)

Contact

Fault

Figure 40.—Caney Creek Wilderness, Arkansas.

CANEY CREEK WILDERNESS, ARKANSAS

By GEORGE E. ERICKSEN,[1] U.S. GEOLOGICAL SURVEY, and

MAYNARD L. DUNN, JR., U.S. BUREAU OF MINES

SUMMARY

Metallic and nonmetallic mineral resources identified in the Caney Creek Wilderness during a study in 1978, include many small manganese deposits in areas of substantiated manganese resource potential and moderate to large deposits of novaculite, tripoli, shale, and slate. Small amounts of hand-sorted manganese-oxide ore have been recovered from several of the manganese deposits during sporadic mining activity from the late 1880's to the mid-1950's. Additional manganese resources remain in the known deposits, but the amount in any given deposit is small. Large resources of novaculite, tripoli, shale, and slate are in the wilderness but even larger resources exist in this region outside the wilderness and nearer to markets. No energy resources were identified in this study.

CHARACTER AND SETTING

The Caney Creek Wilderness extends over an area of 22.5 sq mi in the Cossatot Mountains, a southern segment of the Ouachita Mountains of west-central Arkansas. The area is elongate, being about 8 mi long and 3–3.5 mi wide. Located in Polk County, Arkansas, the northwest corner of the wilderness is 12 air miles southeast of Mena, the county seat. The wilderness is accessible by State Route 375 from Mena and by State Route 246 from U.S. Highway 71, south of Mena. The area is encircled by unimproved roads, and the interior is accessible by a well-maintained trail along Caney Creek and an unmaintained trail that follows a former road along Short Creek.

The wilderness encompasses three prominent east-west ridges and the intervening valleys of Caney and Short Creeks, which drain westward into the Cossatot River. Altitudes range from 940 ft at the confluence of Caney Creek and the Cossatot River to 2320 ft at Buckeye Mountain, the highest peak in the wilderness. The crests of the three principal ridges slope gently westward from altitudes of 2000–2300 ft in the east to 1500–1700 ft in the west.

The wilderness is in a region of deformed Paleozoic sedimentary rocks having an aggregate thickness of 8000–9000 ft. Six formations crop out in the wilderness. From oldest to youngest these are Ordovician Bigfork Chert and Polk Creek Shale, Silurian Blaylock Sandstone and Missouri Mountain Shale, Devonian and Mississippian Arkansas Novaculite, and Mississippian Stanley Shale. The highly resistant, ridge-forming Arkansas Novaculite, about 900 ft thick, is the dominant formation in the wilderness. The Stanley Shale is about 6000 ft thick, and is by far the thickest formation in this region. Only the lower part of this formation is exposed in the wilderness. The Arkansas Novaculite and Stanley Shale were of particular interest in our study because at many places in western Arkansas these formations contain mineral deposits, chiefly manganese-oxide and tripoli in the Arkansas Novaculite and bedded barite in the Stanley Shale. The novaculite is also the source of the famed Arkansas wetstones.

The Paleozoic sedimentary rocks were intensely deformed during late Paleozoic orogeny, which produced tightly folded anticlines and synclines. The repetition of formations across the wilderness is the result of erosion of these folds.

Our investigations included reconnaissance geochemical sampling of stream sediments and rocks, field checking and modifying existing geologic maps, examination and sampling of prospects, and a search of courthouse records for mining claims in the wilderness. This report is based on the results of these investigations (Ericksen and others, in press).

[1]With contributions from S.H. Patterson, USGS, and D. K. Harrison, USBM.

MINERAL RESOURCES

Manganese oxide is the only mineral commodity that has been produced from the wilderness. Most of the manganese deposits are in the northeastern section of the wilderness where deposits were first prospected in the late 1880's; a few deposits are scattered westward along Short Creek valley. Prospect workings on the lower north slope of Tall Peak, opened by the Arkansas Development Company in 1887–1889, consisted of two adits, the longest of which was 100 ft. Other prospect workings were opened on Buckeye Mountain at this time. Additional prospecting was done in the Buckeye Mountain-Tall Peak area during World Wars I and II, when some manganese oxide was mined, but most of the work in this area apparently was done during the 1950's in response to the U.S. stockpile purchase program. Aerial photographs taken in the mid-1950's and courthouse records indicate that most prospecting and mining of manganese along Short Creek was done during the stockpile purchase program.

The total tonnage of manganese oxide produced from the wilderness is not known, but to judge from incomplete production records it could not have been more than a few hundred tons. Manganese oxide resources exist in small deposits, and it is possible that additional resources exist in yet-to-be-found deposits in the wilderness. However, it is unlikely that any undiscovered deposits are larger or richer than the identified deposits.

The manganese deposits of the Caney Creek Wilderness occur chiefly in the upper of the three major units that comprise the Arkansas Novaculite, and near the top of the lower unit. All are of secondary origin, having formed as local concentrations of manganese oxides deposited from ground water that had previously leached the manganese from manganese-bearing carbonate minerals in the novaculite and perhaps other Paleozoic formations. The deposits consist of the manganese oxide minerals pyrolusite, hausmannite, lithiophorite, and cryptomelane occurring chiefly as irregular masses and short veins within linear zones of fractured and brecciated novaculite. A few occurrences are in other formations near the contact with the novaculite. Deposits that have been prospected are commonly a few tens of feet to about a hundred feet long and a few feet to 10 or 20 ft wide. Masses of high-grade manganese ore are rarely more than a few feet in maximum dimensions.

Relatively pure manganese oxide ore ranges from about 29 percent to 40 percent manganese, and it is estimated that most of the hand-sorted ore shipped from the wilderness contained about 40 percent manganese. The manganese ore also contains small amounts of copper, zinc, nickel, and cobalt. The total content of these metals in most ore is less than 1 percent, but samples collected in the present study show maximum values of 1.5 percent copper, 0.3 percent zinc, 0.2 percent nickel, and 0.3 percent cobalt. Such values suggest that these metals are potential byproducts of the manganese resources. There is a substantiated potential for manganese resources in the area.

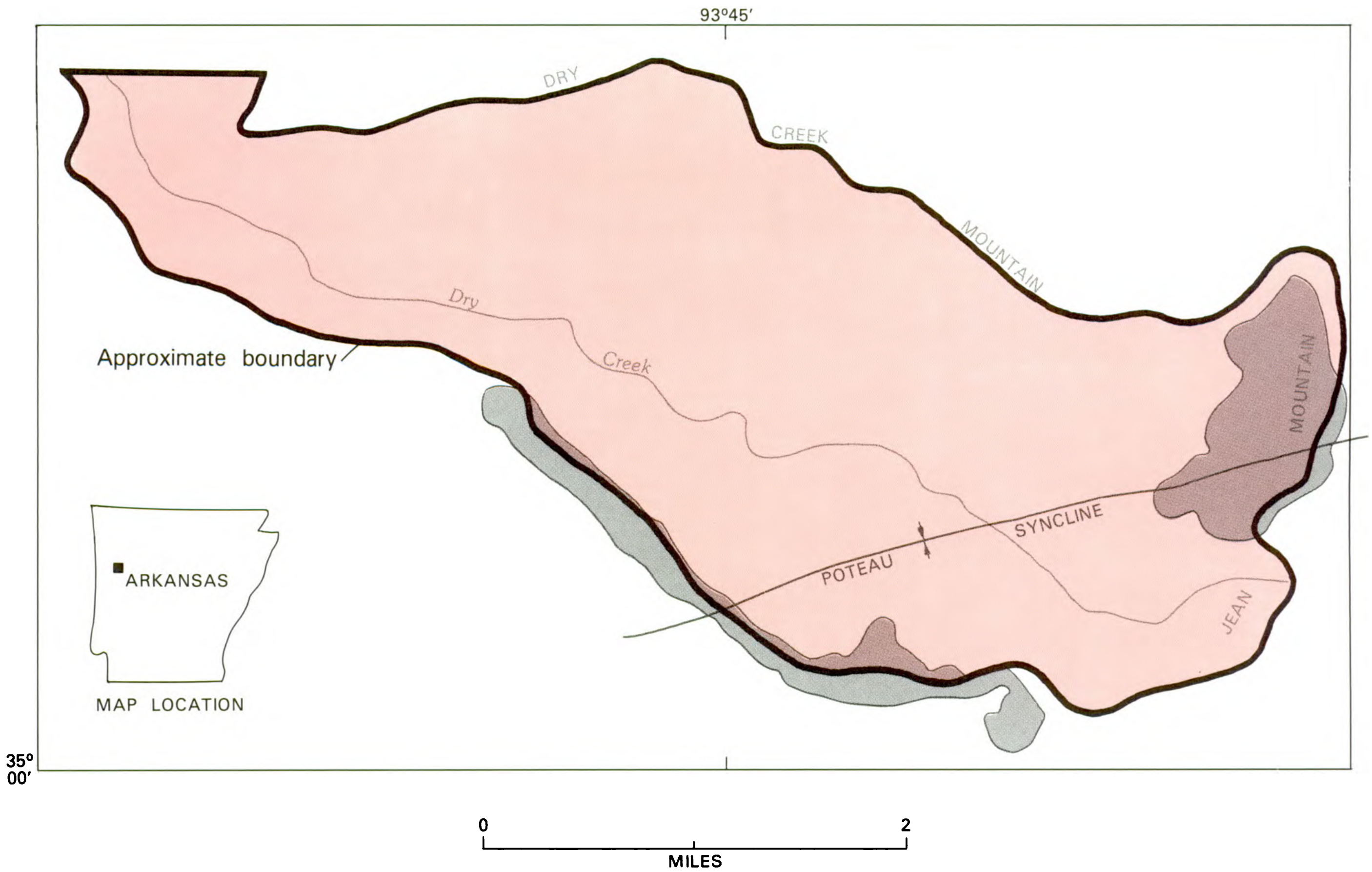
Novaculite suitable for whetstones occurs in the Arkansas Novaculite. Several thousand tons of tripoli, a weathering product of the Arkansas Novaculite, was mined from an open cut about 600 ft south of the southeastern margin of the wilderness. This deposit extends into the wilderness to the east, where it has been prospected. Small amounts of slate have been mined from the Missouri Mountain Shale in Polk County, outside the wilderness. However, the slate in this formation and in other formations in and near the wilderness is relatively low grade, and no slate has been mined in Polk County since the 1950's. Some of the shale in the Stanley Shale is suitable for heavy clay products and brick, and slaty material from the Bigfork Chert will bloat with heat, so that it might be suitable for lightweight aggregate. Although deposits of novaculite, tripoli, shale, and slate occur in the wilderness, large resources of these materials occur widely in the Ouachita Mountains outside the wilderness.

SUGGESTIONS FOR FURTHER STUDIES

Known manganese oxide deposits should be mapped and core drilled, and a search for other deposits be made. New manganese oxide deposits would be expected to occur chiefly in the upper and lower units of the novaculite, and might best be located by detailed geochemical sampling. The most favorable areas for finding such deposits are the northern and northeastern part of the wilderness where the identified deposits occur.

REFERENCES

Ericksen, G. E., Patterson, S. H., Dunn, M. L., and Harrison, D. K., in press, Mineral resources of the Caney Creek Wilderness, Polk County, Arkansas: U.S. Geological Survey Bulletin 1551.



EXPLANATION

Geologic terrane with probable natural gas potential

Rocks of Des Moinesian age

Rocks of Atokan age

Contact

Figure 41.—Dry Creek Wilderness Study Area, Arkansas.

DRY CREEK WILDERNESS STUDY AREA, ARKANSAS

By BOYD R. HALEY, U.S. GEOLOGICAL SURVEY, and

RAYMOND B. STROUD, U.S. BUREAU OF MINES

SUMMARY

A mineral evaluation study of the Dry Creek Wilderness Study Area indicated that the area has a probable resource potential for natural gas and little promise for the occurrence of other mineral commodities.

CHARACTER AND SETTING

The Dry Creek Wilderness Study Area covers an area of about 10 sq mi in parts of Logan, Scott, and Yell Counties, Arkansas. Dry Creek, an intermittent stream that has its headwaters in the extreme southeastern part of the area, flows to the northwest through a canyon that at its maximum is about 800 ft deep and 1.5 mi wide. The study area is entirely within this canyon and extends over nearly all of the drainage basin of Dry Creek. The results of a mineral survey of the area were published by Haley and others (1980).

The rocks in the area consist of shale, sandstone, and some siltstone and are folded into the Poteau Syncline. Most of the rocks are of Atokan age with rocks of Des Moinesian age (both Middle Pennsylvanian) capping the hills on the south side and east end.

MINERAL RESOURCES

Geochemical studies indicate that the study area has little promise for the occurrence of metallic mineral resources. Coal is not known to be present in the area. Sandstone suitable for use in construction occurs in the study area, but equal quality sandstone occurs elsewhere.

Less than 100,000 cu ft/day of natural gas is being produced from one well about 4 mi north of the area. Two wells drilled south of that well and one well drilled about 8 mi southeast of the area were reported as dry holes. Small quantities of natural gas may be present in the rocks under the Dry Creek Wilderness Study Area and the area has a probable gas resource potential.

REFERENCE

Haley, B. R., Earhart, R. L., and Stroud, R. B., 1980, Mineral resources of the Dry Creek Wilderness Study Area, Logan, Yell, and Scott Counties, Arkansas: U.S. Geological Survey Open-File Report 80-355, 13 p.

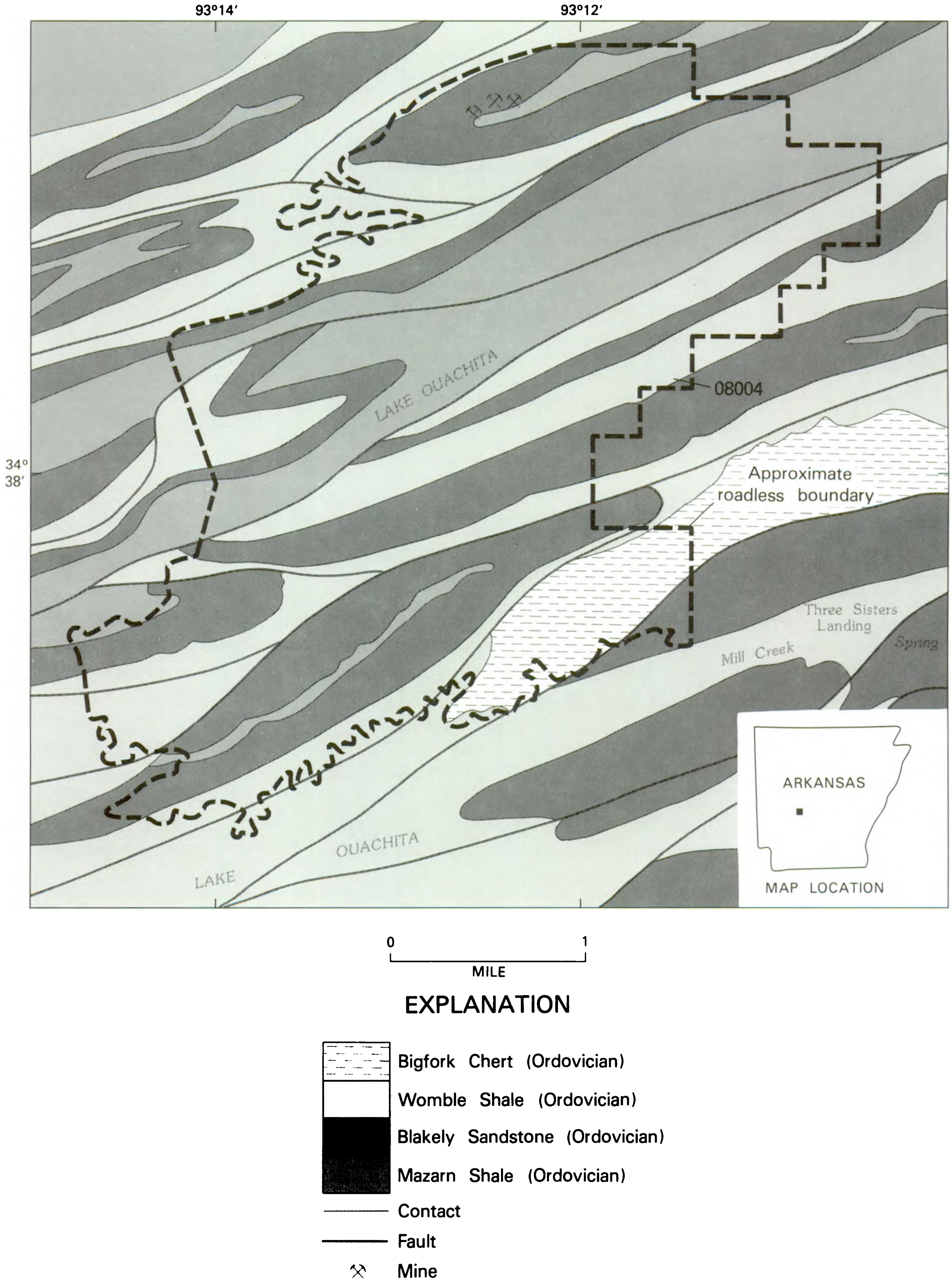


Figure 42.—Little Blakely Roadless Area, Arkansas.

LITTLE BLAKELY ROADLESS AREA, ARKANSAS

By MARY H. MILLER, U.S. GEOLOGICAL SURVEY, and

ROBERT H. WOOD II, U.S. BUREAU OF MINES

SUMMARY

Based on geologic and geochemical surveys in 1981, Little Blakely Roadless Area has little promise for the occurrence of metallic mineral resources or for the occurrence of oil and gas. Quartz crystal occurs in the Blakely Sandstone and the Womble Shale (Engel, 1951).

CHARACTER AND SETTING

Little Blakely Roadless Area covers about 9 sq mi of the Ouachita National Forest in Garland County, Arkansas. Access to the western, northern, and southern portions of the roadless area is by boat from Lake Ouachita. Access to the eastern parts of the area is by unimproved logging roads.

Strata in the Ouachita Mountains are folded, overturned, and thrust faulted toward the north (Haley and others, 1979). Formations exposed in the Little Blakely Roadless Area are the Mazarn Shale and Blakely Sandstone of Early Ordovician age, the Womble Shale of Early and Middle Ordovician age, and the Bigfork Chert of Middle Ordovician age (Haley and others, 1979).

MINERAL RESOURCES

Quartz crystal has been mined from this region for more than 50 years. Although crystal occurs in the Womble Shale, Crystal Mountain Sandstone (outside the area), and the Blakely Sandstone, only the Blakely Sandstone has produced significant amounts of crystal from or near the roadless area. Mines were operated in secs. 11 and 12, T. 1 S., R. 21 W. on the W. T. Beard property. Although the quartz crystal occurs in the roadless area, these quartz crystal-bearing formations are exposed over large areas outside of the area.

Phosphate occurs in the Mazarn and Womble Shales and in the Bigfork Chert in Garland County (C. G. Stone, written commun., 1982), and phosphate and vanadium are present in wavellite in the Bigfork Chert near Avant and Mountain Pine, Arkansas (C. G. Stone, written commun., 1982; Foster and Schaller, 1966). Although the Mazarn and Womble Shales and the Bigfork Chert crop out in the roadless area, it is unlikely that the size of the phosphate occurrences or the size and vanadium content of wavellite occurrences are sufficient for either to be identified as having resource potential (J. B. Cathcart, oral commun., Jan. 1983).

Although some gas has been produced from the 25-1 Weyerhaeuser well in the Ouachita Mountains core area in southeastern Oklahoma, core areas, including the area of Little Blakely Roadless Area (Caplan, 1963; Haley and others, 1979), have little promise for the occurrence of oil or gas (Goldstein, 1975; Miller and others, 1983).

Geochemical analyses of stream-sediment and rock samples from Little Blakely Roadless Area indicate that there is no significant mineralization in the rock formations exposed within the roadless area (Miller and others, 1983).

A Bouguer gravity map of Arkansas (Hendricks and others, 1981) shows no anomalies in the roadless area.

SUGGESTIONS FOR FURTHER STUDIES

Although quartz crystal probably will continue to be discovered in formations in the region, such deposits within the Little Blakely Roadless Area would not be sufficiently unique to justify additional study of the roadless area. Deposits of phosphate and vanadium elsewhere that have greater significance make it unlikely that either of these commodities will soon be sought from the Little Blakely Roadless Area. Exploration for oil and gas in this region appears unlikely to meet with significant positive results.

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RICHLAND CREEK ROADLESS AREA, ARKANSAS

By MARY H. MILLER, U.S. GEOLOGICAL SURVEY, and

ROBERT H. WOOD II, U.S. BUREAU OF MINES

SUMMARY

On the basis of geologic and mineral surveys made in 1981, Richland Creek Roadless Area, Arkansas, has little promise for the occurrence of metallic mineral resources, gas and oil, or oil shale. The Boone Formation of Mississippian age and the Everton Formation of Ordovician age, both known to contain zinc and lead deposits in northern Arkansas, underlie the roadless area. The presence or absence of zinc and lead deposits in these formations in the subsurface can be neither confirmed nor ruled out without exploratory drilling. Most of the Richland Creek Roadless Area is under lease for oil and gas; however two wells drilled near the eastern boundary of the area did not show contained gas or oil.

CHARACTER AND SETTING

Richland Creek Roadless Area covers about 15 sq mi in the Ozark National Forest, Newton and Searcy Counties, Arkansas. Access to the area is by USFS roads.

Strata in the area of Richland Creek are nearly horizontal. A normal fault extending across the southern part of the area displaces beds a maximum of 280 ft (Glick and Frezon, 1965). Formations exposed in the roadless area are Mississippian carbonates, sandstones, and shales; and Pennsylvanian sandstones, siltstones, and shales. Beds in the subsurface include Devonian or Silurian limestones, and Ordovician shales, sandstones, and carbonates (Glick and Frezon, 1965; Haley and others, 1980).

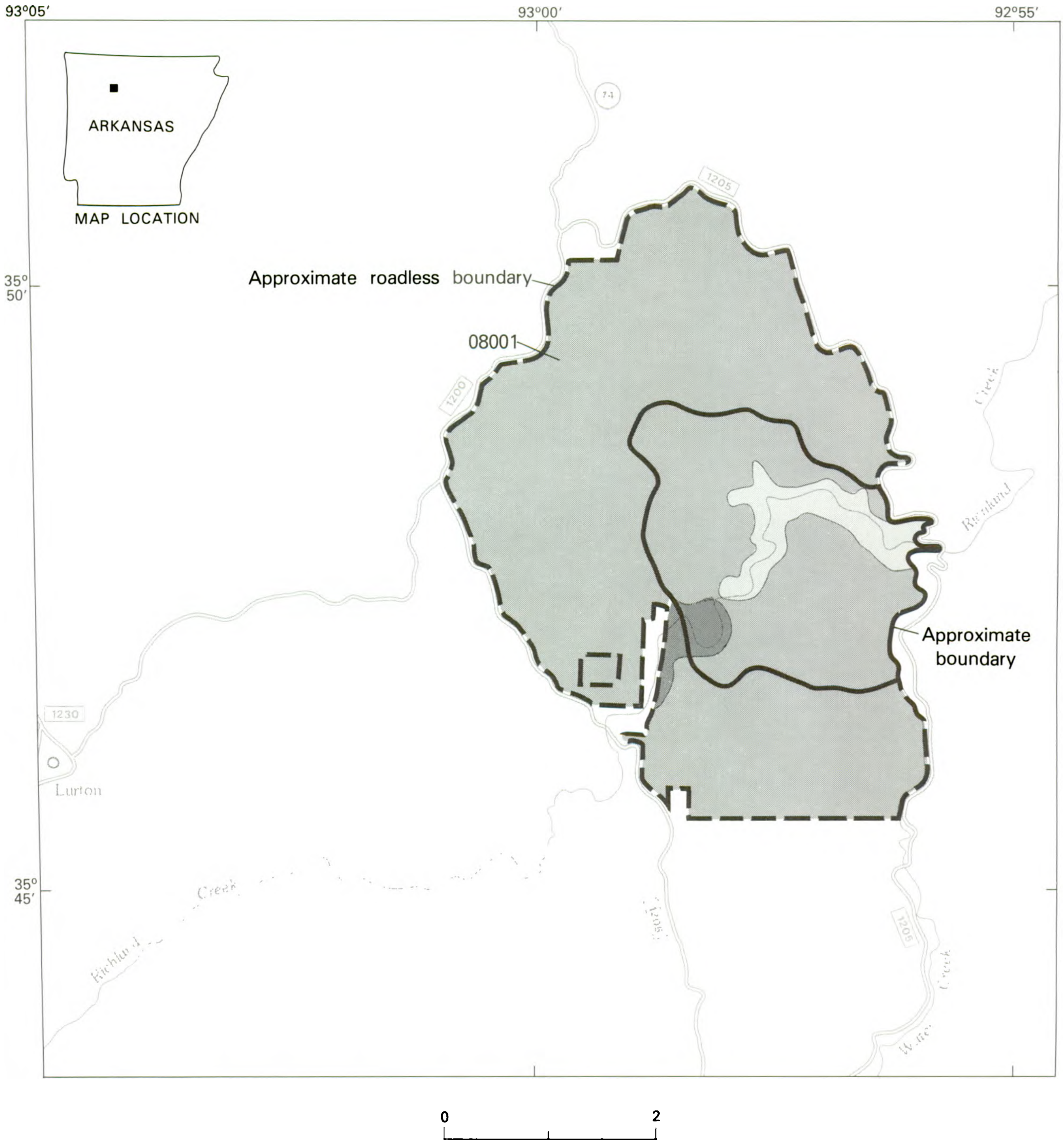
MINERAL RESOURCES

No mining districts lie in or adjacent to the Richland Creek Roadless Area. About 4700 tons of zinc and lead concentrates were produced during World War I from the Cave Creek district, about 3 mi north of the roadless area (McKnight, 1935). Zinc and lead deposits in the Cave Creek district are related to faults and fractures in the Boone Formation. The Boone Formation underlies the roadless area, and faults are present in the southern part of the roadless area. The Everton Formation, zinc- and lead-bearing in northern Arkansas, probably is buried 800–1500 ft below the surface. The resource potential of these formations cannot be assessed without exploratory drilling. The zinc and lead contents of surface samples analyzed in this study are very low and there is little or no promise for the occurrence of zinc and lead resources in surface or near surface rock units. No potential for zinc and lead resources was identified along the fault zone in the southern part of the area.

The Batesville Sandstone, Fayetteville Shale, and Pitkin Limestone of Mississippian age and the middle and upper units of Morrowan age may be possible reservoir rocks for natural gas, and the Fayetteville Shale and middle and upper Morrowan units may be sources of shale oil. Shales from the Fayetteville Shale and from the middle unit of Morrowan age are somewhat petroliferous, but Fischer assays of shale samples do not show commercial oil concentrations (Haley and others, 1980). No resource potential for gas and oil was identified in this study.

SUGGESTIONS FOR FURTHER STUDIES

Deep exploratory drilling along the fault in the southern part of Richland Creek Roadless Area will confirm the presence or absence of zinc and lead deposits. Exploratory drilling for natural gas is necessary to ascertain its presence or absence.



EXPLANATION

- Alluvium (Quaternary)
- Morrowan sedimentary rocks (Pennsylvanian)
- Sedimentary rocks (Mississippian)
- Contact

Figure 43.—Richland Creek Roadless Area, Arkansas.

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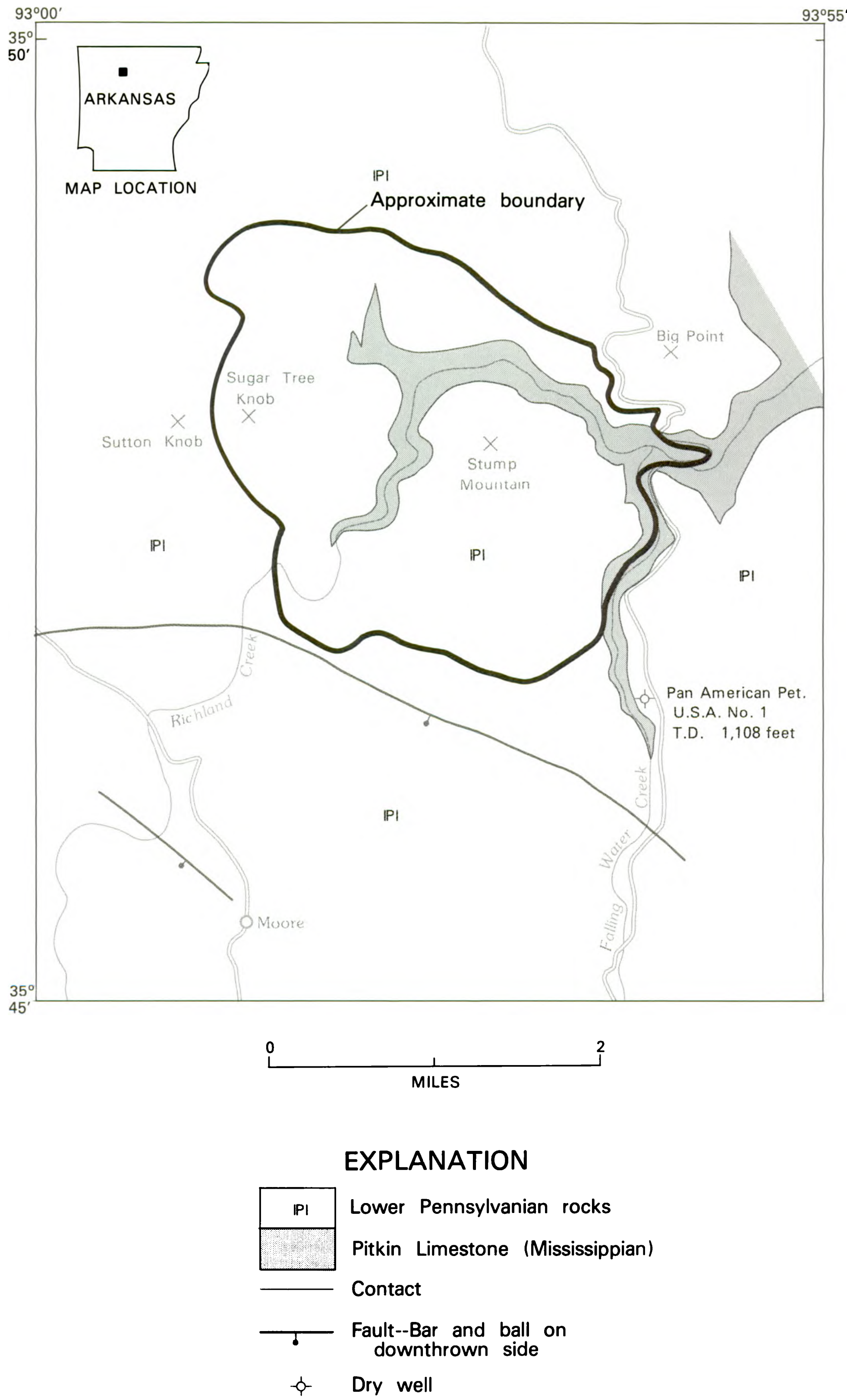

Figure 44.—Richland Creek Wilderness Study Area, Arkansas.

RICHLAND CREEK WILDERNESS STUDY AREA, ARKANSAS

By BOYD R. HALEY, U.S. GEOLOGICAL SURVEY, and

RAYMOND B. STROUD, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Richland Creek Wilderness Study Area indicated that the rocks in the area have little promise for the occurrence of energy or metallic mineral resources.

CHARACTER AND SETTING

The Richland Creek Wilderness Study Area covers an area of about 5 sq mi in parts of Newton and Searcy Counties, Arkansas. Richland Creek flows eastward through the study area in a narrow steep-sided valley that is about 1 mi wide and 1000 ft deep. The forest-covered valley walls are a series of shale slopes and sandstone bluffs. The bluffs are as much as 100 ft high. The resource potential of the area was evaluated and the results published by Haley and others (1980).

The rocks exposed at the surface in the study area are sedimentary, dip south at about 100 ft/mi, and are of two ages: limestone and subordinate amount of shale of the Pitkin Limestone of Late Mississippian age are found along Richland Creek; and, above the Pitkin, shale, sandstone, siltstone and some limestone of Morrowan or Early Pennsylvanian age are found.

The Pan American Petroleum Corporation U.S.A. No. 1 well drilled about 0.5 mi east of the study area penetrated limestone, shale, and chert of Mississippian age, limestone of Silurian age, and limestone and sandstone of Late Ordovician age.

MINERAL RESOURCES

Geochemical studies of the outcropping rocks and stream sediments in the study area indicate that these rocks have little promise for the occurrence of metallic mineral resources. Lead, zinc, and manganese whose common ore minerals are galena, sphalerite, and psilomalene have been mined from older rocks (Mississippian Boone Formation, Orodvician Cason Shale, and Fernvale Formation) to the north and east of the study area, but were not noted in the samples of these formations where they were penetrated by the Pan American Petroleum Corp. U.S.A. No. 1 well.

There is little promise for the occurrence of natural gas within the area because the Pennsylvanian age rocks have been breached by erosion and the other potential reservoir (Devonian to Middle Ordovician) rocks were reported as dry in the U.S.A. No. 1 well.

Some of the sandstone and limestone could be used for commercial purposes but equal or better quality stone is present in more accessible parts of northern Arkansas.

REFERENCE

Haley, B. R., Earhart, R. L., and Stroud, R. L., 1980, Mineral resources of the Richland Creek Wilderness Study Area, Newton and Searcy Counties, Arkansas, 1980: U.S. Geological Survey Open-file Report 80-354, 29 p.

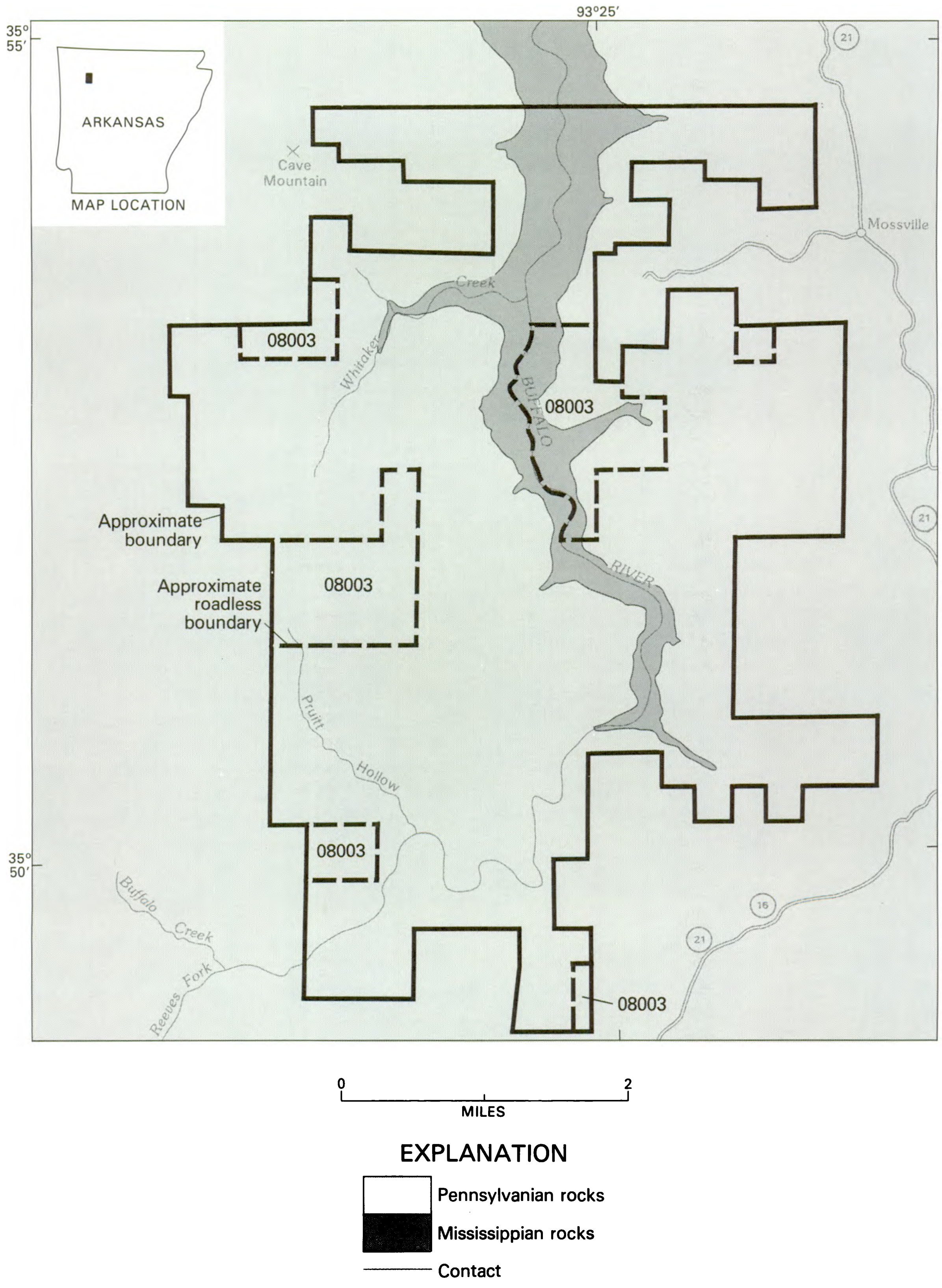

Figure 45.—Upper Buffalo Wilderness and Buffalo Addition Roadless Area, Arkansas.

UPPER BUFFALO WILDERNESS AND BUFFALO ADDITION ROADLESS AREA, ARKANSAS

MARY H. MILLER, U.S. GEOLOGICAL SURVEY, and

MICHELLE K. ARMSTRONG, U.S. BUREAU OF MINES

SUMMARY

On the basis of geologic and geochemical surveys by the USBM in 1977 and 1979, and by the USGS in 1982, the Upper Buffalo Wilderness and Buffalo Addition Roadless Area in northwestern Arkansas have little promise for the occurrence of metallic mineral or energy resources.

CHARACTER AND SETTING

The Upper Buffalo Wilderness and Buffalo Addition Roadless Area (referred to here as study area) covers about 19 sq mi in the Ozark National Forest, Newton County, Arkansas. Access to the area is by Arkansas State Highways 16 and 21 and by USFS roads. Interior access is difficult because of 40–80 ft bluffs at about 1900 ft.

Strata in the area are nearly horizontal, and no faults have been mapped in the study area. Formations exposed in the study area consist of Mississippian and Pennsylvanian limestone, sandstone, and shale. Ordovician carbonate rocks are present in the subsurface (Morrison, 1971; Zachry and Haley, 1975). Interpretation by several investigators (Smith, 1978; Konig, 1974; Kirk and Walters, 1968) of lineaments shown on LANDSAT imagery indicate that zinc-lead deposits in the Ponca-Boxley district to the north of the area coincide with a northeast-trending lineament. It is thought that this lineament reflects a major fracture or shear zone in the Earth's crust that functioned as a channelway for fluid migration (Konig, 1974). Another similar lineament crosses the area coincident to part of the Upper Buffalo River (Kirk and Walters, 1968).

MINERAL RESOURCES

There are no mines or prospects within the study area; however, the nearby Ponca-Boxley and Little Buffalo districts produced about 7200 tons of zinc and lead concentrates intermittently from the time of the Civil War through World War I (McKnight, 1935). Ores in these districts are associated with fractures and minor faults in the Mississippian Boone Formation. The Boone crops out in the northern part of the area and underlies the entire study area.

No metal-bearing minerals were observed during geologic mapping, and analyses for zinc and lead contents in surface rock and sediment samples from the study area are not anomalous (Miller and others, 1983). No drilling information is available so an assessment of the mineral-resource potential for zinc and lead or other metals in the Boone Formation and the underlying Ordovician Everton Formation (McKnight, 1935; Smith, 1978; Konig, 1974; Kirk and Walters, 1968) cannot be made at this time.

SUGGESTIONS FOR FURTHER STUDIES

Exploratory drilling into the Boone Formation and (or) the Everton Formation will be necessary to evaluate the mineral-resource potential of zinc and lead in the study area.

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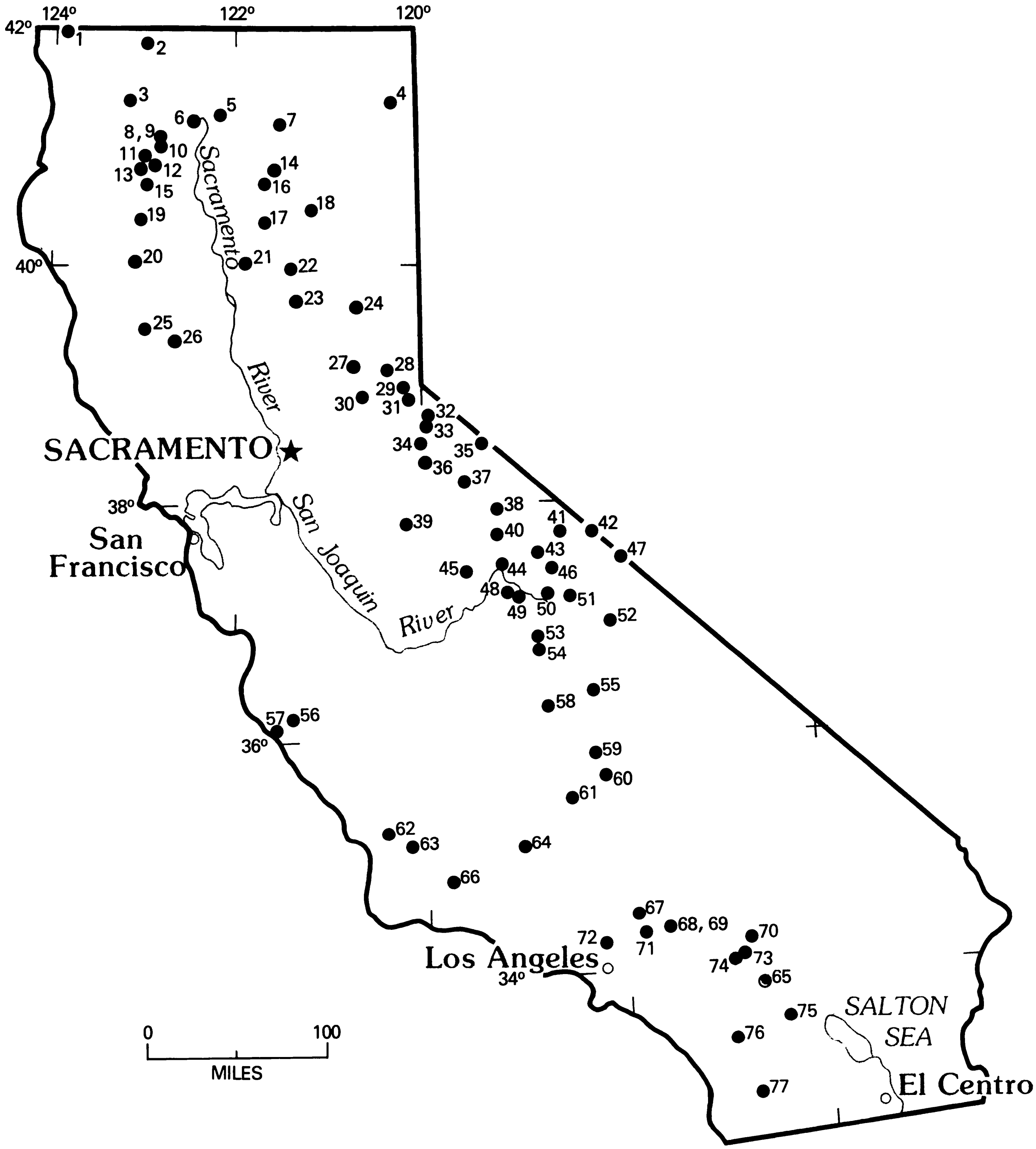
C A L I F O R N I A



Location of areas studied.

CALIFORNIA

Map No.	Name of Area
76	Agua Tibia Primitive Area
52	Andrews Mountain, Mazourka, and Paiute Roadless Areas
72	Arroyo Seco Roadless Area
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41	Benton Range Roadless Area
25	Black Butte and Elk Creek Roadless Areas
47	Blanco Mountain and Black Canyon Roadless Areas
22	Bucks Lake and Chips Creek Roadless Areas
46	Buttermilk Roadless Area
75	Cactus Spring Roadless Area
17	Caribou Wilderness and Trail Lake Roadless Area
36	Carson-Iceberg Roadless Areas
19	Chanchelulla Roadless Area
2	Condrey Mountain Roadless Area
51	Coyote Southeast and Table Mountain Roadless Areas
69	Cucamonga Roadless Areas
61	Cypress Roadless Area
31	Desolation Valley Wilderness
71	Devil Canyon-Bear Canyon Primitive Area
49	Dinkey Lakes Roadless Area
59	Domeland Wilderness, Domeland Addition, and Woodpecker Roadless Areas
32	East part of the Raymond Peak Roadless Area
24	East Yuba and West Yuba Roadless Areas
37	Emigrant Basin and Hoover Wildernesses and adjoining roadless areas
13	Fisher Gulch Roadless Area
33	Freel and Dardanelles Roadless Areas
55	Golden Trout Wilderness
28	Granite Chief Wilderness study area
12	Granite Peak Roadless Area
53	High Sierra Primitive Area
21	Ishi, Mill Creek, Polk Springs, and Butt Mountain Roadless Areas
50	John Muir Wilderness
48	Kaiser Wilderness
54	Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas
10	Lake Eleanor Roadless Area
43	Laurel-McGee and Wheeler Ridge Roadless Areas
14	Lost Creek Roadless Area
3	Marble Mountain Wilderness
40	Minarets Wilderness and adjacent areas
63	Miranda Pine, Horseshoe Springs, Tepusquet Peak, La Brea, Spoor Canyon, Fox Mountain, and Little Pine Roadless Areas
34	Mokelumne Wilderness and adjacent roadless areas
58	Moses and Dennison Peak Roadless Areas
6	Mount Eddy and Castle Crags Roadless Areas
45	Mount Raymond Roadless Area
5	Mount Shasta Wilderness study area
27	North Fork of the American River Wilderness study area
1	North Fork Smith River Roadless Area, California and Oregon
8	Orleans Mountain Roadless Area (B5079)
9	Orleans Mountain Roadless Area (C5079, B5079)
67	Pleasant View Roadless Area
29	Pyramid Roadless Area
74	Raywood Flat Roadless Areas
30	Rubicon Roadless Area
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73	San Gorgonio Wilderness
65	San Jacinto Wilderness
44	San Joaquin Roadless Area
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60	Scodies Roadless Area
64	Sespe-Frazier, Diablo, Matilija, Dry Lakes, Sawmill-Badlands, Cuyama, Antimony, and Quatal Roadless Areas
68	Sheep Mountain Wilderness Study Area and Cucamonga Wilderness and Additions
77	Sill Hill, Hauser, and Caliente Roadless Areas
26	Snow Mountain Wilderness Study Area
4	South Warner Wilderness
70	Sugarloaf Roadless Area
35	Sweetwater Roadless Area, California and Nevada
16	Thousand Lakes Wilderness
7	Timbered Crater Roadless Area
38	Tioga Lake, Hall Natural Area, Log Cabin-Saddlebag, and Horse Meadows Roadless Areas
39	Tuolumne River Roadless Area
57	Ventana Wilderness
56	Ventana Wilderness Additions and the Black Butte, Bear Mountain, and Bear Canyon Roadless Areas
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42	White Mountains and Birch Creek Roadless Areas, California and Nevada
18	Wild Cattle Mountain and Heart Lake Roadless Areas
20	Yolla Bolly-Middle Eel Wilderness and Big Butte-Shinbone, East Fork, Murphy Glade, and Wilderness Contiguous Roadless Areas

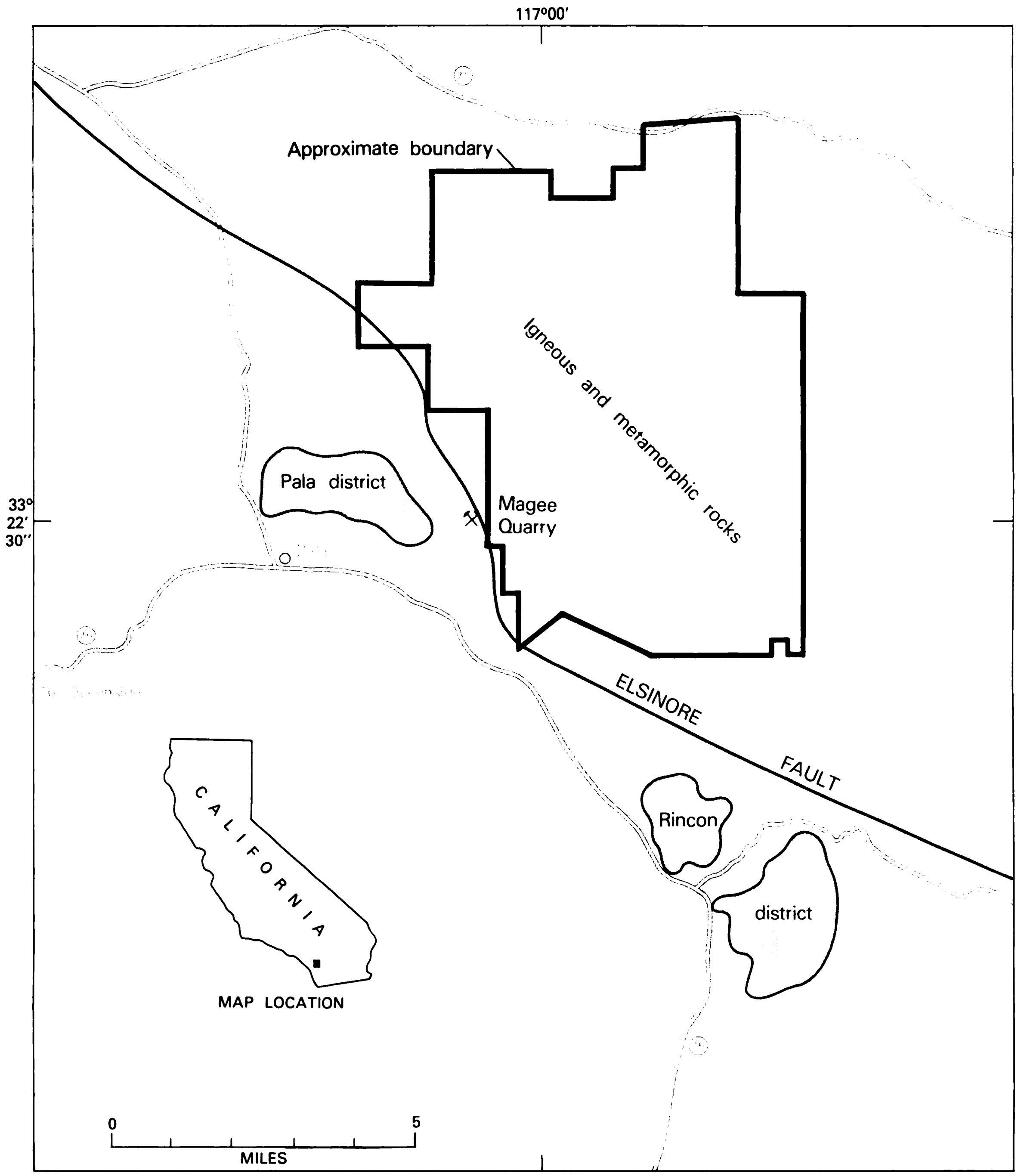

Figure 46.—Agua Tibia Primitive Area, California.

AGUA TIBIA PRIMITIVE AREA, CALIFORNIA

By WILLIAM P. IRWIN, U.S. GEOLOGICAL SURVEY, and

HORACE K. THURBER, U.S. BUREAU OF MINES

SUMMARY

The Agua Tibia Primitive Area in southwestern California is underlain by igneous and metamorphic rocks that are similar to those widely exposed throughout much of the Peninsular Ranges. Evidence of deposits of metallic or nonmetallic minerals was not seen during our study in 1969, nor is the presence of such deposits indicated from analysis of numerous stream-sediment samples and an aeromagnetic survey. No record of past or existing mineral claims was found.

CHARACTER AND SETTING

The Agua Tibia Primitive Area covers about 43 sq mi of the Cleveland National Forest, about 40 mi north of San Diego, California. The principal topographic feature of the primitive area is Agua Tibia Mountain, which rises 2500 ft higher than the adjacent lowland and merges with Palomar Mountain to the southeast beyond the boundary of the area. Most of Agua Tibia Mountain is covered by dense brush, but small stands of timber are present at the crest of the mountain and at the bottom of the canyons.

In the spring of 1969, the USGS spent 2 man-months in the area to assess the mineral potential (Irwin and others, 1970). Geologic traverses were essentially restricted to roads, trails, and streams, because of the general cover of dense brush. Pertinent published and unpublished maps that cover part of the region were compiled along with the reconnaissance mapping to aid in a geologic evaluation of the mineral potential of the primitive area. To detect the presence of any concealed mineral deposits, samples of stream sediments were collected along the various creeks that head in the mountain. As an additional aid in evaluating the mineral potential, an aeromagnetic survey was made and was interpreted by Andrew Griscom of the USGS. A search for records of past or existing mining claims within the primitive area was made in the assessor's and recorder's offices of San Diego and Riverside County Courthouses by the USBM, but none was found.

The Agua Tibia Primitive Area is in the Peninsular Ranges geologic province, which is characterized by northwest-trending mountain ranges that consist mostly of plutonic and metamorphic rocks of Mesozoic age. The plutonic rocks are much more abundant than the metamorphic rocks in the Agua Tibia region and mostly range from granite to gabbro. Varieties of granitic rocks, mainly granodiorite with subordinate tonalite, occupy a much greater area of outcrop on Agua Tibia Mountain than the gabbro. The metamorphic rocks of the region include schist, amphibolite, and calc-silicate granulite, and probably represent Jurassic or older sedimentary and volcanic rocks that were metamorphosed by the intrusion of the plutonic rocks during later Jurassic and Cretaceous time. Along the southwest side at the base of Agua Tibia Mountain, the plutonic and metamorphic rocks are cut by the Elsinore fault, which locally is marked by a zone of brecciated rock ¼ to ½ mi wide. Although the fault is a major regional structure, the amount and sense of displacement are not clearly known. Virtually all of the Agua Tibia Primitive Area is on the northeast side of the Elsinore fault. On the southwest side of the fault, opposite the primitive area, some of the plutonic rocks contain sills and dike swarms of pegmatite, but little evidence of similar pegmatite was seen in the primitive area.

MINERAL RESOURCES

Evidence of past or present mining activity was not seen in the Agua Tibia Primitive Area, but appreciable mining has been done nearby in the area southwest of the Elsinore fault. Some of the pegmatites have been mined for semiprecious gemstones, including tourmaline, kunzite, and beryl, and for lepidolite (lithium-bearing mica). The Pala district, centered about 2 mi west of the primitive area, had yielded gemstones and lepidolite valued at more than $750,000 by 1947 (Jahns and Wright, 1951), and it is estimated that at least an equal value has been produced since that time (E. E. Foord, U.S. Geological Survey, oral commun., 1982). The Rincon district, centered about 4 mi south of the primitive area, has yielded beryl valued at less than $2000 (Weber, 1963). Gabbro has been mined at the Magee quarry just west of the Elsinore fault. It is referred to commercially as "black granite" and is used for monuments and facing stone. Total production from the Magee quarry probably has not exceeded a few tens of thousands of tons.

To detect the possible presense of concealed metalliferous deposits in the primitive area, stream-sediment samples were collected along the principal creeks. These samples, in addition to samples of typical rocks of the area, were analyzed spectrographically; both groups of samples were also analyzed by the atomic absorption method for their content of gold, copper, lead, zinc, and silver, and by the paper chromatography method for uranium. Essentially all the samples were barren of anomalous concentrations of metals and minerals. The results of the geochemical sampling give little promise for the discovery of mineral resources in the Agua Tibia Primitive Area.

The aeromagnetic survey of the region has been interpreted to show two large positive anomalies, only one of which is mostly within the primitive area. The anomalies are on opposite sides of the Elsinore fault and both are centered over large gabbro bodies. A smaller anomaly is centered over gabbro nearby to the south. According to Andrew Griscom of the USGS (oral commun., 1969) the positive anomalies cover too large an area relative to their amplitudes to suggest the presence of concealed ore bodies and could be caused by the gabbro bodies which commonly contain 2–3 percent magnetite.

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ANDREWS MOUNTAIN, MAZOURKA, AND PAIUTE ROADLESS AREAS, CALIFORNIA

By EDWIN H. MCKEE,[1] U.S. GEOLOGICAL SURVEY, and

STEVEN W. SCHMAUCH, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey carried out in 1979–81, local areas near and within the Andrews Mountain, Mazourka, and Paiute Roadless Areas have probable and substantiated mineral-resource potential. The principal metallic mineral resources in these roadless areas are gold, copper, and silver with lead, zinc, and tungsten, as lesser resources. A zone of probable resource potential for talc, graphite, and marble is identified in the Mazourka Roadless Area. Metallic mineralization occurs mostly in vein deposits in silicic and carbonate metasedimentary rocks peripheral to Mesozoic plutons and locally in granitic rocks as well. There is little promise for the occurrence of fossil fuel resources in the roadless areas.

CHARACTER AND SETTING

The contiguous Andrews Mountain, Mazourka, and Paiute Roadless Areas occupy an area of about 234 sq mi in the northern Inyo Mountains, Inyo County, California. Big Pine, California is about 6 mi west of the north end of the combined study area and Independence California is about 6 mi from the southwest corner of the study area. The terrain is rugged and steep with relief of about 7000 ft along the east side of the range. Altitudes range from about 3800 ft above sea level in Owens Valley near Independence to 11,123 ft above sea level at Waucoba Mountain. The climate is arid to semiarid with a wide range in temperature controlled primarily by altitude.

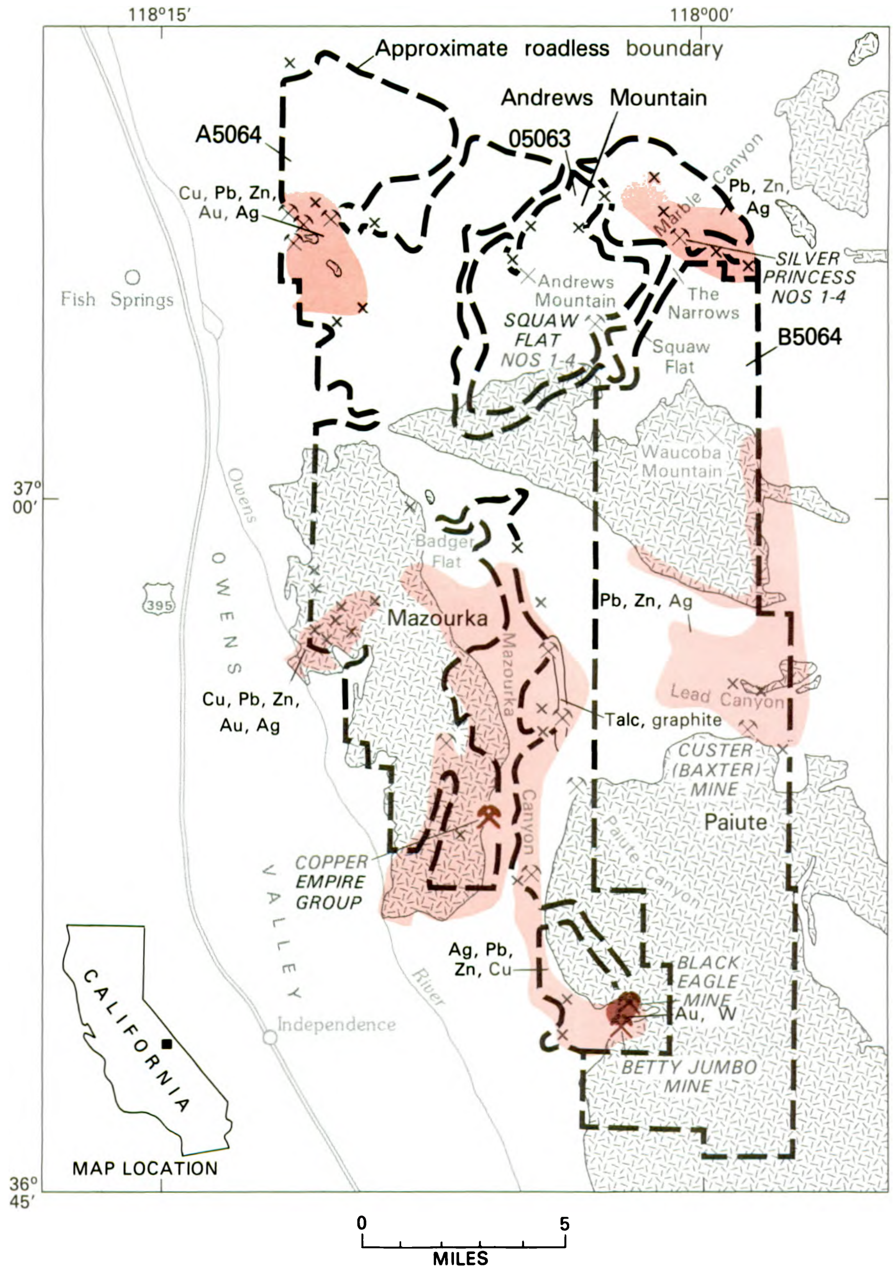
The geology of the three roadless areas has been studied in detail and is published as maps by Ross (1965, 1967) and Nelson (1966, 1971). A compilation and summary of these maps is by Langenheim and others (1983).

The rocks in the study area can be divided into major groups according to age and type. The oldest are sedimentary rocks of Late Proterozoic to Permian age; rocks of intermediate age are the granitoid plutonic rocks of middle to late Mesozoic age; and the youngest are Cenozoic volcanic rocks and surficial deposits. The strata of Late Proterozoic to Permian age represent sediments that accumulated in a shallow-marine-shelf environment. The total aggregate thickness of these strata is at least 35,000 ft but no single section has been found that contains more than a small fraction of this thickness. The rocks are mostly clastic types made of about equal amounts of quartzose (sandstone and shale) and carbonate (limestone and dolomite) varieties. They are tightly compacted, recemented, and partially recrystallized almost everywhere. Locally, a low-grade metamorphic mineral assemblage including andalusite, sericite, metamorphic biotite, and coarsely crystalline calcite and dolomite has developed.

Mesozoic plutonic rocks make up about half of the pre-Cenozoic exposures in the study area and are regarded as satellitic parts of the Sierra Nevada batholith (Bateman and others, 1963; McKee and Nash, 1967; Ross, 1969). These plutons intrude and metamorphose the sedimentary rocks of Late Proterozoic and Paleozoic age of the region. They generally have steep and sharp contacts with the surrounding country rocks and contact metamorphic effects extend as far as 2 mi from the contacts. Most of the plutonic rock is granodiorite but there are significant quartz monzonite, monzonite, and diorite plutons as well. The rocks are generally medium to coarse grained, porphyritic, and nonfoliated.

Small remnants of upper Cenozoic basalt, mainly lava flows and agglomerate occur on the east side of the

[1]With contributions from James L. Donahoe, USGS and Peter N. Gabby and David A. Lipton, USBM.



EXPLANATION

- Geologic terrane with substantiated gold and tungsten resource potential and probable potential for other mineral resources
- Geologic terrane with probable mineral-resource potential
- Granitic rocks
- Sedimentary rocks
- Contact

Cu	Copper	Ag	Silver
Au	Gold	W	Tungsten
Pb	Lead	Zn	Zinc

- Mine or deposit
- × Mineral occurrence
- Mine

Figure 47.—Andrews Mountain, Mazourka, and Paiute Roadless Areas, California.

range near the mouth of Paiute Canyon and along the west front of the range west of Badger Flat. These basalts have been isolated by erosion from their sources; those on the east from the Saline Range and those on the west from vents in Owens Valley. The rocks are medium to dark gray, dense to vesicular, and locally scoriaceous.

Sedimentary deposits of Cenozoic age fill the valleys adjacent to the Inyo Mountains and within the mountains shallow accumulations floor the major canyons and cap the higher alluviated areas. The oldest rocks are Tertiary deposits that occur in scattered areas along the east side of the range. Quaternary deposits consist of older, partly dissected fans, pediment deposits and valley fill and younger alluvial fans and other types of alluvium presently being deposited.

Structural features in the northern part of the Inyo Mountains represent at least three distinct periods of deformation. These structural episodes include deformation that took place before emplacement of the plutonic rocks; deformation associated with emplacement of the plutonic rocks; and basin and range faulting that is responsible for the present uplift of the Inyo Mountains. Preplutonic deformation (pre-middle Jurassic) is characterized by many high-angle normal and reverse faults and open north-trending folds. These structures predate and postdate regional thrusting of the Last Chance thrust, a large fault with about 20 mi displacement that thrust upper Proterozoic and lower Paleozoic rocks onto upper Paleozoic rocks. Deformation associated with emplacement of the plutonic rocks during the middle and late Mesozoic affected almost all the upper Proterozoic and Paleozoic formations. This deformation is characterized by folds caused by forceful emplacement of the plutons and local metamorphic fabric in the rock.

MINERAL RESOURCES

The northern part of the Inyo Mountains, an area that includes the Andrews Mountain, Mazourka, and the Paiute Roadless Areas has substantiated resource potential in a small area near several existing mines for gold and tungsten and probable resource potential for silver, lead, zinc, and copper at other places. There is a probable resource potential for talc, graphite and marble in the Mazourka Roadless Area. The large number of mines and prospects throughout the study area is an indication of the widespread nature of alteration and mineralization. The suite of elements including molybdenum, lead, zinc, and silver with local additions of copper, gold, and molybdenum is found in anomalously high concentrations at many places as well. This group of elements, indicative of base-metal vein deposits formed by hydrothermal systems is what might be expected within the geologic framework of the northern Inyo Mountains. Hydrothermal solutions associated with the large granitoid plutons of the region would have found a suitable host for vein deposits in the much fractured and faulted Proterozoic and Paleozoic metasediments they intruded. The general distribution of the enrichment of this suite of metals is peripheral to, or within, the plutons.

There are 51 mining properties in the three roadless areas; thirteen of these are mines with some record of past production. One of the productive mines is in the Andrews Mountains Roadless Area, 10 are in the Mazourka Roadless Area, and 2 are in the Paiute Roadless Area. The most important are 3 mines along the southern boundary of the Mazourka Roadless Area. The Copper Empire Group (loc. 1) has some mineralization along a 3-mi granitic contact zone with demonstrated resources of 66,000 tons averaging 1.57 percent copper. The Betty Jumbo mine (loc. 2) has two sheelite-bearing tactite bodies; one is nearly mined out, the other has estimated inferred resources of 53,000 tons averaging 0.7 percent tungsten trioxide. The Black Eagle mine (loc. 3) has a small, demonstrated resource of 11,000 tons averaging 0.21 oz gold/ton. On the northeast edge of the Paiute Roadless Area the Silver Princess nos. 1–4 (loc. 4) produced some lead, zinc, and silver and has probable potential for additional resources of these metals. The Custer (Baxter) mine (loc. 5) in the Paiute Roadless Area produced a small amount of the same metals and more may exist in or near this mine.

Little promise for the occurrence of significant mineral resources exists in the Andrews Mountain Roadless Area. Weak anomalies in molybdenum, zinc, copper, gold, and tungsten were detected in stream-sediment samples from one drainage west of Andrews Mountain. Four mining properties in the roadless area, including the Squaw Flat Nos. 1–4 (loc. 6) which had a small production of silver and lead, were determined to offer little promise for the occurrence of additional resources.

The Mazourka Roadless Area has substantiated mineral potential for gold and tungsten in the area adjacent to the Black Eagle and Betty Jumbo mines that are near the southern part of the roadless area. There is probable resource potential for silver and copper in the vicinity of the Copper Empire mine near the mouth of Mazourka Canyon. There is also probable resource potential for silver with lead and zinc in the northeastern part of the roadless area in the vicinity of The Narrows and areas to the east of The Narrows. There is probable resource potential for silver, lead, zinc, copper, and gold throughout most of Mazourka Canyon, and at several other localities along the west front of the range. An area of probable resource potential for talc and graphite is located along the east side of Mazourka Canyon about 5 mi from its mouth.

The Paiute Roadless Area has probable resource potential for silver and associated lead and zinc in the area around Lead Canyon. This estimate is based on high anomalous values of lead, zinc, molybdenum, and silver from stream-sediment and heavy-mineral concentrate samples as well as inferred resources in several mines and prospects in or near the area. Although anomalous amounts of molybdenum are ubiquitous in samples from the Paiute Roadless Area, no molybdenum resource potential was identified.

SUGGESTIONS FOR FURTHER STUDIES

Three mines along the south edge of the Mazourka Roadless Area, the Copper Empire Group, Betty Jumbo, and Black Eagle mines, have demonstrated mineral resources. A drilling program at these sites might better define and extend the limits of mineralized rock.

The specific areas of probable mineral-resource potential should be studied in detail to identify the sources of the geochemical anomalies detected by stream-sediment and (or) panned-concentrate sampling.

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ARROYO SECO ROADLESS AREA, CALIFORNIA

By ROBERT E. POWELL,[1] U.S. GEOLOGICAL SURVEY, and

PETER N. GABBY, U.S. BUREAU OF MINES

SUMMARY

On the basis of geologic mapping, a geochemical stream-sediment survey, and a survey of mines, quarries, and prospects conducted in 1982, the Arroyo Seco Roadless Area has a probable resource potential for small gold occurrences in the southern part of the area. Sand, gravel, and stone suitable for construction materials are found in the roadless area, but similiar or better quality materials are abundant and more accessible outside the area.

CHARACTER AND SETTING

Situated in the southwestern San Gabriel Mountains in Los Angeles County, California, the Arroyo Seco Roadless Area encompasses about 8 sq mi within the Angeles National Forest. The roadless area includes Bear and Little Bear Canyons and most of upper Arroyo Seco between Red Box Gap and Oakwilde Picnic Area. The roadless area is approximately bounded on the north by the Angeles Crest Highway (California State Highway 2) and on the south by CCC Ridge and the Brown Mountain-Mount Lowe-Mount Markham ridge. Altitude within the roadless area ranges from 1800 ft in Arroyo Seco at Oakwilde Picnic Area to nearly 6000 ft atop Mount Disappointment. This report summarizes results presented by Powell and others (1983) and Gabby (1982).

The roadless area is situated in a wedge between the San Gabriel fault zone along its northern margin and the Sierra Madre fault zone along its western and southwestern margin. Both faults are characterized by late Cenozoic right-lateral displacement. Crystalline units in the area generally trend northwest. The oldest rocks consist of pelitic metasedimentary gneiss interlayered with dark-colored Precambrian biotite-quartz-feldspar augen gneiss that originally intruded the metasedimentary rocks as porphyritic granodiorite and monzogranite. The Precambrian gneiss is intruded by the Permian and (or) Triassic Mount Lowe Granodiorite of Miller (1926, 1934) that consists of two principal phases within the roadless area: monzodiorite with coarse-grained hornblende partially rimmed by epidote and scattered ovoid alkali feldspar phenocrysts in a fine-grained matrix of plagioclase, alkali feldspar, and quartz; and leucocratic porphyritic monzodiorite with ovoid gray alkali feldspar phenocrysts, coarse-grained hornblende or clots of biotite, and garnet in a fine-grained matrix of plagioclase, alkali feldspar, and quartz. The two phases appear to be transitional over a few feet. Quartz is generally present within the range of 5 to 10 percent. Both phases are foliated. Between the San Gabriel and Sierra Madre fault zones, these older crystalline units are successively intruded by Mesozoic syenogranite (Echo Granite of Miller, 1930, 1934, which is considered Mesozoic by L. T. Silver, oral commun., 1977), dark-colored hornblendite, hornblende gabbro and diorite, hornblende-biotite-sphene tonalite and granodiorite, porphyritic biotite-hornblende monzogranite, and coarse-grained, nonporphyritic biotite monzogranite, all of which are foliated to varying degrees. Mafic dikes, probably derived from the mafic Mesozoic plutonic units, crosscut the Echo Granite, the Mount Lowe Granodiorite, and probably the Precambrian gneiss. Along the Angeles Crest Highway west of the Sierra Madre fault zone and north of the San Gabriel fault zone, coarse-grained, foliated hornblende-biotite monzodiorite has been intruded by fine-to medium-grained, foliated leucocratic biotite monzogranite.

No producing or developing mines, active or patented mining claims, or mineral leases are in the roadless area. The Dawn mine, just south of the roadless area, produced gold between 1895 and 1950 (Gay and Hoffman, 1954). An occurrence of molybdenite and copper minerals, reported by Gay and Hoffman (1954) from a prospect at the west end of the roadless area, was not located during this study.

A reconnaissance geochemical survey in the Arroyo Seco Roadless Area and vicinity was conducted to

[1]With contributions from Jonathan C. Matti, Brett F. Cox, and Curtis M. Obi, USGS.

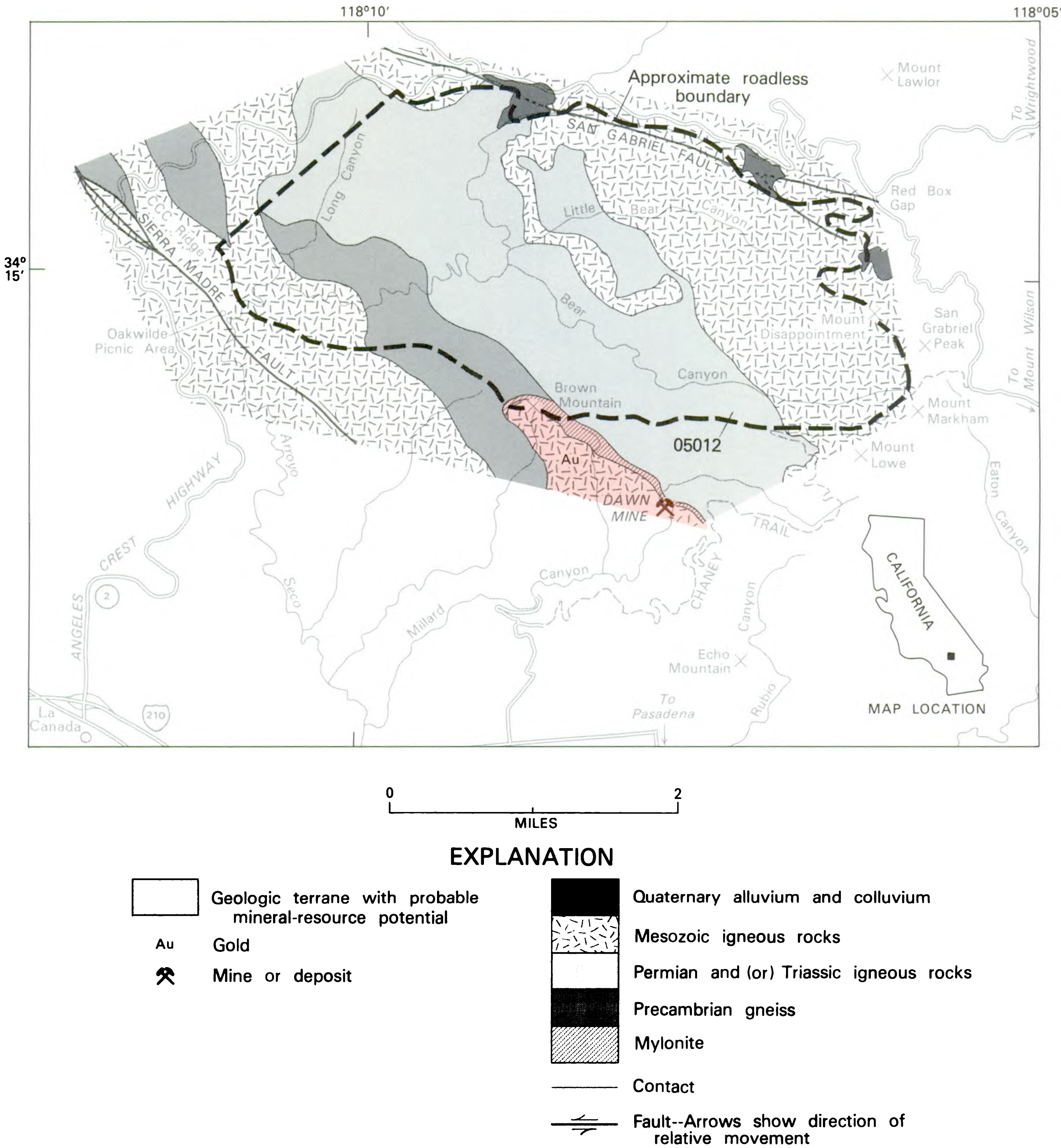

Figure 48.—Arroyo Seco Roadless Area, California.

determine spatial variations in stream-sediment chemistry that might indicate the occurrence of metal concentrations.

MINERAL RESOURCES

There is an area of probable gold resource potential just inside the south edge of the Arroyo Seco Roadless Area. Sand, gravel, and stone suitable for construction materials are found in the roadless area, but similar or better quality materials are more abundant and more accessible outside the area.

Mineral concentrations have not been observed along any of the structures or intrusive contacts mapped within the roadless area, nor in any lithologic units within the area. Neither prominent veining nor extensive alteration has been observed.

None of the elemental concentrations found in stream-sediment samples suggest the presence of resources. Most of the analyses fall within ranges that are reasonable for nonmineralized igneous and metamorphic rock and derivative stream-sediments. The few values that exceed the geochemical background appear to be related to common petrologic processes or, in some cases, possibly to contamination from litter rather than to processes of ore concentration and deposition.

About 0.5 mi south of the Arroyo Seco Roadless Area, gold is found in a pyrite-bearing quartz vein at the Dawn mine, where there are demonstrated resources of about 1000 tons of gold-bearing rock that averages 0.046 oz gold/ton. The host rock at the Dawn mine and at several reported gold prospects in the vicinity, is the distinctive Echo Granite that extends only to the southern boundary of the roadless area at Brown Mountain. Thin, fine-grained, generally foliated mafic dikes also crosscut the Echo Granite at the Dawn mine. Although gold mineralization is spatially associated with similar-looking mafic dikes in older rocks elsewhere in the region, no evidence for significant mineralization was found in the vicinity of the roadless area other than at the Dawn mine. Very little of the host unit is exposed within the roadless area and it is unlikely that much of the unit is present, even in the subsurface. A probable gold resource potential is assessed to that small portion of the granite that extends into the roadless area.

SUGGESTIONS FOR FURTHER STUDY

Because of their regional association with gold mineralization, the thin and poorly exposed mafic dikes in the Echo Granite, the Mount Lowe Granodiorite, and the Precambrian gneiss in and around the roadless area offer the most promising avenue for additional study of the resource potential of the area.

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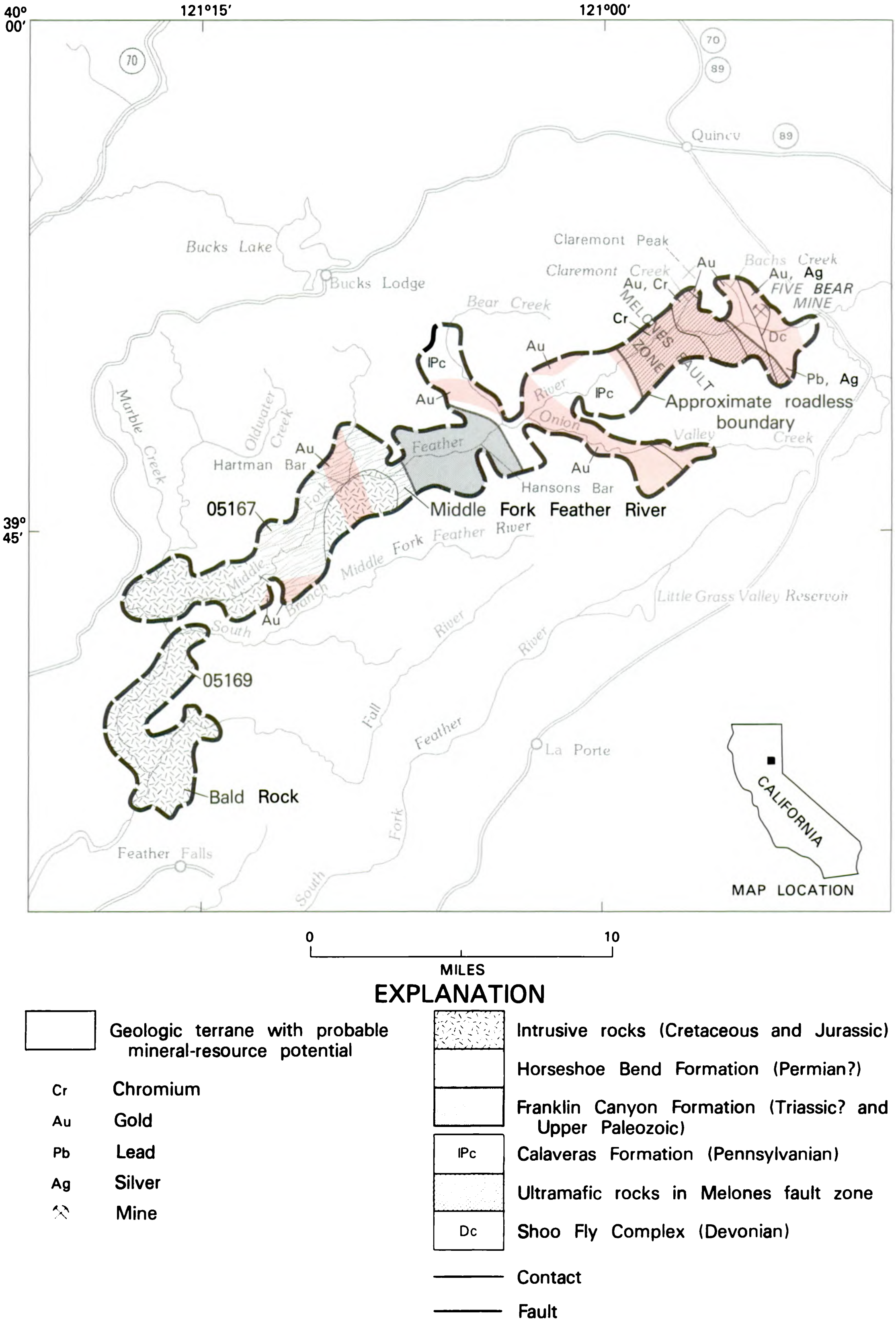

Figure 49.—Bald Rock and Middle Fork Feather River Roadless Areas, California.

BALD ROCK AND MIDDLE FORK FEATHER RIVER ROADLESS AREAS, CALIFORNIA

By MARTIN L. SORENSEN,[1] U.S. GEOLOGICAL SURVEY, and

ALAN R. BUEHLER, U.S. BUREAU OF MINES

SUMMARY

The results of a mineral-resource assessment of the Bald Rock and Middle Fork Feather River Roadless Areas conducted during 1980–82 indicate several areas within the Middle Fork Feather River Roadless Area that have probable mineral-resource potential. A probable potential for placer gold exists at various localities, both in areas covered by Tertiary volcanic rocks and in small streams that drain into the Middle Fork of the Feather River. A probable potential for small deposits of chromite exists in tracts underlain by ultramafic rocks in the Melones fault zone. A probable potential for lead-silver deposits is recognized at the east end of the Middle Fork Feather River Roadless Area. There is little promise for the occurrence of coal, oil, gas, or geothermal energy resources in the roadless areas.

CHARACTER AND SETTING

The Bald Rock and Middle Fork Feather River Roadless Areas are in the Plumas National Forest on the west slope of the Sierra Nevada, 5 to 28 mi south to southwest of Quincy, California. The Bald Rock Roadless Area consists of about 6 sq mi in Butte County, and the Middle Fork Feather River Roadless Area comprises about 46 sq mi in Butte and Plumas Counties, California. The roadless areas are alined along the Middle Fork of the Feather River and several tributary drainages. The canyon bottom of the Middle Fork is classified as a National Wild and Scenic River and, although included within the roadless areas, was not authorized by the USFS to be evaluated during the mineral-resource survey.

The roadless areas are in the northern part of the western Sierra Nevada metamorphic belt. Steeply dipping faults divide the region into four north- to northwest-trending belts of Paleozoic and Mesozoic metasedimentary and metavolcanic rocks that have been intruded by Mesozoic granitoid plutons and partially covered by Cenozoic volcanic rocks (Hietanen, 1973, 1976, 1981a, 1981b). The easternmost part of the Middle Fork Feather River Roadless Area is underlain by the Shoo Fly Complex, a metasedimentary unit of pre-Late Devonian age. The rocks of the Shoo Fly are bordered on the west by ultramafic rocks coincident with the Melones fault zone. West of the Melones fault zone are several sequences of upper Paleozoic and lower Mesozoic metasedimentary and metavolcanic rocks. The easternmost of these is the Calaveras Formation, a dominantly metasedimentary unit that has been determined to be Pennsylvanian in age in this region (Hietanen, 1981a, p. 17). West of the Calaveras is the Franklin Canyon Formation, a series of mostly metavolcanic rocks considered to be late Paleozoic and Triassic(?) in age. The westernmost sequence within the roadless areas is the Horseshoe Bend Formation of Permian(?) age, consisting of interbedded and possibly tectonically interleaved metasedimentary, metavolcanic, and ultramafic rocks. The various metasedimentary, metavolcanic, and ultramafic rock units were intruded by granitoid plutons during middle and late Mesozoic time. The area was elevated, eroded, and partially covered by volcanic deposits by late Tertiary time. In places, the Tertiary volcanic rocks cover lower Tertiary stream-bed deposits that locally contain placer gold. The geology of the roadless areas has been summarized by Sorensen and Pietropaoli (1982).

The results of spectrographic and chemical analyses of rock, stream-sediment, and pan-concentrate samples (Sorensen and others, 1982) show local, slightly anomalous values for barium, bismuth, gold, molyb-

[1]With contributions from Andrew Griscom and Henry Pietropaoli, USGS.

denum, silver, tin, and tungsten. Aeromagnetic and gravity maps of the roadless areas were prepared as an aid in the evaluation of the mineral-resource potential. Examination of the aeromagnetic map (Andrew Griscom, unpub. data, 1982) indicates that most of the magnetic anomalies occur over the fault-bounded ultramafic bodies, and that the magnetic expression of the other rock units is generally one of low-amplitude anomalies and relatively smooth magnetic field. The gravity map (Oliver and others, 1982) displays a large gravity low associated with the granitoid plutons and a gravity gradient between the Shoo Fly Complex and the Calaveras Formation. Neither the aeromagnetic nor the gravity data provide any specific information for the identification of additional mineral-resource potential.

The Bald Rock and Middle Fork Feather River Roadless Areas are near the northern end of the principal zone of placer gold deposits of the western Sierra Nevada. Tertiary and Quaternary placer deposits in and near the roadless areas have been mined by hydraulic and drift methods since the mid-19th century and currently are the focus for recreational gold panning and dredging. Chromite has been mined since World War I from small deposits in ultramafic rocks within the Melones fault zone (Rynearson, 1953). In areas underlain by the Calaveras, Franklin Canyon, and Horseshoe Bend Formations, prospects have been claimed on the basis of reports of chromite, copper, gold, and silver. Although many of these prospects are mentioned in reports of the State Mineralogist, production records were not located for any and it is assumed that production, if any, from these deposits was minimal.

MINERAL RESOURCES

A probable potential for the occurrence of placer gold resources exists west of the Melones fault zone where Tertiary volcanic rocks are exposed over approximately 2 sq mi and may overlie Tertiary auriferous stream deposits. Haley (1923) concluded that an early Tertiary stream probably trended northwest near the present location of Onion Valley Creek. Thus upper Tertiary volcanic rocks at the southeast corner of the Middle Fork Feather River Roadless Area may overlie concealed auriferous stream deposits, as may similar volcanic rocks exposed 5 mi to the northwest. Small unmapped remnants of Tertiary stream deposits may be present along the probable trends of Tertiary stream courses as determined by Haley (1923, pl. 7), so a probable potential for placer gold resources in Tertiary stream deposits is recognized near Hartman Bar, in Bear and Onion Valley Creeks, and southeast of Claremont Peak.

Gold is reported present in sediments collected from small streams that drain into the Middle Fork of the Feather River (Sorensen and others, 1982), including Bachs, Claremont, and Onion Valley Creeks, as well as drainages near Hansons and Hartman Bars. The presence of gold in many of the analyzed samples indicates a probable potential for placer gold resources, but the steep gradient of the drainages from which the samples were collected suggests that any such deposits are probably very small.

A probable resource potential for small, low- to medium-grade deposits of chromite exists near the eastern end of the Middle Fork Feather River Roadless Area where approximately 6 sq mi are underlain by ultramafic rocks within the Melones fault zone. Small deposits in these rocks near the Middle Fork of the Feather River have produced approximately 1000 long tons of chromite since World War I. It is probable that any new deposits will be small (less than 50 long tons), pod-shaped, and confined to shear zones within the ultramafic rocks of the Melones fault zone.

A probable potential for low-grade lead-silver deposits exists at the east end of the Middle Fork Feather River Roadless Area. Analyses of four rock samples collected there show slightly anomalous values for lead and silver and indicate low-grade mineralization. The sample localities form a linear that trends north-northwest through the Five Bear mine.

The Bald Rock and Middle Fork Feather River Roadless Areas have little promise for the occurrence of coal, oil, gas, or geothermal energy resources.

SUGGESTIONS FOR FURTHER STUDIES

Lower Tertiary stream deposits may be present beneath upper Tertiary volcanic rocks at two localities near Onion Valley Creek in the Middle Fork Feather River Roadless Area. The presence or absence of these potentially auriferous deposits can best be determined by drilling through the relatively thin cover of volcanic rocks.

Small unmapped remnants of Tertiary stream deposits may be present near Hartman Bar, in Bear and Onion Valley Creeks, and southeast of Claremont Peak. The presence or absence of these potentially auriferous deposits can best be determined by detailed geologic mapping at a much larger scale than that of the present study.

Undiscovered chromite deposits are best sought by detailed geologic mapping of faults and shear zones in ultramafic rocks within the Melones fault zone.

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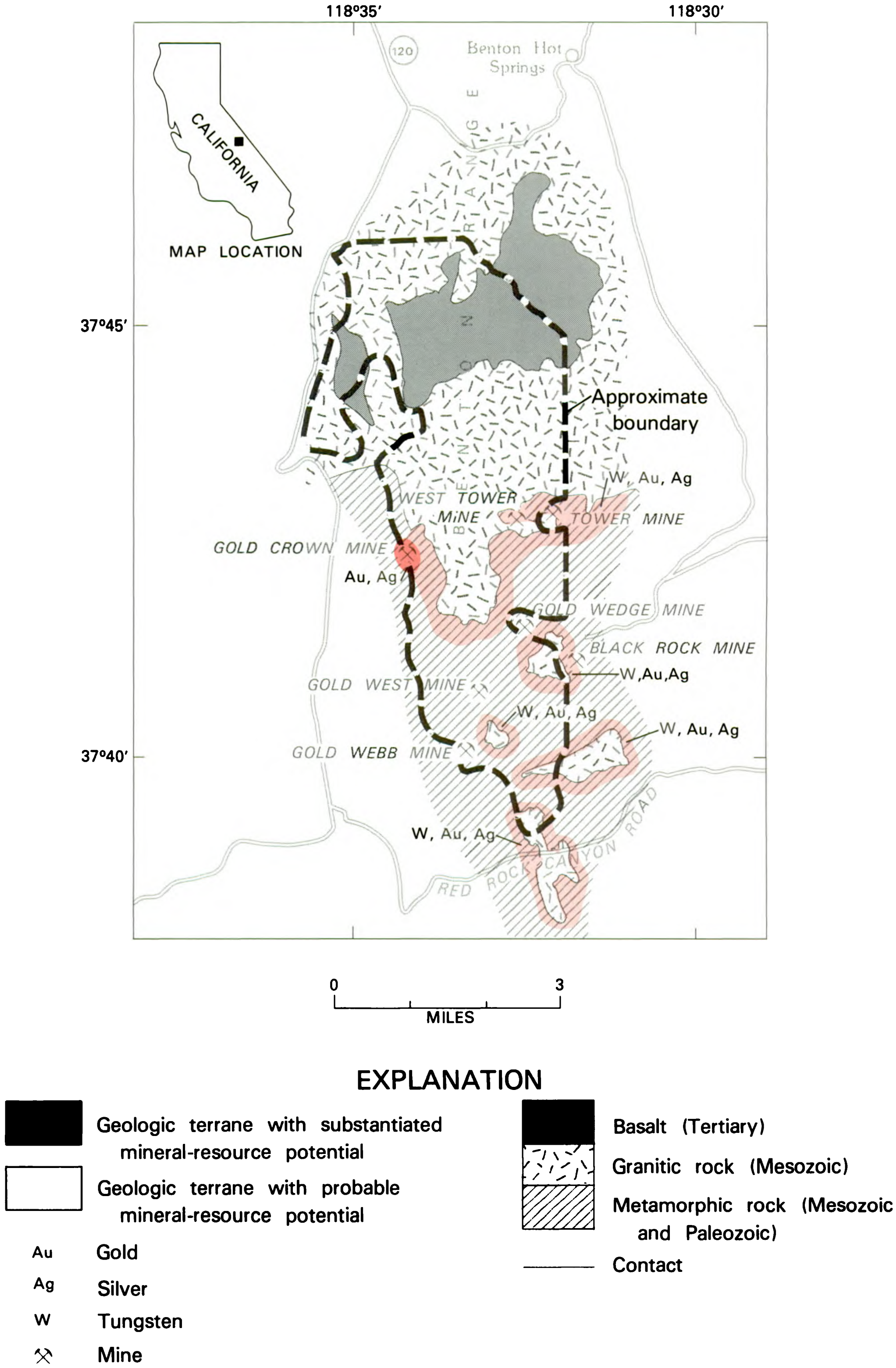

Figure 50.—Benton Range Roadless Area, California.

BENTON RANGE ROADLESS AREA, CALIFORNIA

By EDWIN H. MCKEE,[1] U.S. GEOLOGICAL SURVEY, and

RICHARD L. RAINS, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey in 1980–81, two parts of the Benton Range Roadless Area are considered to have mineral-resource potential. The central and southern part of the roadless area, near several nonoperating mines, has a probable potential for tungsten and gold-silver mineralization in tactite zones. The central part of the area has a substantiated resource potential for gold and silver in quartz veins.

CHARACTER AND SETTING

The Benton Range Roadless Area covers about 17.5 sq mi at the southern end of the Benton Range at the north end of Owens Valley. The area is approximately 33 mi southeast of Mono Lake and 27 mi north of Bishop, California. There is easy access to the area from Benton Hot Springs, California, located on State Highway 120.

The Benton Range is composed of about equal amounts of metamorphic, plutonic, and volcanic rocks (McKee and Donahoe, 1981). The southern part of the area consists mostly of metamorphic rocks of Paleozoic age that are part of a large pendant engulfed in Mesozoic granitic rocks of the Sierra Nevada batholith. The central and northern part of the area is composed mostly of granitic rocks that are also part of this batholith. The granitic rocks are mostly coarse grained porphyritic granodiorites but include a variety of compositional and textural types. A swarm of felsic and dioritic dikes of uncertain, but possibly Mesozoic age, intrudes the metamorphic and granitic rocks on the western side of the roadless area. Tertiary basalt lava flows lie on the eroded Mesozoic granitic rocks in the northern part of the area.

MINERAL RESOURCES

Tactite, formed at the contact between intrusive and calcareous metasedimentary rocks, locally contains the tungsten mineral scheelite. In mines outside but near the roadless area large amounts of scheelite have been mined in the past. In addition to scheelite, the tactite zones have yielded small quantities of gold and silver in sulfides. The geologic environment (tactite) in the southern part of the roadless area is similar to areas with production nearby and therefore has a probable potential for resources of tungsten and some gold and silver.

Native gold, and gold and silver sulfides, occur in quartz veins and small shear zones in metamorphic and granitic rocks outside and locally within the roadless area. Numerous porphyritic felsic dikes as much as 30 ft thick occur near the Gold Crown mine on the west edge of the area. These are associated with quartz veins that contain gold and silver minerals, and small amounts of these metal-bearing minerals are disseminated in the adjacent metamorphic country rocks. The vicinity of the Gold Crown mine has a substantiated resource potential for gold and silver. Other areas within or near the roadless area contain abandoned mines and have probable resource potential for gold and silver on the basis of geologic features, geochemical anomalies, and evaluation of existing mines.

A reconnaissance geochemical study is published in Donahoe and Chaffee (1982) and a mineral-resource appraisal by Donahoe and others (1982).

SUGGESTIONS FOR FURTHER STUDIES

Detailed mapping and geochemical sampling for tungsten, gold, and silver in the central and southern part of the roadless area might indicate targets for shallow drilling exploration. Although this area has

[1]With contributions by James L. Donahoe, USGS.

been heavily prospected for nearly 100 years exploration has been confined to panning and surface sampling.

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BLACK BUTTE AND ELK CREEK ROADLESS AREAS, CALIFORNIA

By HENRY N. OHLIN,[1] U.S. GEOLOGICAL SURVEY, and

R. J. SPEAR, U.S. BUREAU OF MINES

SUMMARY

A mineral investigation conducted by the USGS and the USBM in 1980–81 in the nearly contiguous Black Butte and Elk Creek Roadless Areas of northern California, indicates that small parts of both roadless areas have a probable mineral-resource potential for small manganese-copper- or chromite-type deposits. There is little promise for the occurrence of energy resources in the areas.

CHARACTER AND SETTING

The Black Butte and Elk Creek Roadless Areas each comprise approximately 40 sq mi in Mendocino National Forest, Mendocino, Glenn, and Lake Counties, California, and are nearly contiguous. The roadless areas are in the eastern part of the northern California Coast Range and are characterized by northwest-trending ridges separated by steep-sided valleys. Altitudes range from 1500 ft to 6100 ft, commonly with gradients of 1000 ft/mi. The steep slopes are covered by brush, grassland, oak, and conifer forests. Access to the areas is by California State Highway 261 from Covelo and by a county road from Potter Valley to Lake Pillsbury. USFS Route M1 connects these two roads along a north-south trend.

The Black Butte and Elk Creek Roadless Areas are underlain by metamorphosed and highly deformed rocks ranging in age from Middle Jurassic to early Late Cretaceous (about 160 to 96 million years ago), assigned to the Franciscan assemblage. Isolated lenticular masses of serpentinite occur along faults in the area. The rocks of the Franciscan assemblage are divided into four structural units based on different lithologies, degrees of metamorphism, and styles of deformation.

The Central belt melange of the Franciscan assemblage is the structurally lowest unit, consisting primarily of argillite and thin-bedded metasandstone that are regionally metamorphosed to pumpellyite and lawsonite grade. Following, or perhaps during regional metamorphism, the argillite and metasandstone were extensively sheared and chaotically mixed with scattered blocks of mafic metaigneous rocks, manganiferous metachert, limestone, and high-grade glaucophane schist. These blocks range in length from inches to 50 or more feet. Fossils from metamorphosed blocks within the melange unit are Late Jurassic (140 million years ago) to early Late Cretaceous (96 million years ago) in age, indicating that regional metamorphism and the mixing together of rocks in the melange occurred less than 96 million years ago.

The metasandstone and argillite of Sanhedrin Mountain overlies the Central belt melange in the southwest part of the area. Intercalated with metaclastic rocks of the unit are thick lenses of metachert and mafic metavolcanic rock. The rocks of Sanhedrin Mountain have been modified texturally to low-grade slate and phyllite, and the sandstones typically are metamorphosed to lawsonite grade. This unit has been assigned a mid-Cretaceous age (Etter, 1979; Jordan, 1974) although no fossils have been found.

To the east of Sanhedrin Mountain is another unit of metamorphosed sandstone and argillite, referred to as the metasandstone and argillite of Hull Mountain. The Hull Mountain rocks are weakly to moderately modified texturally, and contain metamorphic mineral assemblages similar to the Sanhedrin Mountain unit. Both units locally contain intercalated radiolarian metachert and mafic igneous rocks with sheared contacts. The Hull Mountain unit also contains rare unsheared gabbroic rocks with intrusive contacts. The Hull Mountain unit has less abundant metachert than the Sanhedrin Mountain unit, and the metaclastic rocks locally include prominent quartz-pebble metaconglomerate and metagrit. Fossils indicate a middle Cretaceous (about

[1]With contributions from Robert J. McLaughlin, USGS.

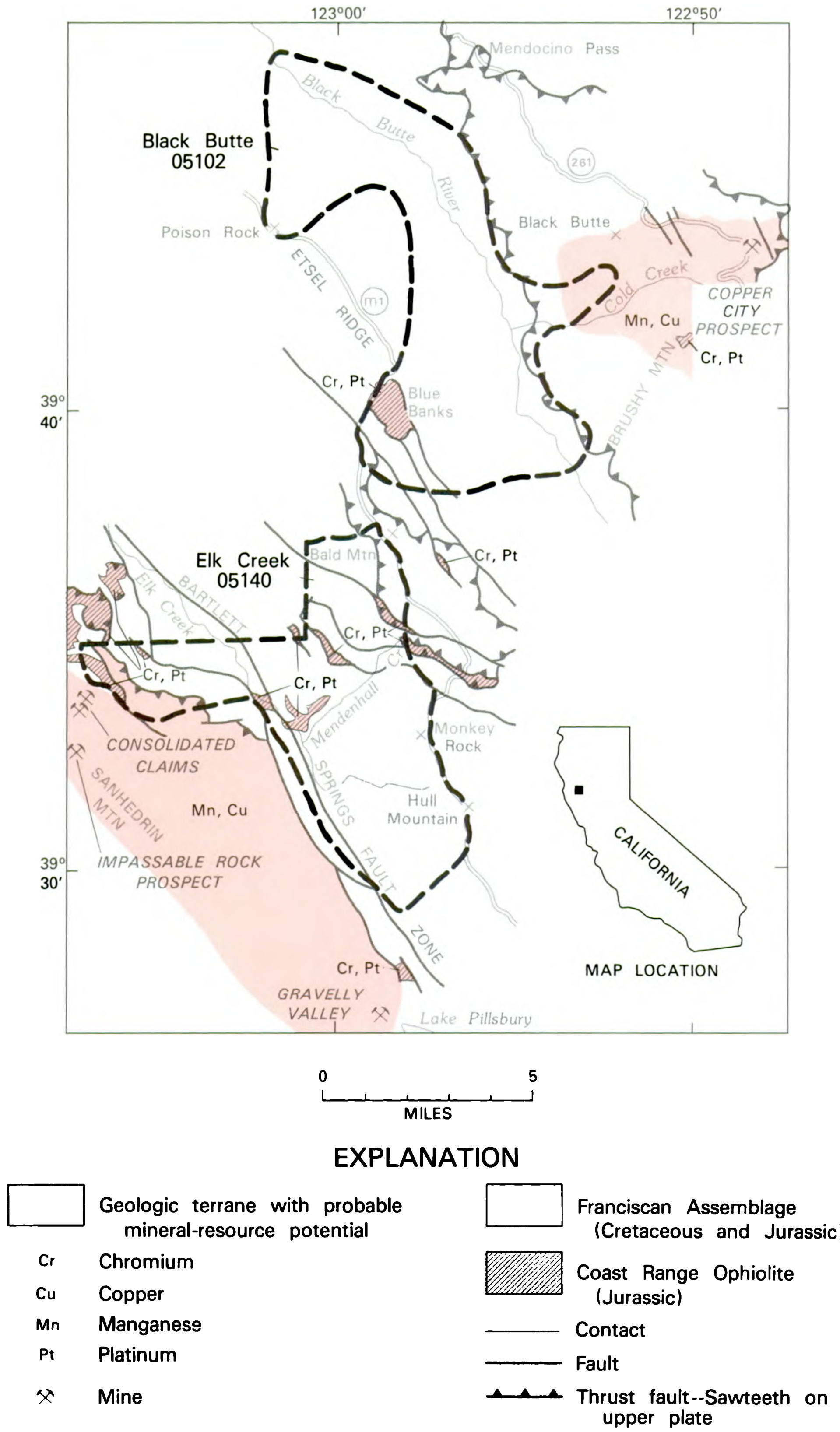

Figure 51.—Black Butte and Elk Creek Roadless Areas, California.

96–110 million years ago) age for the metasandstone and argillite.

The metasandstones and metavolcanic rocks of Black Butte and Bald Mountain are the structurally highest rocks of the map area. These rocks overlie the metasandstone and argillite of Hull Mountain and the Central belt melange along a low-angle thrust fault. The metasandstone and metavolcanic rocks of Black Butte and Bald Mountain are extensively modified texturally to schist or phyllite, and they contain lawsonite.

Serpentinite occurs in lenticular masses along high-angle and low-angle faults in the roadless areas. Most notably, serpentinite occurs at Blue Banks, the Devils Rock-Barley Lake area, along Elk Creek, and in the Bennet Valley-Eden Valley areas, and on Brushy Mountain.

Samples collected for geochemical analysis in the roadless areas included panned stream sediment and mineralized and nonmineralized bedrock. Geochemical analyses of these samples, using quantitative and semiquantitative spectrographic, atomic absorption and fire assay techniques, were then used in evaluating the metallic-resource potential of the roadless areas (Ohlin and others, 1983).

MINERAL RESOURCES

Metallic element concentrations above average crustal abundance are locally present in all bedrock units of the Black Butte and Elk Creek Roadless Areas, and small parts of each area have a probable mineral-resource potential, mainly for manganese-copper and chromite deposits.

Minor manganese mineralization is associated with metachert and metavolcanic rocks in the Elk Creek Roadless Area. Three occurrences of manganese mineralization within the Sanhedrin Mountain structural unit have been prospected, but they are 0.5 to 3.0 mi outside the Elk Creek Roadless Area. Two of these prospects, Consolidated Claims and Gravelly Valley, are reported to have produced less than 150 tons of manganese ore (Trask and others, 1943). No production is known from the Impassable Rock prospect. At the Consolidated Claims and Impassable Rock prospects the manganese mineralization is associated with metachert or metaigneous rocks. Manganese carbonates were reported at Impassable Rock (Trask and others, 1943). At the Gravelly Valley occurrence manganese oxide mineralization is concentrated along bedding in folded metachert or along faults and fractures cutting the metachert. Copper, nickel, zinc, cobalt, molybdenum, and gold are associated with the manganese, in trace amounts. The Sanhedrin Mountain rocks extend into the Elk Creek Roadless Area and are considered to have a probable potential for manganese and copper.

At the Copper City prospects, 4 mi east of Black Butte Roadless Area, veinlets of specular hematite and minor blue and green copper staining (azurite and malachite) were observed in slightly manganiferous metatuff and metachert of the Black Butte structural unit. Eric (1948) reported disseminated cuprite in these rocks and possibly this extends into the roadless area. There has been no known production but the area is assessed a probable resource potential for manganese and copper.

Minor chromite mineralization and trace amounts of platinum group metals are associated with the lenticular masses of serpentinite that occur along faults in the roadless areas. The serpentinite is considered to have a probable mineral-resource potential for chromite and associated platinum group elements.

Two springs along northwest-trending faults alined with Sanhedrin Creek discharge hydrogen sulfide gas. Although these springs were not studied in detail, they show no obvious evidence of geothermal potential. Heat flow measurements, from three explorations wells in and near the roadless areas, are normal for the region (Lachenbruch and Sass, 1980). No evidence of any oil or natural gas resource potential was identified in this study.

SUGGESTIONS FOR FURTHER STUDIES

No further mineral-resource investigations are recommended for areas within the boundaries of the Elk Creek or Black Butte Roadless Areas. However, 20 mi to the south of the roadless areas is the Geysers-Clear Lake geothermal area. Between Lake Pillsbury 3 mi south of the Elk Creek Roadless area, and Clear Lake, numerous thermal springs discharge along the Bartlett Springs fault zone (in part the Hot Springs shear zone of Etter, 1979). Investigation of geothermal resource potential and of the potential for other hydrothermal base- and precious-metal mineralization along this fault zone should be initiated.

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BLANCO MOUNTAIN AND BLACK CANYON ROADLESS AREAS, CALIFORNIA

By MICHAEL F. DIGGLES,[1] U.S. GEOLOGICAL SURVEY, and

RICHARD L. RAINS, U.S. BUREAU OF MINES

SUMMARY

The mineral survey of the Blanco Mountain and Black Canyon Roadless Areas, conducted in 1980 and 1981 indicated that areas of probable and substantiated mineral-resource potential exist only in the Black Canyon Roadless Area. Gold with moderate amounts of lead, silver, zinc, and tungsten, occurs in vein deposits and in tactite. The nature of the geolgic terrain indicates little likelihood for the occurrence of energy resources in the roadless areas.

CHARACTER AND SETTING

The Blanco Mountain and Black Canyon Roadless Areas occupy 27 and 48 sq mi, respectively, in the southern White Mountains about 10 mi east of Bishop, California. They are bounded on the west by Owens Valley, on the east by Fish Lake Valley, and are accessible from secondary roads off U.S. Highway 395 and the road to the research station on Mount Bancroft. A geologic map of roadless areas in the White Mountains is presented by McKee and others (1982). Personnel from the USGS carried out a geochemical sampling program in 1980 and the results and interpretation are included in Diggles and others (1982) and Diggles (1983). An aeromagnetic and gravity study was also conducted. The USBM evaluated mines, prospects, and other known mineral deposits in 1980 and 1981. A summary of the results of these studies and an evaluation of the mineral-resource potential is presented by Diggles and others (1983), by Schmauch and others (1982), and in unpublished data by R. L. Rains.

The two roadless areas are underlain primarily by Late Proterozoic through Cambrian strata consisting of a carbonate-sandstone-shale sequence. These strata are metamorphosed to marble, quartzite, and phyllite; in many places, quartz veins are common. Mesozoic plutonic rocks of the Inyo batholith occur in three bodies. A large granite body extends into the eastern edge of the Blanco Mountain Roadless Area with a smaller body located west of it. Another small granitic body is exposed in Redding Canyon in the Black Canyon Roadless Area. Tertiary volcanic rocks are exposed in the northern Blanco Mountain Roadless Area.

The structural history of the roadless areas is marked by three periods of deformation. Prior to emplacement of the batholithic rocks, a thrusting event displaced younger Cambrian strata over older Cambrian rocks which elsewhere in the White Mountains are found in conformable sequences. Emplacement of the Mesozoic plutons locally deformed much of the older rock. Tertiary through Holocene basin-and-range faulting is responsible for the present steep, rugged topography.

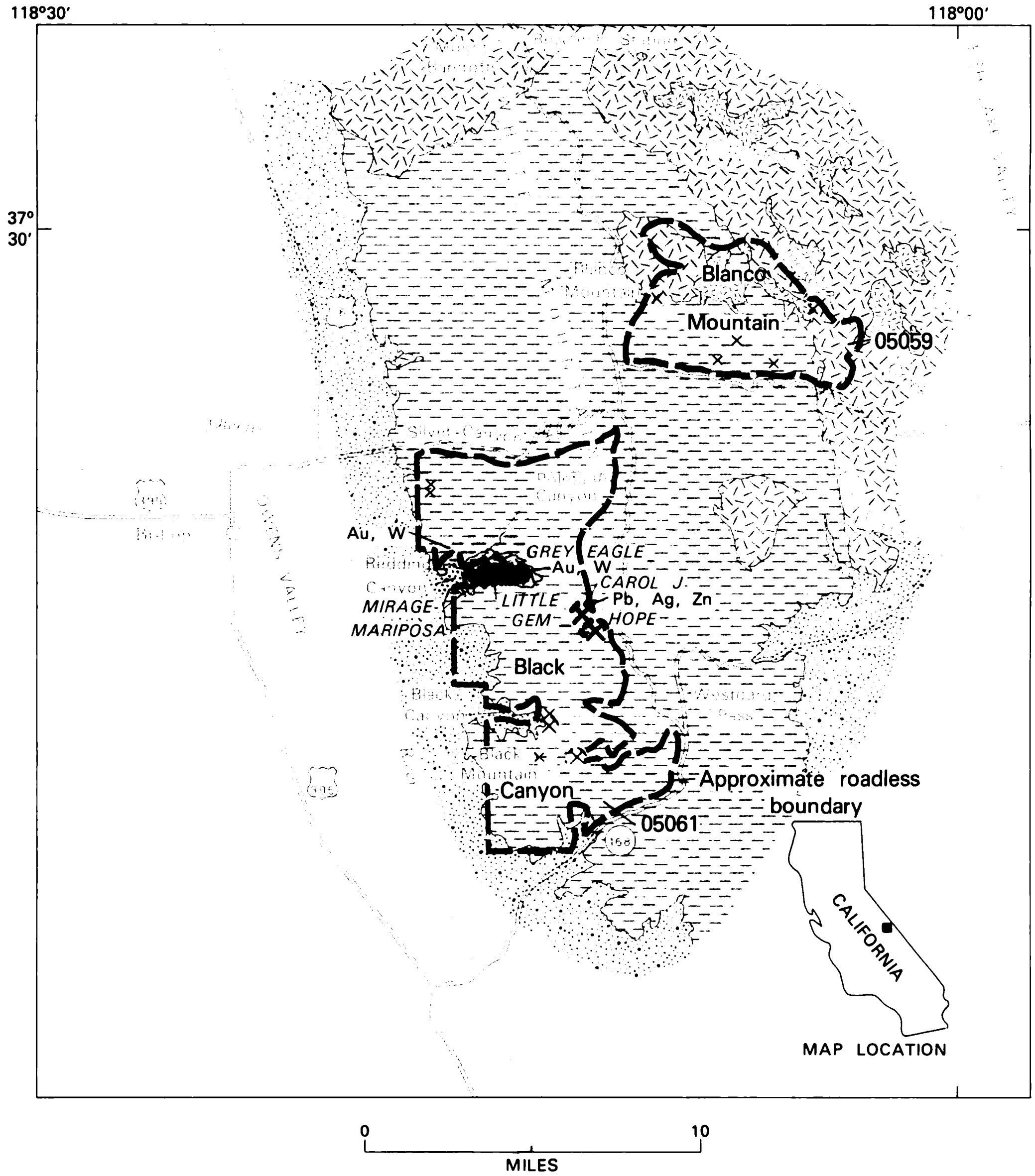
Mining activity in the Black Canyon Roadless Area dates back to the early 1860's; no claims were filed in the Blanco Mountain Roadless Area until about 1900. In the Black Canyon Roadless Area there is one mine which produced 11 tons of ore containing gold, silver, and copper; this and five additional properties within the roadless area contain 49,600 tons of demonstrated resources as determined by a mineral-deposit survey by the USBM.

MINERAL RESOURCES

In the Black Canyon Roadless Area, gold associated with veins of quartz, and lead, silver, and zinc in calcareous rocks are the major types of metal deposits which must be assessed. Tungsten is also known to be present in contact zones between granitic and calcareous rocks.

A single area with substantiated mineral-resource potential was identified in Redding Canyon on the

[1]With contributions from Steven W. Schmauch, USBM.



EXPLANATION

Geologic terrane with substantiated mineral-resource potential

Geologic terrane with probable mineral-resource potential

Au	Gold	W	Tungsten
Pb	Lead	Zn	Zinc
Ag	Silver		

⚒ Mine or deposit

× Mineral occurrence

⚒ Mine

Surficial deposits (Quaternary)

Volcanic rocks (Tertiary)

Plutonic rocks (Mesozoic)

Sedimentary rocks (Paleozoic and Proterozoic)

Contact

Figure 52.—Blanco Mountain and Black Canyon Roadless Areas, California.

western side of the Black Canyon Roadless Area. Gold-bearing quartz veins are present in the Gray Eagle mine inside the roadless area and the Little Gem mine, outside, but near, the roadless area. Tungsten-bearing skarn deposits outside the roadless area in this canyon occur at the Mirage-Mariposa mine. This type of deposit forms when hot, mineral-bearing fluids from intruding magma react with calcareous country rock and form the tungsten mineral scheelite. The contact zone from the Mirage-Mariposa mine extends into the Black Canyon Roadless Area. A geochemical survey in the mouth and interior of Redding Canyon showed slightly anomalous amounts of tungsten and moderately anomalous amounts of gold. An area of substantiated resource potential for gold and tungsten surrounded by an area of probable potential, is based on geologic and geochemical information, and the resources estimated at the Gray Eagle mine.

At the upper end of Redding Canyon, on the east edge of the Black Canyon Roadless Area, the Hope Group of claims includes the Carol-J mine in the roadless area and the Hope mine just outside the roadless area. Lead, silver, and minor zinc and gold were produced from these properties. Slightly anomalous gold and lead values were found during the geochemical survey. An area of probable resource potential occurs on the east edge of the Black Canyon Roadless Area for lead, silver, and zinc resources.

South of Silver Canyon, relatively anomalous amounts of gold, silver, lead, and barium were found during the geochemical survey. Barite in small veins is present in the Barite Queen prospect. Samples from Black Canyon were anomalous in lead, silver, and gold. Silver and gold occur in quartz veins in shear zones at the Black Beauty mine, outside the area. The Hall Extension prospect, inside the area, contains lead and silver in a fault-terminated quartz vein. Based on available data, there is little promise for the occurrence of resources in these areas.

In the northwestern part of the Blanco Mountain Roadless Area a contact zone between granitic rocks and calcareous strata may be the source of geochemical anomalies of tungsten found in this survey. The Blizzard Extension prospect within the area contains gold in small quartz veins. This property is along an igneous-sedimentary contact. Based on available information, there seems to be little likelihood of the occurrence of gold resources.

Tertiary basalt caps cover older stream gravels in the eastern part of the Blanco Mountain Roadless Area. Small amounts of gold have been produced from these gravels outside the area at the Blue Bird Nos. 1-3 claims, but there seems little promise for resources inside the roadless area.

The nature of the geologic terrain suggests little likelihood of the occurrence of energy resources in the roadless areas.

SUGGESTIONS FOR FURTHER STUDIES

In the Redding Canyon area detailed geologic mapping might better define the extent of gold mineralization. Detailed stream-sediment sampling and analysis of heavy-mineral concentrations could better define tungsten resource potential.

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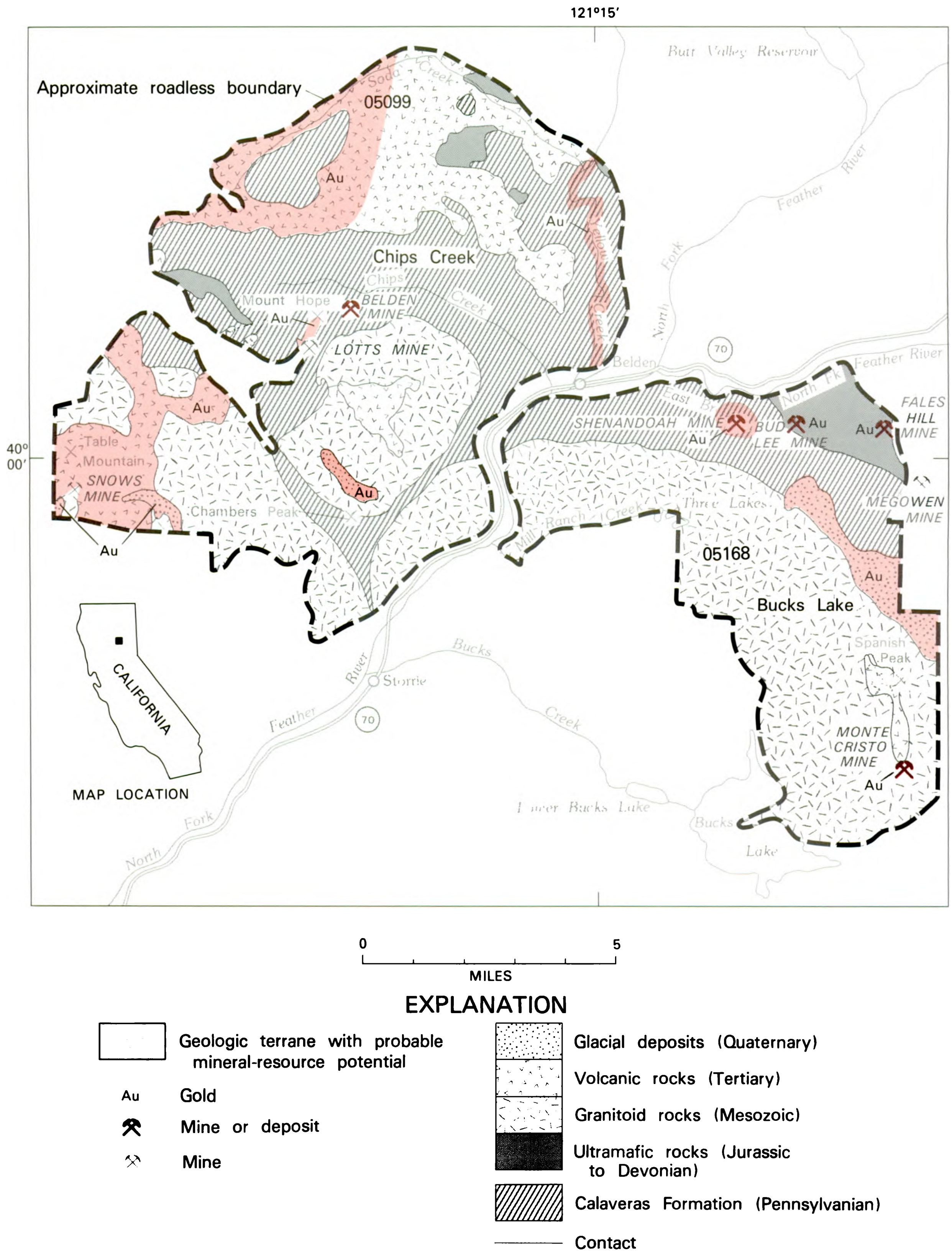

Figure 53.—Bucks Lake and Chips Creek Roadless Areas, California.

BUCKS LAKE AND CHIPS CREEK ROADLESS AREAS, CALIFORNIA

By MARTIN L. SORENSEN,[1] U.S. GEOLOGICAL SURVEY, and

J. MITCHELL LINNÉ, U.S. BUREAU OF MINES

SUMMARY

The results of a mineral-resource assessment of the Bucks Lake and Chips Creek Roadless Areas conducted during 1980–82 indicate several areas with mineral-resource potential. In the Bucks Lake Roadless Area, demonstrated and inferred low-grade lode gold resources exist at and near the Shenandoah mine. Demonstrated and inferred placer gold resources occur at the Bud Lee, Fales Hill, and Monte Cristo mines within the Bucks Lake Roadless Area. A probable placer gold resource potential exists in the Bucks Lake Roadless Area in areas covered by Quaternary glacial deposits. In the Chips Creek Roadless Area, demonstrated and inferred low-grade copper-gold-lead-zinc-silver resources exist at and near the Belden mine. An area of substantiated placer gold resource potential in the Chips Creek Roadless Area is located around the Lotts and Morris mines, and areas of probable placer gold resource potential exist in Quaternary glacial gravel around the Snows mine and along Yellow Creek. An area of probable placer gold resource potential exists between the Lotts and Morris mines and the Snows mine where auriferous (gold-bearing) Tertiary stream deposits may exist beneath Tertiary volcanic rocks. A similar area of probable placer gold resource potential exists beneath Tertiary volcanic rocks in the northwest corner of the Chips Creek Roadless Area. No other metallic mineral or any energy resources were identified in this study.

CHARACTER AND SETTING

The Bucks Lake and Chips Creek Roadless Areas are on the west slope of the Sierra Nevada approximately 20 mi west of Quincy, California. The Bucks Lake Roadless Area consists of 30 sq mi in Plumas National Forest. The Chips Creek Roadless Area comprises 70 sq mi in Lassen and Plumas National Forests. The two areas are separated by California Highway 70 and the canyon of the North Fork of the Feather River.

The Bucks Lake and Chips Creek Roadless Areas are in the northern part of the western Sierra Nevada metamorphic belt. Steeply dipping faults subdivide this metamorphic belt into four north- to northwest-trending belts of Paleozoic and Mesozoic metasedimentary and metavolcanic rocks that have been intruded by Mesozoic granitoid plutons and partially covered by Cenozoic volcanic rocks (Hietanen, 1973, 1981a, b). The two roadless areas encompass part of one of the fault-bounded belts. This belt consists mainly of metasedimentary rocks of Pennsylvanian age (Sorensen and Pietropaoli, 1982).

A mineral-resource study of the Bucks Lake and Chips Creek Roadless Areas (Sorensen and others, 1983) was conducted during 1980–82. The USGS did reconnaissance geologic mapping in selected areas, field-checked published geologic mapping, collected and analyzed rock and stream-sediment samples (Sorensen and others, 1982), and conducted a geophysical study of the roadless areas. The USBM studied the mines and prospects in and near the roadless areas and collected and analyzed samples from mines, prospects, mineralized areas, and major streams.

The Bucks Lake and Chips Creek Roadless Areas are near the northern end of the principal zone of placer gold deposits of the western Sierra Nevada. Tertiary and Quaternary placer gold deposits in and near the roadless areas have been mined by hydraulic and drift methods at various times since 1850 when gold was discovered at

[1]With contributions from Andrew Griscom and Henry Pietropaoli, USGS, and Scott A. Stebbins and Donald E. Graham, USBM.

Rich Bar on the East Branch of the North Fork of the Feather River. Claims have been filed in and near the roadless areas for lode deposits of chromite, copper, gold, lead, silver, and zinc, but with the exception of limited production from one lode gold deposit (Shenandoah mine) within the Bucks Lake Roadless Area and two lode gold deposits (Edman and Megowen mines) adjacent to the Bucks Lake Roadless Area, very little production is recorded for any of these metals from deposits within or immediately adjacent to the roadless areas. At the time of this study, the Callahan Mining Corporation was conducting an evaluation of the Shenandoah mine within the Bucks Lake Roadless Area, and placer gold was being mined from a gravel bar at the Bud Lee mine. Current mining activity within the Chips Creek Roadless Area consists of assessment work and recreational gold panning and dredging on Chips and Yellow Creeks.

MINERAL RESOURCES

Demonstrated and inferred lode gold resources exist at and near the Shenandoah mine in the Bucks Lake Roadless Area. The Shenandoah mine has produced 95 oz of gold from a zone of irregular bunches and stringers of quartz with occasional kidney-shaped enlargements (Averill, 1928, p. 295–296). Sampling data of the USBM indicate the presence of approximately 7500 tons of demonstrated and inferred resources averaging 0.19 oz/ton gold at the Shenandoah mine. The mineral potential of the Shenandoah mine is currently being evaluated by the Callahan Mining Corporation (R. D. Thomas, Callahan Mining Corp., written commun., 1981).

The Bud Lee, Fales Hill, and Monte Cristo placer gold mines in the Bucks Lake Roadless Area are developed on Tertiary auriferous gravel deposits. The Bud Lee mine, currently being worked, has demonstrated and inferred resources consisting of an estimated 89,000 cu yd of Tertiary river gravels having an average assay value of $0.27/cu yd. The operator reports recovering an amount of gold equivalent to an average of $10/cu yd from local, high-grade parts of the deposit. At the Fales Hill mine, gold has been recovered from deposits in deeply weathered bedrock, where the gold was concentrated during earlier hydraulic mining operations. Approximately 154,000 cu yd of demonstrated and inferred gold-bearing resources are at the Fales Hill mine, but there are difficulties in extracting gold from the weathered bedrock. Approximately 56,000 cu yd of demonstrated and inferred gold-bearing gravel resources are at the Monte Cristo mine. Nearby exposures of Tertiary river deposits suggest that any extensions of the Monte Cristo deposit will contain very little gold.

Quaternary surficial deposits in the Bucks Lake Roadless Area may contain gold reworked from Tertiary stream deposits. An area of glacial deposits in the eastern part of the Bucks Lake Roadless Area has probable resource potential for reworked placer gold.

Demonstrated and inferred resources of copper, gold, lead, and silver exist in a vein at the Belden mine in the Chips Creek Roadless Area. Production is not recorded for this deposit, but 6400 to 15,000 tons of low-grade resources averaging 0.08 oz/ton gold, 0.52 oz/ton silver, 0.52 percent copper, and 1.69 percent lead are present at the Belden mine. Additional resources may occur along strike or at depth in the vein.

An area around Mt. Hope that contains the Lotts and Morris mines has a substantiated potential for placer gold deposits. These mines contain demonstrated and inferred resources of 188,000 cu yd of auriferous Tertiary stream gravels.

A probable resource potential for placer gold deposits exists in an area around the Snows mine, southwest of the Lotts and Morris mines. The deposit is not exposed at present, but the operators were reported to have been working in gravel with a high gold content when operations were halted due to a cave-in (Lindgren, 1911, p. 96).

A probable resource potential for placer gold is recognized in the area between the Lotts, Morris, and Snows mines, where Tertiary stream deposits mined at those properties are probably present beneath Tertiary volcanic rocks. Similarly, a probable resource potential for placer gold exists in the northwest corner of the Chips Creek Roadless Area, where Tertiary volcanic rocks may overlie a concealed extension of the deposits mined at the Lotts and Morris properties.

A probable resource potential for placer gold deposits is present along Yellow Creek near the east boundary of the Chips Creek Roadless Area. Panned concentrates of stream sediments collected during this study contained as much as 100 parts per million gold (Sorensen and others, 1983). Tertiary auriferous gravel deposits traversed by Yellow Creek north of the roadless area have contributed reworked placer gold to the Yellow Creek drainage (Haley, 1923, p. 102). The presence of this gold is disclosed by chemical analysis and strongly suggested by numerous mining claims along Yellow Creek just north of the North Fork of the Feather River.

Quaternary surficial deposits may contain gold reworked from Tertiary stream deposits. Glacial deposits north of Chambers Peak are considered to have a probable resource potential for reworked detrital gold.

Claims are recorded for copper and chromite deposits in the roadless areas, but the results of the present study suggest that there is little promise for the occurrence of resources of these minerals. No potential for oil, gas, coal, or geothermal resources was identified within the study area.

SUGGESTIONS FOR FURTHER STUDIES

Early Tertiary stream deposits may be present beneath late Tertiary volcanic rocks between the Snows and Lotts mines and north of these properties in the Chips Creek Roadless Area. The presence or absence of these potentially auriferous deposits can best be determined by drilling through the relatively thin cover of volcanic rocks.

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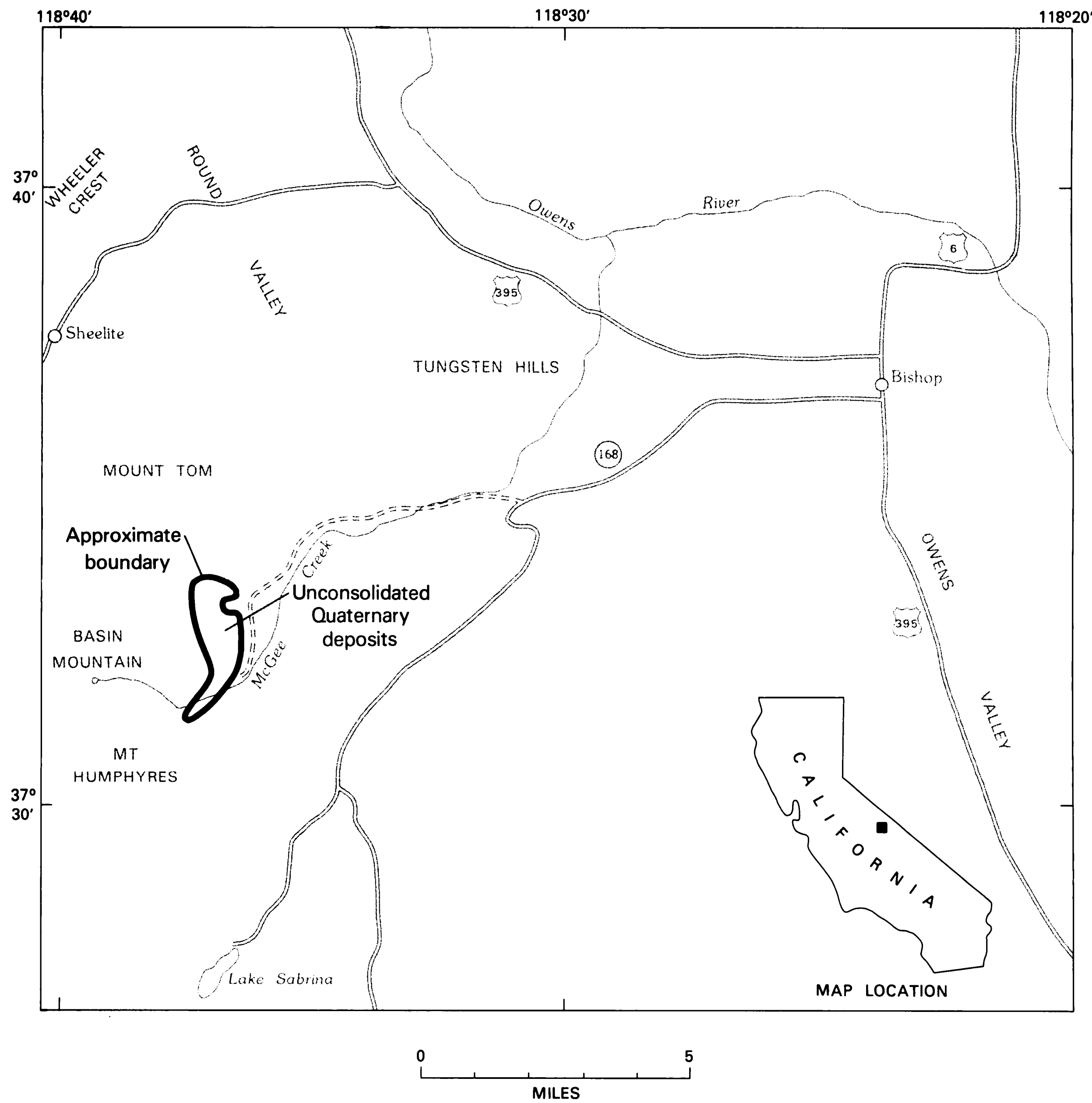

Figure 54.—Buttermilk Roadless Area, California.

BUTTERMILK ROADLESS AREA, CALIFORNIA

By EDWIN H. MCKEE, U.S. GEOLOGICAL SURVEY, and

STEPHEN R. IVERSON, U.S. BUREAU OF MINES

SUMMARY

The results of geologic, geochemical, and mining activity and production surveys made in 1980 in the Buttermilk Roadless Area indicate little or no promise for the discovery of metallic or energy resources in the area (McKee and Iverson, 1982). Glacial till and other types of surficial alluvium cover the bedrock to a depth of tens and probably hundreds of feet preventing examination and evaluation of possible minerals that might be present in the bedrock. No mining claims are known to be in the area and the nearest mining activity is too far removed to reasonably project mineralization into the buried bedrock of the roadless area. The glacial till has little promise for placer deposits because the eroded debris has had little or no sorting and concentration by natural hydraulic action.

CHARACTER AND SETTING

The Buttermilk Roadless Area is on the eastern side of the Sierra Nevada about 12 mi west of Bishop, California. It is contiguous with the John Muir Wilderness on its west side. The roadless area is 1.5 sq mi and lies at elevations between 7700 and 8700 ft above sea level. Easy access to its eastern boundary is by an unimproved dirt road that leads to McGee Creek, a major water source for Bishop.

The Buttermilk Roadless Area is covered entirely by unconsolidated Quaternary deposits including glacial till from at least three glacial periods recognized in the Sierra Nevada, and younger talus and alluvial-fan deposits. Bedrock is at an unknown depth beneath these surficial deposits but it is probably several tens to hundreds of feet beneath the surface. Outcrops of Triassic and Cretaceous granitic and Triassic or older mafic metavolcanic rock occur within about one half mile of the roadless area but the highly faulted nature of the eastern front of the Sierra Nevada make projection of the depth of bedrock beneath alluvium very speculative.

The glacial deposits are unsorted piles of rock rubble transported to their present site by flowing glaciers. As such, they contain a wide size range and variety of rock types. Glacial deposits classified as belonging to the Sherwin, Tahoe, and the Tioga Glaciations consist of remmants of moraines and other glacial detritus. The talus includes rock glaciers and some reworked till or modified moraine deposits; the alluvial fans are the debris that accumulated where a significant flattening in slope occurs and alluvium gathers. Less steep parts of the roadless area are covered with variable thicknesses of talus and alluvial fans that are younger than the glacial till deposits.

MINERAL RESOURCES

Examination of the Buttermilk Roadless Area and sample analyses failed to reveal any indication of metallic, nonmetallic, or energy resources. The entire area is covered by a considerable thickness of glacial debris and bedrock which might prove a target for exploration is at variable depths probably measured in tens or hundreds of feet. Analyses of gravel samples taken where gold or other heavy metals would tend to accumulate contain no valuable heavy minerals. Glacial till which comprises most of the surficial deposits in the area is not particularly good as host for placer deposits because of the lack of natural hydraulic action to concentrate minerals of differing specific gravity.

SUGGESTIONS FOR FURTHER STUDIES

Further study of the roadless area offers little promise for the identification of hidden mineral deposits. Bedrock exposures are no closer than about 0.5 mi from the roadless area and have no known mineral deposits so that subsurface exploration does not seem warranted.

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CACTUS SPRING ROADLESS AREA, CALIFORNIA

By JONATHAN C. MATTI,[1] U.S. GEOLOGICAL SURVEY, and

LUCIA KUIZON, U.S. BUREAU OF MINES

SUMMARY

Geologic, geochemical, and geophysical studies by the USGS in 1980–82, together with a review of historic mining and prospecting activities by the USBM, indicate that the Cactus Spring Roadless Area has little promise for the occurrence of mineral or energy resources. Marble bodies occur in the northern part of the roadless area and are possible resources for building stone, crushed and quarried aggregate, and lime and magnesium for Portland cement and industrial applications. No resource potential was identified for the marble because the quantity and quality of the resources was not established.

CHARACTER AND SETTING

The Cactus Spring Roadless Area is located in the Santa Rosa Mountains, about 25 mi southeast of Palm Springs and about 10 mi south of Palm Desert, California. The roadless area consists of about 30 sq mi within the San Bernardino National Forest, and includes rugged mountainous terrain covered with coniferous forest and dense chaparral as well as rolling high-desert terrain that supports a blend of desert scrub and pinon-juniper woodland. Topographic relief within the roadless area ranges from about 4000 ft to about 7600 ft; prominent summits in the vicinity include Martinez Mountain (6562 ft) and Toro Peak (8716 ft). Two major stream drainages bisect the roadless area: Horsethief Creek flowing northwestward into Deep Canyon, and an unnamed perennial stream flowing southeastward through Martinez Canyon. Access to the roadless area is limited because it is almost entirely surrounded by rugged ground that has no roads and few established trails. One foot trail that does provide access originates near California State Highway 74 at the northwest corner of the roadless area.

The Cactus Spring Roadless Area is underlain by plutonic igneous rocks and metamorphosed sedimentary rocks. The crystalline units have been deformed during at least two major events (Sharp, 1979): a period of intense ductile shearing that stretched and squeezed the rocks and produced foliated and layered fabrics (mylonitic fabrics); and a period of brittle deformation during which different rock types were juxtaposed by large-scale lateral movements on thrust faults. Valley areas within the roadless area locally are mantled by Quaternary deposits of sand and gravel, and landslides are developed on some hillslopes.

The oldest rocks in the roadless area consist of metasedimentary units that include biotite schist and phyllite, gneiss, metaquartzite, and calcareous and dolomitic marble. These rocks represent ancient accumulations of clay, silt, sand, and calcareous sediment that were deposited in the sea, probably during the Paleozoic Era or during Precambrian time. During the Mesozoic Era, the lithified sedimentary rocks were intruded by large plutonic bodies of granitic magma. High temperature and pressure associated with these igneous events converted the sedimentary rock to schist, phyllite, metaquartzite, gneiss, and marble by metamorphic processes that partially melted the sedimentary rocks, folded and sheared-out the sedimentary layering, and produced new mineral assemblages. The igneous bodies produced during these events include various types of granitic rock (monzogranite, granodiorite, tonalite, and quartz diorite) that occupy much of the Cactus Spring Roadless Area. Although these plutonic and metamorphic events provided a geologic setting within which mineralizing systems could have operated to produce mineral deposits in the Cactus Spring Roadless Area, we did not observe geologic evidence for mineral concentrations or deposits.

Toward the end of these plutonic and metamorphic events, some rocks in the region were subjected to intense ductile shearing that stretched and squeezed the

[1]With contributions from Brett F. Cox, Robert E. Powell, Bradley Erskine, Eduardo A. Rodriguez, Scott E. Carson, and Curtis M. Obi, USGS.

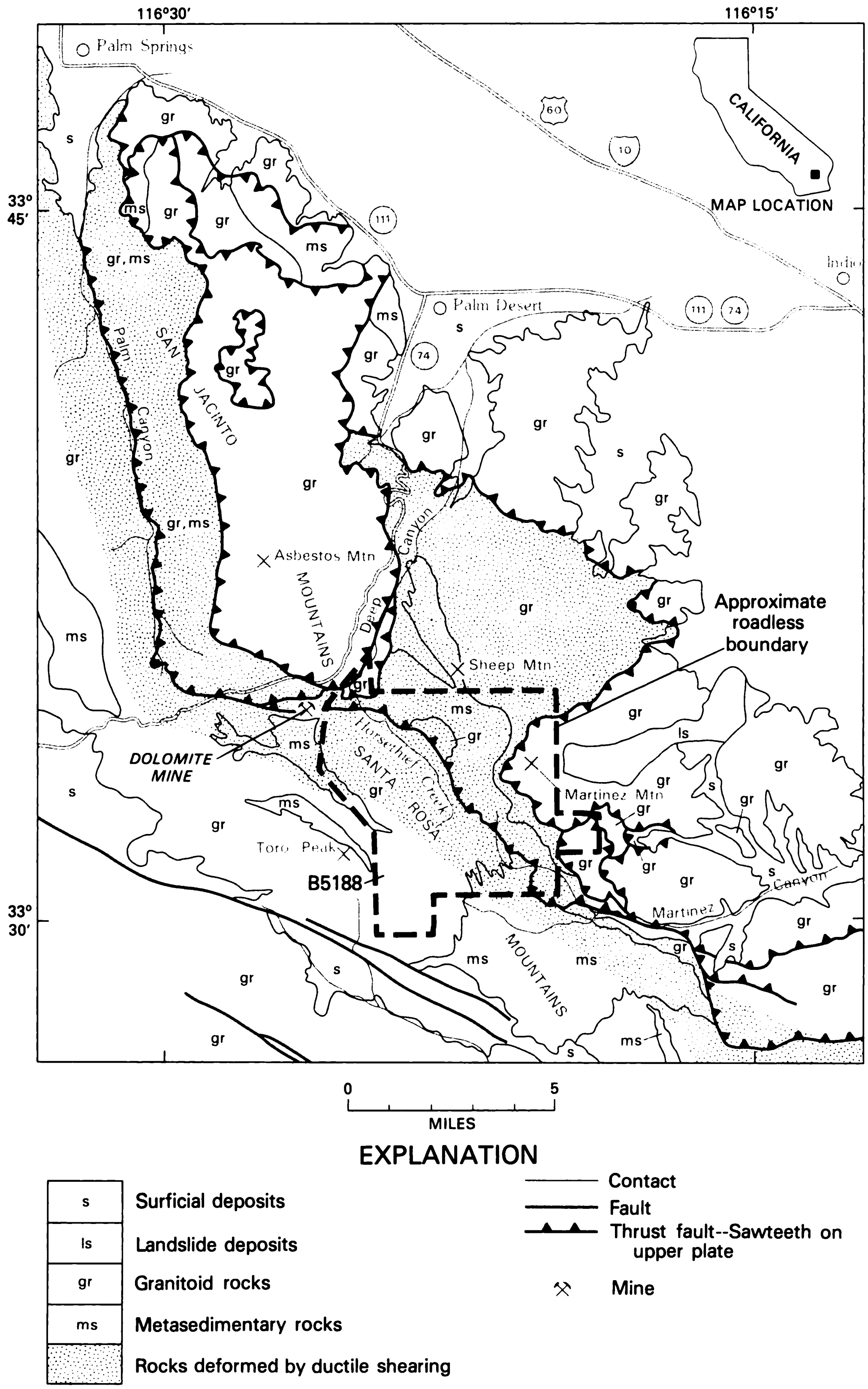

Figure 55.—Cactus Spring Roadless Area, California.

rocks, resulting in a variety of deformational fabrics. Rocks in the southwest part of the roadless area generally escaped this deformation, or only were affected mildly by it. However, northeastward toward Horsethief Creek, the rocks progressively display increasing evidence of shearing. In the deformed zone, the rocks are strongly foliated, culminating in mylonitic fabrics that largely obscure the original plutonic or metamorphic appearance of the rocks. The most intensely deformed rocks are represented by a narrow belt of dark-colored, fine-grained mylonite that occurs along the south flank of Horsethief Creek. Northeast of Horsethief Creek, toward Sheep Mountain, the rocks also are foliated and mylonitized, although not so intensely as the mylonite along Horsethief Creek. There is no evidence that mineral deposits were produced within the Cactus Spring Roadless Area during this period of ductile shearing.

After the period of ductile deformation, rocks in the roadless area were cut by low-angle thrust faults that broke the rocks into brittle slabs or plates and carried these plates laterally. Some thrust-fault-bounded plates may have been displaced only a short distance. However, other plates may have been displaced a few miles or even a few tens of miles laterally, as suggested by relationships on Martinez Mountain where a thrust–faulted plate of relatively undeformed granitic rock overlies a plate of highly deformed granitic and metasedimentary rocks. Mineral deposits apparently were not produced within the Cactus Spring Roadless Area during this period of thrust faulting. Instead, rocks that may have been mineralized during earlier geologic events merely were redistributed within the mountain range by movements on the thrust faults.

A reconnaissance geochemical survey of stream sediment in the Cactus Spring Roadless Area was conducted to identify spatial variations in stream-sediment chemistry that might reflect local concentrations of ore minerals in bedrocks drained by the streams. The patterns of chemical composition determined by the geochemical survey do not indicate significant mineralization within the roadless area. Most of the analyses fall within ranges that are reasonable for nonmineralized crystalline rocks and derivative stream sediment; few elemental values are anomalous with respect to average geochemical abundances for the roadless area. An aerial magnetic survey of the roadless area (U.S. Geological Survey, 1982) did not reveal any abnormal patterns of rock magnetism and thus provides no indication of mineral resources.

Our investigation of historic mining and prospecting activity indicates that no mineral production has come from the Cactus Spring Roadless Area, no mines and prospects exist in the area, and only three currently inactive claims have been filed within the boundaries of the roadless area.

MINERAL RESOURCES

Geologic, geochemical, and geophysical investigations, together with a review of prospecting and mining activities, indicate that the Cactus Spring Roadless Area has little promise for the occurrence of mineral or energy resources.

Although geologic mapping within the roadless area has identified geologic environments potentially favorable for mineralization, we did not observe evidence of mineral concentrations or mineral deposits within these environments. Small-scale occurrences of tungsten in tactite (skarn) settings have been identified elsewhere in the Santa Rosa Mountains, where bodies of metasedimentary rock have been engulfed by granitic rock. However, we did not observe evidence for tungsten mineralization in metasedimentary rocks of the roadless area. Bodies of marble (metamorphosed limestone and dolomite) occur within the roadless area in the belt of metasedimentary rock north of Horsethief Creek. The marble units are possible resources for crushed aggregate, building stone, and lime and magnesium for Portland cement and industrial applications. The marble has variable magnesium content, ranges from pure carbonate to carbonate containing nodules of silica and clots of calc-silicate minerals, and includes relatively thick monolithologic carbonate units as well as thin lenticular units that are interlayered complexly with noncarbonate metasedimentary rocks. Because the marble units have variable quantity, composition, quality, thickness, and extent, detailed mapping and sampling would be needed to assess the resource potential of this commodity.

Generally low concentrations of metallic and nonmetallic elements in stream sediments sampled within the roadless area indicate that elemental abundance generally fall within background ranges expected for nonmineralized rocks.

Aeromagnetic patterns do not point to the existence of economic concentrations of magnetic minerals.

Within the boundaries of the roadless area, prospecting activities have been limited and short lived, no production has been reported, and no deposits of metallic or radioactive minerals have been discovered. The three currently inactive claims within the roadless area were filed for marble deposits similar to those that occur at the Dolomite mine. Two of the claims do not contain marble and the third contains marble units that are thin extensions of the marble occurring at the Dolomite mine; no carbonate resources were identified.

SUGGESTIONS FOR FURTHER STUDIES

The results of the mineral-resource survey indicate that further study of the roadless area for mineral and energy resources is not warranted. In the event that future mineral resource investigations are contemplated, it is recommended that the terrane of marble be mapped and sampled carefully in order to evaluate the quantity and quality of the carbonate resources.

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CARIBOU WILDERNESS AND TRAIL LAKE ROADLESS AREA, CALIFORNIA

By ALISON B. TILL,[1] U.S. GEOLOGICAL SURVEY, and

EDWARD L. MCHUGH, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Caribou Wilderness and Trail Lake Roadless Area conducted in 1979 revealed no indications of a potential for mineral or fossil fuel resources in the areas. The wilderness is in the Cascade volcanic province, a setting locally favorable for geothermal resources, but no geothermal resource potential was identified in the wilderness or roadless area.

CHARACTER AND SETTING

The Caribou Wilderness and Trail Lake Roadless Area are part of Lassen National Forest, in northeast California. They are adjacent to the east boundary of Lassen Volcanic National Park and together are roughly 8.5 mi from north to south and 6 mi from east to west, a total of about 34 sq mi. Susanville, California, the nearest population center, is 25 mi to the east. Redding, California is 65 mi to the west.

Caribou Wilderness and Trail Lake Roadless Area lie within the southernmost part of the Cascade Range. The wilderness and roadless area are near the juncture of three major geologic provinces: the Cascade volcanic province, the Modoc plateau volcanic province, and the Sierra Nevada province of metamorphic and plutonic rocks. Geologic units within the area may be assigned to the High Cascade Volcanic series of Macdonald (1966), the post-Miocene rocks that form the crest of the Cascade Range. Oldest units of the High Cascade series are deeply eroded block-faulted lavas assigned a latest Pliocene age by Macdonald (1964). The lavas of the Caribou Wilderness and Trail Lake Roadless Area are less deeply eroded, less pervasively block faulted, and are probably Pleistocene to Holocene in age. The wilderness is a high plateau of Pleistocene basaltic andesite flows and basalt buttes. A thin veneer of glacial and lacustrine deposits occupies the central valley of the plateau. A Holocene basaltic cinder cone and flows that emanated from it sit on the north end of the plateau. The Trail Lake Roadless Area is on the east flank of the Caribou Wilderness. Rocks exposed there are the Pleistocene basaltic andesite which forms the high plateau of the Caribou Wilderness. Northwest of Silver Lake the wilderness and roadless area are physically separated by a vertical fault scarp as much as 150 ft high.

A light-medium-gray porphyritic basaltic andesite is the major unit in the wilderness and the only unit in the roadless area. It is a thick composite unit which includes flows and a subordinate volume of cinders erupted from numerous vents. The most prominent vents within the wilderness are North Caribou and South Caribou. Lavas erupted from Red Cinder overlie the basaltic andesite and are medium dark gray, sparsely porphyritic and glomeroporphyritic, and commonly platey and vesicular. Abundant red cinders cap the peak itself. The basaltic andesite and the basalt of Red Cinder have been glaciated. Both units are cut by near vertical faults trending roughly north south. A series of steep, talus-sided flat-topped buttes from 1/3- to 1/2-mi in diameter and as high as 300 ft are found in the central valley of the wilderness. They are composed of glassy olivine basalt, sit on the basaltic andesite, and were erupted along a roughly north-south trending line which is parallel to the vertical faults which cut the basaltic andesite. The general shape, limited lateral extent, glassy texture, and jointing perpendicular to the margins of the buttes are characteristics strongly suggestive of subglacial origin. The glacial deposits in the central valley of the wilderness consist of a thin veneer of ground moraine that is locally overlain by lacustrine deposits. The flows that emanate from Black Butte, a prominent cinder cone on the north boundary of the wilderness, are the youngest in the area. The flows are blocky, generally unvegetated, reddish gray, and 6 to 30 ft thick.

[1]With contributions from Clayton M. Rumsey, USBM.

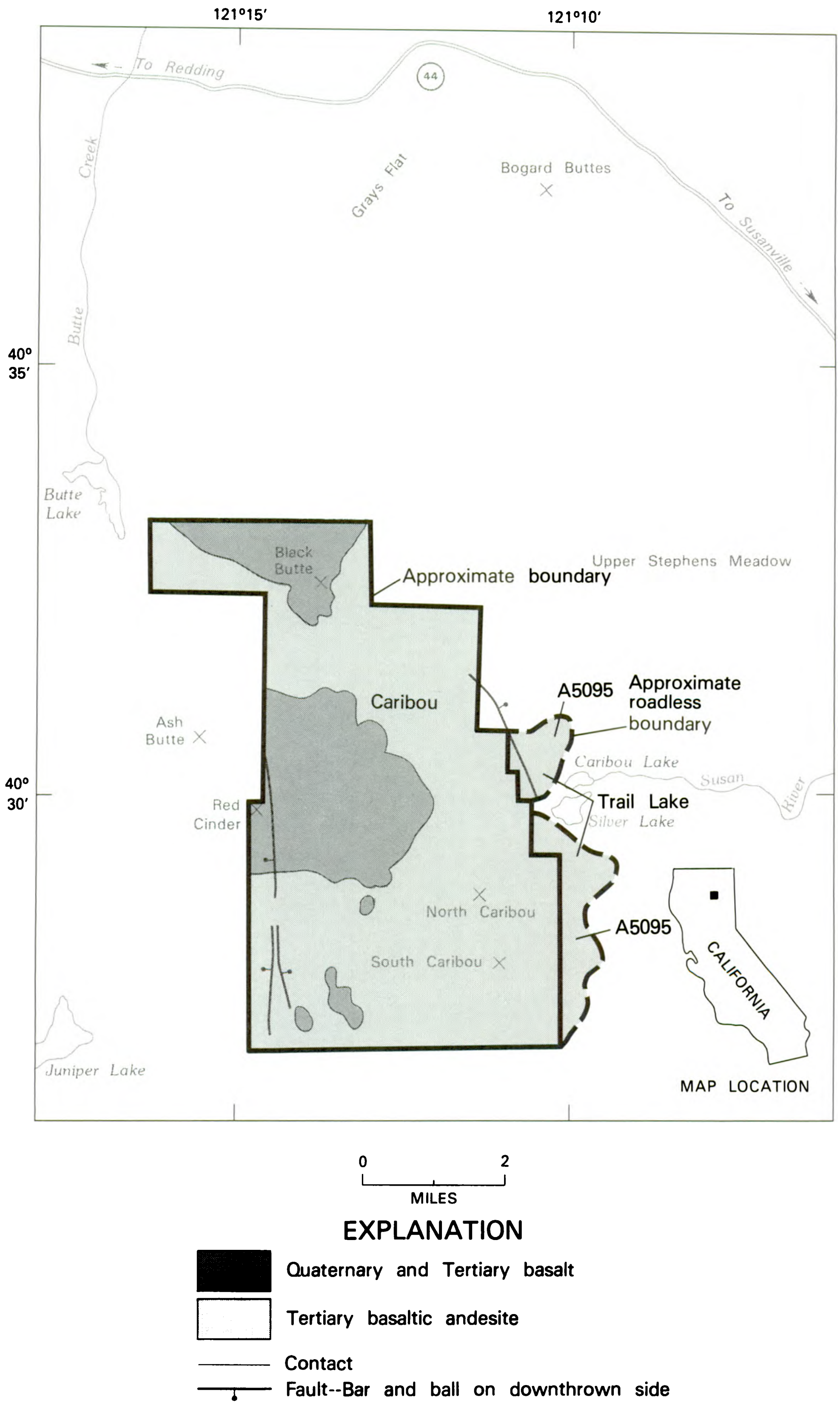

Figure 56.—Caribou Wilderness and Trail Lake Roadless Area, California.

MINERAL RESOURCES

Geologic mapping, geochemical sampling, and aeromagnetic surveys by the USGS and field assessment by the USBM have found little promise for the occurrence of metallic mineral or energy resources in the Caribou Wilderness and Trail Lake Roadless Area. Cinders, suitable for road metal, are locally abundant but difficult to access relative to more plentiful deposits outside of the wilderness. Hot springs, mineral sublimates from fumaroles, or other surface features indicating geothermal resource potential were not found. The wilderness is 1 mi northeast of the Morgan Springs Geothermal Resource Area (KGRA) that adjoins the south side of Lassen Volcanic National Park and more than 100 hot springs are known 7–15 mi west of the area (Waring, 1968, p. 20–21). Although known geothermal resources occur in the vicinity of Lassen Volcanic National Park, drilling is necessary to assess the geothermal resource potential of the Caribou Wilderness and Trail Lake Roadless Area.

No mining claims have been located, and no mines or prospects are known within the area studied. Mining for gold has occurred in Mesozoic granitic rocks in the Diamond Mountain gold district, 25 mi to the southeast, and in Mesozoic rhyolitic tuffs at Hayden Hill, 36 mi northeast of the wilderness and roadless area. Copper was mined 27 mi southeast of the area in the Plumas copper belt. Host rocks for these deposits are older than rocks of the Caribou Wilderness. In Lassen Volcanic National Park, the Supan Sulphur Works 15 mi west of the wilderness produced a small amount of sulfur before 1900 (Lydon, 1957, p. 616). The sulfur was deposited from hot gasses or water released at the Earth's surface. No sulfur was identified in the wilderness and roadless area.

Volcanic cinders have been mined from at least 14 sites within 10 mi of the wilderness. Most were used as road building material, railroad ballast, or as lightweight aggregate in concrete. Several million cubic yards of good quality cinders are available within the wilderness at Black Butte, Red Cinder, and other smaller cones, but abundant cinders are available at sources outside these areas.

Large volumes of basalt and andesite within the areas studied are potential sources of stone for construction uses. Quarries throughout the region have yielded undetermined quantities of stone, mostly used for road building and stone sources outside the wilderness, are sufficient to meet future needs.

SUGGESTION FOR FURTHER STUDIES

Further study of the wilderness and roadless area is not likely to identify mineral resources. The geologic setting is favorable for geothermal resources, but regional studies and drilling would be necessary to identify geothermal resource potential.

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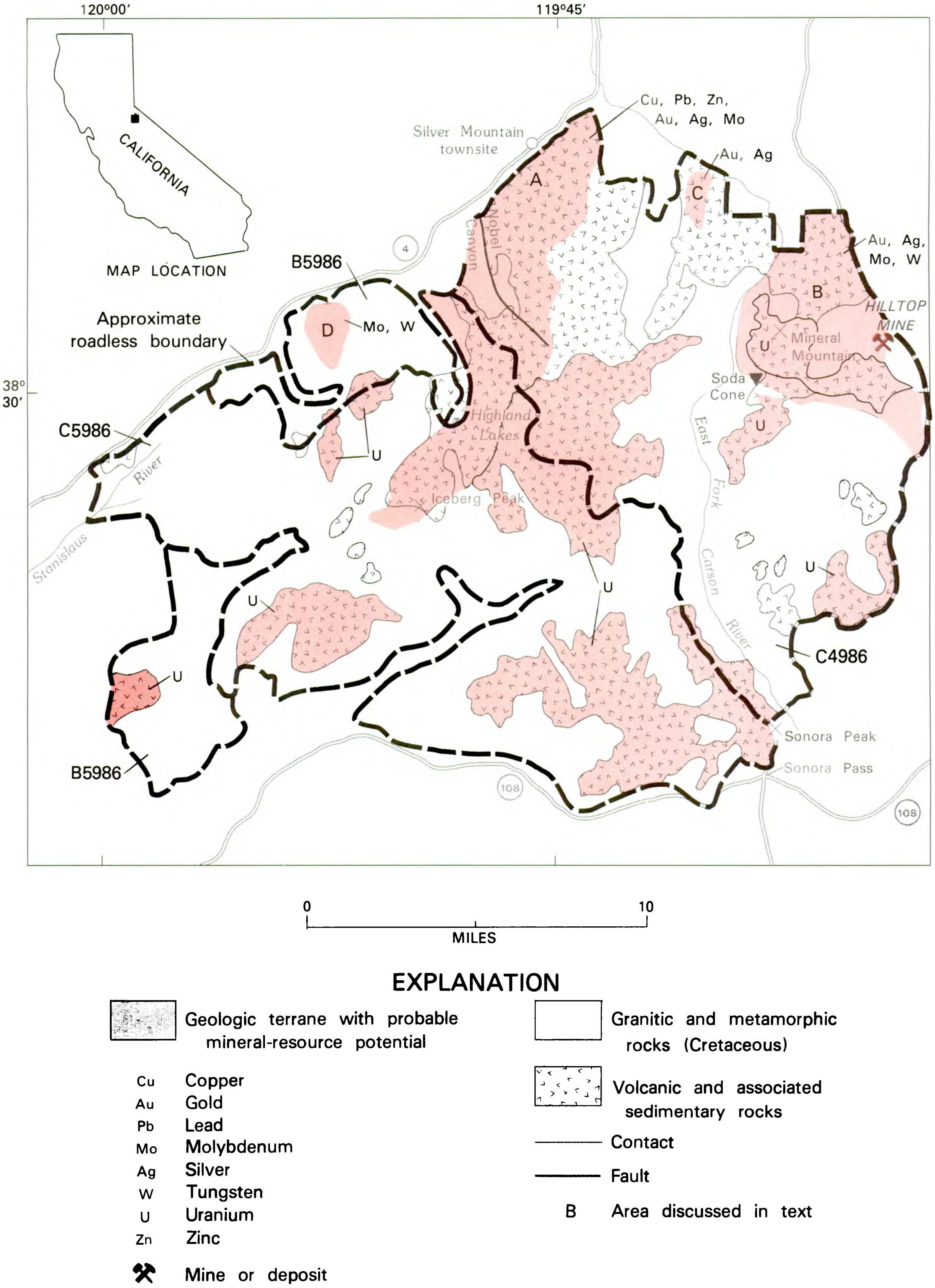

Figure 57.—Carson-Iceberg Roadless Areas, California.

CARSON-ICEBERG ROADLESS AREAS, CALIFORNIA

By WILLIAM J. KEITH,[1] U.S. GEOLOGICAL SURVEY, and

MICHAEL S. MILLER, U.S. BUREAU OF MINES

SUMMARY

Areas of probable mineral-resource potential for base and precious metals, molybdenum, tungsten, and uranium were identified in 1979–81 by the USGS and the USBM in the Carson-Iceberg Roadless Areas, California. During the mineral-resource study existing geologic mapping was modified and supplemented with new mapping; geophysical studies were conducted in the form of gravity and aeromagnetic surveys; stream-sediment and rock samples were collected in all of the drainage basins and chemically analyzed; and the USBM personnel conducted studies of mines, prospects, and known mineralized areas. No evidence of fossil fuel resource potential was found in the study.

CHARACTER AND SETTING

The Carson-Iceberg Roadless Areas form a roughly circular area of 343 sq mi in Alpine and Tuolumne Counties, California. The roadless areas are bisected by the northwest-trending boundary of the Stanislaus and Toiyabe National Forests which coincides with the crest of the Sierra Nevada. The Carson-Iceberg Roadless Areas are bounded approximately on the east by the Mono-Alpine County boundary; on the south by California State Highway 108; on the west by the west boundary of the Dardanelles Cone 15-minute quadrangle, and on the north by California State Highway 4 and the East Fork of the Carson River. The area is quite rugged containing many peaks over 10,000 ft in altitude and at least one that reaches 11,462 ft (Sonora Peak).

The oldest rocks in the roadless areas are Cretaceous granitic gneisses and undivided metamorphic rocks. These are either surrounded by or included in plutonic rocks of Mesozoic age. The plutonic rocks are mostly granodiorite, although small bodies of alaskite, tonalite, and adamellite occur locally.

Tertiary and Quaternary age volcanic rocks and minor interbedded sedimentary rocks intrude and overlie the older rocks.

[1]With contributions from Maurice A. Chaffee and Donald Plouff, USGS.

MINERAL RESOURCES

There are four areas (A-D, on map) in the Carson-Iceberg Roadless Areas that have probable mineral-resource potential. These areas of probable potential are discussed in order of their importance.

The Nobel Canyon drainage basin in the northern part of areas C4–986 and C5–986 (area A, on map) contains geochemically anomalous concentrations of silver, arsenic, lead, and copper in stream sediments. It contains both plutonic and volcanic rocks, including younger silicic volcanic rocks which are strongly favorable host rocks. This area also contains a zone of intense hydrothermal alteration as indicated by the presence of an iron-barium-strontium-cobalt alteration suite, silicification, argillization, and strong bleaching and pyritization. A fault in Nobel Canyon is probably one of the feeders for alteration and mineralization in the area.

Further south in area A, sediment from a stream draining the Highland Lakes contains anomalous amounts of silver, copper, lead, zinc, iron, and barium. Sediments from streams draining Iceberg Peak, at the southern end of the strip, contain anomalous concentrations of silver, copper, cadmium, molybdenum, barium, and strontium. Although there are no known mineral deposits in this area, it has been heavily prospected in the past, and trace amounts of placer gold can still be found in various creeks in the area.

Area A extends northward, outside the roadless areas, into the Silver Mountain mining district which has many inactive gold and silver mines and prospects.

Area B contains drainage basins with anomalous concentrations of lead, arsenic, silver, antimony, bismuth, tin, beryllium, boron, and molybdenum. Favorable rock types in this area consist of metamorphic rocks and granitic rocks. The rocks contain many areas of shearing and quartz veining and are largely hydrothermally altered. The area has been extensively prospected. The Hilltop mine, on the west edge of the area, has demonstrated resources of 720,000 tons containing an estimated 0.17 oz gold/ton. The mineral resources in this area would most likely be precious-metals in veins or porphyry molybdenum-tungsten-type deposits.

Drainage basins in area C contain anomalous amounts of copper, lead, silver, arsenic, and antimony and also minor amounts of alteration and shearing. There is a probable potential for vein-type precious metal resources.

Area D contains only minor amounts of alteration, shearing, and anomalous amounts of molybdenum, tin, and tungsten. Resources here would probably be molybdenum or tungsten of the quartz vein or pegmatite type.

Areas of probable uranium potential are shown where the geologic environment would support the presence of uranium oxide. Uranium is concentrated in the basal sedimentary rocks of the largely volcanic Miocene Relief Peak Formation which is widespread in the roadless areas. The uranium was probably leached from the overlying Miocene Eureka Valley Tuff also largely of volcanic origin. A mine south of the roadless area produced 45,000 lbs of uranium oxide from 1963 to 1966 in areas of similar geologic environment and age.

SUGGESTIONS FOR FURTHER STUDIES

Areas A and B contain combinations of geologic and geochemical indicators strong enough to warrant further study of these two areas. However, the location of these areas, the limited access, and the fact that these areas are used extensively for recreation, probably preclude large-scale exploration attempts.

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CHANCHELULLA ROADLESS AREA, CALIFORNIA

By DONALD F. HUBER,[1] U.S. GEOLOGICAL SURVEY, and

SCOTT A. STEBBINS, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey in 1980–82, there seems to be little likelihood for the occurrence of mineral resources in the Chanchelulla Roadless Area, California, except for a demonstrated resource of about 7200 tons containing 0.084 oz gold/ton, 0.84 oz silver/ton, and accessory copper at the Chanchelulla prospect. This prospect is located on a northwest-trending quartz vein. Limestone and small amounts of magnetite occur in the area but on the basis of available data no resources are identified. No potential for energy resources was identified.

CHARACTER AND SETTING

The Chanchelulla Roadless Area occupies an area of about 18.6 sq mi in the Klamath Mountains about 8 mi southeast of Hayfork, California. Altitude above sea level ranges from 2850 ft on the north, along East Fork Hayfork Creek, to 6399 ft on Chanchelulla Peak, near the center of the roadless area.

The roadless area is underlain by sedimentary rocks in the northwest and northeast. The remainder of the roadless area is underlain by mafic and ultramafic rocks. The sedimentary rocks were accreted to the North American continent by plate-tectonic processes between 230 and 185 million years ago (Early Triassic to Early Jurassic). The mafic and ultramafic rocks were intruded between 160 and 170 million years ago (Middle Jurassic). The sedimentary rocks in the roadless area are all in fault contact with the mafic and ultramafic rocks.

Streams draining the roadless area were sampled, and representative samples of the rock types in the area were collected. Samples from all mines and prospects were collected and analyzed to check the nature of the mineralized rock. The rock sample analyses were used to establish background values to compare with the stream sediment analyses, and evaluated in terms of geologic setting and resource significance.

Mining in the Klamath Mountains began in 1848 with the discovery of gold in the Trinity River and has continued intermittently since then. The gravels of the East Fork of Hayfork Creek, just north of the roadless area, have been mined using various placer techniques. The Midas mine 3 mi south of the roadless area, was one of the largest gold producers in Shasta County during the early part of the century. Various prospects and claims have been located in or near the roadless area. Within the roadless area the prospects include the Chanchelulla and the Potato Creek. Near the boundaries of the roadless area the prospects include the Iron Chief, the Deer Lick Springs, and the High Channel.

[1]With contributions from Scott C. Nelson and Luis A. Fraticelli, USGS.

MINERAL RESOURCES

Lode gold and silver are present in the roadless area at the Chanchelulla prospect. The prospect was discovered in 1929 and produced 1 oz of gold and 14 oz of silver in 1958. Demonstrated resources of over 7200 tons are estimated from a quartz vein 1.5 ft thick, 480 ft northwest-southeast along strike and 120 ft down dip. Actual exposure of the vein is 240 ft along strike. The quartz vein contains 0.084 oz gold/ton, 0.84 oz silver/ton, and accessory copper, and the gold and silver contents appear to be persistent throughout. Copper might be recovered as a co-product.

No other quartz veins similar to the one at Chanchelulla prospect were found in the roadless area during this study, nor have they been found by prospectors who have extensively explored this region since the 1850's. This activity makes the occurrence of additional lode gold-silver deposits at the surface very unlikely. Quartz veins with gold and silver that do not crop out

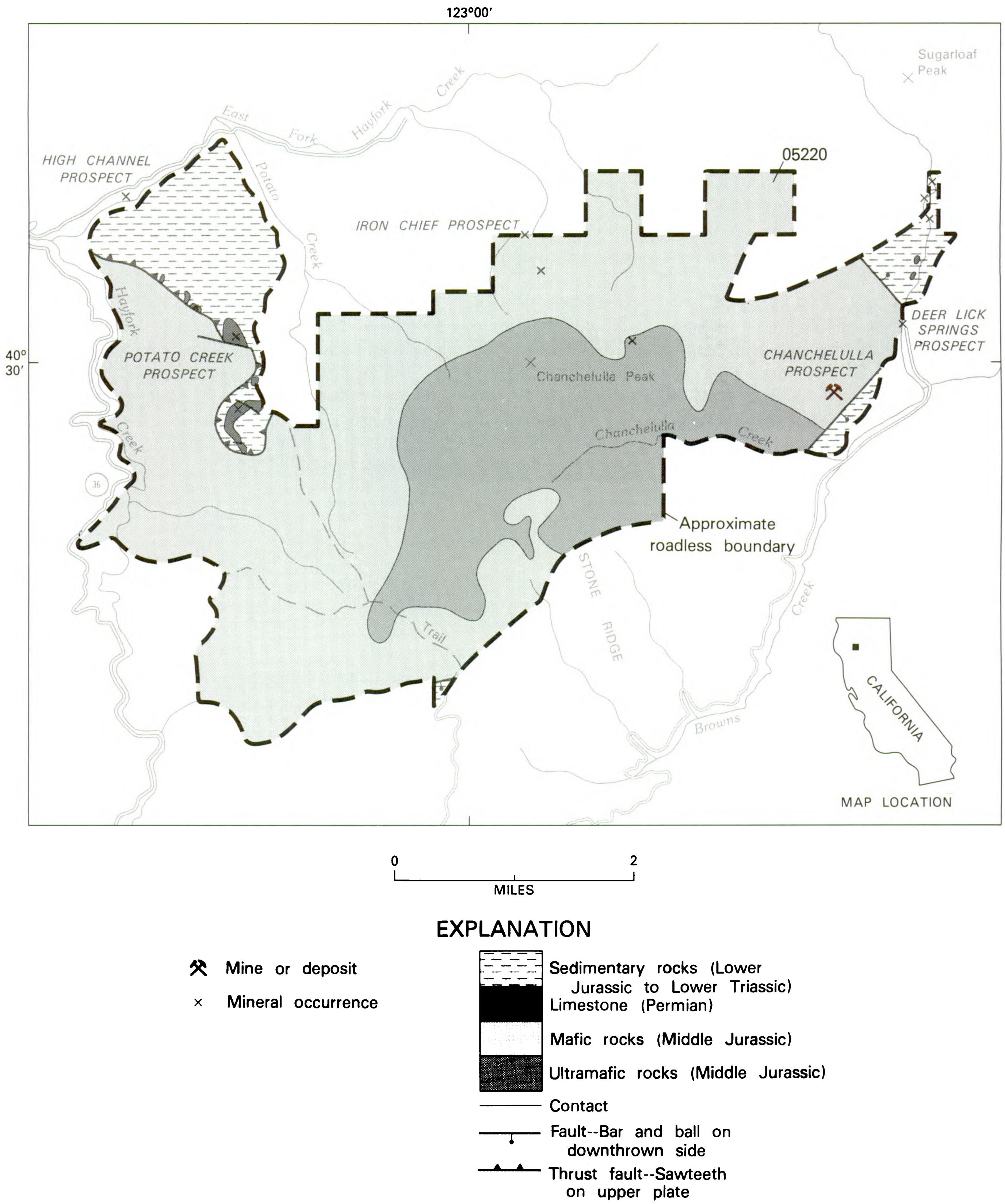

Figure 58.—Chanchelulla Roadless Area, California.

might possibly be present in the roadless area, but because there are no indications to narrow the search for these occurrences, they would be difficult to locate by present-day methods. There seems, therefore, little likelihood for the occurrence of gold resources beyond the Chanchelulla prospect, based on available data.

Placer gold has been recovered from the gravels of the East Fork of Hayfork Creek, just north of the roadless area, notably from the High Channel prospect. Placer gold has also been recovered from many places along the Hayfork Creek and a portion of this creek runs along the western margin of the roadless area. This reach of the creek is a steep-walled, narrow canyon that contains small amounts of sand and gravel. Small, portable, underwater suction-dredge operations may recover small amounts of gold from the sand and gravels that are present. Because the analyses of stream-sediment samples from streams that drain the roadless area do not show significant amounts of gold, the placer gold recovered from Hayfork Creek was probably derived from sources outside the roadless area.

The background levels for chromium, nickel, and cobalt are fairly high throughout the Chanchelulla Roadless Area, but are consistant with their occurrence as common minor elements in mafic and ultramafic rocks. Some concentration was noted in stream sediments as chromium, nickel, and cobalt minerals are highly resistant to, and may be concentrated by, weathering processes. Small amounts of platinum-group elements also are common in mafic and ultramafic rocks. Where detected in stream-sediment samples, the platinum-group element values do not exceed the background levels. Like placer gold, the platinum-group elements recovered from the Hayfork and East Fork of Hayfork Creeks were probably derived from other sources outside the roadless area.

Magnetite occurs at the Iron Chief prospect, in a prospect pit in a saddle east of Chanchelulla Peak and on the north slope of Chanchelulla Peak, but not enough magnetite is present to identify a resource for iron.

The Potato Creek prospect is a deposit that contains approximately 13 million tons of limestone. There is little likelihood that this deposit constitutes a resource because this limestone is too far from present and anticipated markets. Other limestone bodies that occur throughout this region are closer to main roads.

The Deer Lick Springs prospect, just outside the roadless area on the east, is located on a group of mineral springs that have been developed as therapeutic baths. There are three undeveloped mineral springs just north of Deer Lick Springs along Browns Creek, two of which are inside the roadless area. There is little likelihood for use of these three springs because the volumes of flow are small and the well-developed therapeutic baths at Deer Lick Springs meet the anticipated usage.

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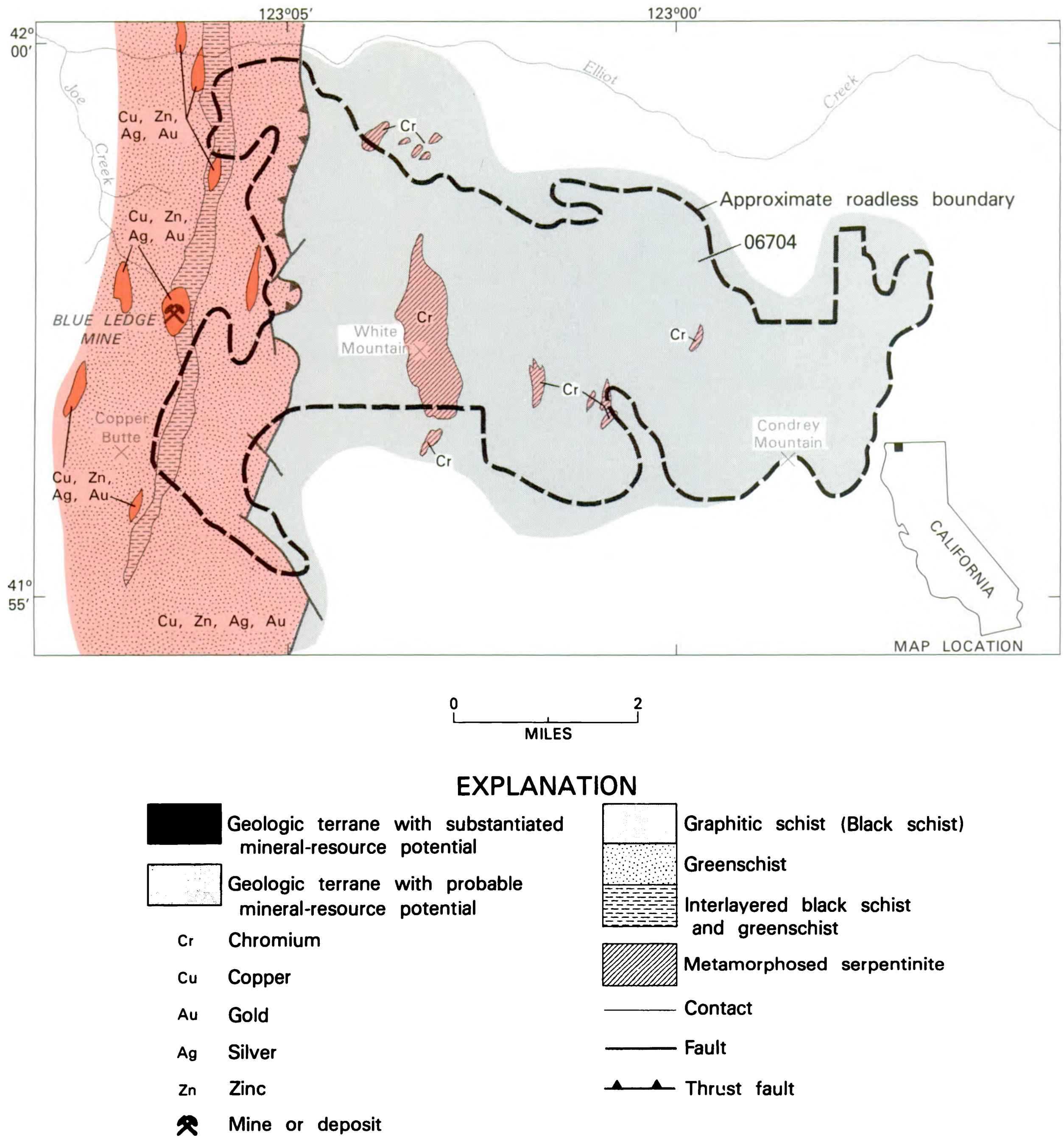

Figure 59.—Condrey Mountain Roadless Area, California.

CONDREY MOUNTAIN ROADLESS AREA, CALIFORNIA

By R. G. COLEMAN,[1] U.S. GEOLOGICAL SURVEY, and

RON MAYERLE, U.S. BUREAU OF MINES

SUMMARY

A mineral-resource study carried out by the USGS and the USBM in 1980 and 1981 indicate that the Condrey Mountain Roadless Area has areas of probable resource potential for copper, zinc, gold, and silver in the westernmost extremities of the area. Although there are no presently exposed chromite concentrations in the serpentinite bodies within the roadless area, the possibility that chromite occurs in the subsurface within these bodies should not be overlooked and they are shown as areas of probable chromite resource potential. No potential for energy resources was identified in the study.

CHARACTER AND SETTING

The Condrey Mountain Roadless Area lies along the crest of the Siskiyou Mountains in northern California, about 30 mi northwest of the town of Yreka. The area is accessible by State Highway 96, often called the Klamath River Highway. Access to the roadless area is afforded by unpaved roads leading from the villages of Seiad Valley and Klamath River. The roadless area extends along the Siskiyou Divide, a physiographic feature ranging from 6000 to 7000 ft in altitude which marks the natural boundary between Oregon and California in this region.

Geologic and geophysical studies carried out by the USGS in 1980 and 1981 were supplemented by detailed investigations of mines, prospects, and mineralized areas by the USBM. The results of these investigations are the basis for this report.

The Condrey Mountain Roadless Area is underlain by Jurassic metamorphic rocks exposed in a structural dome, whose core consists of highly deformed metasedimentary and metavolcanic rocks known as the Condrey Mountain Schist (Coleman, Helper, and others, 1983). The most abundant rock type is a fine-grained gray to black graphitic schist whose parent rock was probably a graywacke containing abundant organic debris. The metavolcanic rocks are laminated greenschists which probably represent metamorphosed volcanogenic sedimentary rocks. Distinctive thin units locally interlayered with the greenschist and graphitic schist extend north and south from the vicinity of the Blue Ledge mine. They consist mainly of quartz and muscovite with minor amounts of barite, and have been referred to as "silver schist." The "silver schist" parent rock was probably silicic volcanic rock. These schists are often associated with copper and zinc mineralization, as at the Blue Ledge mine.

Tabular and lens-shaped bodies of metaserpentinite are present within the schist and consist mainly of antigorite with minor amounts of magnetite and brucite. No concentrations of chromite were observed in these bodies.

Geochemical studies carried out during the course of this assessment delineated the previously known mineralization in the Blue Ledge mine area. A copper-zinc geochemical anomaly was found in the drainage basin of Joe Creek, which contains the Blue Ledge mine. No other geochemical anomalies were found.

Aeromagnetic studies supplemented geologic and geochemical investigations of the roadless area. Prominent magnetic anomalies reflect the locations and shapes of the metaserpentinite bodies within the Condrey Mountain Schist. Although the metaserpentinites are potentially favorable hosts for chromite, there are no presently exposed concentrations of chromite within the area.

The only recognized mining district of importance near the roadless area boundaries includes the Blue Ledge mine and zones of associated mineralization which may extend into the roadless area. The Blue Ledge mine, last active in 1930, lies outside the western boundary of the roadless area. Production records from

[1]With contributions from R. Jachens and D. Smith, USGS.

Hundhausen (1947) for the years 1917–20 and 1930 report that 11,151 tons of copper-zinc ore were shipped from the mine during those years. Most of the mineralization is found within the drainage basin of Joe Creek, a tributary of Elliot Creek. Throughout the greenschist exposure in the Joe Creek drainage, thin layers of "silver schist", usually less than about 10 ft thick, contain copper and zinc sulfide minerals. At the Blue Ledge mine itself, lenses of copper-zinc ore associated with "silver schist" are reported to be several hundred feet long with a maximum thickness of over 12 ft. The actual ore zone is reported to have been about 5 ft thick, and consists mainly of massive sulfides in the following order of abundance: pyrrhotite, pyrite, chalcopyrite, and sphalerite. Minor amounts of galena and covellite are present, and it is considered that gold and silver are contained within the copper sulfide minerals. The ore bodies appear to have been stratabound (that is, concordant with original sedimentary layering), but metamorphism and deformation have obscured the original relationships. The mineralization appears to pre-date metamorphism, and is most likely related to the formation of the "silver schist" as a silicic volcanic rock. Based on the regional structural grain, and the fact that altered "silver schist" is present in the roadless area, massive sulfide zones may also extend into the roadless area.

MINERAL RESOURCES

The westernmost part of the Condrey Mountain Roadless Area has probable resource potential for copper, zinc, gold, and silver in stratabound sulfide deposits. Copper and zinc sulfide minerals in small areas of substantiated resource potential are associated with the "silver schist" outside the boundary of the roadless area, and ore-bearing zones may extend into the roadless area. Small amounts of gold and silver may occur within the copper sulfide minerals. An indication of demonstrated resources in the known areas of substantiated potential is given by the estimate calculated by Shenon (1933), and is considered to be approximately correct: 250,000 tons of ore, with average copper, 4.4 percent; average gold, 0.125 oz/ton; average silver, 5.6 oz/ton; and average zinc, 2.0 percent.

Although no chromite concentrations are presently exposed, unexposed parts of the metaserpentinite bodies within the roadless area may contain chromite. The metaserpentinite bodies are shown on the map as areas of probable chromite resource potential. If improved subsurface exploration techniques become available in the future, chromite concentrations in such bodies may be found.

SUGGESTIONS FOR FURTHER STUDY

The common association of the "silver schist" and copper-zinc mineralization suggests the two are genetically related. Further study of favorable lithologies in the westernmost part of the roadless area are warranted to refine the estimate of resource potential.

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COYOTE SOUTHEAST AND TABLE MOUNTAIN ROADLESS AREAS, CALIFORNIA

By EDWIN H. MCKEE,[1] U.S. GEOLOGICAL SURVEY, and

DONALD O. CAPSTICK, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey in 1982 the contiguous Coyote Southeast and Table Mountain Roadless Areas have one area of probable and two areas of substantiated mineral-resource potential. Mineral occurrences in these areas are in tactite deposits with tungsten as the most important metal; copper, molybdenum, and gold may occur in small amounts in the same deposits. One area in the southwestern part of the Coyote Southeast Roadless Area has anomolous amounts of uranium in stream-sediment samples but no resource potential was identified. The geologic terrane precludes the occurrence of fossil fuel resources.

CHARACTER AND SETTING

The Coyote Southeast and Table Mountain Roadless Areas include about 90 sq mi along the eastern front of the Sierra Nevada in Inyo County between Big Pine and Bishop, California. The two roadless areas are in a region of relatively low relief east of the main crest of the Sierra Nevada. Altitudes range from about 12,000 ft above sea level at several places in the roadless areas to about 4000 ft in the Owens Valley near Bishop. An extensive level area, called Coyote Flat, exists at about 10,000 ft in the southwest part of the Coyote Southeast Roadless Area. The climate is semiarid and vegetation sparse, as the area is in the rainshadow of the Sierra Nevada crest. Access to the Coyote Southeast Roadless Area is from the north by a steep four-wheel-drive road. State Highway 168 to Lake Sabrina and South Lake give access to the southern parts of the Table Mountain Roadless Area.

The geology of the region, including the two roadless areas, was mapped in detail by Bateman (1965), and a new geologic map using Bateman's report and more recent information was compiled by Elliott and McKee (1982). A tabulation of chemical analyses determined as part of a geochemical study was published by Elliott and others (1982).

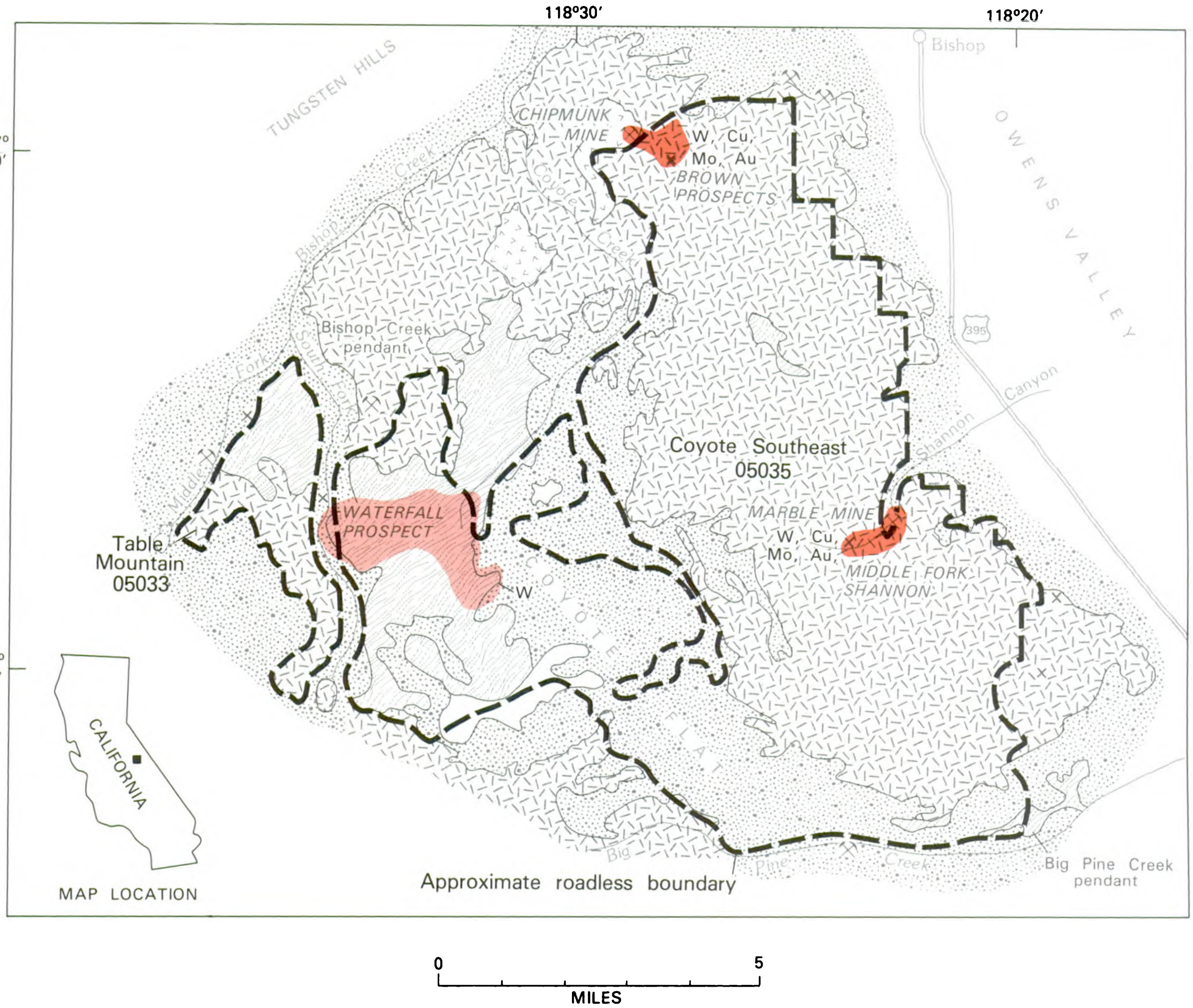
The eastern Sierra Nevada records a complex history involving Paleozoic shallow-marine sedimentation, late Paleozoic and Mesozoic deformation, Mesozoic granitic plutonism, and late Tertiary and Quaternary igneous activity and faulting. The rocks can be divided into four major groups according to age and type: (1) lower through middle Paleozoic metasedimentary rocks consisting of marble, quartzite, pelitic, hornfels, schist, and chert; (2) upper Paleozoic metavolcanic rocks; (3) granitic rocks that were intruded in late Triassic to late Cretaceous time; and (4) basaltic and andesitic intrusives and extrusives of Miocene age. These Miocene volcanic rocks were erupted on ancestral Basin and Range topography from feeder dikes controlled in many places by high-angle Basin and Range faults.

The largest body of metasedimentary rocks in the roadless areas, called the Bishop Creek pendant, covers approximately 20 sq mi and includes about 6500 ft of strata which range in age from early Ordovician to Devonian. Other, smaller bodies include the Big Pine Creek pendant and scattered uncorrelated metamorphic rocks. Triassic to upper Cretaceous granitic rocks of the Sierra Nevada batholith underlie most of the Coyote Southeast and Table Mountain Roadless Areas. The batholithic rocks are mostly granodiorite but include hornblende gabbro, quartz diorite, quartz monzonite, granite and alaskite.

MINERAL RESOURCES

The Coyote Southeast Roadless Area contains one

[1]With contributions from Maurice A. Chaffee and Geoffrey S. Elliott, USGS.



EXPLANATION

(black)	Geologic terrane with substantiated mineral-resource potential
(stippled)	Geologic terrane with probable mineral-resource potential
Cu	Copper
Au	Gold
Mo	Molybdenum
W	Tungsten
×	Mineral occurrence
⚒	Mine

Alluvium

Volcanic rocks

Granitic rocks

Metasedimentary rocks

Contact

Figure 60.—Coyote Southeast and Table Mountain Roadless Areas, California.

area of probable and two areas of substantiated mineral-resource potential, but all the known mineral deposits are small and low-grade and any undiscovered deposits are also likely to be small and low grade.

The geologic setting of the roadless areas is similar to that of the nearby Pine Creek tungsten mine, suggesting that the areas have a potential for mineralized tactite deposits. The most important metal in such deposits is tungsten; gold, silver, copper, and molybdenum are of secondary importance. Consequently, the metamorphic rocks in the roadless areas were searched for tactites and for evidence of prospecting. Rock, stream-sediment, and panned concentrate samples were evaluated for tungsten, gold, silver, copper, and molybdenum and for other elements that might indicate the presence of mineralized tactities.

No mineralized tactite deposits of significance were identified. Analysis of samples and evaluation of the Waterfall property on the boundary of the Coyote Southeast Roadless Area indicate a probable resource potential for tungsten mineralization over an area extending eastward and south from the prospect. Tungsten-bearing tactite occurs in two areas of substantiated resource potential in the Coyote Southeast Roadless Area. One area contains the abandoned Chipmunk mine (outside the area) and the Brown prospects. The other area contains the Marble mines directly outside the east boundary of the Coyote Southeast Roadless Area, and the Middle Fork Shannon prospect within the roadless area. Substantiated resource potential for low-grade and small tungsten deposits exists around these properties. Numerous other small, low-grade tungsten occurrences were found within the Coyote Southeast Roadless Area but no resource potential was identified.

One area in the southwestern part of the Coyote Southeast Roadless Area has anomalous amounts of uranium in stream-sediment samples, probably from small veins in the granitic and metamorphic rocks of this area. These veins, if present, would be dispersed over a wide area and would contain a small amount of total uranium; no resource potential for uranium was identified.

SUGGESTIONS FOR FURTHER STUDIES

Further study of these roadless areas offers little promise for the identification of hidden mineral deposits due to the small and discontinuous nature of the mineralized tactite occurrences. More detailed geochemical sampling of rocks and eroded material in the areas with metamorphic rock might reveal additional small tungsten resources at or near the surface in tactite deposits.

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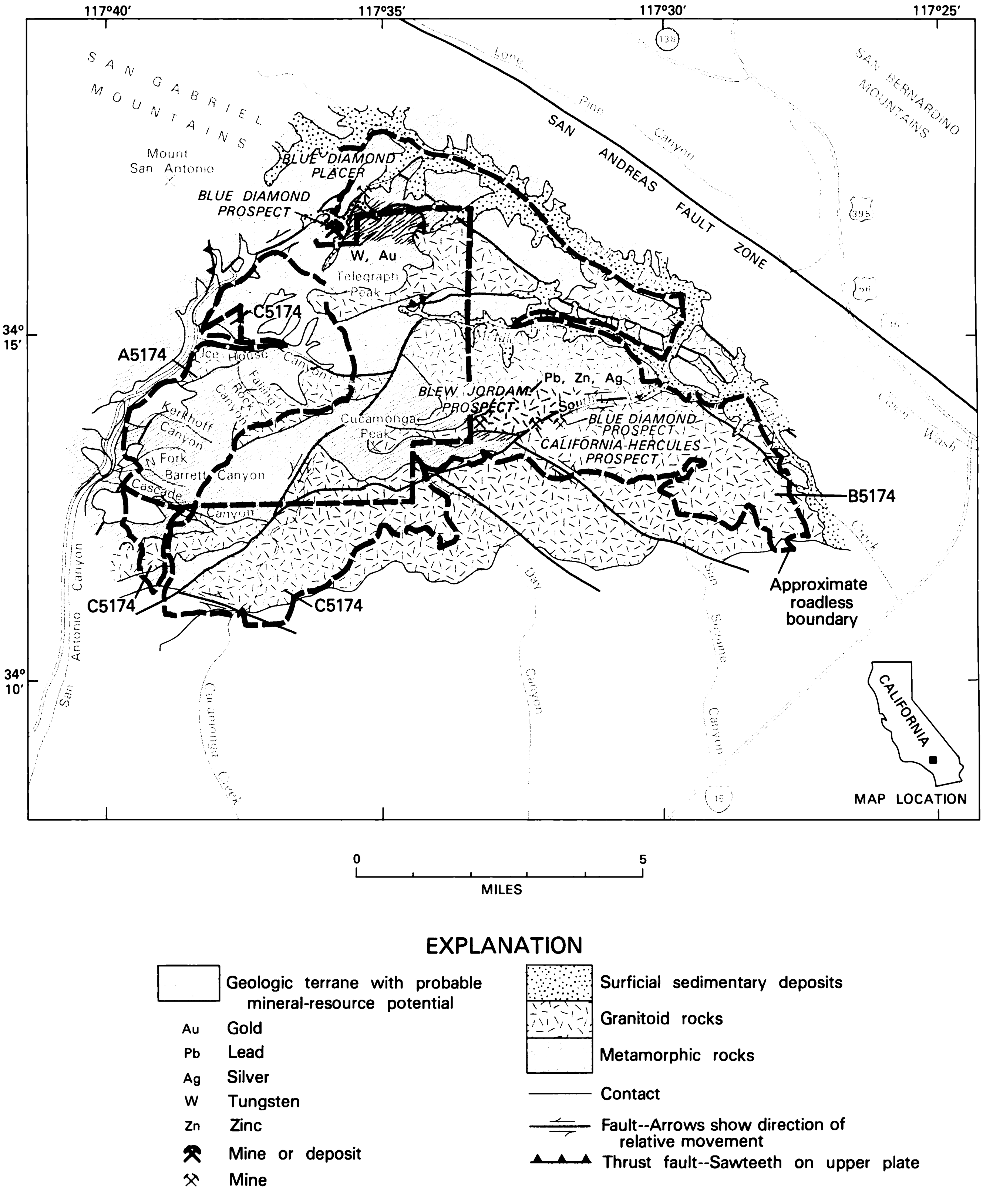

Figure 61.—Cucamonga Roadless Areas, California.

CUCAMONGA ROADLESS AREAS, CALIFORNIA

By DOUGLAS M. MORTON,[1] U.S. GEOLOGICAL SURVEY, and

THOMAS J. PETERS, U.S. BUREAU OF MINES

SUMMARY

On the basis of geologic, geochemical, and geophysical surveys in 1972–82, and an investigation of mines, prospects, and mineralized areas in 1980, the Cucamonga Roadless Areas have two areas of probable mineral-resource potential. An area of probable mineral-resource potential for low-grade tungsten and gold resources is located in the northern part of the roadless areas, and an area of similar potential for small deposits of silver, lead, and zinc is located in the southwestern part of the roadless areas. There is little promise for the occurrence of other mineral or any energy resources in the area.

CHARACTER AND SETTING

The Cucamonga Roadless Areas are located about 10 mi northwest of San Bernardino and about 10 mi northeast of Pomona, California. The Cucamonga Roadless Areas comprise about 37.5 sq mi that surround the existing Cucamonga Wilderness in the Angeles National Forest in the southeastern San Gabriel Mountains. The area consists of rugged mountainous terrain, including Telegraph and Cucamonga Peaks, and is chiefly drained by San Antonio Canyon, Cucamonga Creek, and Lytle Creek. Relief is considerable with altitudes ranging from about 2500 to 7500 ft. Access to the roadless areas is by dirt roads that lead from the foothill communities to the south, and paved roads which border the roadless areas on the east and west.

The roadless areas are situated at the eastern end of the San Gabriel Mountains in the eastern part of the Transverse Ranges Province of Southern California. This geomorphic-geologic province is east-oriented, contrasting with the prominent northwest orientation of the other geologic-geomorphic provinces in California.

The roadless areas are underlain by a wide variety of metamorphic and plutonic rocks. The older metamorphic rocks are considered to be of Precambrian age, with younger ones both of Mesozoic and of probable Paleozoic age. Plutonic rocks are both of Mesozoic (Cretaceous) and of Tertiary (Miocene) age. Many faults cross the area and occur near its boundaries. The oldest of the faults, the Vincent Thrust, a major structural discontinuity of probable Mesozoic age, lies interior to the mountain ranges, and has been segmented by younger faults. Reverse faults of the Cucamonga fault zone, located near the south margins of the roadless areas, have uplifted the San Gabriel Mountains. Major strike-slip faults occur within and adjacent to the roadless areas. Landslides are common throughout the eastern San Gabriel Mountains. Surficial alluvial deposits occur along all major drainages.

A geochemical survey of stream sediments from 48 localities in the Cucamonga Roadless Areas was conducted for 31 elements to determine if spatial variations in stream-sediment chemistry reflect any concentrations of ore minerals.

No significant systematic patterns of anomalous element concentrations were noted. Most of the analyses fall within ranges that are reasonable for nonmineralized crystalline rocks and sediments derived from them.

MINERAL RESOURCES

Data obtained from the investigations all suggest that although most of the Cucamonga Roadless Areas have little promise for the occurrence of mineral resources two areas have probable mineral-resource potential. During the investigations, a few localized zones of mineralized rock were found, but, with one exception, geologic environments favorable for the occurrence of mineral deposits have not produced extensive zones of mineralization. Cataclastic rocks above the

[1]With contributions by Eduardo A. Rodriguez, Curtis M. Obi, and Robert W. Simpson, Jr., USGS.

Vincent Thrust in the northern part of area B5174 have a probable mineral-resource potential for low-grade tungsten and gold. The Blue Diamond tungsten prospect, in the northwest part of the area, is within these highly deformed rocks and has an estimated 16,000 tons of demonstrated and inferred resources averaging 0.16 percent tungsten trioxide (WO_3).

Garnet-epidote tactite occurs locally where carbonate metamorphic rocks are engulfed, or partly so, by quartz diorite. The Blew Jordam and California-Hercules prospects, minor occurrences of silver-lead-zinc mineralization associated with calc-silicate rock and tactite, are located in an area of probable mineral-resource potential near the upper part of the South Fork of Lytle Creek. Other occurrences of calc-silicate and tactite rock have rarely observable blebs of sulfide minerals. No tungsten mineralization was noted within the calc-silicate tactite rock. In Cascade Canyon, a local metasomatized part of this carbonate sequence contains a small amount of lazurite (lapis lazuli). In the vicinity of the lazurite occurrence, a leucocratic granitic rock intrusive into carbonate rock locally contains pink-corundum of non-gem quality. No potential was identified in the area of these occurrences. The lower parts of some perched and elevated alluvial sand and gravel deposits in San Antonio Canyon, Cucamonga Canyon, and Lytle Creek drainages have been prospected, and a few mined on a small scale, for placer gold, however no potential for resources was identified.

A few stream-sediment samples from the Barrett and Cascade Canyon areas have anomalous values of gold. These areas are spatially related to metamorphosed carbonate rock and quartzite. A few anomalous values for gold in samples from upper Day Canyon, the South Fork of Lytle Creek, and Falling Rock Canyon are also related to these rocks. Gold values in samples from the north side of Icehouse Canyon are spatially related to cataclastic gneiss.

In Coldwater Canyon, high gold and tungsten values are probably related to cataclastic rock in the vicinity of the Vincent Thrust, which is apparently the site of gold and tungsten mineralization farther to the west in the San Gabriel Mountains (Evans, 1982).

A few somewhat high chromium and nickel values for some isolated samples from near the mouth of the South Fork of Lytle Creek, and somewhat high chromium values for samples from Icehouse Canyon may be related to pyroxene or other mafic minerals in the metamorphic rocks.

Because the Cascade, Barrett, Kerkhoff, and Icehouse Canyon areas have long been the sites of human activity, contamination of the geochemical samples should be considered. Lead contamination is possible in sediments from all the major drainages in the eastern San Gabriel Mountains.

The results of the geochemical survey are compatible with the geologic evidence, all of which suggests a probable resource potential for low-grade gold and tungsten in rock above the Vincent Thrust, and for small tonnages of silver-lead-zinc in tactite pods in the small area near the head of the South Fork of Lytle Creek.

An interpretation of an aeromagnetic survey of the Cucamonga Roadless Areas in 1979 showed magnetic anomalies and patterns (R. W. Simpson, Jr., unpub. data, 1979) closely related to magnetic variation in rock units, but indicated no unknown areas of mineral-resource potential.

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CYPRESS ROADLESS AREA, CALIFORNIA

By GEORGE L. KENNEDY,[1] U.S. GEOLOGICAL SURVEY, and

DONALD O. CAPSTICK, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys of the Cypress Roadless Area, located in the southern part of the Sierra Nevada, California, were conducted in 1980–82. On the basis of these investigations, the eastern part of this roadless area has probable resource potential for gold with associated silver in quartz veins. This area has been extensively prospected since the late 1800's. The geologic terrane precludes the occurrence of energy resources.

CHARACTER AND SETTING

The Cypress Roadless Area comprises 3 sq mi of Sequoia National Forest in the southern Sierra Nevada, approximately 30 mi east-northeast of Bakersfield, Kern County, California. Isabella Lake is 5 mi north of the area and the nearest communities are Bodfish and Lake Isabella. Access to the roadless area is by Piute Mountain Road, which parallels the west and south sides of the roadless area, and by unimproved jeep roads from the north in Myers and Bodfish Canyons.

The area is characterized by its rugged and steep terrain, and altitudes range from 3900 ft in Myers Canyon to 6437 ft on the ridge crest that approximates the southern border of the area. The Cypress Roadless Area contains the largest of only nine known groves of Piute cypress, *Cupressus nevadensis* Abrams.

The mineral-resource evaluation of the roadless area (Kennedy and others, 1983) was based on reconnaissance field checking of a previously published geologic map, geochemical analyses of rock, stream-sediment, and heavy-mineral concentrate samples (Chaffee and others, 1983), and an examination of mines, prospects, and mineralized areas (Capstick, 1983). Geophysical surveys were not done for this study.

The geology of the roadless area is typical of the Sierra Nevada. Intensely deformed metamorphic rocks of sedimentary and volcanic origin occur as roof pendants scattered throughout an intrusive country rock composed predominantly of granitic rocks of the Sierra Nevada batholith.

Metamorphic rocks are exposed in the western half of the roadless area. They are predominantly quartzite and mica schist, and are referred to as the Kernville series of Miller (1931). Similar metasedimentary rocks nearby contain fossil mollusks that are about 215 to 175 million years old (Late Triassic to Early Jurassic in age).

In the northwest part of the roadless area, the Kernville series has been intruded by a small pluton of mafic igneous rock that is assigned to the Summit gabbro of Miller and Webb (1940). Contact metasomatism of carbonate rocks in the Kernville series along this contact has resulted in the formation of limited amounts of tactite. The Tripoli tungsten prospect is located in this tactite.

The dominant rocks of the Sierra Nevada batholith are lighter colored granitic rocks of varying composition. Those in the Kern River area are assigned to the Isabella granodiorite of Miller (1931) and are about 80 million years old (Late Cretaceous in age). Rocks of this type comprise the eastern half of the roadless area. Surface exposures are normally deeply weathered and covered by a veneer of grus. A shallowly eastward dipping system of quartzofeldspathic to milky-quartz dikes and veins occurs in the granodiorite in a north-trending fault system, and is the probable source of precious metals in the area.

The contact between the metamorphic rocks of the roof pendant and the Isabella granodiorite occurs in a north-trending gradational zone of mixed metamorphic and granitic rocks through the central part of the roadless area. Contacts elsewhere are more sharply defined, but are often obscured by weathering and surficial debris.

Mining activity in the region dates to the 1850's, when gold was discovered in the Kern River area. By

[1]With contributions from M. A. Chaffee, J. F. Seitz, and J. L. Harner, USGS.

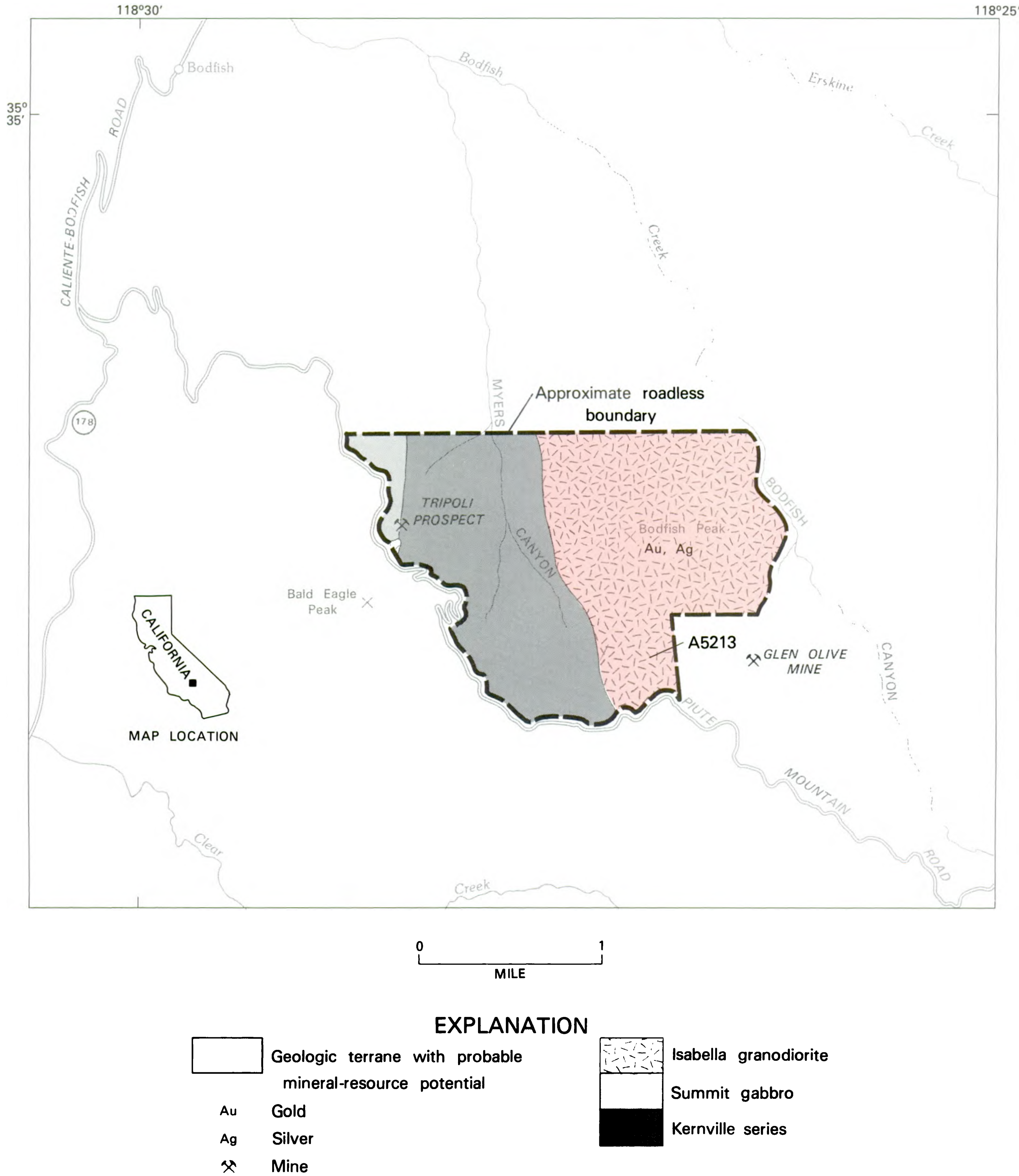

Figure 62.—Cypress Roadless Area, California.

the middle 1860's, substantial amounts of gold were being produced from four local mining districts, none very far from the present roadless area. Total production of gold and silver from these districts since 1880 has been estimated at several million dollars (Troxel and Morton, 1962). Several claims and (or) mines in the roadless area, among them the Pickwick mine near Bodfish Peak (presently known as the Devils Hole prospects?), appear to have had limited, but unrecorded production in the past. None is presently active. The Glen Olive mine, 0.3 mi southeast of the roadless area was located about 1888 and produced an estimated $500,000 worth of gold by 1914; considerably less has been produced since. The mine was operated almost continuously until its closing in 1942. In 1982, the mine appeared to be under preparation for renewed operation.

Tungsten has been mined in Kern County in the southern Sierra Nevada since 1905. Production, never great, was both intermittent and modest until 1950, when the importation of Chinese tungsten stopped. Additional sources were sought and encouraged by price supports from the U.S. Government. Most of the southern Sierran mines and prospects were discovered in the period 1951–56, but most were abandoned when price supports were withdrawn in 1957 (Troxel and Morton, 1962, p. 294–295). The Tripoli prospect is the only tungsten prospect in the roadless area.

Uranium was discovered in 1954, 5 mi west-northwest of the roadless area in what is now known as the Kern River uranium area (MacKevett, 1960). About 189 tons of ore were produced from small secondary deposits localized in fracture systems in granitic rocks.

MINERAL RESOURCES

The Cypress Roadless Area is a small part of an areally extensive geologic terrain that locally has yielded small amounts of tungsten, base-metal, and uranium minerals along with substantial amounts of gold and associated silver over the past 100 years. On the basis of the geologic reconnaissance, a geochemical survey of rock and stream-sediment samples, and examination of mines and prospects, the eastern part of the roadless area is regarded as having probable resource potential for small deposits of lode gold with associated silver in veins.

Lode gold has been produced from several mines along the ridge of Isabella granodiorite that extends through, and to the southeast of, the roadless area. At the Glen Olive mine just outside of the area, free-milling gold was produced from two quartz veins that strike northwest and dip to the northeast (Troxel and Morton, 1962, p. 151). These may be part of, or related to, the shallowly eastward dipping system of quartzofeldspathic to milky-quartz dikes and veins that crop out in Isabella granodiorite below Bodfish Peak on the east side of Myers Canyon. These gold-bearing dikes and veins are in a north-northwest-trending fault system through the center of the roadless area. At least 30 adits have explored this system within the roadless area; a few may have had limited, but unrecorded, production. One, the Pickwick mine, probably had production before 1916. Analyses of samples from these workings suggest a sporadic distribution of the gold, a characteristic apparently shared by similar prospects and mines in the region.

At the Fairview(?) mine in the northeast corner of the roadless area are workings consisting of a 450-ft long (haulage?) tunnel, caved raise, and caved incline shaft. A limited production, although unrecorded, is suggested by the extent of these workings.

Anomalous concentrations of gold and silver were recovered from stream-sediment and heavy-mineral concentrate samples from Myers Canyon, in the roadless area, and from areas draining Isabella granodiorite outside of the roadless area. However, the steep terrain, extensive bedrock exposures, and lack of gravel accumulations in Myers Canyon precludes accumulation of placer resources in the roadless area.

Metamorphic rocks of the Kernville series in roof pendants east and west of the roadless area have yielded small amounts of tungsten and base-metal minerals. Scheelite, a tungsten mineral, occurs in small amounts in limited tactite deposits at the Tripoli prospect, in the northwest part of the roadless area. The occurrence is in the contact zone between the Kernville series and the Summit gabbro that intruded it. Samples from this prospect assayed 0.25 to 0.5 percent scheelite, but the amounts of mineralized rock are very small and no resource potential was identified. There has been no recorded production from this prospect (Troxel and Morton, 1962, p. 324).

No tactite was observed in the mixed zone of metamorphic and granitic rocks in Myers Canyon. Stream-sediment and heavy-mineral concentrate samples from areas draining exposures of the Kernville series contain slightly anomalous concentrations of elements constituting a suite that might be related to tungsten mineralization, but the anomalous metals do not appear to have been derived from sources in the roadless area.

The Isabella granodiorite locally contains abnormal amounts of uranium in the Kern River uranium area 5 mi west-northwest of the roadless area, but these concentrations do not appear to extend into the roadless area.

SUGGESTIONS FOR FURTHER STUDIES

Because the Cypress Roadless Area is small and has been extensively prospected since the late 1800's, it is unlikely that further studies would refine understanding of the mineral-resource potential of this area.

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DESOLATION VALLEY WILDERNESS, CALIFORNIA

By F. C. W. DODGE, U.S. GEOLOGICAL SURVEY, and

P. V. FILLO, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Desolation Valley Primitive Area, now Desolation Valley Wilderness, conducted in 1966, disclosed the presence of a small mineralized area with demonstrated gold resources. Geologic terranes elsewhere in the area show little potential for the occurrence of mineral resources.

CHARACTER AND SETTING

The Desolation Valley Wilderness covers an area of 101 sq mi in El Dorado County, California, near the southwestern shore of Lake Tahoe. Topographically, the area is dominated on the east by peaks and subsidiary spurs of the main crest of the Sierra Nevada and on the west by the crest of a parallel-trending range with altitudes ranging from about 6500 to nearly 10,000 ft. Pleistocene glacial erosion was largely responsible for shaping surface features of the area.

Igneous rocks of the Sierra Nevada batholith, remnants of metamorphic rocks, and younger surficial deposits underlie the wilderness. The oldest rocks consist of a thick sequence of metamorphosed sedimentary and volcanic deposits, at least some of which were deposited in the Early Jurassic. This entire sequence was buried, folded, and intruded by plutonic bodies before the Late Cretaceous. Prolonged erosion since intrusive emplacement has unroofed the batholith, and repeated uplift has elevated the mountains to their present heights. During the late Cenozoic, lavas were extruded over an extensive part of the batholith; however, only two small patches of the resulting volcanic rocks remain within the wilderness. The youngest geologic units within the area are Quaternary glacial moraines, lacustrine deposits, talus, stream gravels, and soils, all in small scattered deposits.

A mineral survey of the Desolation Valley Primitive Area was made in 1966 in accordance with the Wilderness Act of 1964 (Dodge and Fillo, 1967). The area surveyed is not identical with the Desolation Valley Primitive Area as originally defined, because modifications of the boundary were proposed for the area to be considered for wilderness status. The USGS made a reconnaissance of the geology of the area, field checked existing geologic maps, and carefully examined areas considered possibly favorable for mineral deposits. During field studies, samples of fresh, altered, or mineralized rocks and panned stream-sediment concentrates were collected and subsequently analyzed. The USBM conducted a search in the El Dorado County recorder's office, which showed that three groups of unpatented claims were located in the area and that all were subsequently abandoned.

It is reasonable to assume that the area was thoroughly prospected after the mid-19th century discoveries of the Mother Lode to the west and the Comstock Lode to the east; however, no productive mineral deposits have been discovered in, or immediately adjacent to, the area, and only a few claims have been filed in the area.

MINERAL RESOURCES

A small area in the wilderness south of Gilmore Lake in the east- central part of the area contains significant amounts of gold and must be regarded as having a demonstrated gold resource. In this mineralized area, hornfelsic metavolcanic rocks contain sulfide minerals and gold in veinlets occupying small fractures and in disseminated grains. Of 48 samples taken in an area of about 2000 by 150 ft, 15 contained 1 ppm or more in gold—the richest containing 46 ppm or about 1.5 troy oz/ton of rock. Insofar as known from surface outcrops, the deposit is low grade, and the gold is erratically distributed; however, further exploration is necessary

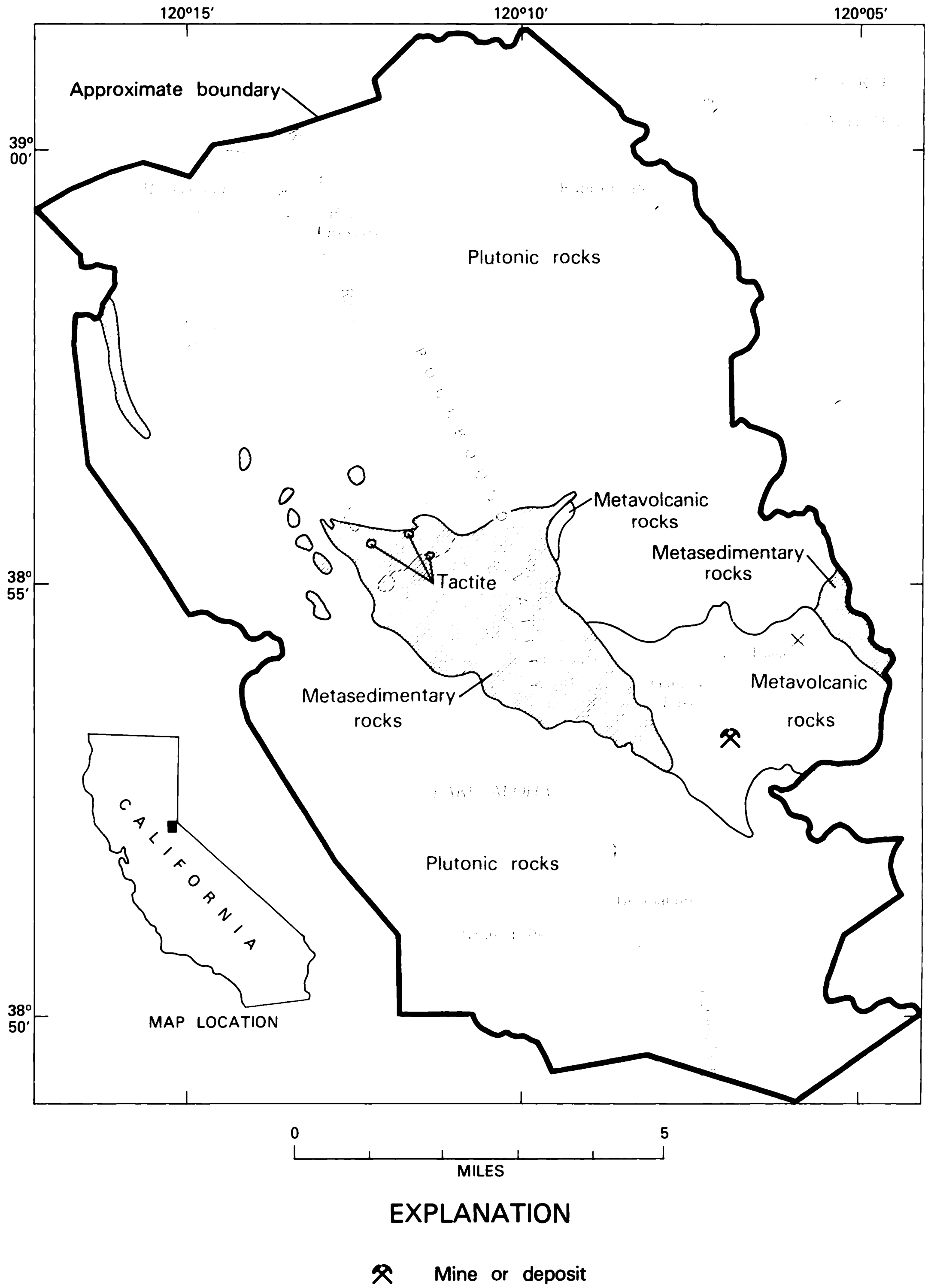

Figure 63.—Desolation Valley Wilderness, California.

to better assess the potential for discovery of significant quantities of gold.

Geologic terranes elsewhere in the area show no evidence favorable for mineral-resource discovery. Tactite bodies, which are important hosts for tungsten minerals in other parts of the Sierra Nevada, are small and do not contain important concentrations of valuable minerals. Pegmatites and massive quartz veins are exceedingly rare, and those observed are not mineralized. Granitic rocks that are stained with iron oxide were found to have no enrichment of base or precious metals appreciably greater than the unstained counterparts.

No buried placer deposits are believed to occur within the area. Glacial erosion has stripped any remnants of Tertiary stream channels that formerly may have been present. Panned concentrates of Holocene stream sediments do not contain concentrations of valuable metallic minerals or metals.

SUGGESTIONS FOR FURTHER STUDIES

Exploratory drilling is necessary before the resource potential of gold-bearing rocks south of Gilmore Lake can be assessed. Any additional study of the wilderness offers little likelihood of discovery of additional mineral deposits.

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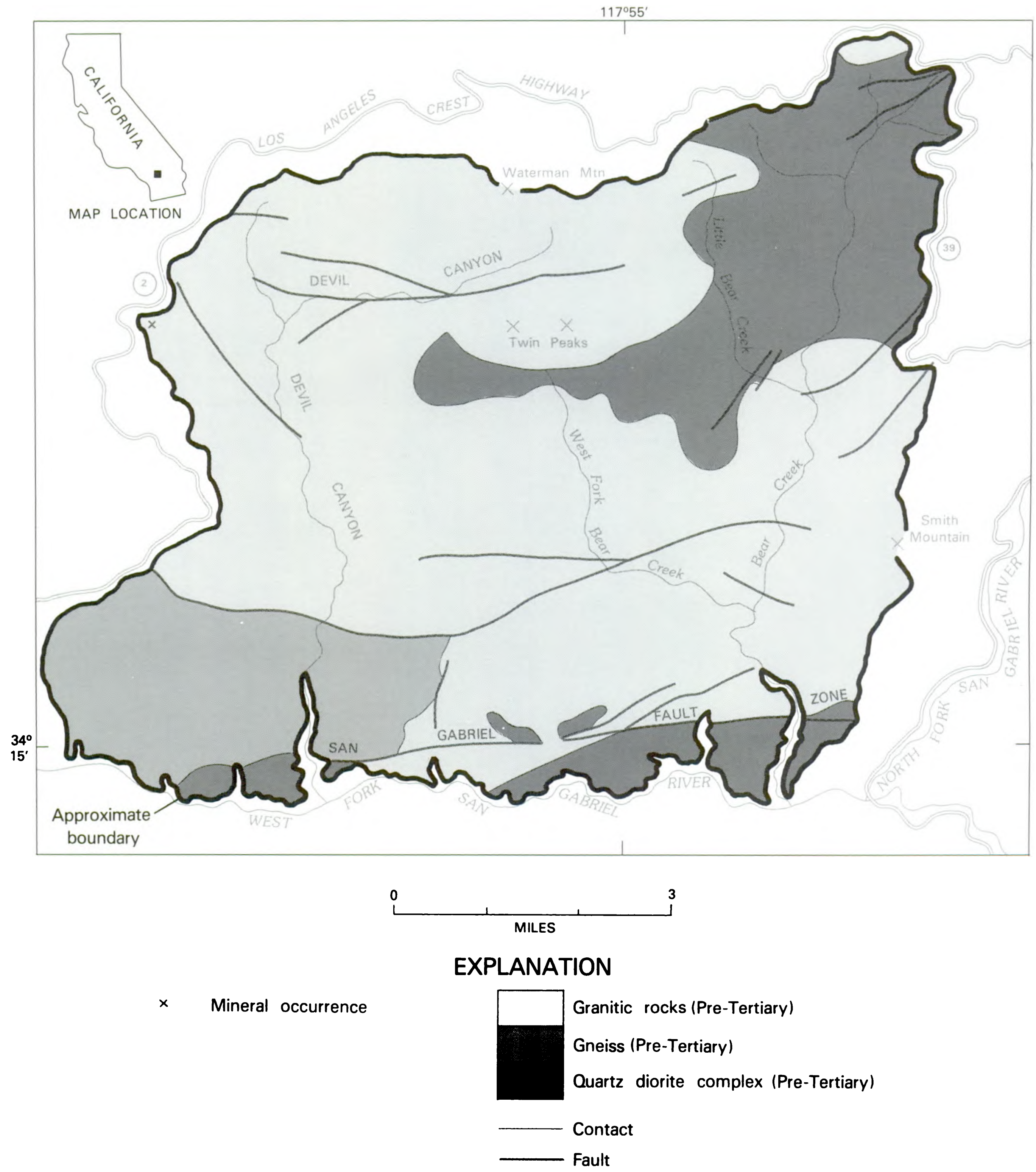

Figure 64.—Devil Canyon-Bear Canyon Primitive Area, California.

DEVIL CANYON-BEAR CANYON PRIMITIVE AREA, CALIFORNIA

By DWIGHT F. CROWDER,[1] U.S. GEOLOGICAL SURVEY, and

PAUL V. FILLO, U.S. BUREAU OF MINES

SUMMARY

A mineral-resource survey made in 1966 concluded that there is little promise for the occurrence of metallic resources in the Devil Canyon-Bear Canyon Primitive Area, California. This conclusion was based on chemical analyses of fractured, altered, and mineralized rocks in this area, of soils over such rocks, of stream sediments, and of heavy minerals from stream sediments.

CHARACTER AND SETTING

The Devil Canyon-Bear Canyon Primitive Area, located about 10 mi northeast of Pasadena in the Angeles National Forest, Los Angeles County, California, is an area about 8 mi long by 6 mi wide. Located on the south slope of the San Gabriel Mountains overlooking the Los Angeles metropolis, the 48 sq mi area is bounded on three sides by California Highways 2 and 39, both paved, and on the fourth side by an improved but unpaved road that is closed to the public. Few trails exist in the primitive area.

On the north border of the area, the crest of the San Gabriel Mountains rises to an altitude of 8038 ft at Waterman Mountain. Devils Canyon and Bear Creek run south around Twin Peaks, the dominant crags in the north-central part of the area; 6000 ft below, these canyons join the major stream of the area, the West Fork of the San Gabriel River. Because the West Fork is cutting channels more rapidly than its branches, these tributaries descend over waterfalls and through narrow gorges on their way to join the West Fork. Dikes of resistant rocks that occur in streams cause falls and rapids. Excellent rock exposures are found in all stream valleys because of the rapid erosion.

Most of the Devil Canyon-Bear Canyon Primitive Area is underlain by a variety of old crystalline rocks similar to those that form much of the rest of the San Gabriel Mountains; these rocks are cut locally by dark-colored dikes. The primitive area lies between two major fault zones: the San Andreas fault zone, 5 mi to the north and well outside the area, and the San Gabriel fault zone, near the south boundary of the area. Broken and altered rocks are found associated with the San Gabriel fault. Although some gneisses occur in the southwest corner of the area and an intrusive complex crops out in the San Gabriel fault zone and in the northeast corner of the area, the area is primarily underlain by granitic rocks that are part of a once-molten mass that solidified deep in the Earth. This mass may have produced mineralizing emanations, but any deposits that may have formed were removed by the deep erosion that has since exposed these rocks. The gulches and stream valleys are partly floored by sand and gravel deposits composed of a heterogeneous mixture of rocks and mineral grains from the rock now exposed within the area.

The only significant mining activity in the vicinity of the primitive area has been placer mining for gold along the East Fork of the San Gabriel River, a few miles from the southeast corner of the area (Gay and Hoffman, 1954, p. 495–6). Debris flows, lack of water, catastrophic floods, and exhaustion of the deposits have ended all mining activity.

To evaluate the mineral-resource potential of the area, geologic examinations were made by foot traverses in March 1966. Samples of fresh, altered, and mineralized rocks, of sand, gravel, and other sediments, and of some panned concentrates from stream sediments were collected and analyzed. Results were reported in the following year (Crowder, 1967).

MINERAL RESOURCES

There is little promise for the occurrence of metallic resources in the Devil Canyon-Bear Canyon Primitive Area. This conclusion was based on (1) an evaluation of

[1]With contributions from W. H. Raymond, USGS. Abstracted from a report by Crowder (1967) by H. E. Hodgson.

the geology of the area; (2) the absence of significant concentrations of metals and ore minerals in deposits at the surface, as well as in sheared, broken, and altered rocks; and (3) the evaluation of mineral production and occurrences in nearby areas.

Mineral occurrences include antimony, copper, gold, molybdenum, and silver found in the southwestern part of the area, but they are small and do not constitute a mineral resource.

Rocks in the primitive area that might possibly be mineralized by introduced metals are those that are fractured, altered, or iron stained. Analyses of these rocks and of soils along the north boundary of the area, however, indicated no anomalous concentrations of metals. The sheared and conspicuously oxidized lenses of gneiss in the southwest corner of the area did contain anomalous traces of molybdenum and gold. The traces of antimony, copper, gold, molybdenum, and silver are found chiefly near the contact of the granitic rocks with the gneiss in the southwestern part of the area.

Although placer mining for gold has undoubtedly occurred in the West and North Fork drainages, little, if any, gold appears to have been mined. Absence of placer deposits on the West Fork is significant inasmuch as this stream drains the entire primitive area. Careful panning of the stream gravels in the area produced no visible gold, and analyses of the panned concentrates indicated that the stream gravels contain an average of 0.0002 oz or less gold per ton of gravel. Inasmuch as the patches of perched gravels were derived from very near the present erosion level, they can be expected to be as barren of placer gold as the present stream deposits. The only prospect found in the area, the Boatwright prospect, consists of a 60-ft adit driven along a quartz vein that is 18 in. wide at its widest spot in the surface outcrop and less than 1 in. wide at the end of the adit. In the surface outcrop the vein occurs as a short segment between two faults. Analysis of the quartz vein revealed trace amounts of molybdenum and no detectable gold.

Near Cogswell Dam, just outside the primitive area, sparce copper sulfides occur with quartz and muscovite in widely scattered pods. Traces of antimony and silver occur with the copper in these pods. In the primitive area itself, however, only one broken and sheared pod was found within the San Gabriel fault zone.

SUGGESTIONS FOR FURTHER STUDIES

Although it has been some years since this investigation was completed, no further study is warranted. The geologic setting, the lack of significant concentrations of metals and ore minerals, and the absence of mining activity in the area preclude the need for additional work.

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DINKEY LAKES ROADLESS AREA, CALIFORNIA

F. C. W. DODGE, U.S. GEOLOGICAL SURVEY, and

F. E. FEDERSPIEL, U.S. BUREAU OF MINES

SUMMARY

The results of a mineral survey conducted in 1980, show that parts of the Dinkey Lakes Roadless Area have substantiated resource potential for tungsten and marble and probable resource potential for quartz crystal gemstones. A probable resource potential for geothermal energy exists in one small area. No potential for other metallic mineral or energy resources was identified in this study.

CHARACTER AND SETTING

The Dinkey Lakes Roadless Area occupies an area of about 184 sq mi on the western slope of the Sierra Nevada, California, about 50 mi northeast of the city of Fresno. Altitudes in the roadless area range from over 10,500 ft to less than 6500 ft. Small lakes and alpine meadows dot the area's rugged mountainous terrain, much of which is covered with forests of pine and fir. The spectacular scenery is typical of glaciated regions of the Sierra Nevada. California State Highway 168 provides access to the roadless area from the southwest and passes near its northern boundary. Several paved and dirt roads branch from State Highway 168, providing access to margins of the area.

Much of the roadless area is underlain by granitic rocks extensively mantled with glacial debris; however, remnants of pregranitic rocks are locally present. A variety of metasedimentary rocks, principally quartzite, schist, marble, and hornfels, occur in a roof pendant in the southwest part of the area and as scattered inclusions south of the pendant. These rocks were metamorphosed and locally metasomatized during intrusion of plutonic rocks. Metavolcanic rocks, chiefly of rhyolite or rhyodacite composition, occur along the northeastern boundary of the area in a second roof pendant. Ages of the metamorphic rocks are not known with certainty, but based on regional setting and lithologic correlations, the metasedimentary rocks are believed to be Paleozoic or early Mesozoic, and the metavolcanic rocks, early or middle Mesozoic.

Numerous bodies of plutonic rocks ranging in composition from gabbro to granite are separated by sharp, steeply dipping or vertical contacts. The oldest plutonic rocks, believed to be Jurassic, are included in the metavolcanic roof pendant. Most of the granitic rocks in the southwest third belong to an Early Cretaceous sequence. Granitic rocks in the northwestern two-thirds of the roadless area belong to a Late Cretaceous sequence.

The USGS and USBM conducted field investigations during the summer of 1980 to determine the mineral-resource potential of the Dinkey Lakes Roadless Area. Field investigations included a reconnaissance of the geology of the area and field checking existing geologic maps, comprehensive examination of terrains with possible mineral-resource potential, geochemical sampling, and detailed examination of mines, prospects, and mineralized zones.

The Dinkey Creek mining district in the southwest part of the Dinkey Lakes Roadless Area is the only district in the area. Tungsten production has been recorded from two mines. The Rainbow mine has been worked by stoping methods intermittently since 1942, with total production of about 3000 short-ton units of tungsten trioxide concentrate. From 1953 to 1956 the Mud Lakes mine yielded about 4,800 short-ton units of tungsten trioxide concentrate from an open pit; a substantial portion of the ore body has been removed.

MINERAL RESOURCES

There is substantiated resource potential for tungsten in the southwestern part of the roadless area. Tungsten resources are in contact metamorphic deposits along the margins of the metasedimentary Dinkey Lakes roof pendant and in inclusions in granitic rocks near the pendant. Tactite interbedded in the schist unit of the

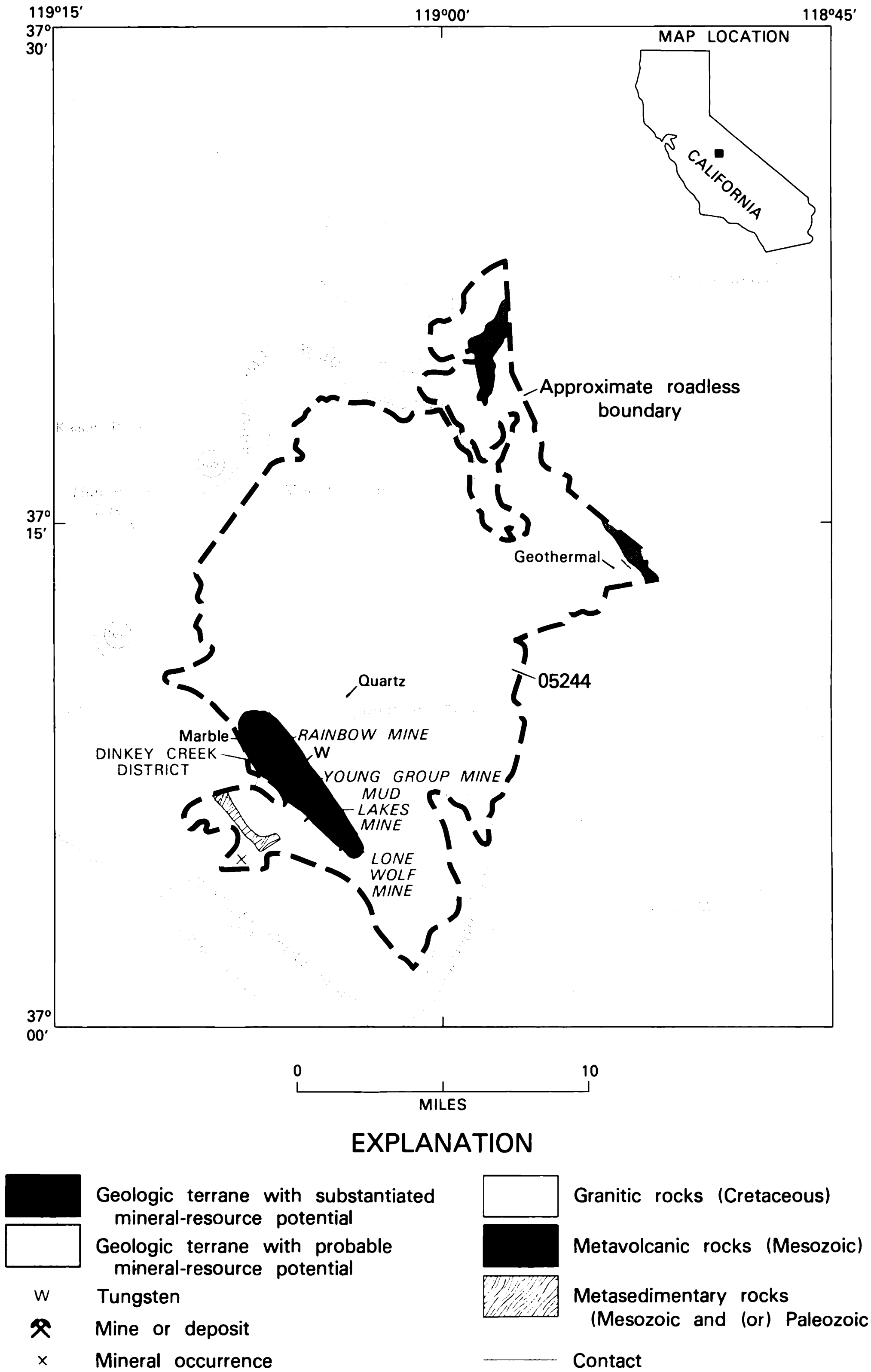

Figure 65.—Dinkey Lakes Roadless Area, California.

pendant and small inclusions of tactite south of the pendant are particularly favorable geologic environments for the occurrence of scheelite (calcium tungstate)-rich lenses and shoots.

The Rainbow, Mud Lakes and Lone Wolf mines, and Young Group properties have 164,000, 20,000, 17,000, and 800 tons of demonstrated tungsten resources, respectively, averaging about 0.13 percent WO_3; a total for the area of approximately 220,000 tons.

A finely laminated marble unit occurs in the roof pendant in the southwestern part of the roadless area. The gray marble is probably clastic in origin; it is nearly pure calcite and chemically meets limestone specifications for portland cement. The marble unit is exposed over an area of at least 1300 ft long and 400–600 ft wide; it may contain more than 20 million tons of demonstrated limestone resources. Transportation costs would greatly limit the distance the material could be shipped to major markets.

Smoky quartz (morion) crystals that occur at a well-known collecting locality in a 0.25 sq mi area in the south-central part of the roadless area are a potential semi-precious gemstone resource. Singly and doubly terminated smoky-grayish-brown to black quartz crystals are present in numerous miarolitic cavities in light-colored, garnet-bearing granite. Crystals 6 in. long have been found in some of the larger cavities. The area has a probable resource potential for quartz crystals.

Thermal-spring activity in the northeastern part of the area is an identified hot-water convection system. Reservoir temperatures are estimated to be most likely 130°F. The system may be adequate for space and process heating; however, electrical generation requires significantly greater temperatures and the area is assessed as having a probable geothermal resource potential.

Sulfide-bearing quartz samples containing low gold and silver values have been collected from a prospect adjacent to the southwestern boundary of the area. A minor amount of gold (6.48 troy oz) was produced in the late nineteenth century from quartz veins that discontinuously outcrop along the margins of a granitic intrusion. No gold or silver resources were identified at this locality.

Although small low-grade placer gold deposits are present near the roadless area, none are known to occur within the area. Sand and gravel resources are abundant in the area; however, similar and more accessible deposits are available closer to potential markets.

SUGGESTIONS FOR FURTHER STUDIES

Most of the scheelite-bearing surface outcrops in the roadless area have probably been found; however, subsurface exploration may lead to the discovery of additional tungsten resources in the southwestern part of the roadless area. Any further study of the area offers little likelihood of identification of other mineral resources.

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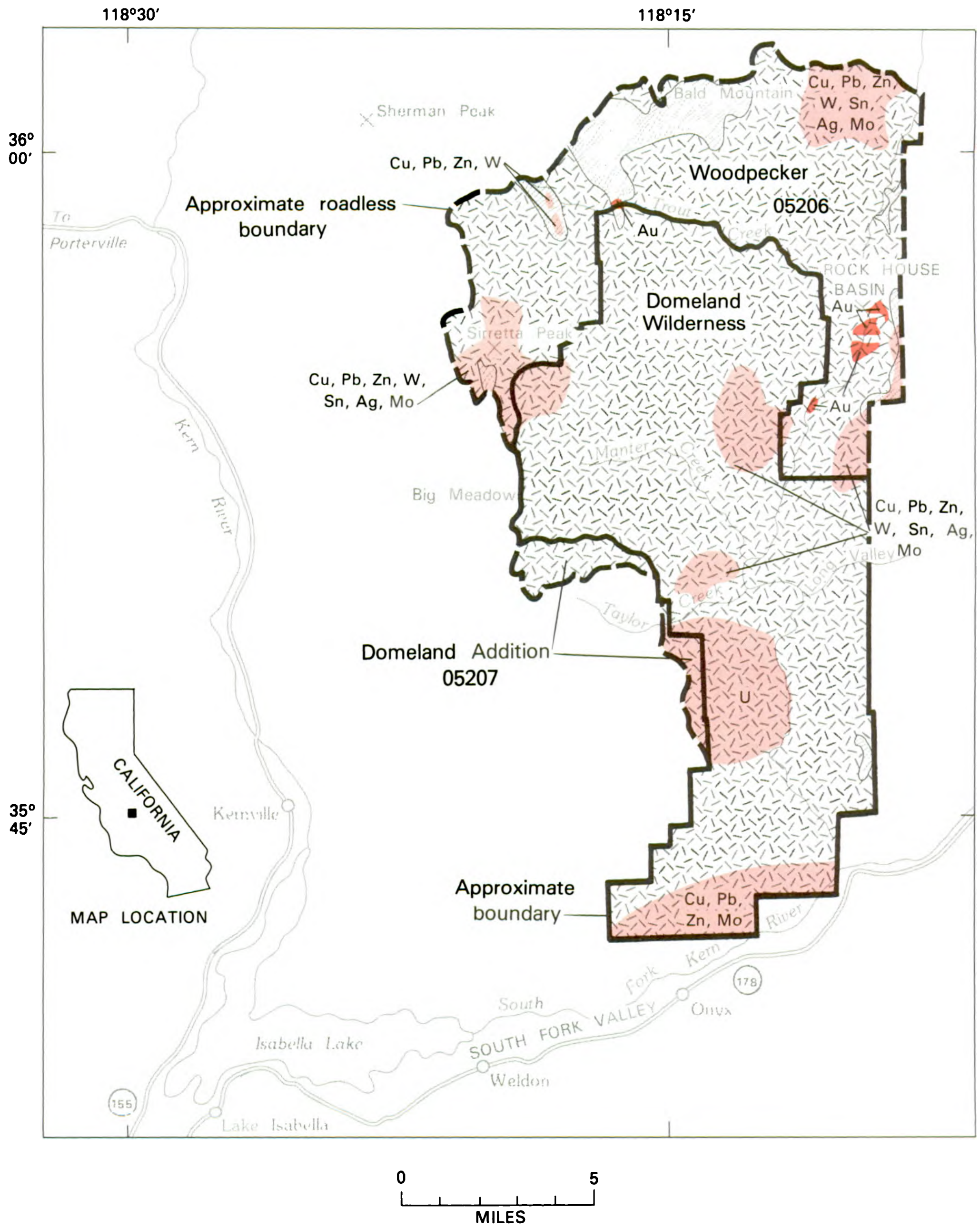

EXPLANATION

Geologic terrane with substantiated mineral-resource potential

Geologic terrane with probable mineral-resource potential

Granitic rocks (Mesozoic)

Metamorphic rocks (Pre-Middle Jurassic)

Contact

Cu	Copper	Sn	Tin
Au	Gold	W	Tungsten
Pb	Lead	U	Uranium
Mo	Molybdenum	Zn	Zinc
Ag	Silver		

Figure 66.—Domeland Wilderness, Domeland Addition, and Woodpecker Roadless Areas, California.

DOMELAND WILDERNESS, DOMELAND ADDITION, AND WOODPECKER ROADLESS AREAS, CALIFORNIA

By JOEL R. BERGQUIST,[1] U.S. GEOLOGICAL SURVEY, and

JAMES M. SPEAR, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Domeland Wilderness and the contiguous Domeland Addition and Woodpecker Roadless Areas was made in 1978–80 by the USGS and USBM. The study delineated areas of substantiated and probable mineral-resource potential. The areas of substantiated resource potential are in the Woodpecker Roadless Area where alluvial gravel in Rockhouse Basin and on Upper Trout Creek contains small, irregular, low-grade deposits of placer gold. There is a probable resource potential for very small deposits of uranium in fractures in granitic rocks west of the South Fork of the Kern River in the Domeland Wilderness. Geochemical data indicate a probable potential for a porphyry-molybdenum deposit at the southern end of the Domeland Wilderness, and for very small deposits of tungsten, copper-lead-zinc, tin, silver, and molybdenum at several places in the wilderness and roadless areas. The geologic terrane precludes the occurrence of organic fuel resources.

CHARACTER AND SETTING

The Domeland Wilderness, the Domeland Addition, and Woodpecker Roadless Areas are in the Sequoia National Forest on the crest of the Sierra Nevada near the southern end of the range. The Domeland Wilderness includes 98 sq mi, the Domeland Addition Roadless Area 5 sq mi, and the Woodpecker Roadless Area 69 sq mi. The town of Kernville is 10 mi west of the wilderness at the north end of Lake Isabella, and Bakersfield is 45 mi southwest. The southern end of the wilderness is accessible by roads leading from California State Highway 178. Access from the west, north, and east is by state, county, and USFS roads that in places parallel the boundary of the Woodpecker Roadless Area.

The South Fork of the Kern River flows south through both the Woodpecker Roadless Area and the Domeland Wilderness, then west through South Fork valley into Lake Isabella. The river has cut a steep and rugged V-shaped canyon in the wilderness, as deep as 3000 ft, between Rockhouse Basin and South Fork valley. At the northern end of the Domeland Wilderness is the Domeland, a unique area of approximately 35 sq mi that is characterized by numerous hemispherical to elongate, nearly white, granitic exfoliation domes. The domes vary in size from a few hundred feet in diameter and 50–100 ft high, to approximately 5 mi long, 1–2 mi wide, and more than 2000 ft high. The domes are relatively barren of vegetation except for brush and trees growing in crevices.

Altitudes range from about 3000 ft near South Fork valley in the southern part of the Domeland Wilderness to 9997 ft at Sirretta Peak near the western edge of the Woodpecker Roadless Area. Lower altitudes support desert flora including cacti and Joshua trees. The higher altitudes have open coniferous forests of red fir, white fir, yellow pine, and Jeffrey pine. The Domeland Wilderness and Woodpecker Roadless Area are crossed by numerous hiking trails including the Pacific Crest Trail.

Metamorphic and plutonic rocks typical of the Sierra Nevada underlie the area. Older (pre-Middle Jurassic) metamorphic rocks were intruded by a succession of younger (Mesozoic) granitic plutons of varying composition. The metamorphic rocks occur as roof pendants with steeply dipping beds that commonly erode to "tombstone" rocks. The metamorphic rocks consist mostly of interbedded quartzite, schist, phyllite, and marble, with minor amounts of slate and metavolcanic rocks. The marble and associated tactites are of particular interest because elsewhere they are host rocks for tungsten and other mineral deposits.

[1]With contributions from William R. Miller and Robert C. Jachens, USGS, and Andrew M. Leszcykoswki, USBM.

Overlying the metamorphic and granitic units are erosional remnants of more recent (late Tertiary) volcanic flows of basalt and andesite.

The area was covered by geologic, geochemical, geophysical, and mineral-occurrence surveys in 1979–80 (Bergquist and Nitkiewicz, 1982; Jachens, 1983; Miller and others, 1983a, b; Miller and McHugh, 1983).

MINERAL RESOURCES

There is no recorded production of minerals from the wilderness or roadless areas. The closest mining district, the Cove district, is near Kernville approximately 8 mi west of the southern end of the Domeland Wilderness. Areas along the Kern River near the Cove mining district were prospected and mined for placer gold beginning in 1851, but by 1855 most mining ceased. Gold-quartz veins were discovered in the Cove district in 1860. A total of $5 to 8 million in gold was produced, mostly before 1883.

The Kern River uranium area is 17 mi southwest of the southern end of the wilderness. Uranium deposits discovered there in 1954 occur locally along fractures in the granitic rocks. Only about 189 tons of ore were reported to have been shipped; the richest shipment was 46 tons of ore that averaged 0.62 percent uranium oxide.

There are no patented mining claims in the wilderness or roadless areas and only 38 mining claims have been located within the Domeland Wilderness. The first mining in Woodpecker Roadless Area was in 1901 when gold placers were worked in Rockhouse Basin along the South Fork of the Kern River. Between 1901 and 1968, 34 placer claims were staked along the South Fork of the Kern River in Rockhouse Basin. Old placer workings are still in evidence in lower Rockhouse Basin, but there is no evidence of recent activity.

A demonstrated resource of approximately 4.5 million cu yds of gold-bearing gravel occurs in fan deposits along the South Fork of the Kern River in four areas of substantiated gold resource potential in Rockhouse Basin. At $500/troy oz of gold, the resources are valued at an average of approximately 40 ¢/cu yd. Selective mining probably could not produce more than a few tens of thousands of cubic yards of gravel averaging more than $1/cu yd.

Gold-bearing gravels on upper Trout Creek in the western part of the Woodpecker Roadless Area yielded as much as $4.50/cu yd; however, the average grade is much lower, just as it is in the gold-bearing gravels in Rockhouse Basin. These gravels are in a small area of substantiated gold resource potential, but the deposits are small in size (only about 1000 cu yds of gravel) and are remote.

Geochemical data indicate a probable resource potential for very small deposits of uranium in the relatively inaccessible rugged canyons on the west side of the South Fork of the Kern River within the Domeland Wilderness. On the basis of the occurrence and production of uranium in the Kern River uranium area 17 mi southwest of the wilderness, any uranium deposits in the wilderness will probably have no more than a few tens of tons of rock averaging as much as 0.5 percent uranium oxide.

At the southern end of the Domeland Wilderness, a geochemical suite of base metals and molybdenum indicates an area of probable mineral-resource potential for porphyry-type molybdenum mineralization. However, the geochemical anomalies are of relatively low magnitude and there is a lack of any corroborating evidence.

Small, irregular tactite bodies occur locally at the contacts of metamorphic rocks and granitic rocks. Two areas of tactites near Trout Creek in the Woodpecker Roadless Area have a probable resource potential for small deposits of tungsten and other base-metal mineralization.

Several other areas have probable potential for very small vein or tactite-type deposits of tungsten, copper-lead-zinc, tin, silver, and molybdenum. These areas were identified on the basis of geochemical data, but the low magnitudes of the anomalies and the lack of other evidence indicates that the occurrences would be small and difficult to identify.

SUGGESTIONS FOR FURTHER STUDIES

Further studies are not recommended. Additional studies might confirm the presence of porphyry-type molybdenum mineralization at the southern end of the Domeland Wilderness. Further study in other areas is unlikely to reveal significant mineral deposits.

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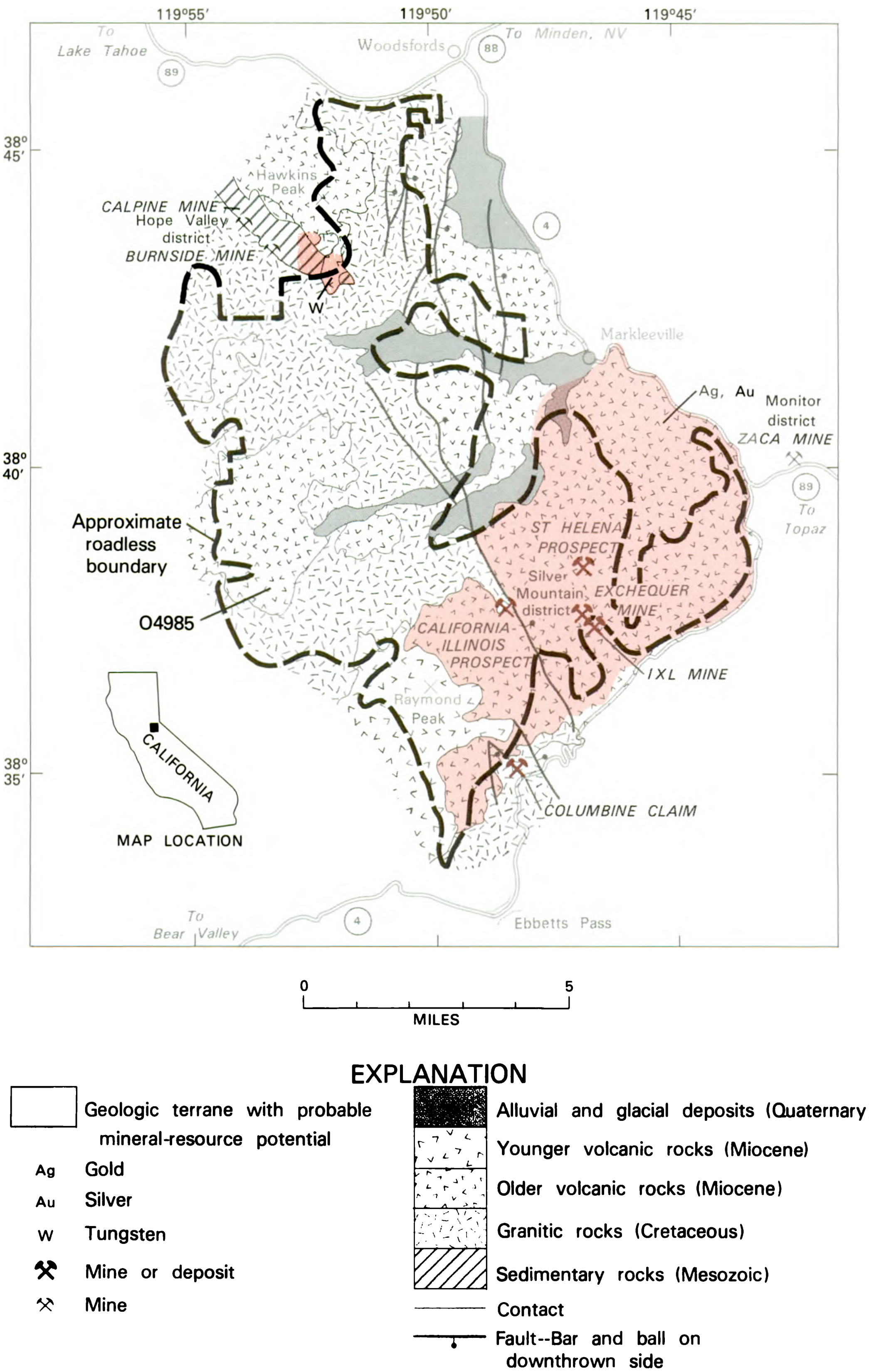

Figure 67.—East part of the Raymond Peak Roadless Area, California.

EAST PART OF THE RAYMOND PEAK ROADLESS AREA, CALIFORNIA

By DAVID A. JOHN, U.S. GEOLOGICAL SURVEY, and

FRANK E. FEDERSPIEL, U.S. BUREAU OF MINES

SUMMARY

Based on a mineral survey in 1979–80, there are demonstrated silver-gold resources at five properties within a large area of probable silver-gold potential in the east part of the Raymond Peak Roadless Area. A small area with probable mineral-resource potential for skarn-type tungsten resources occurs at the north end of the roadless area. The geologic setting precludes the presence of fossil fuels and no other energy resources were identified in the study.

CHARACTER AND SETTING

The east part of the Raymond Peak Roadless Area, Alpine County, California encompasses about 58 sq mi along the crest and eastern slope of the Sierra Nevada, about 15 mi south of Lake Tahoe. The topography of the area is characterized by deeply incised canyons with glacially scoured walls. The jagged volcanic pinnacles forming Raymond Peak may be seen from miles away while traveling along U.S. Highway 395 south of Carson City, Nevada. The spectacular Ebbetts Pass road (California Highway 4) passes just south of the area and forms the southeastern boundary. Altitudes range from about 5600 ft to more than 10,000 ft on Raymond and Hawkins Peaks. Markleeville, the county seat of Alpine County, is just east of the area.

The east part of the Raymond Peak Roadless Area, to be referred to as the study area, consists of two contrasting geologic environments. Most of the northwestern half is underlain by granitic rocks of the Sierra Nevada batholith. There are 13 granitic plutons, all of Late Cretaceous age, exposed in the study area. Except for areas where these granitoids intrude calcareous metasedimentary rocks, there is no mineral-resource potential associated with them.

Most of the southeastern half of the study area is underlain by volcanic rocks of late Tertiary age which unconformably overlie the granitic rocks. These rocks are part of an extensive volcanic terrain lying primarily to the east and to the south of the Raymond Peak Roadless Area. An unusually thick section of volcanic rocks (as much as 7000 ft) is preserved near the southeast corner of the study area; this is thought to occur because of the presence of a nearby eruptive center and because of major normal faulting which has downdropped the volcanic rocks relative to the older granitic rocks. Most known mineralization in the east part of the Raymond Peak Roadless Area is in the volcanic rocks.

Pleistocene glaciation extensively modified the topography of the study area, and thick glacial deposits cover the bottoms of major valleys.

Mining activity began near the Raymond Peak Roadless Area in the 1850's shortly after the discovery of the Comstock lode in Virginia City, Nevada. Mining properties in and adjacent to the southeastern part of the study area are in the Silver Mountain district. Production from the Silver Mountain district is thought to have been less than $300,000 mostly in silver and gold in the 1870's (Clark, 1977). The northwest end of the study area lies in the Hope Valley district. Small amounts of tungsten and gold were produced from two mines just outside the area in the 1950's.

The mineral-resource potential described in this report is based on studies conducted during 1979–80. Studies included geologic mapping of the area (Armin and others, 1982), interpretation of aeromagnetic and gravity maps (Plouff, 1983), geochemical sampling of stream sediments (S. J. Sutley, unpub. data, 1982), and examination of mines and mineralized areas. All of these data are summarized in John and others (1983).

MINERAL RESOURCES

Two diverse geologic settings, each with different types of possible mineral deposits, are present in the east part of the Raymond Peak Roadless Area. Tertiary volcanic rocks in the eastern Sierra Nevada host precious-metal (silver-gold) deposits at several localities including a number of mines and prospects along the southeastern margin of the study area and in the Monitor district 2 mi to the east. Metasedimentary rocks intruded by granitic rocks of the Sierra Nevada batholith host numerous tungsten deposits including three small deposits in the Hope Valley district just northwest of the area.

Two types of silver-gold mineralization are present in Tertiary volcanic rocks near the study area. Most of the silver-gold mineralization in the Silver Mountain district occurs in quartz veins filling shears and fault zones in the lower part of the volcanic section. Along the edges of these veins, argillic (clay) alteration is superimposed on earlier propylitic alteration, which is a widespread feature throughout the district and in the nearby Monitor district. The source of the mineralizing fluids is unclear but may be related to nearby unmineralized rhyolite intrusions.

A second type of silver mineralization occurs in the Zaca mine (the largest mine in the Monitor district) and is apparently genetically related to a rhyolite plug that intrudes and hydrothermally alters andesitic rocks which had been previously propylitized. Intense argillic alteration and silicification are present in the rhyolite, and most of the ore occurs in altered rhyolite.

Three properties within the study area have been identified by the USBM as having demonstrated resources of silver and (or) gold. These properties are the St. Helena prospect with 1,500,000 tons of demonstrated resources averaging 0.01 oz gold/ton and 2.5 oz silver/ton; the California-Illinois prospect with 270,000 tons of demonstrated resources averaging 0.03 oz gold/ton; and the Exchequer mine with 56,000 tons of demonstrated resources averaging 0.04 oz gold/ton. In addition, mineralized zones in the Columbine claim and in the IXL mine, which lie just outside of the boundary of the study area, probably extend into the study area. Estimated resources in the Columbine claim are 94,000 tons of demonstrated resources averaging 0.005 oz gold/ton and 0.5 oz silver/ton and in the IXL mine are 150,000 tons of demonstrated resources averaging 0.01 oz gold/ton and 0.93 oz silver/ton and additional 15,000 tons of demonstrated resources averaging 0.56 oz gold/ton and 48.47 oz silver/ton.

Either or both types of silver-gold mineralization described previously may be present in an area of probable resource potential in the southeastern part of the study area. Most of the area of probable potential for silver and gold is propylitically altered, and there are local areas of argillic alteration and silicification similar to alteration in the Monitor district. Analyses of geochemical samples indicate anomalous concentrations of many elements including silver, copper, molybdenum, lead, and zinc throughout much of this area. The hydrothermal alteration, geochemistry, and presence of properties with demonstrated silver-gold resources suggest that additional silver-gold deposits may be present and the area has a probable resource potential.

Tungsten-skarn mineralization occurs at the Calpine and Burnside mines just north of the study area along the contact between metasedimentary rocks and a granitic pluton. There is probable mineral-resource potential for tungsten in an area of metasedimentary rocks, in part covered by Tertiary volcanic rocks, intruded by the same granitic rocks as those at the mines extending into the northern part of the study area. Structural data suggests that the metasedimentary horizons which contain skarn mineralization at the mines extends into this area (Parker, 1961). Stream-sediment geochemistry shows anomalous concentrations of tungsten and other metals in this area which are apparently unrelated to contamination from prior mining activities therefore the area is considered to have probable potential for tungsten resources.

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EAST YUBA AND WEST YUBA ROADLESS AREAS, CALIFORNIA

By JOEL R. BERGQUIST,[1] U.S. GEOLOGICAL SURVEY, and

WILLIAM W. WHITE, III, U.S. BUREAU OF MINES

SUMMARY

The East Yuba and West Yuba Roadless Areas, which are located in the northern Sierra Nevada, California, have been evaluated on the basis of geologic, geochemical, and geophysical investigations by the USGS in 1980–81 and an investigation of mines, prospects, and mineralized area by the USBM in 1981–82. Both areas have demonstrated resources of gold and locally associated silver, in lode and placer deposits in areas of substantiated gold and silver resource potential. Large areas having a probable gold placer resource potential exist where Tertiary gravel deposits lie beneath Tertiary volcanic rocks in the roadless areas. There are active lode and placer gold mines in the roadless areas. Two areas of substantiated resource potential for small deposits of iron occur in the East Yuba Roadless Area. Each roadless area has an elongate area of probable resource potential for small deposits of chromite. There is little promise for the occurrence of energy resources in the roadless areas.

CHARACTER AND SETTING

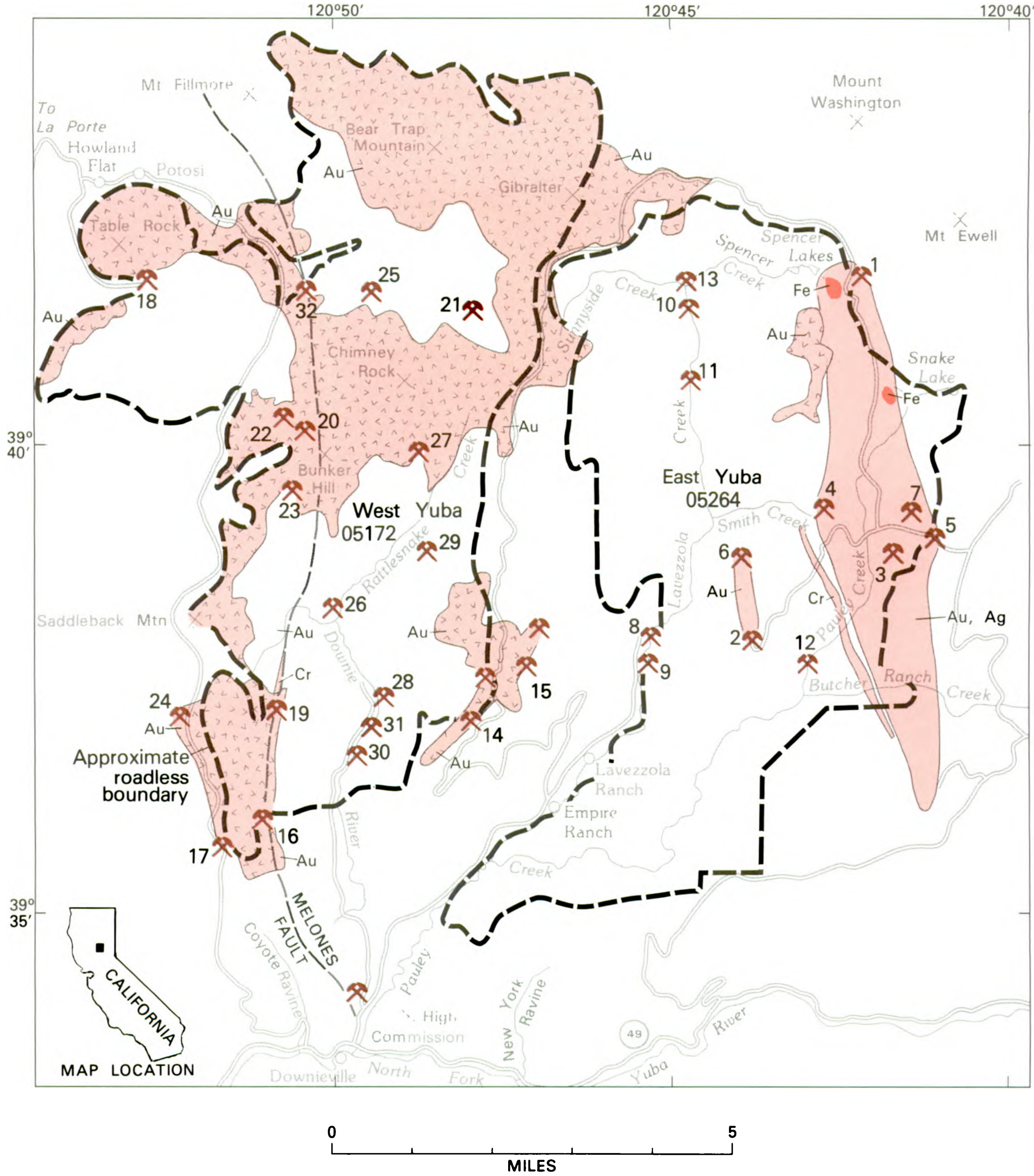
The East Yuba and West Yuba Roadless Areas are located on the west side of the crest of the northern part of the Sierra Nevada in the California Mother Lode gold country. The East Yuba Roadless Area includes 28 sq mi in the Tahoe National Forest, Sierra County, California. The West Yuba Roadless Area includes about 23 sq mi in the Tahoe National Forest in Sierra and Plumas Counties. The roadless areas are a few miles north of the North Fork of the Yuba River. California Highway 49 follows the river and links Downieville, located about 2 mi south of the roadless areas, and Sierra City, located about 4 mi southeast of the East Yuba Roadless Area. Access to and into the roadless areas is provided on all sides by graded roads and jeep trails. The site of Poker Flat, the gold rush town made famous by Bret Harte's book "The Outcasts of Poker Flat," is on Canyon Creek at the northwest edge of the West Yuba Roadless Area.

Altitudes in the roadless areas range from about 4000 ft to more than 7000 ft. The topography of the areas is generally rugged, and at lower altitudes the areas are typically cut by rugged ravines and canyons. Cascades and small waterfalls are common. The higher areas, in the eastern part of the East Yuba Roadless Area, have many lakes. At higher altitudes, the areas are generally covered by open forests of fir and pine, and at lower altitudes, hardwood trees, manzanita, oak, and other plants of the chapparal are common.

The East Yuba and West Yuba Roadless Areas are in the northern part of the metamorphic belt of the western Sierra Nevada. The bedrock in the roadless areas is mostly older (Paleozoic) metamorphic rock that is locally overlain by younger (Tertiary) volcanic rocks and gold-bearing river gravel. The Melones fault zone trends northward through the western part of the West Yuba Roadless Area and is the contact between two metamorphic rock units that include a variety of metamorphosed sedimentary and volcanic rocks. A third metamorphic rock unit consists of metamorphosed volcanic rocks and is located in the eastern part of the East Yuba Roadless Area. A few small areas of intrusive granitic rocks occur in the East Yuba Roadless Area. Overlying all of the metamorphic formations are younger (Tertiary), locally thick, deposits of volcanic mudflows and lava flows. Locally underlying these volcanic rocks are remnants of gold-bearing river gravel of Eocene (early Tertiary) age that are now elevated above the levels of present-day streams.

Soon after the discovery of placer gold in 1848, the river gravels in the area of Downieville and Sierra City were mined. Many placer gold and lode gold mines and

[1]With contributions from Susan S. Page, USGS, and Douglas F. Scott, USBM.



EXPLANATION

Figure 68.—East Yuba and West Yuba Roadless Areas, California.

prospects are located within and near the roadless areas in gold-bearing Tertiary gravels and have recorded production of at least a few hundred thousand dollars (Clark, 1970). Gold that is in part reworked from Tertiary gravels is presently being mined from modern creek and river gravels in and near the roadless areas.

The Poker Flat mining district is located around Poker Flat at the north end of the West Yuba Roadless Area, and includes mostly placer mines, although a few lode mines are also in the district. The area was first mined in the gold rush of 1849 for placer gold; hydraulic mining continued from the late 1850's through the 1880's, and lode mining continued through the early 1900's (Clark, 1970, p. 109).

Geochemical sampling of stream drainages and many rock types within the roadless areas was done in order to find possible signs of undiscovered mineral deposits. The analytical results are listed in Page and Bergquist (1982).

MINERAL RESOURCES

There is recorded production of gold and lesser amounts of silver from lode and placer mines within the roadless areas. Mines located within the roadless areas have produced about 12,500 oz of gold from Tertiary river gravels and about 21,300 oz of gold and 13,400 oz of silver from lode deposits. More than 300 active placer and lode claims are recorded for the West Yuba Roadless Area and more than 200 for the East Yuba Roadless Area.

In the East Yuba Roadless Area, most of the gold resources are in gold-bearing quartz veins and quartz-veinlet stockworks in lode mines and prospects, including some in the Sierra City mining district. Clark (1970, p. 117) reported that the district was most productive from 1870 to 1914, with additional mining in the 1920's and 1930's, and that total estimated production is at least $30 million. Of that total, Clark (1970, p. 117) estimated that about $2 million in gold was produced from the Four Hills mine (loc. 1, on map), which is adjacent to and partly within the northeast part of the East Yuba Roadless Area. The Four Hills (loc. 1), Big Boulder (loc. 2), Empire (loc. 3), Gold King (loc. 4), Lone Star (loc. 5), Sisson (loc. 6), and Willoughby (loc. 7) mines are on gold-silver lode deposits and have demonstrated resources. Production records for the Empire, Four Hills, and Willoughby mines indicate mined ore contained 0.26 to 0.48 oz gold/ton and 0.05 to 1.3 oz silver/ton. The Dragonfly (loc. 8), Jay Bird (loc. 9), Rebate (loc. 10), Upper Lavezzola Creek (loc. 11), Upper Pauley Creek (loc. 12), and Whipoorwill (loc. 13) placer properties have demonstrated low-grade gold resources in bench gravels. Minor amounts of placer gold are produced from active drainages.

Two small areas containing about 16 separate occurrences of magnetite (an iron oxide mineral) have a substantiated mineral-resource potential for iron in the north part of the East Yuba Roadless Area. The occurrences are all small and were found in the nineteenth century, but there has been no attempt at mining, and they are all of low tonnage.

In the West Yuba Roadless Area, most gold mining has been in isolated remnants of Tertiary river gravels although there has been some mining of gold in lode deposits. Currently, small-scale mining of placer gold in active drainages is carried out on a seasonal basis. The Downieville mining district is located around and north of the town of Downieville. The gold mines in this district are in placers in gold-bearing Tertiary gravel underlying younger volcanic rocks, and in gold-quartz vein lode deposits. The placer gold mines on Craycroft Ridge (loc. 15) are in an area of substantiated gold resource potential in this district. In the West Yuba Roadless Area, the Bummer (loc. 14), Craycroft-Wideawake (loc. 15), Excelsior (loc. 16), Monte Cristo (loc. 17), New California (loc. 18), and Sol Wood (loc. 19) mines have demonstrated low-grade placer gold resources in remnants of Tertiary river gravels in areas of substantiated gold resource potential. The Bunker Hill (loc. 20), Gibraltar (loc. 21), Golden Scepter (loc. 22), Herkimer (loc. 23), Telegraph (loc. 24), and Tennessee (loc. 25) mines have demonstrated placer gold resources in gold-bearing Tertiary gravel. The Buckshot (loc. 26), Clark Canyon (loc. 27), Crescent (loc. 28), D-B-K (loc. 29), Deep Moon (loc. 30), and Progressive (loc. 31) properties have demonstrated resources of gold-bearing bench gravels, and most of these are being developed or mined. The Poker Flat prospect (loc. 32) has recorded production of about 500 oz of gold from gold-bearing quartz veins, and there are additional demonstrated resources.

All of these mines (locs. 20–32) occur in Tertiary gravels in and around areas of younger volcanic deposits. There is probable resource potential for the occurrence of additional gold-bearing Tertiary river gravels beneath the Tertiary volcanic deposits.

Four chromite mines 2–4 mi south of the West Yuba Roadless Area have produced about 2500 tons of ore during World Wars I and II with the Oxford mine having produced most of the ore. Examination and analyses of similar host rocks within both roadless areas revealed only minor amounts of associated chromite. There is a probable potential for small undiscovered deposits of chromite in areas along the Melones fault in the West Yuba Roadless Area and in the southeast part of the East Yuba Roadless Area.

Large volumes of sand and gravel are in Tertiary river gravels in the West Yuba Roadless Area, and may be a local resource, but abundant quantities exist outside the area.

The East Yuba and West Yuba Roadless Areas have no indications of potential for oil, gas, coal, geothermal energy, or radioactive minerals.

SUGGESTIONS FOR FURTHER STUDIES

Specialized geophysical methods could be used to try to locate gold-bearing Tertiary river gravels that may underlie the Tertiary volcanic rocks. Detailed studies of mines within the roadless areas may reveal additional data on potential resources.

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EMIGRANT BASIN AND HOOVER WILDERNESSES, AND ADJOINING ROADLESS AREAS, CALIFORNIA

By EDWIN W. TOOKER,[1] U.S. GEOLOGICAL SURVEY, and

NICHOLAS T. ZILKA, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys conducted in 1967–1978 led to the conclusion that there was little promise for the occurrence of mineral or energy resources in the Emigrant Basin Wilderness, whereas the Hoover Wilderness and adjoining roadless areas contain areas with probable and substantiated potential for base- and precious-metal resources. The metal contents in the rocks of the Emigrant Basin are generally no greater than the abundance levels that characterize nonmineralized regions, as shown by a geochemical survey. In contrast, an area in the southern part of the Hoover Wilderness has substantiated resource potential for small discontinuous precious-metal deposits along veins. This classification was made on the basis of an extension of an area containing known precious-metal deposits. Extensions of known, or the possibility of discovery of new, tungsten deposits in the Roadless Areas 5–662 and 4–664 indicate parts of these areas have probable mineral-resource potential. A mineralized area with probable mineral-resource potential for disseminated copper and molybdenum is present at the north end of the Hoover Wilderness and in the northeastern part of roadless area 4–664. No resource potential for uranium, geothermal, or organic fuel energy sources was identified in this study.

CHARACTER AND SETTING

The Emigrant Basin and Hoover Wildernesses lie along the west and east sides of the crest of the Sierra Nevada in Tuolumne and Mono Counties, California. These wildernesses, which contain about 412 sq mi of generally roadless lands, are located within parts of the Stanislaus, Toiyabe, and Inyo National Forests. Four roadless areas, 4–662, 4–664, 4–666, and 5–662 (also known as the Emigrant Basin Primitive Area) lie along the northern and eastern sides of the Hoover Wilderness. These areas are bounded by Yosemite National Park on the south, by Bridgeport Valley, Mono Lake, and tributaries of the East and West Walker Rivers on the east, by two paved highways that cross the Sierra Nevada at Sonora Pass on the north and Tioga Pass on the south, and the headwaters of the Middle Fork of the Stanislaus and Tuolumne Rivers on the west. The region is one of marked relief and spectacular scenery that has been enhanced by glacial erosion.

[1]With contributions from H. T. Morris, H. W. Oliver, M. A. Chaffee, R. H. Hill, W. J. Keith, Donald Plouff, J. F. Sietz, and S. J. Sutley, USGS; P. V. Fillo and A. M. Leszcykowski, USBM; and G. F. Brem, California State University, Fullerton, Calif.

Field investigations were made by the USGS and USBM in the Emigrant Basin Wilderness in 1967 and 1968 (Tooker and others, 1970), and in the Hoover Wilderness and adjoining roadless areas in 1977 and 1978 (Tooker and Zilka, 1983). Geologic mapping, geochemical sampling, and gravity and magnetic geophysical surveys were conducted by the USGS, and mapping and sampling of the mines and prospects and a survey of claim records were made by the USBM.

The Emigrant and Hoover Wildernesses are in the west-central part of the Sierra Nevada, an asymmetrical north-trending structural block 400 mi long and 40 to 80 mi wide having a gently inclined western slope and an irregular steep escarpment along its eastern side. This block consists chiefly of several batholiths of Mesozoic granitic rocks containing roof pendants of upper Paleozoic and lower Mesozoic metasedimentary rocks (Bateman and Wahrhaftig, 1966). All of these rocks are discontinuously overlapped along the northern borders of the wilderness areas by a partly eroded blanket of Tertiary volcanic and sedimentary rocks (Slemmons, 1966). Local areas of pyritized and argillized granitic, metasedimentary, and volcanic rocks crop out

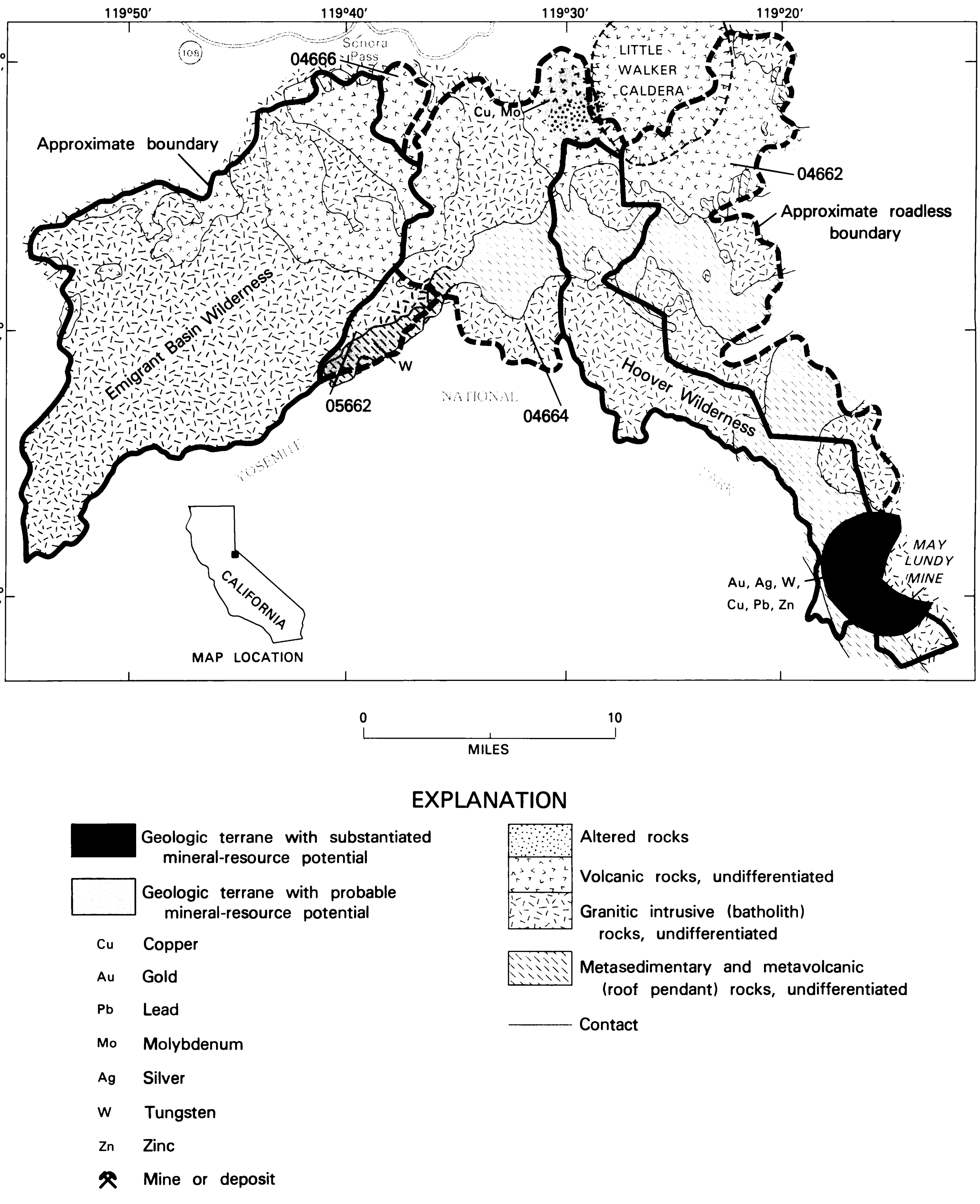

Figure 69.—Emigrant Basin and Hoover Wildernesses and adjoining roadless areas, California.

along the northern and eastern sides of the Hoover Wilderness area. Five major geologic events are recorded in these rocks: (1) a long period of deposition of marine sediments during the Paleozoic Era (from 230 to 600 m.y. (million years) ago); (2) formation of a great synclinal basin during latest Paleozoic or earliest Mesozoic time that became filled by volcanic and sedimentary debris; (3) deformation and intrusion by granitic batholithic masses followed by uplift and deep erosion before the close of the Mesozoic Era (about 62 m.y. ago); (4) subsequent uplift, tilting and faulting, preceeded and accompanied by volcanism in the late Cenozoic (9 to 26 m.y. ago); and (5) carving of present topography by erosion and Quaternary glaciation (about 1 m.y. ago).

MINERAL RESOURCES

The Sierra Nevada region is well known for the Mother Lode gold belt and related placers in the foothills along the western side of the Sierra Nevada batholith and the Pine Creek roof pendant tungsten deposits south of Yosemite Park, on the eastern side of the Sierra Nevada. Several small base- and precious-metal, tungsten, and uranium mines and prospects are located in and adjacent to the wildernesses. Records indicate 44 lode and placer claims for tungsten within roadless area 5-662, which is located between the Emigrant Basin and Hoover Wildernesses, and approximately 1100 mining claims for gold, silver, and tungsten, mainly in the southern part of the Hoover Wilderness and adjoining roadless areas. The earliest claim locations in the Hoover area were made in 1859; they were followed by the establishment of the now abandoned Tioga and Homer mining districts in 1878 and 1879. Total production from these areas is not known, but more than 42,500 oz gold and 18,000 oz silver were produced mainly from the May Lundy mine. Limited exploration for precious metals continues in this vicinity.

Mineral occurrences are associated mainly with three groups of rocks shown on the map: upper Paleozoic and lower Mesozoic metasedimentary and metavolcanic roof pendants throughout the Emigrant Basin and Hoover Wildernesses; the margins of granodioritic Mesozoic plutonic bodies in the southern part of the Hoover Wilderness; and possibly with Tertiary volcanic rocks related to the Little Walker caldera structure in the northern part of the Hoover Wilderness. High-angle faults provided access channelways for the movement of hydrothermal solutions that concentrated the base and precious metals and tungsten in these rocks. The extensive and complex folding and faulting in the roof pendant rocks, particularly in the area of gold deposits, is obscured by later batholithic intrusion. Shear faults subparallel to bedding in the pendants, and steeply dipping cross faults, which locally offset pendant strata and separate plutonic bodies, are the main regional structures.

Gold, silver, and minor base-metal resources are located mainly in the southern part of the Hoover Wilderness in the region of the May Lundy mine. Early plutonic bodies along the eastern margin of the Sierra Nevada and their adjacent locally argillized wallrocks are the sites of steeply dipping north-northwest-trending gold-bearing veins, which pinch and swell, split and branch. They are composed of quartz, brecciated host rock, and gold. Pyrite and arsenopyrite are common, and galena, chalcopyrite, sphalerite, and molybdenite are sporadic associated minerals. No known precious-metal vein deposits are associated with the later Mesozoic plutons along the western side of the area. The southern part of the Hoover Wilderness contains substantiated resource potential for gold; no gold is known to occur in the Emigrant Basin Wilderness. The May Lundy mine is estimated to contain demonstrated resources of as much as 140,000 oz of gold. Adjacent mines may also be expected to contain smaller amounts of recoverable gold and silver. Only small amounts of ore are expected owing to the small size limits of the high-grade discontinuous ore shoots in this region.

Tungsten, in the mineral scheelite ($CaWO_4$), and associated base-metal minerals occur in discontinuous lenses in recrystallized limestone and garnet-epidote skarn where they are in contact with granodiorite. A number of small mines and prospects were developed in the roof pendants located in the westernmost roadless area 5-662 and area 4-664, which includes the headwaters of Cherry Creek. These areas have a probable tungsten resource potential.

The main occurrences of tungsten at the southern part of the Hoover Wilderness are in sheared carbonate beds along or close to the contact with granodiorite and these carbonate beds have a small substantiated tungsten resource potential. Where carbonate beds are not sheared or in contact with intrusives, they are not mineralized. There is only limited promise for occurrence of significant amounts of tungsten in the Emigrant Basin and Hoover Wildernesses because of the shallow depth for most pendant bodies, the small size of the metalliferous skarn zone lenses adjacent to plutonic bodies, and the limited amount of limestone or dolomite in the pendants. Occurrence of base-metal and uranium deposits in areas 5-662 and 4-664 is considered unlikely under existing geologic conditions.

An argillically altered zone in volcanic rocks on the western margin of the Little Walker caldera at the north end of the Hoover Wilderness and area 4-664, is intruded by a fine-grained granodiorite plug and is the site of strong geochemical anomalies for copper and molybdenum as well as gravity and magnetic geophysical anomalies (Tooker and others, 1981). The characteristics of this zone are favorable for the occurrence of disseminated (porphyry-type) copper and molybdenum at depth, an ore type similar to deposits known in western Nevada (Wallace, 1979). This area has a probable resource potential for copper and molybdenum.

A geothermal resource potential also exists outside the eastern margin of the wilderness, but probably does not extend into it. There is no known potential for fossil fuel deposits in this region.

SUGGESTIONS FOR FURTHER STUDIES

Additional studies of the main parts of the wildernesses offer little promise for the discovery of concealed mineral deposits. Geologic and subsurface exploration of the altered area on the west side of the Little Walker caldera, and more detailed investigation of several other altered and geochemically anomalous areas reported by Tooker and Zilka (1983) in the Hoover Wilderness may reveal promising areas for exploration.

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FISHER GULCH ROADLESS AREA, CALIFORNIA

By DONALD F. HUBER,[1] U.S. GEOLOGICAL SURVEY, and

ERIC E. CATHER, U.S. BUREAU OF MINES

SUMMARY

On the basis of a study in 1980–81, the Fisher Gulch Roadless Area has a probable potential for small amounts of placer gold resources in a narrow elongate area along the northeast boundary. There is little promise for the occurrence of other metallic, or nonmetallic resources and the geologic terrane precludes the occurrence of fossil fuel resources.

CHARACTER AND SETTING

The Fisher Gulch Roadless Area occupies an area of about 5.2 sq mi near the Trinity Alps in the Klamath Mountains, about 10 mi northwest of Weaverville, California. Altitude above sea level ranges from 2400 ft on the east to 6250 ft on the west. The northern and western boundaries are shared with the proposed Salmon-Trinity Alps Wilderness.

The roadless area is almost entirely underlain by the Salmon Hornblende Schist, a rock that was metamorphosed about 350 million years ago (Devonian). During the time from about 230 to 65 million years ago (Mesozoic), these rocks were accreted to the North American continent by plate-tectonic processes. Overlaying the metamorphic rocks in the northeast part of the roadless area are stream sediments in part derived from glacial debris.

Stream-sediment samples from streams that drain the roadless area were collected and analyzed. Samples of the metamorphic rocks were used to establish background values to compare with the stream-sediment analyses. The East Wind No. 1 mine sample analyses were used to check for mineralization that may be still present in the mine.

Mining has gone on in this area since 1850 with the gravels of Canyon Creek and Fisher Gulch, adjacent to the roadless area on the east and south, being mined using the various placer techniques. Within the southeast part of the roadless area is the East Wind No. 1 mine. One mile to the east of the roadless area are the Globe, Bailey, and Chloride mines, the largest gold-quartz vein mines in the Salmon-Trinity Alps region.

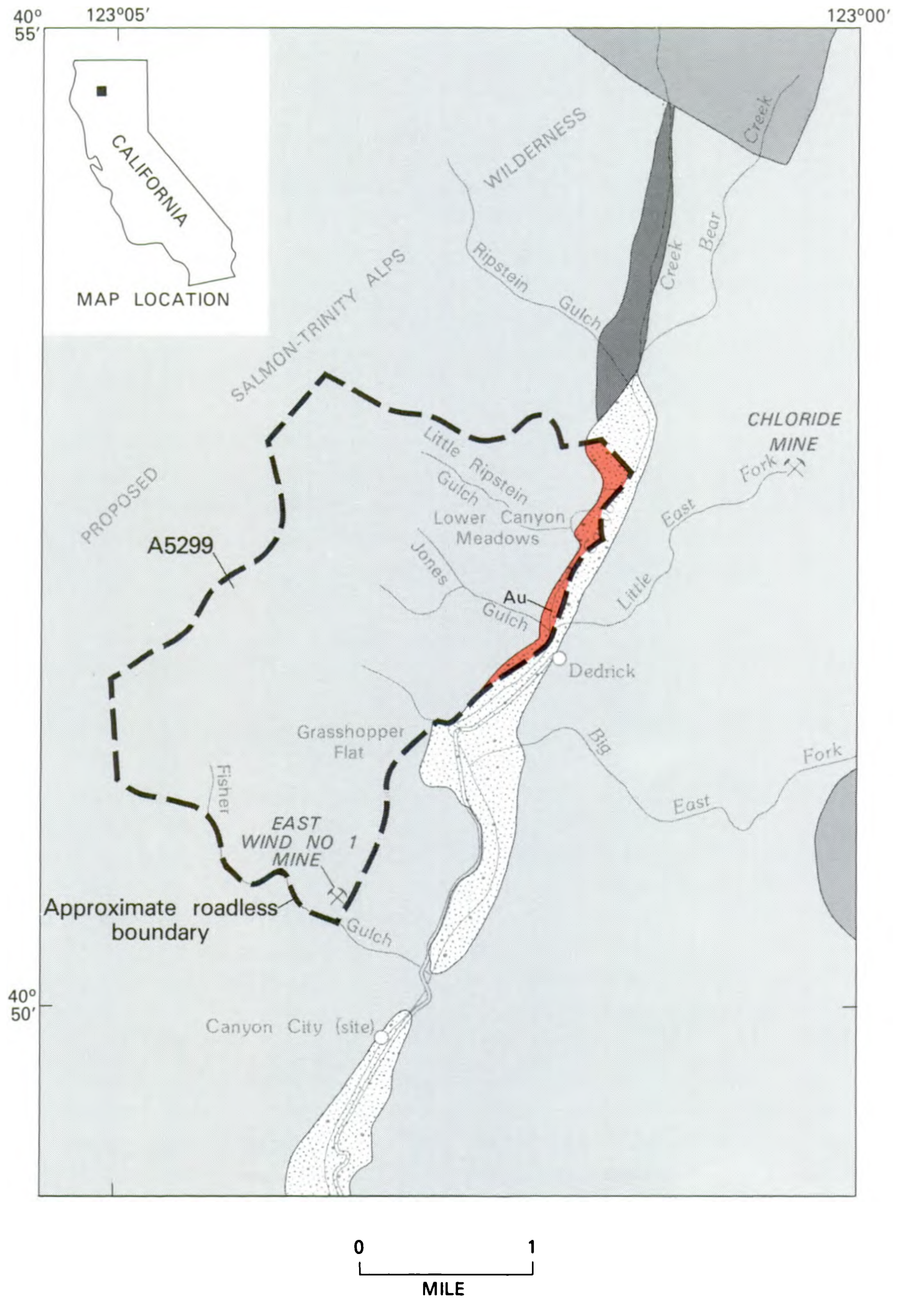
[1]With contributions from Scott C. Nelson, USGS, and Joseph L. Ritchey, USBM.

MINERAL RESOURCES

The area of gravels on Canyon Creek, along the northeastern edge of the roadless area has a probable gold resource potential although the gravels have been extensively mined for placer gold and probably only small amounts of gold remain in present-day river gravels and bars. Analyses of stream-sediment samples from Little Ripstein and Jones Gulches show no significant amounts of gold, suggesting that the gold found in Canyon Creek was derived from other drainages outside the roadless area.

Analyses of gravels of Fisher Gulch and its tributary along the south boundary of the area show small amounts of gold. Local prospectors claim that gold nuggets have been recently recovered from Fisher Gulch. However, there is little promise for the occurrence of placer gold in Fisher Gulch other than the occasional nugget and small amounts of fine gold particles similar to those that have been recovered, because gravel volumes are small.

Gold-bearing lode samples from the East Wind No. 1 mine and the presence of small amounts of placer gold in the gravels of Fisher Gulch indicate that lode gold exists within the Fisher Gulch drainage area, most of which lies within the roadless area. However, the East Wind No. 1 deposit appears to be mined out because both ends of the quartz vein pinch out in the adit, and assays of samples from the vein show little gold. A stockpile sample assayed 0.25 oz gold/ton, indicating that high-grade pockets probably occurred along the vein. Exploration along the vein might reveal additional pockets. However, because no other mines or claims exist within the roadless area and because extensive past exploration and prospecting in the area has been



EXPLANATION

Geologic terrane with probable mineral-resource potential

Au — Gold

⚒ — Mine

Gravels, terraces, and placer mine tailings (Quaternary)

Moraine (Quaternary)

Tonalite (Cretaceous or Upper Jurassic)

Salmon Hornblende Schist (Devonian)

Contact

Figure 70.—Fisher Gulch Roadless Area, California.

unrewarding, the area is concluded to offer little promise for the occurrence of additional surface lode gold deposits.

SUGGESTIONS FOR FURTHER STUDIES

Gold-bearing quartz veins associated with dikes in the Salmon Hornblende Schist may be present beneath the surface in the roadless area. They would be difficult to locate by present-day exploration methods and the gold content along the veins is likely to be sporadic as it is in mines outside the roadless area. Further studies are not warranted.

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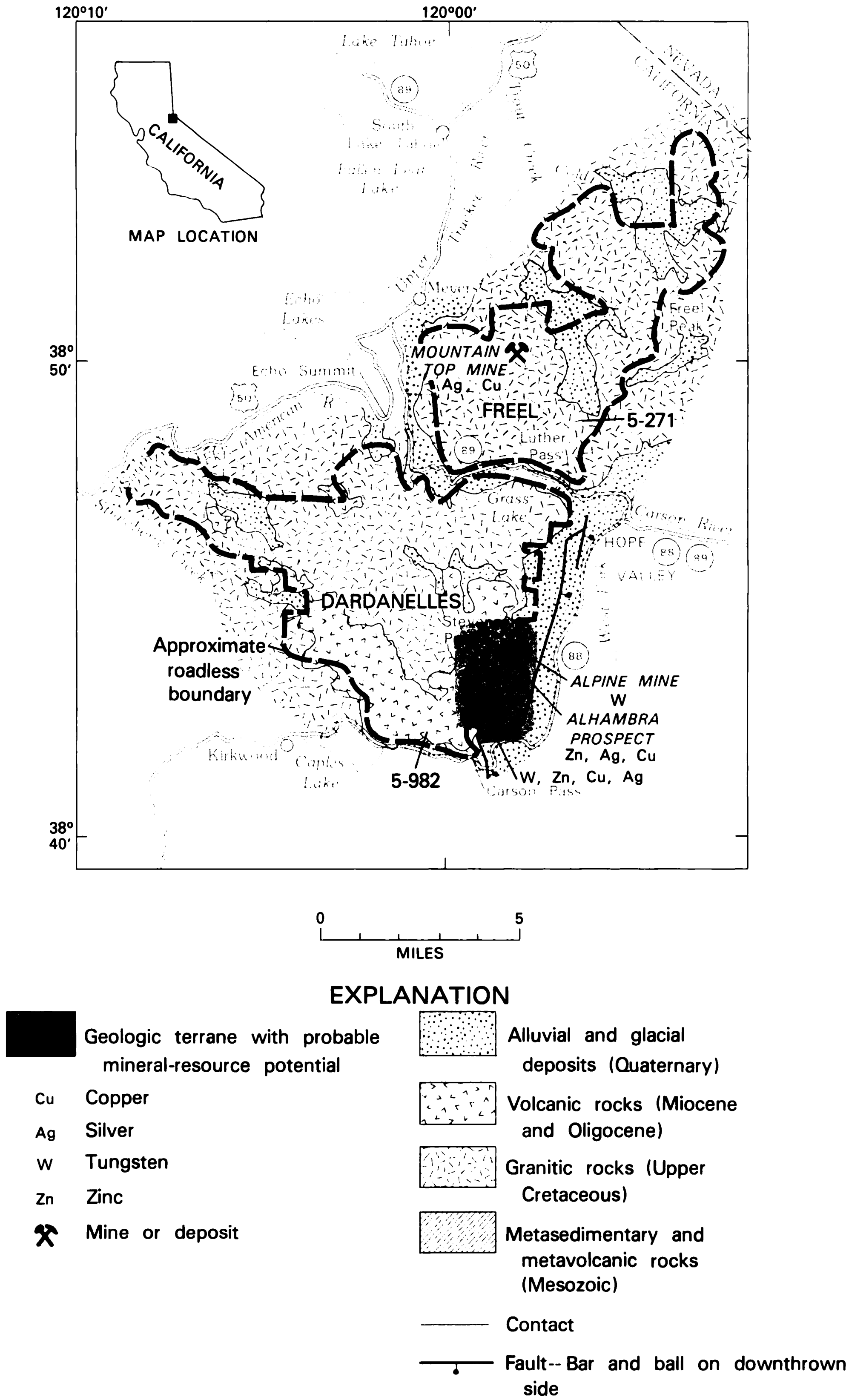

Figure 71.—Freel and Dardanelles Roadless Areas, California.

FREEL AND DARDANELLES ROADLESS AREAS, CALIFORNIA

By DAVID A. JOHN,[1] U.S. GEOLOGICAL SURVEY, and

DOUGLAS F. SCOTT, U.S. BUREAU OF MINES

SUMMARY

As a result of the mineral survey of the Freel and Dardanelles Roadless Areas, California, made in 1978-80, several areas having demonstrated resources were identified: tungsten at the Alpine mine in the Dardanelles Roadless Area; silver and copper at the Mountain Top mine in the Freel Roadless Area; and, zinc, silver, and copper at the Alhambra prospect just outside of the Dardanelles Roadless Area. An area along the southeastern margin of the Dardanelles Roadless Area has probable mineral-resource potential for tungsten, zinc, silver, and copper resources. No potential for energy resources was identified in this study.

CHARACTER AND SETTING

The Freel and Dardanelles Roadless Areas, Alpine and El Dorado Counties, encompass about 60 sq mi in the central Sierra Nevada of eastern California, about 5 mi south of Lake Tahoe. The area consists of rugged mountainous topography with altitudes ranging from about 6000 ft in the western part of the Dardanelles Roadless Area to the 10,881-ft summit of Freel Peak. Spectacular views of Lake Tahoe, the Sierra Nevada, and western Nevada are possible from these areas. Easy access to the areas is possible from California State Highway 89 (Luther Pass road), which separates the two areas, and from California State Highway 88 (Carson Pass) and U.S. Highway 50 (Echo Summit), which form part of the southern and northern boundaries of the Dardanelles Roadless Area, respectively.

Cretaceous granitic rocks of the Sierra Nevada batholith, older metasedimentary and metavolcanic rocks, and Tertiary volcanic rocks are exposed in the area. Most of the area is underlain by twelve granitic plutons, all about 90 to 95 m.y. (million years) old. Freel Peak and most of the high peaks in the Freel Roadless Area are composed of granitic rocks. The granitic plutons intrude several small bodies of metasedimentary and metavolcanic rocks along the eastern side of the Dardanelles Roadless Area. Most mineral deposits in the Freel and Dardanelles Roadless Areas occur where marble layers in the metasedimentary rocks are intruded and mineralized by granitic rocks.

[1]With contributions from T. J. Peters, USBM.

The ridges and peaks at the southern end of the Dardanelles Roadless Area are capped by volcanic rocks of late Tertiary age (5 to 26 m.y.). Most of these rocks are volcanic mudflows and sediments that probably came from the southeast. Stevens Peak, however, is a volcanic neck that may have been a relatively minor source for some of the volcanic rocks in the area.

Pleistocene glaciation extensively modified the topography and left widespread glacial deposits. Glacial features especially evident include Grass Lake, a glacial lake dammed by debris left by a glacier that once flowed from Hope Valley into the Upper Truckee River valley, and numerous lateral moraines on the west side of Hope Valley that form long step-like benches on the east side of the Dardanelles Roadless Area.

Mining activity began in the region in the late 1850's, shortly after the discovery of the Comstock lode in Virginia City, Nevada. Mining properties in and adjacent to the Dardanelles Roadless Area are in the Hope Valley district. Small quantities of tungsten ore were mined at the Alpine mine during the 1940's, and small amounts of tungsten and gold were mined from two other mines in the district about 4 mi east of the area.

The mineral-resource potential described in this report is based on studies conducted during 1978-80. Studies included geologic mapping of the area (John and others, 1981), interpretation of areomagnetic and gravity maps (Plouff, 1983), geochemical sampling of stream sediments, and examination of mines and mineralized areas. All of these data are summarized in John and others (1983).

MINERAL RESOURCES

Two types of mineral resources occur within the roadless areas. In the southeastern part of the Dardanelles Roadless Area, base- and precious-metal resources occur in skarn zones and in shear zones in metamorphic rocks near contacts with granitic rocks. In the Freel Roadless Area, silver and copper resources occur in a quartz vein in a granitic pluton.

The USBM identified two properties that have demonstrated resources of tungsten, copper, and silver within the roadless areas. The Alpine mine, which lies just outside the eastern boundary of the Dardanelles Roadless Area, contains an estimated 1,700,000 tons of demonstrated resources averaging 0.19 percent tungsten trioxide (WO_3) in a skarn zone that averages 100 ft thick, 520 ft long and 170 ft in depth. An estimated 800,000 tons of this resource is in the Dardanelles Roadless Area. In the Freel Roadless Area, the Mountain Top mine contains an estimated 2000 tons of demonstrated resources averaging 0.61 oz silver/ton and 1.59 percent copper in an isolated quartz vein in a granitic pluton. In addition to these resources within the roadless areas, the Alhambra prospect, which lies just outside the eastern boundary of the Dardanelles Roadless Area, contains an estimated 2,000,000 tons of demonstrated resources averaging 1.85 percent zinc, 0.25 oz silver/ton, and as much as 0.17 percent copper, in a shear zone in metamorphic rocks near a contact with granitic rocks.

The southeastern corner of the Dardanelles Roadless Area has a probable mineral-resource potential for tungsten and (or) other base metals (zinc and copper) and silver. This area of probable potential contains the Alpine mine and the Alhambra prospect, as well as four other prospects for base and precious metals. In the area, metamorphic rocks have been intruded by a granitic pluton believed to be responsible for the mineralization at the Alpine mine and the Alhambra prospect, and two other small tungsten mines about 4 mi east of the roadless area. The western part of the area of probable potential also includes a ridge covered with Tertiary volcanic rocks that aeromagnetic and structural studies suggest is underlain by metamorphic rocks, possibly including marble layers similar to those that are mineralized at the Alpine mine. The presence of nearby known deposits and similar geologic environments suggests that this area has probable mineral-resource potential for tungsten, zinc, copper, and silver resources.

Elsewhere in the roadless areas, there is little promise for the occurrence of mineral resources. No resource potential for oil, gas, coal, or geothermal resources was identified in this study.

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GOLDEN TROUT WILDERNESS, CALIFORNIA

By DAVID A. DELLINGER,[1] U.S. GEOLOGICAL SURVEY, and

NICHOLAS T. ZILKA, U.S. BUREAU OF MINES

SUMMARY

The mineral survey of the Golden Trout Wilderness, conducted in 1979, revealed that four areas in the wilderness have resource potential for tungsten and base and precious metals. One, the Mineral King pendant, has substantiated potential for tungsten deposits; the others are designated as having probable resource potential for tungsten and base and precious metals. Demonstrated tungsten resources exist at the Pine Tree mine, a skarn deposit in the Mineral King pendant. There is no evidence for the existence of large undiscovered deposits within the wilderness. The geologic terrane precludes the occurrence of organic fuel resources.

CHARACTER AND SETTING

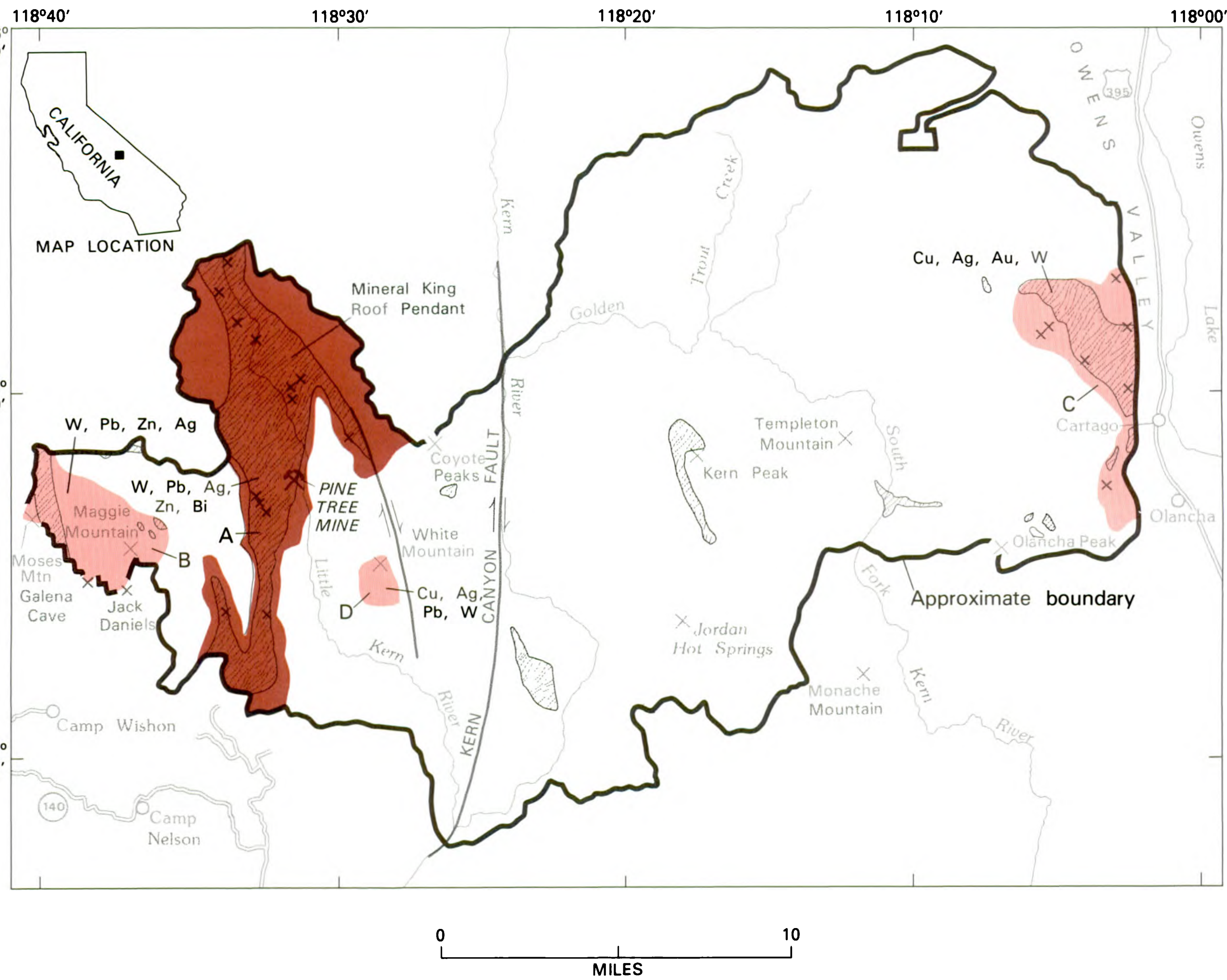
The Golden Trout Wilderness occupies 478 sq mi of the rugged forested part of the southern Sierra Nevada, about 80 mi east-southeast of Fresno. It is bounded on the east by Owens Valley, on the north by Sequoia National Park, and on the west and south by USFS multiple-use lands. The east side of the area is accessible from U.S. Highway 395; the remainder is reached by State, County, and USFS roads from the San Joaquin Valley. The mineral survey included geologic mapping of the area (du Bray and Dellinger, 1981), geochemical sampling (Leach and others, 1983a, b), and an aeromagnetic survey (Jachens, 1983); personnel from the USBM evaluated known mines and prospects. A summary of the results of these studies and an evaluation of mineral-resource potential is in Dellinger and others (1983).

Most of the Golden Trout Wilderness is underlain by granitoid plutonic rocks of the Sierra Nevada batholith. Pendants of metamorphosed roof rocks and wallrocks are preserved between plutons and account for about 10 percent of the outcrop area. The two largest bodies of metamorphic rocks in the wilderness are a large unnamed roof pendant on the east slope of the range, northwest of Cartago, and the Mineral King roof pendant. Smaller masses of metamorphic rocks occur throughout the wilderness. About 5 percent of the area is underlain by young volcanic rocks.

The major structural features in the wilderness are the Kern Canyon fault and the range-front faults near the eastern edge of the wilderness. The Kern Canyon fault is a major strike-slip fault with at least 8 mi of right-slip displacement. Movement on the fault post-dates the emplacement of late Cretaceous plutons, but the fault does not cut 3.5 million year old basalt in the southern part of the wilderness. Its age is thus bracketed between about 80 and 3.5 million years. Kern Canyon, a deep linear valley that enters the wilderness from Sequoia National Park, is the topographic expression of the fault. High-angle faults along the eastern front of the range are the principal structural features associated with the uplift and westward tilting of the Sierra Nevada block. Uplift probably began about 11 million years ago and seems to have accelerated about 3 million years ago. Uplift and westward tilting are still occurring; large earthquakes have occurred on extensions of these range-front faults to the north of the wilderness in historic times (Owens Valley earthquake, 1872). Several mineral prospects in the eastern part of the wilderness (area C, on map) are located on small faults or shears that are probably part of the range-front fault system.

Courthouse records indicate that 143 claims have been located within the wilderness; 38 of these were found and evaluated by the USBM. Of these, only the

[1]With contributions by E. A. du Bray, D. L. Leach, R. J. Goldfarb, and R. C. Jachens, USGS.



EXPLANATION

Geologic terrane with substantiated tungsten resource potential and probable resource potential for lead, zinc, silver, and bismuth

Geologic terrane with probable mineral-resource potential

Bi Bismuth
Cu Copper
Au Gold
Pb Lead
Ag Silver
W Tungsten
Zn Zinc

Mine or deposit

× Mineral occurrence

Granitoid and volcanic rocks

Metamorphic rocks

Contact

Fault--Arrows show relative horizontal movement

B Area discussed in text

Figure 72.—Golden Trout Wilderness, California.

Pine Tree mine is currently active; 36 prospects have been abandoned and Jordan Hot Springs has been developed for recreation.

The Mineral King mining district, now part of Sequoia National Park, adjoins the wilderness on the northwest; the Camp Wishon mining district adjoins it on the west. Both districts are on pendants of metamorphic rocks that extend into the wilderness, but neither has had significant recorded production. Early miners sought precious metals in the interior of these pendants, but more recent interest has focused on possible tungsten deposits at their margins.

MINERAL RESOURCES

Tungsten is the only commodity for which resources are known to exist in the Golden Trout Wilderness and is also the principal commodity likely to exist in four areas of mineral-resource potential. In the western United States tungsten is usually found in narrow bands of highly altered rock (tactite or skarn) at contacts between granitoid intrusions and metamorphosed calcareous sedimentary rocks. These deposits result from the reaction between calcareous roof-pendant rocks and high-temperature fluids associated with the intrusion of granitoid magmas. Deposits formed in this manner are common in the Sierra Nevada and Great Basin, where they have often been mined for copper, molybdenum, lead, or zinc as well as tungsten. All known demonstrated tungsten resources within the wilderness are located at the Pine Tree mine, which is located just inside the eastern edge of the Mineral King roof pendant.

The Mineral King roof pendant (area A) is the area of the wilderness with the greatest promise for the occurrence of small tungsten deposits and contains the only known resources. Anomalous concentrations of ore-related elements occur in many geochemical samples from throughout the area. Ground water from springs within a few miles of the Pine Tree mine is anomalously acid. While not conclusive evidence for mineralization, acid ground water is consistent with the presence of metallic sulfide deposits in the ground-water recharge area. Occurrences of copper, lead, and zinc in sulfides are reported in the Mineral King mining district, located in the same pendant several miles to the northwest of the wilderness, and in the Camp Wishon district located in a similar pendant west of the wilderness. Fourteen abandoned prospects are located in the pendant within the wilderness; traces of gold, silver, lead, or tungsten are present at some of these. The aeromagnetic survey revealed that the part of the Mineral King pendant within the wilderness is characterized by a pronounced magnetic low with steep magnetic gradients above its eastern and western boundaries. This magnetic low results from the nonmagnetic character of the metamorphic rocks of the pendant relative to the surrounding granitoid bodies and is not in itself either indicative of or inconsistent with subsurface mineralization. Modeling of the magnetic data reveals, however, that the pendant is about as deep as it is wide and that the margins are steeply dipping. Subsurface mineral deposits along the margins of the pendant, if they exist, may therefore be located at considerable depths. The Mineral King pendant area is considered to have substantiated potential for tungsten resources on the basis of geologic and geochemical information and known resources at the Pine Tree mine. It also has probable potential for small deposits of lead, zinc, silver, or bismuth.

The Maggie Mountain area (B), west of the Mineral King pendant, is designated as having probable potential for small resources of tungsten, lead, zinc, or silver. Geochemical samples from the area contain anomalous concentrations of ore-related elements. Rock types favorable for mineralization are also present; small bodies of metavolcanic and metasedimentary rocks occur within the two large plutons that underlie most of the area. Five abandoned claims and prospects are located in or very near the area; zinc sulfides occur at the Galena Cave deposit and minor tungsten mineralization occurs at the Jack Danials deposit. Both of these deposits are located just outside the wilderness. No known deposits are located within the area.

The eastern range-front area (C) is considered to have probable potential for small deposits containing copper, silver, gold, or tungsten. The geochemical sampling program was severely limited by steep terrain in this area, but anomalous concentrations of ore-related elements were found in some of the samples that were obtained. Both metavolcanic and metasedimentary rocks occur within the area and the area contains seven abandoned claims. Undiscovered deposits, if they exist, probably consist of tungsten (scheelite) mineralization at the margins of metasedimentary pendants or sulfide mineralization in shear zones in altered metavolcanic rocks.

The White Mountain area (D) differs from the other areas of probable potential in that it is underlain entirely by granitoid rocks. There is, however, evidence for hydrothermal alteration and silica enrichment. Numerous quartz veins, some containing other potentially ore related minerals, are present but there are no known occurrences of mineralization in the area. Geochemical samples from the area are anomalous in ore-related elements, and there is a sharp magnetic anomaly associated with the area. The magnetic anomaly is partially related to topography, but modeling of the data indicates that a region near the top of White Mountain contains a concentration of ferrimagnetic minerals. This concentration may be related to the geochemical anomaly observed in the same area. The geochemical evidence indicates that resources of silver, lead, or tungsten may exist in the White Mountain area. The concurrence of the geochemical and aeromagnetic data with the surface evidence of hydrothermal alteration gives the area a probable resource potential for these elements.

SUGGESTIONS FOR FURTHER STUDIES

More detailed geophysical and geochemical studies might more closely delineate areas of resources or potential resources, particularly in the Mineral King pendant and White Mountain areas. However, the small size of probable deposits indicated by the studies done thus far suggest that further studies may not be worthwhile.

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GRANITE CHIEF WILDERNESS STUDY AREA, CALIFORNIA

By DAVID S. HARWOOD, U.S. GEOLOGICAL SURVEY, and

FRANCIS E. FEDERSPIEL, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral-resource survey of the Granite Chief Wilderness study area in eastern California, conducted between 1979 and 1981, it is concluded that the area has little promise for the occurrence of precious or base metals, oil, gas, coal, or geothermal resources. Sand, gravel, and glacial till suitable for construction materials occur in the area, but inaccessability and remoteness from available markets preclude their being shown on the map as a potential resource.

CHARACTER AND SETTING

The Granite Chief Wilderness study area encompasses 57 sq mi near the crest of the Sierra Nevada 6 mi west of Tahoe City, California, a major four-season recreational center located on the northwest shore of Lake Tahoe. The North Fork and the Middle Fork of the American River head in deep, glaciated canyons, which are interspersed between sharp peaks and ridge crests that rise to elevations of 9000 ft. A number of hiking and equestrian trails spur off from secondary roads located around the perimeter of the study area and from a 16-mi segment of the Pacific Crest Trail that lies within the area. The wilderness study area provides a readily accessible back-country retreat from the relatively urban recreational attractions of the Lake Tahoe Basin.

The rugged mountainous terrane of the Granite Chief Wilderness study area consists of granitic rocks that intrude a variety of older metamorphosed sedimentary and volcanic rocks. The granitic and metamorphic rocks are capped by Tertiary volcanic rocks that originated from a number of ancient volcanic centers located along a major fault system that separates the uplifted Sierra Nevada range from the Tahoe Basin to the east. Periodically during the past few million years a series of ice caps blanketed the study area. Valley glaciers, originating from those ice caps, sculptured the underlying bedrock into scoured and polished canyons separated by sharp-crested ridges and isolated monadnocks. The scouring action of the glaciers left little soil on the canyon walls and ridges, so vegetation is sparse and allows relatively easy and enjoyable cross-country hiking from vista point to vista point.

Geologic, geochemical, and mines and prospect studies were carried out by the USGS and USBM between 1979 and 1981 to assess the mineral-resource potential of the area.

MINERAL RESOURCES

Gold and silver have been the principal interests of prospectors in the region since the California gold rush in 1849. Most production has come from placer and lode deposits in the Mother Lode district located 20 mi west of the Granite Chief Wilderness study area. No mining activity is being conducted currently within the area and no record of past production from the area could be found; no resource potential has been identified in this area. The same country rocks that produced significant gold and silver from the Mother Lode district occur within the study area, but quartz veins, which were hosts for much of the gold produced to the west, are sparsely distributed and of minor volume in the study area. Placer deposits within the study area show minor gold values but the volumes of gravel are small and they are not considered to have a resource potential.

Detailed geologic and geochemical surveys of the area have been published by Harwood (1981, 1982) and a more detailed evaluation of the mineral-resource potential of the area has been published by Harwood and others (1982).

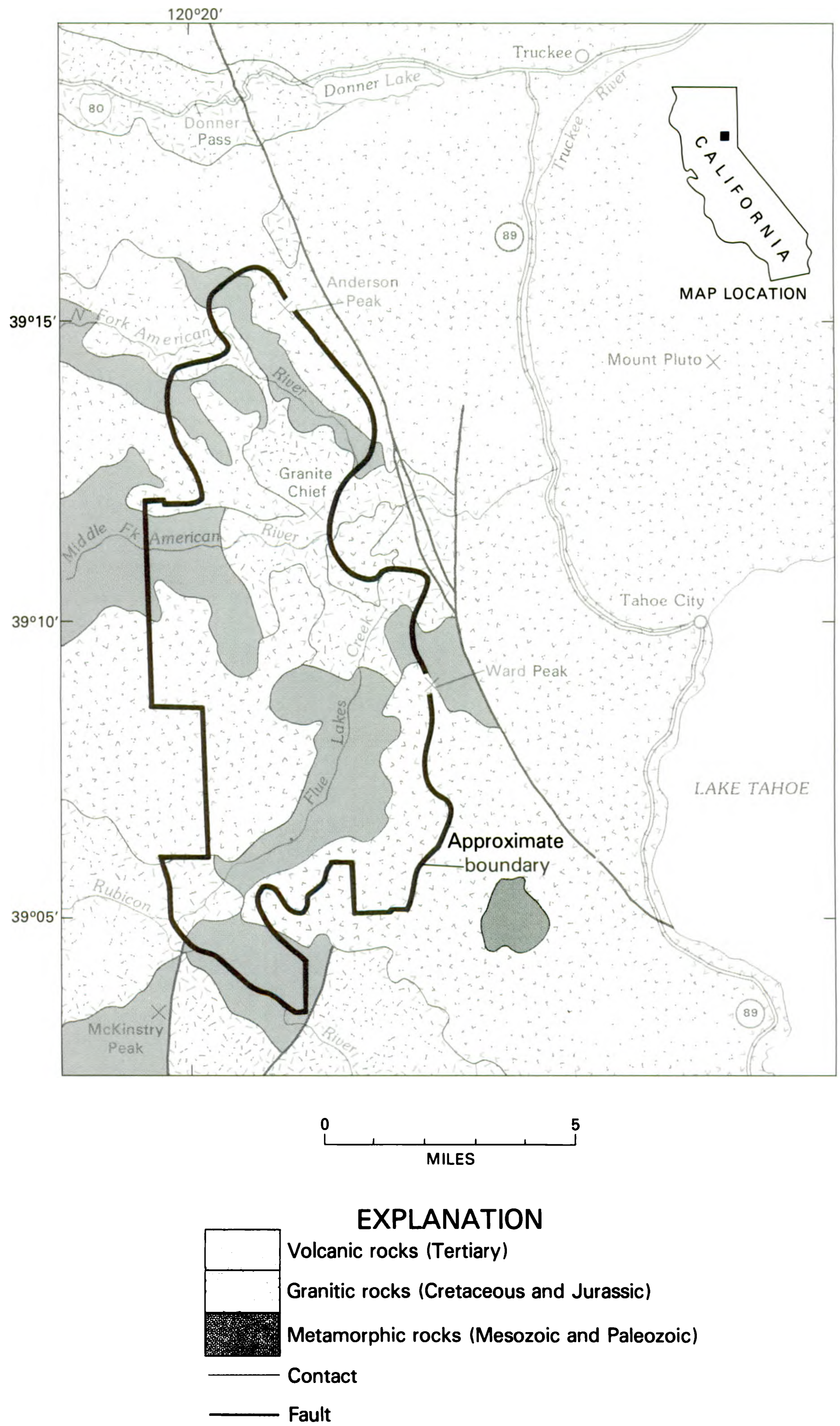

Figure 73.—Granite Chief Wilderness study area, California.

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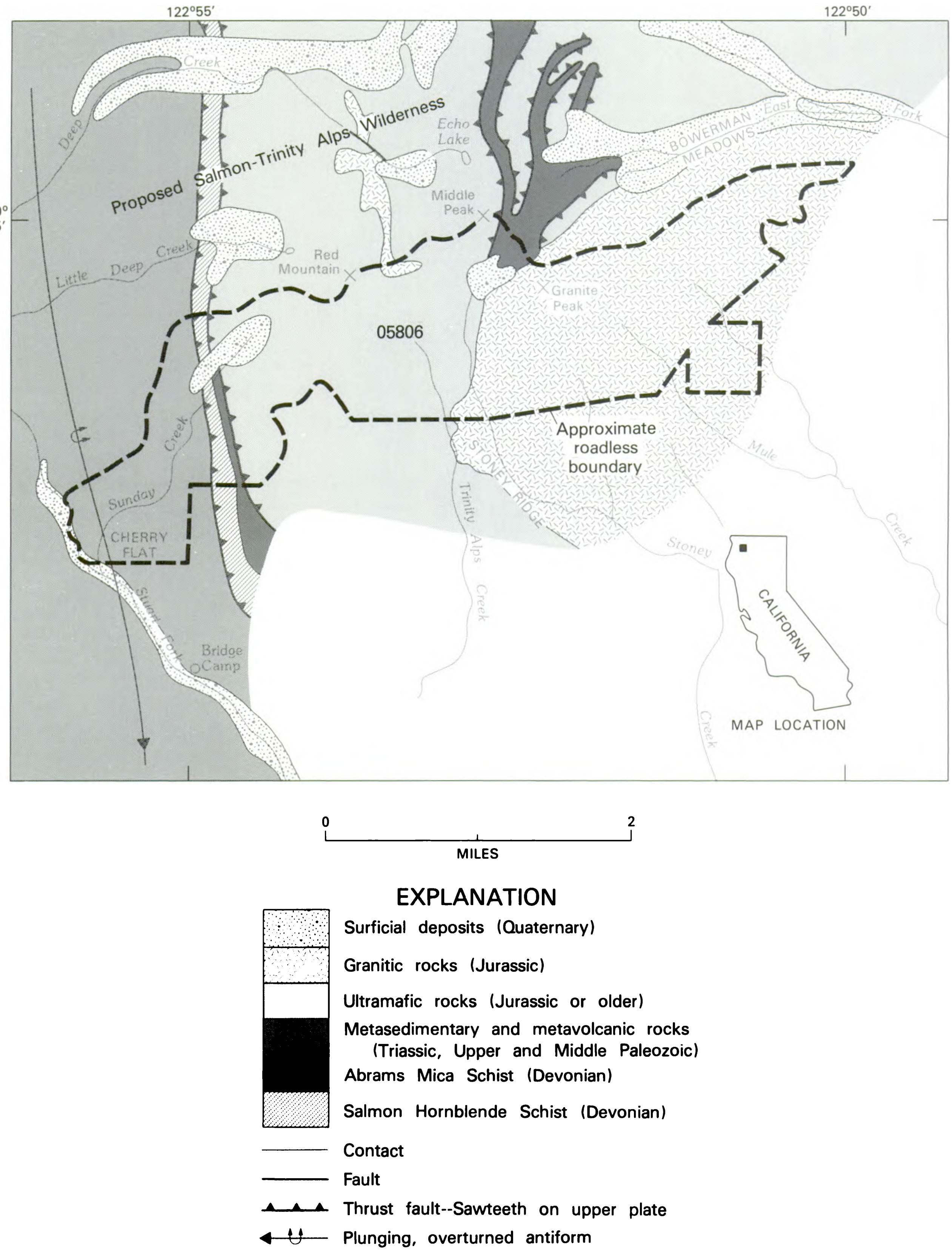

Figure 74.—Granite Peak Roadless Area, California.

GRANITE PEAK ROADLESS AREA, CALIFORNIA

By DONALD F. HUBER,[1] U.S. GEOLOGICAL SURVEY, and

HORACE K. THURBER, U.S. BUREAU OF MINES

SUMMARY

On the basis of mineral surveys conducted in 1968–70 and 1980–81 in the Granite Peak Roadless Area, there seems little likelihood for the occurrence of mineral or energy resources.

CHARACTER AND SETTING

The Granite Peak Roadless Area occupies an area of about 5 sq mi in the southern part of the Trinity Alps of the Klamath Mountains, about 12 mi north-northeast of Weaverville, California. Altitude above sea level ranges from 2900 ft on the southwest, at the Stuart Fork of the Trinity River, to 8091 ft on Granite Peak, near the center of the area. The northern boundary is shared by the proposed Salmon-Trinity Alps Wilderness.

The eastern three quarters of the roadless area is underlain by ultramafic and granitic rocks and the western quarter is underlain by metamorphic rocks. The metamorphic rocks were probably thrust under the ultramafic rocks about 350 million years ago (Devonian). During the time from about 230 to 65 million years ago (Mesozoic), the granitic rocks intruded the ultramafic rocks. Also during this time the metamorphic and ultramafic rocks were accreted to the North American Continent by plate-tectonic processes.

Rock and stream-sediment samples collected during 1968–70 and stream-sediment sample collected during 1980–81 were analyzed. All streams draining the roadless area were sampled and representative samples of the rock types in the area were collected. Background values were established for each element and anomalous values were examined within their geologic settings and evaluated for their significance.

[1]With contributions from Scott C. Nelson, USGS.

MINERAL RESOURCES

There is no history of mining activity within the roadless area, although it probably has been extensively examined by prospectors since the 1850's when mining began in the Trinity Alps area. The results of the geochemical survey do not indicate the presence of mineralized rock at the surface. Such geochemically anomalous values as were found are attributed to differences in sampling and do not reflect accumulation of resources. There is little promise for the occurrence of mineral or energy resources in the area.

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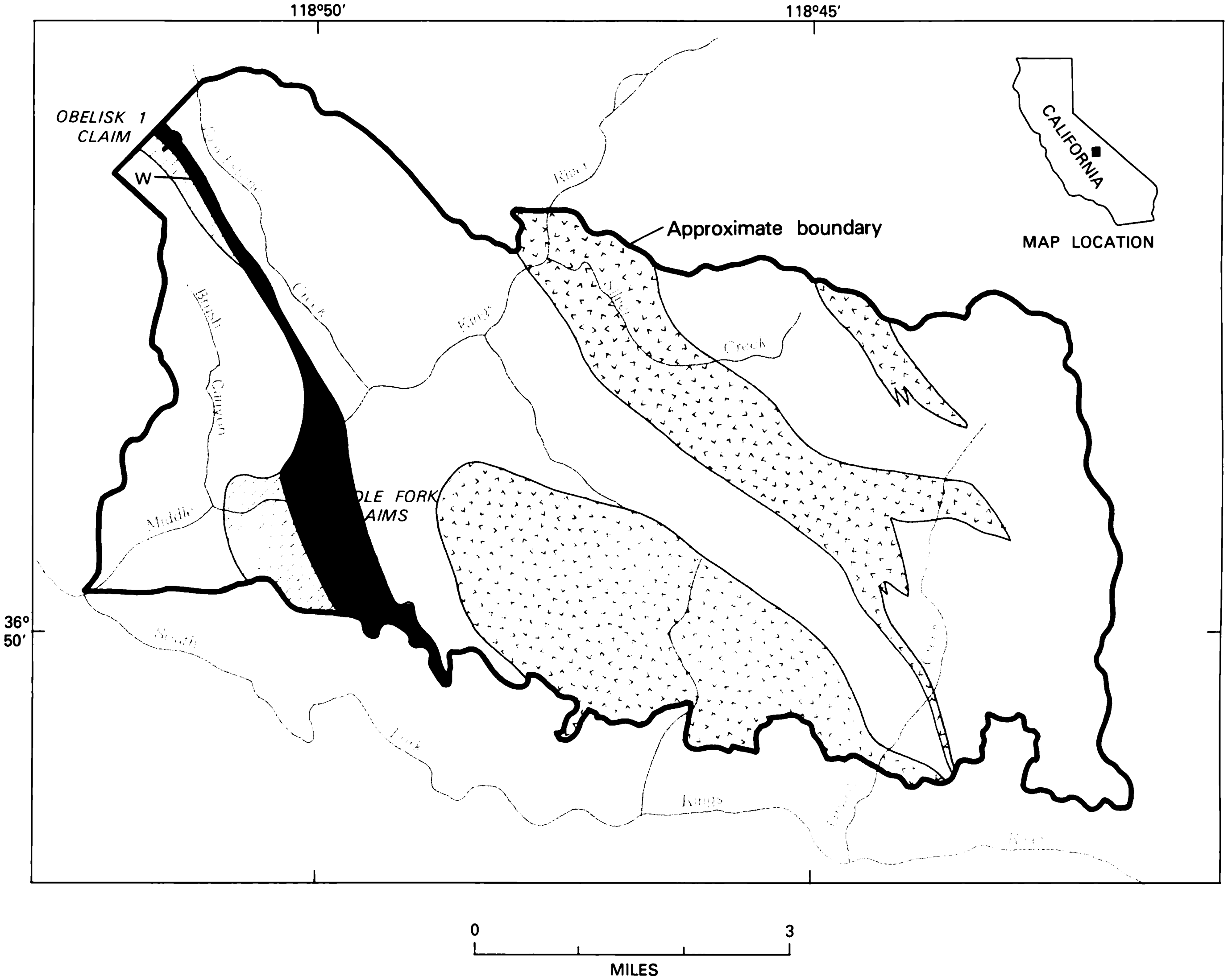

EXPLANATION

- Geologic terrane with probable mineral-resource potential
- W Tungsten
- Mine or deposit
- × Mineral occurrence
- Granitic rocks
- Metavolcanic rocks
- Metasedimentary rocks
- Contact

Figure 75.—High Sierra Primitive Area, California.

HIGH SIERRA PRIMITIVE AREA, CALIFORNIA

By JAMES G. MOORE, U.S. GEOLOGICAL SURVEY, and

LAWRENCE Y. MARKS, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral-resource survey in 1970, the High Sierra Primitive Area was found to have an area of probable mineral-resource potential for tungsten. A small demonstrated tungsten resource is present on the Obelisk claims near the contact of limy metasedimentary rock and granitic rock in the northwest part of the area, and additional small deposits may be expected to occur to the south, in a similar geologic setting.

CHARACTER AND SETTING

The High Sierra Primitive Area includes about 40 sq mi in Sierra and Sequoia National Forests in the central Sierra Nevada. It is adjacent to the west boundary of Kings Canyon National Park. The area is extremely rugged and the canyons of the Kings River are among the deepest in the United States. Total relief in the area is 8880 ft. No roads and few trails occur in the area, and river crossings are hazardous.

Granitic rock forms the dominant bedrock of the area. Occurring as many granitic plutons, generally elongate in a northwesterly direction, the granitic bedrock is primarily Cretaceous in age. Metamorphic bedrock forms discontinuous masses between the granitic plutons. The metamorphic rocks are intruded by, and hence older than, the granitic rocks. In the western part of the area the metamorphic rocks are dominantly of sedimentary origin; they include rocks that were originally shale, siltstone, quartzite, and limestone. In the center and northeastern part of the area metamorphic rocks which were originally of volcanic origin occur; they include andesite to rhyolite tuffs and breccias and sediments derived from volcanic materials.

Field investigations were conducted during the summer of 1970 by teams from the USGS and the USBM (Moore and Marks, 1972). The USGS team mapped the geology, and collected and analyzed 47 stream-sediment samples. The geological work was augmented by analysis of a 1970 aeromagnetic survey by H. W. Oliver. The USBM team investigated mining claims and prospects within the area. Because the Garnet Dike mine, 7 mi west of the primitive area, was a major source of tungsten during World War II, tungsten occurrences are of particular interest.

MINERAL RESOURCES

Analysis of stream sediments and bedrock samples do not indicate the presence of any previously unknown deposits of possible commercial value at the bedrock surface. Magnetic anomalies detected by the aeromagnetic survey can be explained as topographic effects of normally magnetized rocks.

The Obelisk unpatented mining claims are in the northwest part of the primitive area and extend out of the area to the north. The claims are near the contact between granodiorite and limy metasedimentary rock. About 30 tons of ore was produced between 1953 and 1958, and in 1955, 4 tons were mined and handsorted to obtain 70 lbs of concentrate containing 57 percent WO_3 (tungsten oxide). The property was explored by diamond drilling in 1956, and a demonstrated resource of about 8000 tons of tactite containing an average of about 1 percent WO_3 is estimated for the Obelisk 1 claim.

The only other prospect in the area, the Middle Fork prospect, is 3.5 mi south-southeast of the Obelisk claims and within a continuation of the same metasedimentary mass. This prospect contains small quantities of metals in sheared quartzite.

The presence of the tungsten deposit at the Obelisk claims and the presence of similar limy metasedimentary rocks to the south suggests that an area of probable mineral-resource potential for tungsten extends to the south.

SUGGESTIONS FOR FURTHER STUDIES

Tungsten deposits of the type found at the Obelisk claims generally occur near the contact of granitic rock and limy metasedimentary rock. Hence, prospecting for possible additional deposits may be guided by this relationship. It is noteworthy that the only two prospects in the area occur in rather accessible areas, including the brink of the canyon (Obelisk) and the bottom (Middle Fork). Small additional deposits may be expected at other places, but accessibility is generally extremely difficult due to steep terrain.

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ISHI, MILL CREEK, POLK SPRINGS, AND BUTT MOUNTAIN ROADLESS AREAS, CALIFORNIA

By JOCELYN A. PETERSON,[1] U.S. GEOLOGICAL SURVEY, and

DAVID K. DENTON, JR., U.S. BUREAU OF MINES

SUMMARY

Mineral surveys of the Ishi, Mill Creek, Polk Springs, and Butt Mountain Roadless Areas conducted in 1980 and 1982 indicated little promise for the occurrence of mineral resources in much of the areas. Portions of Deer and Mill Creeks are considered to have probable resource potential for small amounts of gold. The geologic setting precludes the occurrence of energy resources and no other metallic mineral resources were identified.

CHARACTER AND SETTING

The Ishi, Mill Creek, Polk Springs, and Butt Mountain Roadless Areas occupy approximately 50 sq mi in an area about 25 mi north of Chico, California, and 25 mi south of Mount Lassen. The areas are characterized by dense brush or forest covering a rugged topography in the southernmost part of the Cascade volcanic province. In late Tertiary and Quaternary time the Ishi, Mill Creek, Polk Spring, and Butt Bountain Roadless Areas were buried beneath extensive pyroclastic deposits and lava flows. Subsequent erosion has exposed a few small outcrops of a prevolcanic basement of Mesozoic and (or) Paleozoic metamorphosed volcanic rocks in the bottoms of the deepest drainages, and, in the northwestern part of the area sandstones of the Cretaceous Chico Formation. Most of the area is covered by the Tuscan Formation which consists of as much as 2000 ft of Pliocene andesite tuff breccia volcanic mud flows and minor thin tuffs and mafic lava flows (Peterson, Bradley, Johnson, and Lydon, 1982). These rocks dip gently to the southwest across the area. Locally overlying the Tuscan Formation are remnants of Quaternary andesitic and basaltic flows. A few small mafic plugs intrude the mud flows and lava flows.

Within the Tuscan Formation are several bleached areas that may be the result of hydrothermal alteration, but there are no visible sulfide minerals in these areas and geochemical analyses (Peterson, Bradley, and Johnson, 1982) indicate no unusual concentrations of trace elements.

River terrace gravels in the Polk Springs Roadless Area were mined for gold, and quartz-vein-bearing metavolcanic and metasedimentary rocks in the Mill Creek Roadless Area have been prospected for gold.

MINERAL RESOURCES

The metamorphic units underlying the Tuscan Formation contain quartz veins that range in size from microscopic to several inches thick. These quartz veins are thought to be the source of gold found in old river terraces on Deer and Ditch Creeks near Polk Springs. Prospecting in this area began in the mid-19th century and assessment work was done on three properties as recently as 1981 (Peterson and others, 1983). Three of the claims visited in 1982 had been mined hydraulically in the past but appeared to be inactive at the time of the visit. A lode claim on Mill Creek northeast of Black Rock was filed at the Tehama County Courthouse. This claim could not be located in 1982, but it is thought to be in the vicinity of the Mesozoic rocks which are known to contain quartz veins.

On the basis of the mineral-resource survey, portions of Deer and Mill Creeks are designated as having probable mineral potential for small amounts of gold.

[1]With contributions from Robin B. Fiebelkorn and Karen A. Johnson, USGS, and Eric E. Cather, Harry W. Campbell, and Peter N. Gabby, USBM.

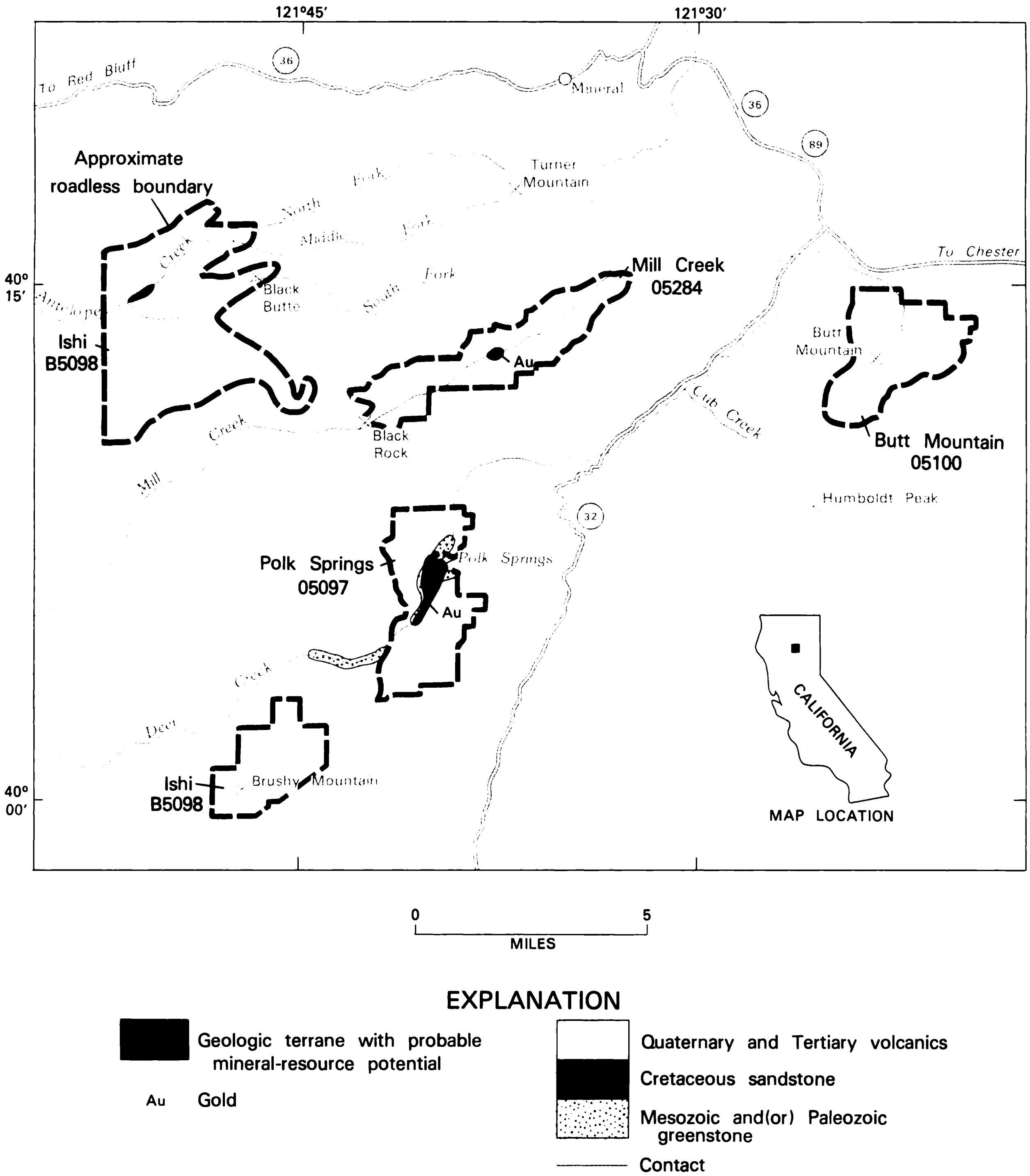

Figure 76.—Ishi, Mill Creek, Polk Springs, and Butt Mountain Roadless Areas, California.

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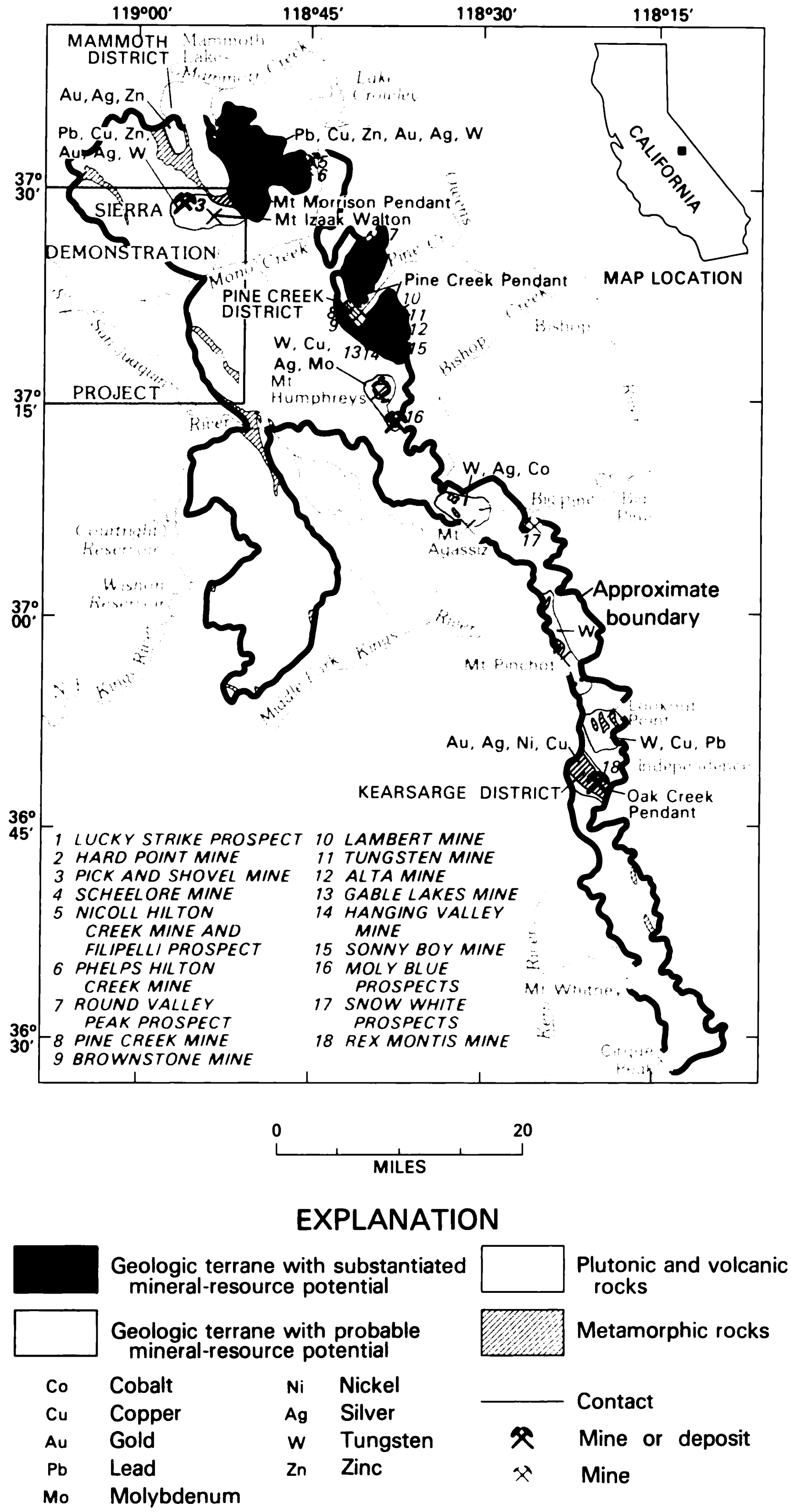

Figure 77.—John Muir Wilderness, California.

JOHN MUIR WILDERNESS, CALIFORNIA

By DAVID A. DELLINGER, U.S. GEOLOGICAL SURVEY, and

FREDERICK L. JOHNSON, U.S. BUREAU OF MINES

SUMMARY

The mineral survey of the John Muir Wilderness, conducted between 1969 and 1978, revealed eight areas of probable and substantiated potential for the occurrence of mineral resources. Tungsten, with accompanying resources of gold, copper, silver, and molybdenum, is found along contacts between granitic rocks and metamorphosed calcareous sedimentary rocks; it is estimated that more than 1 million tons of demonstrated tungsten resources exist in areas of substantiated resource potential within the wilderness. Resources of gold, silver, lead, copper, zinc, molybdenum, and cobalt, occur in small deposits not associated with tungsten; however, the known deposits of these commodities are small and the possibility of the occurrence of larger ones is unlikely. The geologic setting precludes the presence of fossil fuel resources.

CHARACTER AND SETTING

The John Muir Wilderness, situated about 200 mi north of Los Angeles and the same distance east-southeast of San Francisco, occupies 755 sq mi in the rugged southern part of the Sierra Nevada. It surrounds the northern end of Kings Canyon National Park and extends south-southeast along the eastern boundaries of both Kings Canyon and Sequoia National Parks, following the crest of the Sierra Nevada. Thus, most of the steep eastern face of the Sierra Nevada from Mammoth Lakes to Cirque Peak, about 85 mi distant, lies within the wilderness. This area is one of the highest, most spectacular regions in the Sierra Nevada; much of the wilderness is above 10,000 ft in altitude, and Mount Whitney, the highest point in the contiguous United States (14,494 ft), lies on the boundary with Sequoia National Park.

The northwestern part of the area was examined for mineral potential in 1969 as part of the USFS Sierra Demonstration Project (Lockwood and others, 1972). At that time, known deposits were visited and evaluated, stream-sediment and bedrock samples were collected and analyzed, and the resulting data were interpreted on the basis of existing geologic mapping. During the period 1975–78, the USGS and the USBM undertook fieldwork expressly for the purpose of evaluating the mineral-resource potential of the John Muir Wilderness. The USGS conducted an aeromagnetic survey and a program of stream-sediment sampling and analysis, while the USBM estimated the extent of resources at known deposits within the wilderness. Geologic mapping of the area had been nearly complete before fieldwork was begun; the remainder was accomplished in 1976 through 1978. A generalized geologic map of the area was compiled by du Bray (1981), and the results of the stream-sediment sampling program were presented by Dellinger and others (1982). Results of the aeromagnetic survey and evaluation of known resources were summarized by du Bray and others (1982).

Most of the wilderness is underlain by granitic plutons of the Sierra Nevada batholith, but metamorphic and volcanic rocks underlie about 20 percent of the area. The metamorphic rocks were originally sedimentary and volcanic rocks of Paleozoic and Mesozoic age; they were metamorphosed during the emplacement of the granitic rocks, which began in early Mesozoic time (Triassic), but occurred mostly at the end of the Mesozoic Era (Cretaceous). Uplift and westward tilting of the Sierra Nevada block from 90 to 65 million years ago (Late Cretaceous) resulted in rapid erosion of rock overlying the granitic bodies. Periodic eruption of volcanic rocks during the last 12 million years and widespread glaciation during the Pleistocene Epoch (2 million to 10,000 years ago) brought about the present landform of the wilderness. Uplift, which accelerated about 3 million years ago, is still occurring along faults on the eastern edge of the Sierra Nevada, and alpine glaciers persist in the highest parts of the range.

Mining in the John Muir Wilderness began in about

1864 in the Kearsarge district, west of the town of Independence. The district yielded gold and silver, but grade and continuity of ore were insufficient to sustain profitable operations, and most mines were closed by 1883. The Mammoth district, located at the northern end of the wilderness, yielded gold and silver from 1878 through the early 1900's. In 1916, deposits of scheelite, a tungsten-bearing mineral, were discovered in the Pine Creek area, west of Bishop. The Pine Creek mine, just outside the wilderness, began operation in 1918; it has been the largest tungsten producer in the United States during recent years, but was not operating at the time of this report. Deposits associated with the mine form the nation's largest tungsten reserves. Scheelite has also been discovered and mined in the Mount Morrison area in the northeastern part of the wilderness and in several small bodies of calcareous metamorphic rocks in the southeastern part of the wilderness.

MINERAL RESOURCES

Tungsten is the principal metallic commodity found in the John Muir Wilderness. More than 1 million tons of tungsten resources in areas of substantiated tungsten potential are estimated to occur in the wilderness. We feel there is a possibility for the occurrence of 12 individual deposits in the area. About 80,000 tons are considered to be in 5 deposits of more than 1000 tons, average grade 0.27 percent WO_3; about 910,000 tons to be in 6 deposits of more than 1000 tons, average grade 0.36 percent WO_3; and about 16,000 tons to be in 1 deposit, average grade 1.0 percent WO_3. More detailed information about individual deposits has been presented by du Bray and others (1982).

Tungsten, with associated gold, silver, copper, and molybdenum, is found in narrow bands of highly altered rock (tactite or skarn) at contacts between granitic intrusions and metamorphosed calcareous sedimentary rocks at the margins of metamorphic pendants. More than half of all known tungsten resources within the wilderness are located in mines and prospects of the Mount Morrison pendant in the northeastern part of the wilderness. Nearly all the rest are located in deposits of the Pine Creek pendant, west of Bishop. The parts of the Mount Morrison and Pine Creek pendants that lie within the wilderness are classified as having substantiated mineral-resource potential. Four other areas contain small pendants with calcareous metasedimentary rocks that have associated geochemical anomalies; the Mount Humphreys, Mount Pinchot, Lookout Point, and Mount Agassiz areas are considered to have probable mineral-resource potential, but it is unlikely that they contain resources of the same magnitude as the larger pendants to the north.

Resources of gold, silver, lead, copper, zinc, molybdenum, cobalt, and possibly uranium occur in small deposits not associated with tungsten. Gold-silver deposits, some with associated lead, copper, and zinc, occur in two geologic environments: (1) discontinuous quartz veins and fault gouge in metavolcanic rock, granite, and granodiorite and (2) shear zones containing quartz veins and siliceous zones in altered latite and marble. Mines or prospects in the wilderness with more than 1000 tons of demonstrated resources of this type include the Rex Montis mine in the Oak Creek pendant, the Pick and Shovel mine in the Mount Izaak Walton area, and the Lucky Strike prospect in the Mount Morrison pendant. Molybdenum occurs in pods and veins in siliceous zones in granodiorite at the Moly Blue prospect south of Mount Humphreys. A probable cobalt resource potential for small cobalt deposits exists north of Mount Agassiz. The Mount Morrison pendant and Mount Agassiz areas are considered to have substantiated and probable resource potential, respectively, on the basis of possible tungsten mineralization discussed above as well as these non-tungsten deposits. The Oak Creek pendant, Mount Izaak Walton, and Mount Humphreys areas are classified as having probable mineral-resource potential; however, known demonstrated resources in these areas are small relative to important deposits of these commodities elsewhere in the United States (less than 10,000 tons each at the gold-silver deposits and about 30,000 tons at the Moly Blue molybdenum deposit).

The geochemical and geophysical surveys of the John Muir Wilderness did not reveal any large unknown mineral deposits. The aeromagnetic survey indicates that the wilderness contains neither large subsurface deposits of iron and pyrrhotite, comparable to the Iron Mountain deposit located about 5 mi northwest of the wilderness, nor masses of magnetite-rich serpentinite like those that contain gold and silver west of the wilderness in the Sierra Nevada foothills. Most geochemical anomalies (as revealed by analyses of the stream sediments) appear to result from either known mineralization, geologic environments favorable for types of mineralization known to occur in the region (mineralization is inferred), or unmineralized but geochemically anomalous bedrock.

SUGGESTIONS FOR FURTHER STUDY

A geochemical survey of areas within the wilderness that have exposed calcareous metasedimentary rocks using different sampling, sample processing, and analytical techniques might reveal significant tungsten mineralization. In particular, collection of samples from pockets of heavy-mineral accumulations, concentration of samples by panning and heavy-liquid techniques, and analysis of samples by more sensitive methods than were employed in this study might prove useful.

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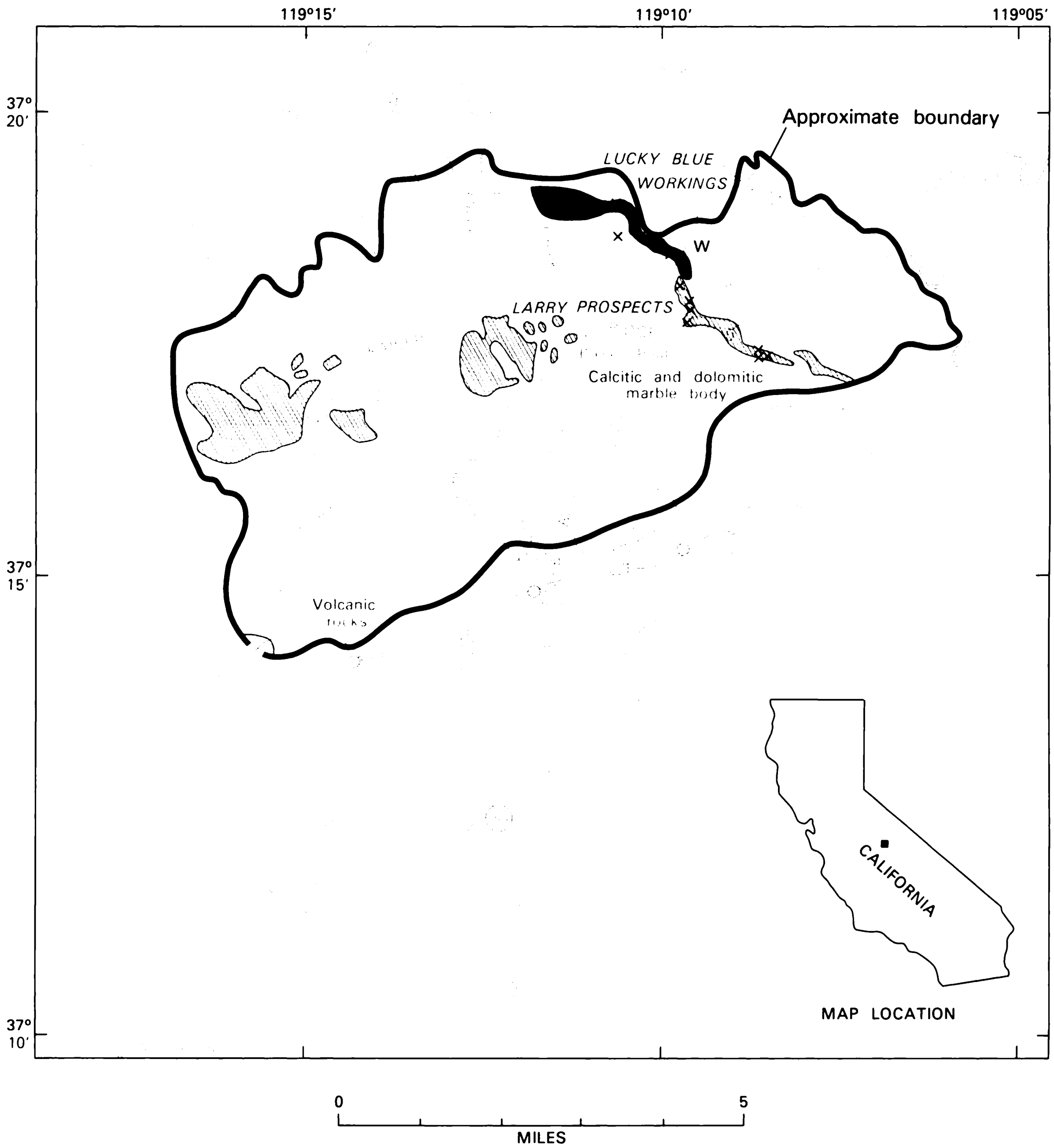

EXPLANATION

- Geologic terrane with probable mineral-resource potential
- W Tungsten
- × Mineral occurrence
- Volcanic rocks (Tertiary)
- Plutonic rocks (Cretaceous and Jurassic)
- Metamorphic rocks (Triassic or Paleozoic)
- Contact

Figure 78.—Kaiser Wilderness, California.

KAISER WILDERNESS, CALIFORNIA

By DAVID A. DELLINGER,[1] U.S. GEOLOGICAL SURVEY and,

ANDREW LESZCYKOWSKI, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey of the Kaiser Wilderness by the USGS and USBM in 1969, a narrow band in the northern part of the wilderness is classified as having probable tungsten resource potential. Tungsten resources exist in this area and small undiscovered deposits may exist at depth. Resources of high-purity calcitic and dolomitic marbles also occur within the wilderness. The geologic terrane precludes the occurrence of fossil fuel resources.

CHARACTER AND SETTING

The Kaiser Wilderness is located on the gently sloping west flank of California's Sierra Nevada about 50 mi northeast of Fresno. Kaiser Ridge, which culminates at Kaiser Peak (10,320 ft), is the principal physiographic feature in the wilderness. Most of the wilderness lies on the south flank of Kaiser Ridge, north of Huntington Lake. The area is mostly forested but includes alpine terrain consisting of lakes, meadows, low shrubs, and stunted trees, typical of the Sierra Nevada crest. Access to the area is by State Highway 168 and several county and logging roads to the south.

The Kaiser Wilderness was established in 1976 and the area was examined for mineral potential in 1969 as part of the USFS Sierra Demonstration Project (Lockwood and others, 1972). At that time, known deposits were visited and evaluated, stream-sediment and bedrock samples were collected and analyzed, and the resulting data were interpreted on the basis of existing geologic mapping. Pertinent information from their report, existing geologic mapping, and available aeromagnetic data were used to evaluate the mineral-resource potential of the wilderness by du Bray and others (1983). The USBM evaluated resources at known deposits within the wilderness.

Granitoid, metamorphic, and volcanic rocks and glacial and alluvial deposits are exposed in the Kaiser Wilderness. Most of the wilderness is underlain by two plutons: the Mount Givens Granodiorite and the granodiorite of Dinkey Creek. Metamorphic rocks account for about 1 percent of the rocks exposed in the wilderness. Quartzite is the most abundant metamorphic rock type; it occurs principally as isolated blocks and masses within the granodiorite of Dinkey Creek. The other metamorphic rock types (marble, calc-hornfels, hornfels, and pelitic schist) are found chiefly in septa between the two principal plutons. The only volcanic rock exposed in the wilderness is trachyandesite, which crops out near the southern wilderness boundary on Black Point.

Mining activity in the wilderness has been minor. Recorded production has occurred only at the Lucky Blue group of claims. Tungsten ore worth about $50,000 was reportedly mined between 1951 and 1956 from the Lucky Blue deposits. Several claims have been filed since 1930 for a massive outcrop of highly pure calcitic and dolomitic marble southeast of the Lucky Blue claims, but no production has been reported and only discovery and exploration pits were found during the mineral survey.

MINERAL RESOURCES

Tungsten is the only metallic commodity known to be present in the Kaiser Wilderness. Tungsten ore material, known as tactite or skarn, is formed by the reaction of calcareous sedimentary or metasedimentary rocks with hot fluids released from intruding granitoid magmas. When the reacting fluids contain sufficient tungsten, the tungsten-bearing mineral scheelite ($CaWO_4$) forms. Tactite deposits occur along many contacts between granitoid and calcareous metasedimentary rocks in the Sierra Nevada, though not all tactites contain scheelite. The largest tungsten reserves in the United States are in tactite deposits at Pine Creek, about 25 mi east of the wilderness.

[1]With contributions from E. A. du Bray, USGS.

The known tungsten deposits in the wilderness are included in the Lucky Blue claim group, located between Avalanche Lake and upper West Kaiser Creek. Tungsten occurs in scattered scheelite-bearing pods along the margins of a narrow band of metasedimentary rocks that in some places separates the Mount Givens Granodiorite from the granodiorite of Dinkey Creek, and in boulders moved by glaciers from their original positions along these contacts. As much as 200 tons of ore has reportedly been produced from the Lucky Blue claims, mostly from glacial erratics. The tactite pods in the bedrock are small and widely spaced; they occur over a lateral distance of about 7000 ft and a vertical distance of about 600 ft. Most samples from these bodies contain less than 0.48 percent tungsten trioxide (WO_3), though one sample contained about one percent WO_3.

The wide lateral and vertical extent of small tactite pods along the contact between metasedimentary rocks and the plutons on either side of them suggests that other tungsten-bearing tactite bodies exist at depth. On this basis, a narrow band along the boundary between the Mount Givens and Dinkey Creek plutons is considered to have probable mineral-resource potential. However, the tactite bodies exposed at the surface are small, widely spaced, and of variable, but generally low, grade. Subsurface exploration would be required to determine whether deposits exist in the subsurface and their size and grade.

Calcitic and dolomitic marbles occur in the Potter Pass-Twin Lakes area in a massive lens-shaped outcrop about 3000 ft long and 500 ft wide. The Larry No. 1 prospect is in this area, but no production has been recorded and only discovery and exploration pits were found. Assay results indicate the body is composed of high-purity calcitic and dolomitic marbles. The lenticular mass may contain as much as 60 million tons of high-purity material, based on the known surface dimensions and an estimated depth of 1500 feet. There is no indication that other similar bodies exist within the wilderness. The marble body is inaccessible, far from potential markets, and marble is readily available in areas closer to markets.

Neither the geochemical nor the aeromagnetic surveys of the Kaiser Wilderness indicated potential for other mineral resources. Four samples in the southern part of the wilderness were anomalous in gold, but no other evidence of gold deposits has been found; gold resources probably do not exist in the wilderness. Copper and molybdenum anomalies also occur, but these are probably related to anomalous bedrock chemistry or minor mineralization in joints rather than the presence of undiscovered resources. The aeromagnetic map does not indicate the presence of concealed ore bodies; the single identified aeromagnetic anomaly is attributed to a body of mafic plutonic rock.

SUGGESTIONS FOR FURTHER STUDIES

Although undiscovered deposits of tungsten may exist in the Kaiser Wilderness, they will be small in size and in the subsurface, and further studies are probably not warranted.

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KINGS RIVER, RANCHERIA, AGNEW, AND OAT MOUNTAIN ROADLESS AREAS, CALIFORNIA

By WARREN J. NOKLEBERG,[1] U.S. GEOLOGICAL SURVEY, and

WARREN D. LONGWELL, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey done in 1979–82, the Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas were found to have several areas with probable mineral-resource potential for tungsten in tactite, and one area with probable mineral-resource potential for lode gold in quartz veins. The extreme relief and inaccessibility in most of the roadless areas make exploration and mining very difficult. The geologic terrane precludes the occurrence of energy resources.

CHARACTER AND SETTING

The Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas occupy an area of about 145 sq mi in the Sierra and Sequoia National Forests in the central Sierra Nevada, adjacent to and west of the boundary of Kings Canyon National Park. The roadless areas are extremely rugged, and the canyons of the Kings River, which constitute part of the roadless areas, are among the deepest in the United States. The eastern boundary of the Kings River Roadless Area includes the deepest part of the Kings River Canyon, 7811 ft deep. Total relief in the roadless areas is about 9250 ft. No roads and few trails occur in the roadless areas, river crossings are hazardous, and there are many extremely steep and brushy areas. Many parts of the roadless areas can only be visited with difficulty on foot. Many of the steep, rugged, and brushy parts of the roadless areas had never been geologically mapped or sampled. California State Highways 168, and 180, Kings Canyon Highway, and Fresno County roads provide access to the roadless areas. The nearest population center is Sanger, California, about 20 mi west of the western margin of the Oat Mountain Roadless Area.

The roadless areas are in the central part of the Sierra Nevada, a faulted and westward-tilted range which is deeply incised by major river systems such as the Kings River. The roadless areas in this part of the range are mainly underlain by granitic rock, with lesser metamorphic rock, and sparse basalt and surfical deposits. The granitic rock occurs as many individual plutons which are generally elongate northwesterly, and which are generally of Early and middle Cretaceous age. The plutons have intruded and contact metamorphosed, highly deformed metasedimentary and metavolcanic rocks, principally of Triassic and Jurassic age. The metasedimentary rocks were originally quartzite, arkose, marl, mudstone, calcareous sandstone, and limestone. The metavolcanic rocks were originally rhyolite and dacite lava flows and tuff. The metasedimentary and metavolcanic rocks were regionally metamorphosed and intensely deformed before intrusion and contact metamorphism.

The two largest bodies of metamorphic rock are the Boyden Cave roof pendant in the Agnew Roadless Area, and the Pine Ridge roof pendant in the Kings River Roadless Area. A few ridges and small peaks are capped by Tertiary basaltic volcanic rocks. Sparse surficial deposits consist of talus, colluvium, and glacial till and moraine.

Field investigations were conducted in 1979 and 1980 by teams from the USBM (Nokleberg and others, 1983). Information was obtained on mining claims by searching the records of Fresno County and the U.S. Bureau of Land Management. Chip and grab lode samples were taken from mines, prospects, dumps, and mineralized areas and chemically analyzed; sand and gravel samples were taken from placer deposits for heavy-mineral determinations. Field investigations were conducted in 1981 and 1982 by a team from the USGS (Nokleberg and others, 1983). All of the roadless areas were geologically mapped at a scale of 1:62,250. Thin sections

[1]With contributions from James G. Moore, USGS, from James M. Spear, USBM.

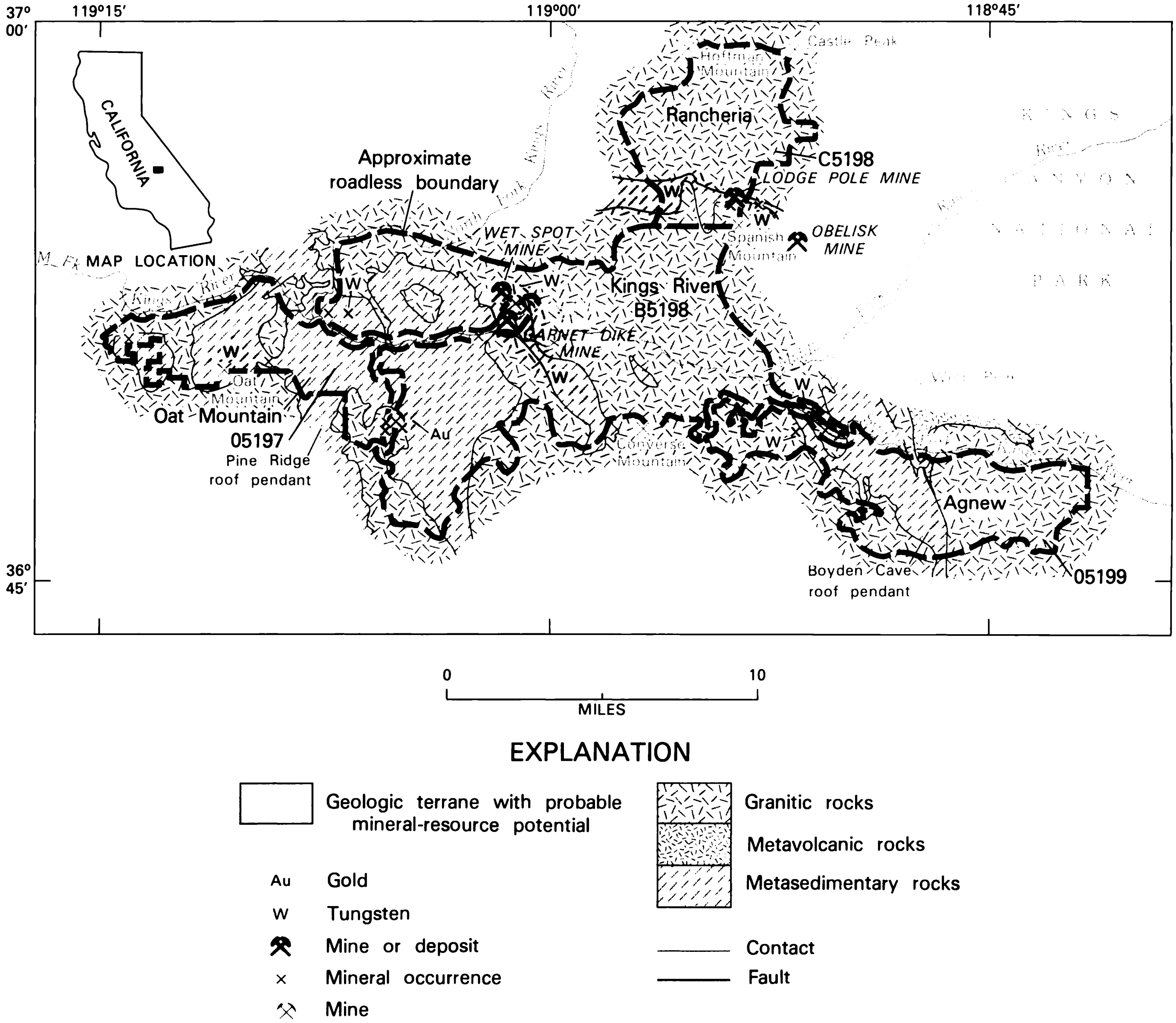

Figure 79.—Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas, California.

of rock samples were examined, rock, stream-sediment, and heavy-mineral concentrate samples were collected and chemically analyzed. The geological work was augmented by analysis of an aeromagnetic survey by Andrew Griscom.

Tungsten, and possible by-product molybdenum, and gold are the only commodities for which there are recorded production in the roadless areas. There are tungsten occurrences and deposits in the central part of the Kings River, southern part of the Rancheria, and southern part of the Agnew Roadless Areas. The Wet Spot prospect, in the north-central part of the Kings River Roadless Area, and the Lodge Pole prospect, in the southeast part of the Rancheria Roadless Area, contain small tonnages of low-grade tungsten mineral resource. About 20,000 tons of tungsten ore were produced from the Garnet Dike mine which is outside the Kings River Roadless Area within a narrow corridor that extends into the area. About 8000 tons of moderate-grade tungsten mineral resources are estimated at the Obelisk prospect to the southeast of the Rancheria Roadless Area, and a small amount of ore was mined in the 1950's (Moore and Marks, 1972).

Lode gold is known to occur in the southwestern part of the Kings River Roadless Area where part of one patented claim extends into the roadless area. Gold and silver values are sporadic and generally low. About 337 lode claims have been staked within and adjacent to the roadless areas for tungsten, gold, copper, molybdenum, chromium, and uranium, as have been about 80 gold placer claims and 9 millsite claims. Except for part of one gold claim that was patented in the Kings River Roadless Area in the 1950's, there are no other patented mining claims or millsites.

MINERAL RESOURCES

Tungsten, as scheelite (calcium tungstate), is the principal commodity produced from this region. It is in contact metasomatic deposits called tactite that generally replace carbonate beds near intrusive contacts with granitic rock. The tactite bodies are generally erratically distributed, small, irregular, and lenticular. Individual tactite bodies range from tiny pods and stringers to layers several hundred feet long. Lode gold, the other commodity found in this region, generally occurs in scattered gash quartz veins in granitic rock. Many veins narrow rapidly with depth and commonly contain accessory sulfide minerals, mostly pyrite.

The mining history, results of recent mine and prospect examinations, and the geologic, geochemical, and geophysical data acquired during the study of the roadless areas indicate a few areas with probable mineral-resource potential for tungsten in the Kings River, Rancheria, Agnew, and Oat Mountain Roadless Areas. There is also one area with probable mineral-resource potential for lode gold in the Kings River Roadless Area. The extreme relief and inaccessibility of most of the roadless areas make exploration and mining difficult. Gold occurs in a few scattered placers in the Kings River Roadless Area; however these occurrences have very low concentrations of gold and no resource potential was identified. Criteria for classification of potential for specific mineral commodities are listed below by roadless area and mineral resource.

An area with probable mineral-resource potential for tungsten is in the central part of the Kings River Roadless Area, as indicated by favorable geologic environment of marble, locally in schist, that is intruded by granitic rock; moderately abundant tungsten deposits and prospects; about 56,000 tons of demonstrated and inferred low-grade tungsten resources averaging 0.27 percent WO_3 in tactite at the Wet Spot prospect; several tungsten prospects and the Garnet Dike mine adjacent to the roadless area; and generally moderate anomalies of tungsten and molybdenum in some heavy-mineral concentrates. This area of probable tungsten resource potential is adjacent to the larger masses of marble where intruded by granitic rock; it extends into the steep, inaccessible south side of the Kings River Canyon, where although abundant marble is intruded by granitic rock, no tungsten occurrences are known. A small area of probable tungsten mineral-resource potential is in the northwest part of the roadless area.

An area with probable mineral-resource potential for lode gold is in the southwestern part of the Kings River Roadless Area, as indicated by prospects; one patented lode gold claim which extends into the roadless area; sparse and generally narrow quartz veins in granitic rock; and low concentrations of gold and silver in quartz veins at prospects.

An area with probable mineral-resource potential for tungsten occurs in the southern part of the Rancheria Roadless Area, as indicated by demonstrated low-grade tungsten mineral resources totaling about 12,000 tons, averaging 0.34 percent WO_3, at the Lodge Pole prospect; an estimated 8000 tons of moderate-grade tungsten mineral resources, averaging about 1 percent WO_3, at the Obelisk tungsten prospect near the roadless area; weakly anomalous concentrations of tungsten and some molybdenum in heavy-mineral concentrates; and locally favorable geologic environment of marble intruded by granitic rock.

Two small areas with probable mineral-resource potential for tungsten are located in the Agnew Roadless Area, as indicated by favorable geologic environment of some marble in schist which is intruded by granitic rock; sparse tungsten occurrences; weakly anomalous concentrations of tungsten and molybdenum in some heavy-mineral concentrates; sparse tactite with anomalous concentrations of tungsten and some molybdenum; and a magnetic anomaly indicating extension of a known tungsten deposit to moderate depth towards the southeast.

An area with probable mineral-resource potential for tungsten is in the central part of the Oat Mountain Roadless Area, as indicated by weakly to moderately anomalous concentrations of tungsten in heavy-mineral concentrates; and a minimally favorable geologic environment of sparse marble interbedded with biotite schist and intruded by granitic rock. Samples from prospects on quartz veins, in the central and western parts of the roadless area, show only traces of gold and silver; quartz veins in this area are extremely sparse.

SUGGESTIONS FOR FURTHER STUDIES

Tungsten deposits of the type found in the roadless areas generally are near the contact of granitic rock and calcareous metasedimentary rock or marble. Prospecting for additional deposits could be done in these contact areas in all four roadless areas. However, the only parts of these areas where extensive prospecting has not already occurred are areas that are extremely steep, rugged, and brushy. Small additional deposits may exist in these areas, and the assessment of resource potential thus refined.

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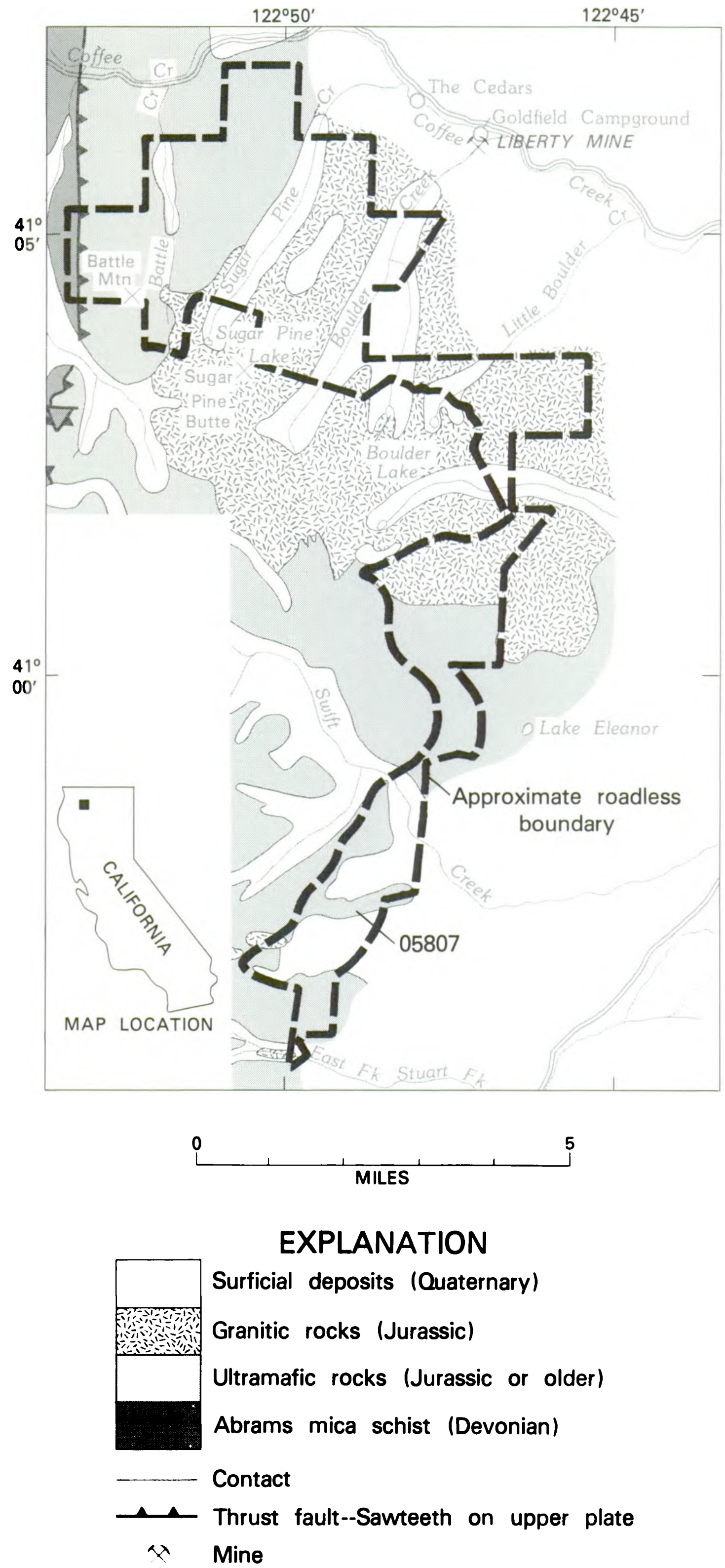

Figure 80.—Lake Eleanor Roadless Area, California.

LAKE ELEANOR ROADLESS AREA, CALIFORNIA

By DONALD F. HUBER,[1] U.S. GEOLOGICAL SURVEY, and

ERIC E. CATHER, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral surveys in 1968–70 and in 1980–81, the Lake Eleanor Roadless Area has little promise for the occurrence of metallic, nonmetallic, or energy resources.

CHARACTER AND SETTING

The Lake Eleanor Roadless Area occupies an area of about 22.3 sq mi in the Trinity Alps of the Klamath Mountains, 14–28 mi north-northeast of Weaverville, California. Altitude above sea level ranges from 3770 ft in the south along Swift Creek, to 7919 ft on Battle Mountain in the northwest part of the roadless area. The roadless area wraps around and shares the eastern and northeastern boundaries of the proposed Salmon-Trinity Alps Wilderness.

Almost the entire roadless area is underlain by ultramafic and granitic rocks; except for a small area of metamorphic rocks that underlies the northwest edge. The metamorphic rocks were probably thrust under the ultramafic rocks about 350 million years ago (Devonian). During the time from about 230 to 65 million years ago (Mesozoic), the granitic rocks intruded the ultramafic rocks. Also during this time the metamorphic and ultramafic rocks were accreted to the North American Continent by plate-tectonic processes.

Mining began in the Trinity Alps about 1850 and has continued intermittently since then. There is no record of mining activity in the Lake Eleanor Roadless Area, but placer and lode mining occurred nearby.

MINERAL RESOURCES

Gravels along the Trinity River and Coffee Creek have yielded gold in the past. However, streams that drain the roadless area and empty into the Trinity River and Coffee Creek contain no significant gold values, indicating that these streams do not drain the principal source areas for the placer gold. It is more likely that the gold washed downstream from other areas.

At the Golden Jubilee and Liberty mines, both of which are less than 1 mi north of the roadless area, gold-silver fissure veins occur in the same granitic and ultramafic rocks that underlie the roadless area, but the veins are fractured and poorly exposed. Similar veins which might occur in the roadless area would probably be covered by glacial debris or soil on all but the steepest slopes. Because of the extensive exploration and mining activity that has occurred throughout the surrounding area there is little promise for the occurrence of lode gold deposits in the Lake Eleanor Roadless Area. It is conceivable that subsurface quartz veins with gold are present in the roadless area, however, geochemical surveys in 1968–70 and 1980–81 failed to reveal any anomalously high gold or other metal values in rock and stream-sediment samples from the roadless area. Sand and gravel are common in most drainages, but are of small volume and far from present markets. No energy resources were identified in the roadless area.

[1]With contributions from Scott C. Nelson, USGS, and Joseph L. Ritchey, USBM.

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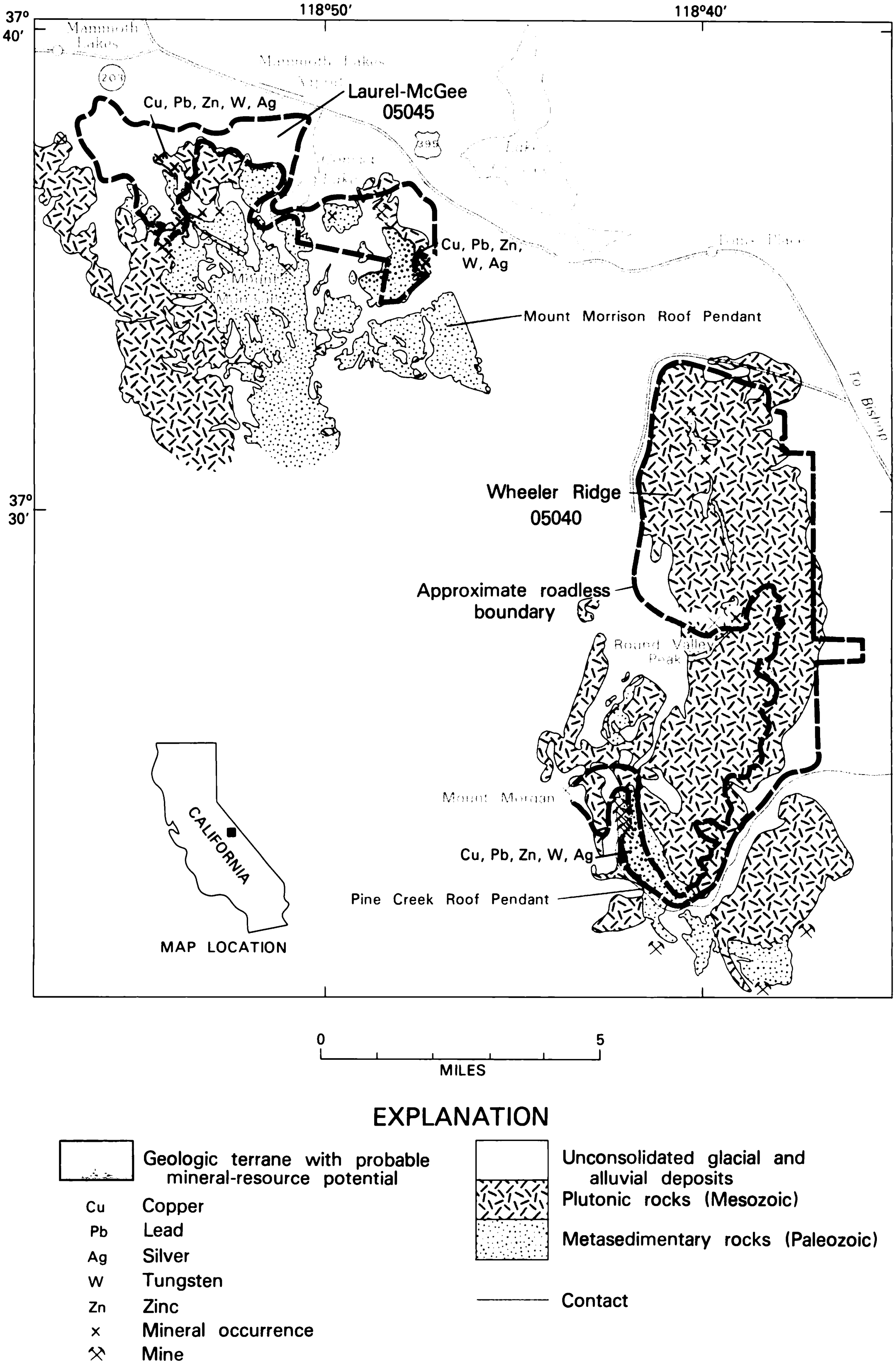

Figure 81.—Laurel-McGee and Wheeler Ridge Roadless Areas, California.

LAUREL-MCGEE AND WHEELER RIDGE ROADLESS AREAS, CALIFORNIA

By MICHAEL A. COSCA,[1] U.S. GEOLOGICAL SURVEY, and

DONALD O. CAPSTICK, U.S. BUREAU OF MINES

SUMMARY

Geochemical sampling and mine and prospect surveys in 1980, identified small areas in the Laurel-McGee and Wheeler Ridge Roadless Areas in the eastern Sierra Nevada, California, that have probable potential for the occurrence of small deposits of tungsten and (or) base and precious metals. A number of mines and prospects in or near the roadless areas are in occurrences of one or more of the metals, tungsten, zinc, silver, copper, and lead. The geologic terrane precludes the occurrence of fossil fuel resources.

CHARACTER AND SETTING

The Laurel-McGee and Wheeler Ridge Roadless Areas occupy 15 and 25 sq mi, respectively, in the Inyo National Forest, Inyo and Mono Counties, California. The areas are approximately 25 mi northwest of Bishop, California, and are accessible by several secondary roads. The Laurel-McGee Roadless Area may be reached by the McGee Creek Road from the southeast or the Convict Lake Road from the east both of which intersect California State Highway 395 near Crowley Lake. The Wheeler Ridge Roadless Area is accessible by the Rock Creek Road from the north, the Old Sherman Grade from the northeast, and the Pine Creek Road from the southeast, all of which intersect State Highway 395. The roadless areas lie between 13,748 ft and 4880 ft in altitude, are semiarid, and sparsely covered with sagebrush, juniper, pinon pine and at higher altitudes limber and yellow pine.

The roadless areas contain a thick sequence of metamorphosed limestone, dolomite, shale, and sandstone of Paleozoic age intruded by granitic rocks of Mesozoic age, which form the backbone of the Sierra Nevada. In some instances, the granitic rocks appear to nearly engulf the layered rocks leaving isolated bodies of strata, now exposed in 3-dimensions because of deep erosion, as roof pendants. These roof pendants, especially at their contact with the granitic rocks, have proven to be favorable localities for the occurrence of tungsten-bearing skarns. One of the best examples of a skarn deposit is at the nearby Pine Creek mine (Newberry, 1982).

Extensive pleistocene glaciation in the areas is evidenced by well-defined glacial moraines at the mouths of major canyons, and small patches of till and erratics on some upland surfaces. Alluvial and colluvial deposits of Holocene age are present in the valley floors.

Major structural features include tight folds related to a prebatholithic regional deformation, and more localized deformation and metamorphism related to the emplacement of the Sierra Nevada batholith. Large normal faults occur in and adjacent to the roadless areas, and are related to the uplift of the Sierra Nevada in late Cenozoic time. Active movement along some of these faults has been documented by the recent earthquakes of 1980, 1981, 1982, and 1983.

MINERAL RESOURCES

The Bishop mining district, which includes the Laurel-McGee and Wheeler Ridge Roadless Areas, began producing tungsten about 1916, and has remained one of the world's largest producers of this commodity. Lesser amounts of molybdenum, copper, silver, and gold have also been mined primarily as a byproduct of tungsten production. In addition, the Bishop district has small nonmetallic deposits of pumice, perlite, barite, talc, building stone, ceramic materials, gravel, and limestone (Bateman, 1965).

To determine the mineral-resource potential of the roadless areas, the USGS and the USBM analyzed samples of rock, stream sediment and heavy-mineral

[1]With contributions from Maurice A. Chaffee, USGS and Fredrick L. Johnson, USBM.

concentrates collected from stream drainages, outcrops, and mines and prospects within or near the roadless areas (Cosca and others, 1983). Results of the geochemical analyses show several drainages, partially within the roadless areas, that contain concentrations of some elements (arsenic, barium, bismuth, copper, gold, lead, molybdenum, silver, and tungsten) above the normal background levels for the region. These elements are typical of the suite of elements common to tactite deposits and (or) base- and precious-metal deposits.

The proximity of the Laurel-McGee and Wheeler Ridge Roadless Areas to known ore deposits with similar geologic settings, the presence of small mines and prospects, and geochemical anomalies from parts of the roadless areas are factors that indicate a probable potential for the occurrence of undiscovered mineral resources. The contact zones between granitic rocks and metasedimentary rocks are the most likely sites for resources, especially tungsten in tactite deposits. However, extensive prospecting and exploration by private individuals has occurred within the roadless areas and has failed to detect any sizable deposits.

SUGGESTIONS FOR FURTHER STUDIES

Results of the studies of the Laurel-McGee and Wheeler Ridge Roadless Areas have delineated small areas with probable potential for the occurrence of tungsten and (or) base- and precious metal resources. Detailed mapping and sampling of these areas should be undertaken in order to determine more precisely the location and size of the mineralized areas.

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LOST CREEK ROADLESS AREA, CALIFORNIA

By L. J. PATRICK MUFFLER, U.S. GEOLOGICAL SURVEY, and

HARRY W. CAMPBELL, U.S. BUREAU OF MINES

SUMMARY

Geologic and mineral-resource investigations in 1981–82 by the USGS and USBM identified no mineral-resource potential in the Lost Creek Roadless Area. Sand and gravel have been mined from alluvial flood-plain deposits less than 1 mi outside the roadless area; these deposits are likely to extend into the roadless area beneath a Holocene basalt flow that may be as much as 40 ft thick. An oil and gas lease application which includes the eastern portion of the roadless area is pending. Abundant basalt in the area can be crushed and used as aggregate, but similar deposits of volcanic cinders or sand and gravel in more favorable locations are available outside the roadless area closer to major markets. No indication of coal or geothermal energy resources was identified.

CHARACTER AND SETTING

The Lost Creek Roadless Area encompasses 13 sq mi of Lassen National Forest in Shasta County, north-central California, about 20 mi north of Lassen Peak. The nearest city is Redding, California, 50 mi to the southwest. Peripheral access is provided by State Highway 89 passing near the west boundary of the roadless area. The Pacific Crest Trail passes along the west margin of Hat Creek Rim adjacent to the east boundary of the roadless area. Most of the roadless area is a valley 3.5 mi wide, sloping from an altitude of 3800 ft at the south boundary to 3220 ft on the north. The Hat Creek Rim, along the east boundary of the roadless area, is a series of precipitous cliffs that rise to altitudes of nearly 4500 ft. Hat Creek flows from south to north not far from the west boundary of the roadless area. Lost Creek enters the valley from the southeast and disappears into the porous basalt and gravels near the Bidwell Ranch.

The Lost Creek Roadless Area lies just east of the crest of the Cascade Range in a major north-south-trending valley containing Hat Creek, the principal northerly drainage of the volcanic highlands 20 mi south near Lassen Peak. The valley is bounded on the east by the conspicuous young fault scarps of the Hat Creek Rim. Faults on the west side of the valley are inconspicuous; the valley can be considered to be an asymetric fault block tilted to the east and partly filled by alluvial material and volcanic rocks derived primarily from the south.

Rocks exposed in the hills to the west of the roadless area are a variety of locally derived andesite flows, faulted and partly eroded. No isotopic age determinations are available, but the degree of faulting and erosion is similar to andesite flows to the south, considered by Macdonald (1964) to be of Pliocene age. The andesite flows are stratigraphically beneath and significantly older than the dacite of Burney Mountain 10 mi to the west, dated at 240,000 years (G. B. Dalrymple, written commun.) by the potassium-argon method.

Rocks exposed on the fault scarps on the east side of the Hat Creek fault block comprise a series of low-potassium high-alumina olivine basalts correlative with those mapped by Macdonald (1964) as Burney Basalt south of the Lost Creek Roadless Area. Similar basalts are widespread over northeastern California east of the Cascade Range and probably range in age from Miocene to Quaternary. Although no isotopic ages are available for the Burney Basalt on the Hat Creek Rim and stratigraphic relationships are not clear, Macdonald's (1964) assignment of the Burney Basalt in the roadless area to the early Pleistocene is accepted.

Geologic units exposed in the Hat Creek fault block are all very young. A few miles north of the Lost Creek Roadless Area is Cinder Butte, a small shield volcano of mafic andesite showing very rugged topography unmodified by erosion but cut by one branch of the young fault system along the Hat Creek Rim. The vent

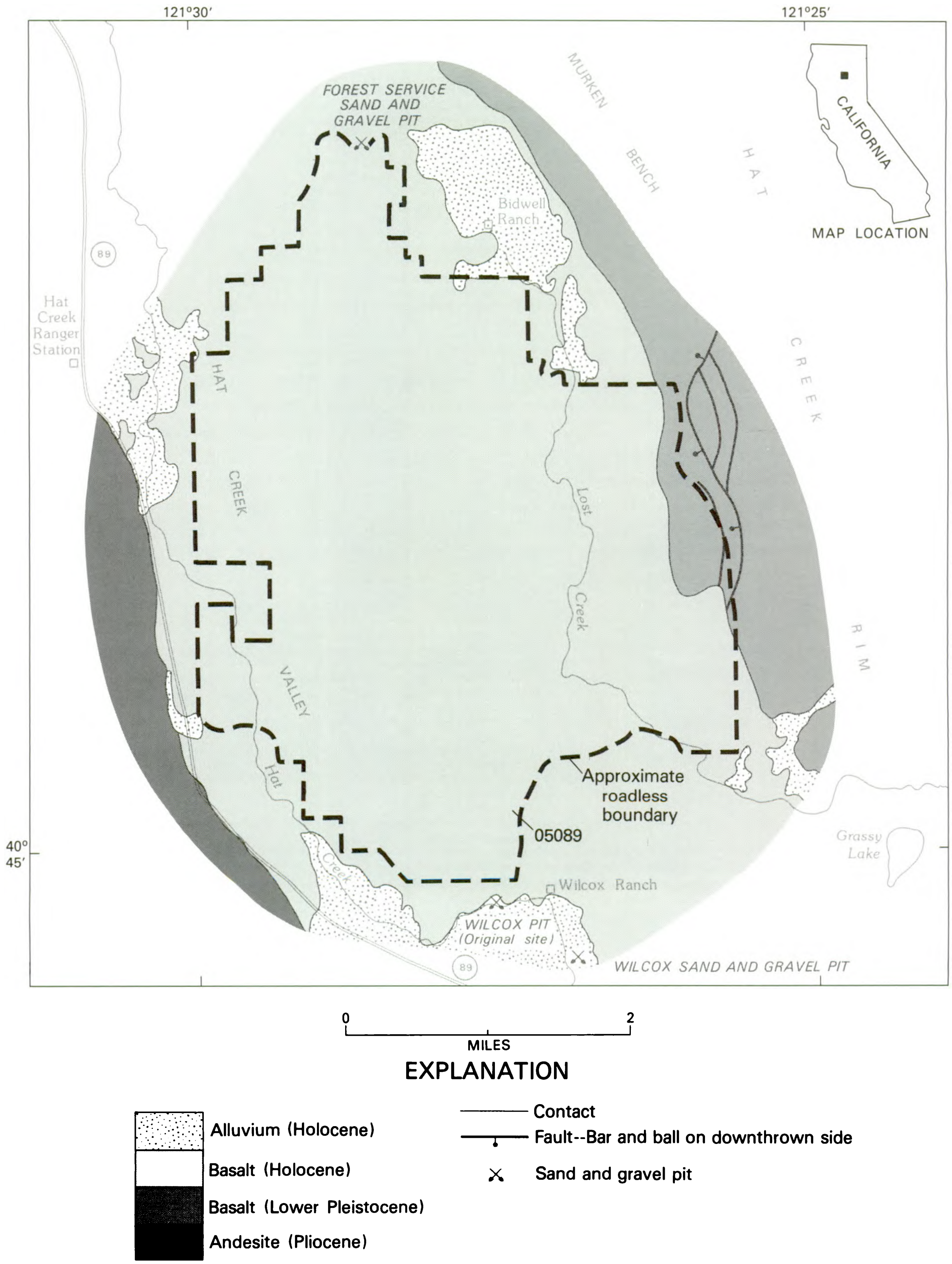

Figure 82.—Lost Creek Roadless Area, California.

areas of this shield volcano lie 2 to 3 mi north of the northernmost part of the Lost Creek Roadless Area. Coarse fluvial gravel and sand at least 30 ft thick are exposed in the Wilcox sand and gravel pit about 0.5 mi southeast of the Lost Creek Roadless Area.

The clasts in the gravel are well rounded and consist of a wide variety of volcanic rocks ranging in composition from basalt to dacite. These rocks are probably all derived from the highlands to the south in and adjacent to Lassen Volcanic National Park. At the deepest part of the gravel pit there are a few angular boulders of olivine basalt, interpreted as the top of a basalt flow underlying the gravel. This basalt has no natural exposures, and its extent and age are unknown.

Overlying the fluvial gravel and sand is the Hat Creek lava flow, a low-potassium high-alumina olivine basalt which flowed north from vents near Old Station, 8 mi south of the southern boundary of the Lost Creek Roadless Area (Anderson, 1940; Macdonald, 1964). The distal extremity of the lava flow is 6 mi north of the Lost Creek Roadless area. The Hat Creek lava flow has a rugged blocky surface with local relief of as much as 20 ft. The thickness of the flow is uncertain, but is unlikely to exceed 40 ft except where the basalt was ponded locally. Conspicuous on the east side of the flow are lava slump scarps, where the cooled crust of the lava slumped westward over the fault scarps of the Hat Creek Rim as underlying still-liquid lava drained to the northwest (Finch, 1933; Anderson, 1940).

The Hat Creek lava flow is almost certainly Holocene in age; preliminary analysis of paleomagnetic secular variation suggest an age of approximately 5000 years (Duane Champion, oral commun., 1982).

Overlying the Hat Creek lava flow and the fluvial gravel and sand are patches of Holocene alluvium, in part interlayered with silicic ash derived from the pyroclastic eruptions that accompanied the extrusion of the Chaos Crags domes in Lassen Volcanic National Park 1050 years ago. The ash commonly has been reworked and winnowed by wind action.

MINERAL RESOURCES

No potential for metallic mineral occurrences was identified in or adjacent to the Lost Creek Roadless Area. An oil and gas lease application is pending that includes the eastern part of the roadless area. No indication of coal or geothermal energy resources was found. The roadless area lies in an area of pronounced low heat-flow caused by regional movement of cold ground water north from the volcanic highlands near Lassen Peak (Mase and others, 1982, fig. 7). Although the Hat Creek basalt flow is indeed very young, its vent area is 8 mi south of the Lost Creek Roadless Area; any thermal energy in the flow itself has long since dissipated.

Significant sand and gravel deposits occur adjacent to the roadless area; the Wilcox sand and gravel pit about 0.5 mi to the southwest is an important source of construction aggregate for the region. This deposit is older than the Hat Creek lava flow and likely extends to the north for an unknown distance under the flow. Utilization of any gravels under the flow, however, would be subject to the necessity of removing the very resistant basalt cover. The basalt itself could be crushed and used as aggregate, but could not compete with volcanic cinders and sand and gravel that are readily available outside the roadless area. Similar considerations would apply to the possible use of the basalt for dimension stone.

SUGGESTIONS FOR FURTHER STUDIES

No further mineral-resource studies are suggested.

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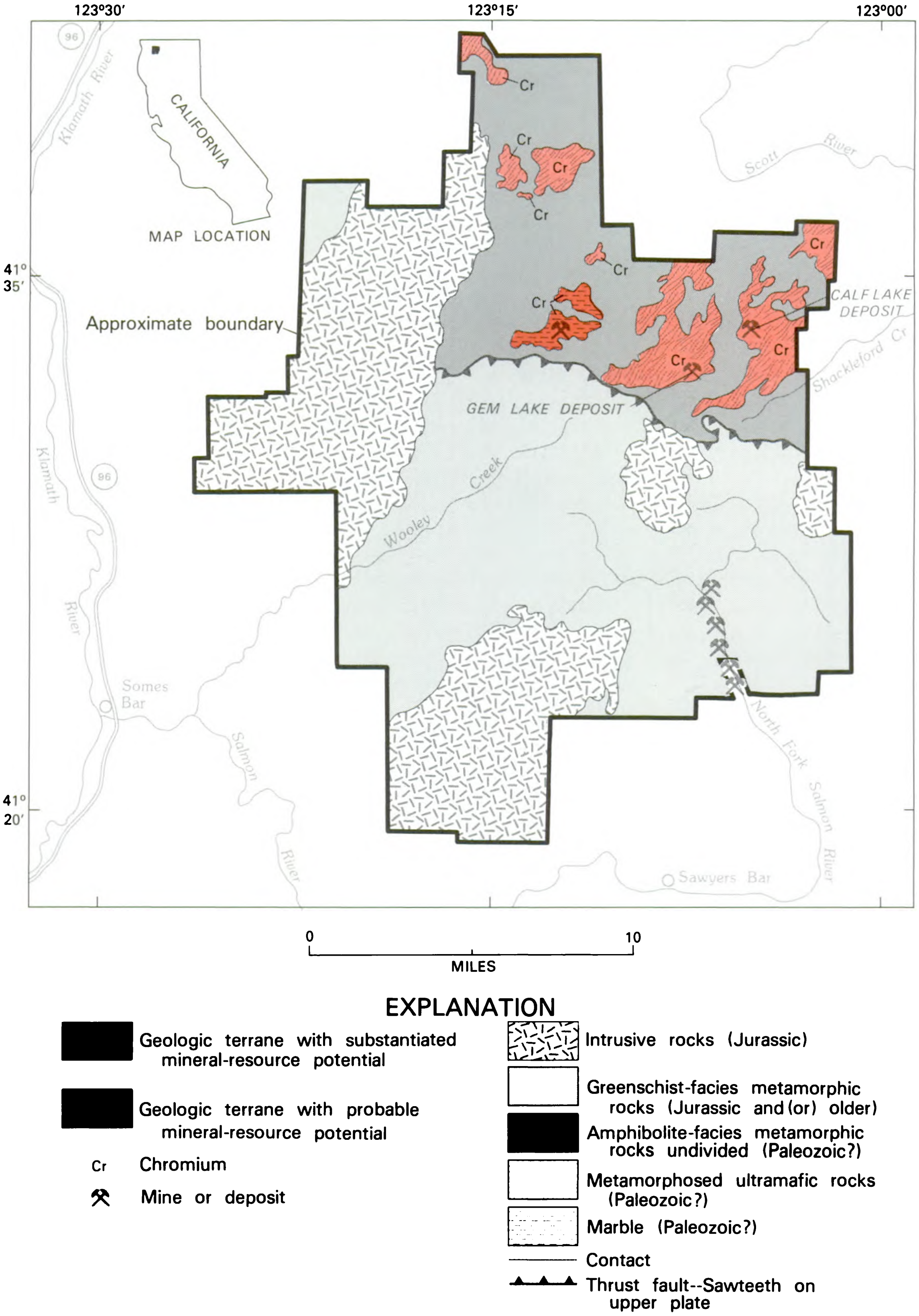

Figure 83.—Marble Mountain Wilderness, California.

MARBLE MOUNTAIN WILDERNESS, CALIFORNIA

By MARY M. DONATO,[1] U.S. GEOLOGICAL SURVEY, and

WILLIAM N. HALE, U.S. BUREAU OF MINES

SUMMARY

Geologic, geochemical, geophysical, and mineral investigations done in 1979–81 indicate that the Marble Mountain Wilderness has areas of probable and substantiated resource potential for placer gold, for chromite, and for marble. Specific areas with mineral potential are gold placer terrace deposits along the North Fork Salmon River, chromite deposits in the Shackleford Creek area, and marble deposits at Marble Mountain. The geologic terrane precludes the occurrence of fossil fuel resources.

CHARACTER AND SETTING

The Marble Mountain Wilderness is located in the north-central Klamath Mountains of northern California, about 40 mi west-southwest of the town of Yreka. The wilderness encompasses about 335 sq mi of steep, rugged terrain between the Scott, Salmon, and Klamath Rivers, at altitudes ranging from 1450 to 8300 ft above sea level. The area is densely vegetated by Douglas-fir and mixed conifer forests at lower altitudes, and by true firs at altitudes above 5000 ft. Trailheads in the northern and western part of the wilderness are accessible via unpaved USFS roads leading south and east from California State Highway 96 (the Klamath River Highway) near the towns of Happy Camp and Somes Bar. The northeastern trailheads are reached by unpaved roads leading from the Scott River road via the town of Fort Jones and California State Highway 3. The southern trailheads are reached via paved and gravel roads leading from the towns of Etna and Sawyers Bar.

The Marble Mountain Wilderness is underlain by metamorphic and plutonic rocks of the western Paleozoic and Triassic belt of the Klamath Mountains geologic province. The metamorphic rocks of the wilderness may be grouped into two units (Donato and others, 1982). The first is a structurally lower amphibolite-facies unit interpreted as a metamorphosed tectonic mélange. This unit, whose age is unknown but possibly Paleozoic, is exposed in the northern part of the wilderness, and contains a wide variety of lithologies, including chert, marble, amphibolite, ultramafic rocks, and schists of mainly sedimentary origin. Of these, only the ultramafic rocks and marble are significant in terms of mineral-resource potential.

The second unit, which structurally overlies the first, is composed of greenschist-facies metasedimentary and metavolcaniclastic rocks of Jurassic and (or) older age. These rocks include a breccia which contains small (as much as a few hundred feet long) blocks of chert, limestone, and serpentinized peridotite in an argillite matrix. The serpentinite blocks are the possible source of geophysical anomalies, but they are insignificant in terms of mineral-resource potential owing to their small size. No chromite was observed in these serpentinite blocks. However, sampling by the USBM yielded placer gold in alluvial deposits in this terrane.

The two metamorphic terranes are juxtaposed along a southward-dipping thrust fault which postdates the main metamorphic event. Both units are in turn cross-cut by the Upper Jurassic Wooley Creek batholith, which underlies much of the western part of the wilderness. Unconsolidated deposits include landslide deposits, which often occur in areas underlain by ultramafic rock, and Pleistocene to Holocene alluvial deposits in stream beds and terraces.

A geochemical survey of the wilderness was undertaken to aid in the resource evaluation. Stream-sediment, panned-concentrate, and whole-rock grab samples were taken throughout the wilderness. The geochemical sampling delineated an area in the northeast quadrant of the wilderness which showed anomalous concentrations of chrome and nickel. The anomalous area is underlain primarily by metasedimentary, metavolcanic, and ultramafic rocks. The high

[1]With contributions by Robert C. Jachens and David B. Smith, USGS.

chrome and nickel values are the result of ultramafic rocks exposed in the drainage basins of individual sediment samples, as confirmed by several analyses of whole-rock samples of ultramafic rocks in the area.

Geophysical surveys were also employed in this investigation. The most useful of these was the aeromagnetic survey, since conspicuous aeromagnetic anomalies are associated with bodies of ultramafic rock, some of which contain small amounts of chromite. Four strong northeast-trending anomalies occur over the amphibolite-facies unit in the northern part of the wilderness and three of these are associated with large exposures of ultramafic rock. Only two magnetic anomalies are associated with exposures of ultramafic rock in the greenschist-facies terrane, neither of which contains chromite. Ultramafic bodies in this terrane are typically composed of antigorite, and are not likely hosts for chromite. The generally featureless magnetic field over other parts of the greenschist-facies terrane within the wilderness indicates that no other large magnetic ultramafic bodies are concealed at shallow depth in this terrane.

Placer gold was produced during the 1930's from Pleistocene terrace deposits on the North Fork of the Salmon River. Mining claims were located for marble (1920's) and gold (1930's) near Marble Mountain, and for chromite (1940's–1950's) and gold (1800's) in the Shackleford Creek region, but no mineral production came from within the wilderness.

Fifty-six mining claims were identified from courthouse records. Five claims were for lode gold, six were gold placer claims, 20 claims were for chromite, and 25 claims were for marble. No patented mining claims, mineral leases, or currently active mining claims are known in the wilderness.

MINERAL RESOURCES

Geologic, geochemical, and geophysical evidence indicates that the Marble Mountain Wilderness has resource potential for placer gold and chromite; marble resources are also present (Donato and others, 1983).

Gold-bearing gravel deposits occur as discontinuous alluvial terraces and as river-level gravel bars at the mouths of tributaries in the southeastern part of the wilderness. Demonstrated placer gold resources occur at six localities along the North Fork of the Salmon River, two of which lie just outside the wilderness boundary. Approximately 0.05 sq mi of terrace and stream gravels were identified. Of these, approximately 0.025 sq mi contain gold. Gold-bearing gravel in the wilderness is estimated to total about 149,000 cu yd averaging 0.002 oz gold/cu yd. Of this quantity, only 4000 cu yd would average over 0.01 oz gold/cu yd.

Chromite occurs as podiform bodies, disseminated stringers, schlieren, or discontinuous layers in metamorphosed ultramafic rock. Demonstrated and inferred resources are found in two localities in the northeastern part of the wilderness; near Gem Lake and near Calf Lake. The largest podiform chromite body, located at Gem Lake, is about 75 ft long by 6 ft wide. It constitutes an estimated 1400 tons of inferred chromite resource. Disseminated chromite veins and stringers also occur there. Demonstrated disseminated chromite resources total 4170 tons of rock averaging 2.4 percent Cr_2O_3. At Calf Lake, chromite occurs in veins and disseminated stringers. Demonstrated disseminated chromite resources total 145 tons of rock averaging 8.2 percent Cr_2O_3.

Known chromite resources in the wilderness are small and low grade. However, because the wilderness contains several large ultramafic bodies, the potential for undiscovered chromite bodies in the subsurface probably exists. Such deposits would be difficult to detect with current exploration techniques. If and when better subsurface detection methods become available, presently unknown deposits may come to light. On this basis areas underlain by ultramafic rock, but containing no identified resources, are classified as having probable mineral resource potential.

Marble Mountain itself is composed of interlayered calcite marble and siliceous and dolomitic schists. The marble is exposed in a massive outcrop 0.5 to 2 mi wide for about 2.5 mi along strike, and averages about 250 ft thick. A smaller outcrop about 0.25 mi wide and the same thickness crops out discontinuously for about 3 mi. Grain size, mineral composition, and purity are highly variable. Because the marble occurs as a tectonic block in the metamorphosed mélange rather than as a laterally continuous sedimentary layer, its extent in the subsurface is difficult to predict. The area of marble outcrop is classed as having a substantiated resource potential.

SUGGESTIONS FOR FURTHER STUDIES

It is unlikely that further studies utilizing current exploration techniques will uncover hidden mineral deposits in the wilderness. If new methods for subsurface exploration are developed in the future, hidden chromite deposits may be found in some of the larger ultramafic bodies.

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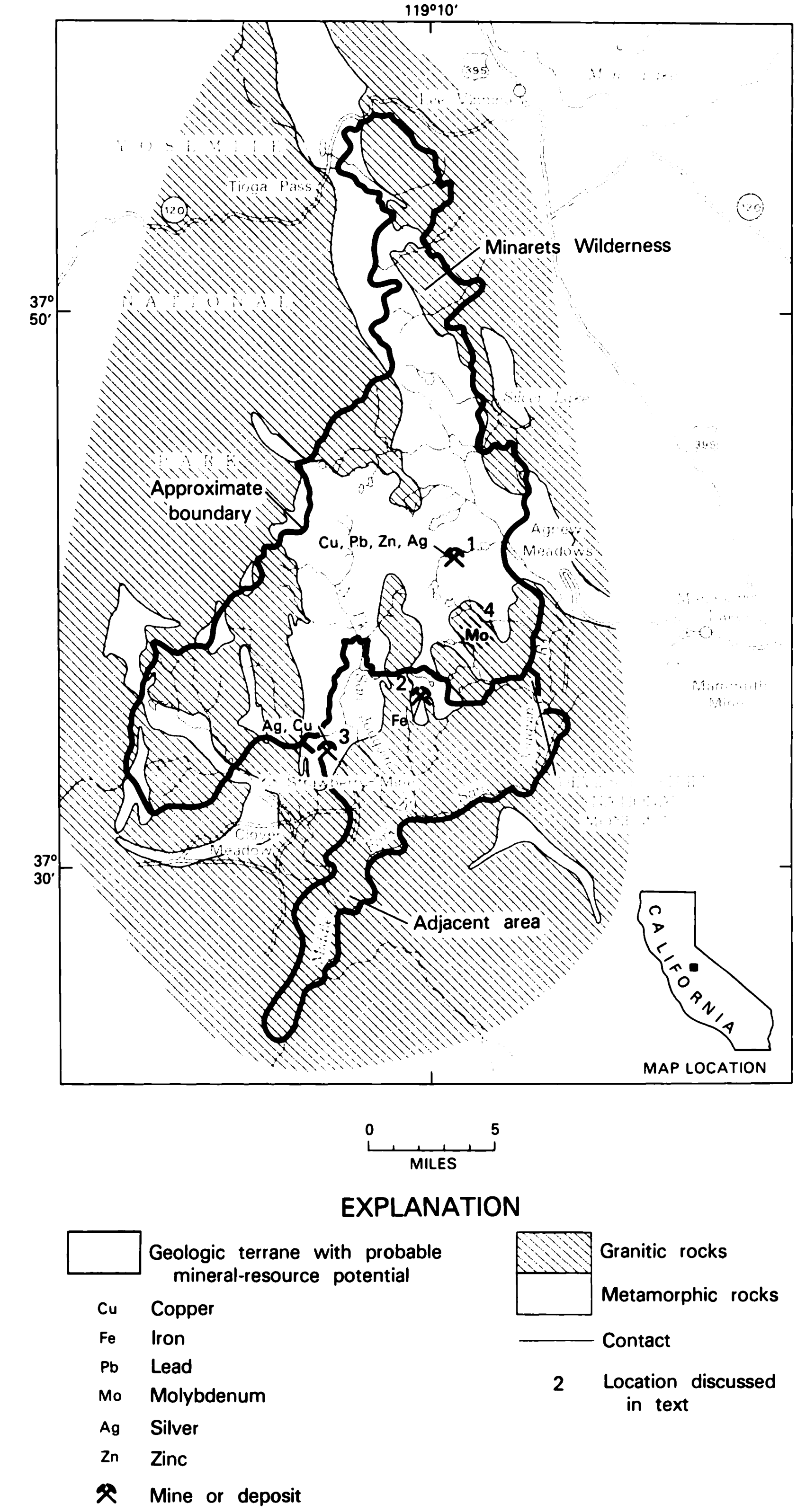

Figure 84.—Minarets Wilderness and adjacent areas, California.

MINARETS WILDERNESS AND ADJACENT AREAS, CALIFORNIA

By N. KING HUBER,[1] U.S. GEOLOGICAL SURVEY and

HORACE K. THURBER, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Minarets Wilderness and adjacent areas in the central Sierra Nevada, California was conducted during 1973–75. The results of the survey indicate that the study area has a substantiated resource potential for small deposits of copper, silver, zinc, lead, and iron, and a probable mineral-resource potential for molybdenum. No energy-resource potential was identified in the study.

CHARACTER AND SETTING

The Minarets Wilderness is located in the east-central part of the Sierra Nevada along the southeast margin of Yosemite National Park. The area studied covers about 237 sq mi, of which about 170 sq mi is within the officially designated Minarets Wilderness. The adjacent areas studied were designated as the San Joaquin and North Fork San Joaquin Roadless Areas at the time of the study. Because of subsequent boundary changes, the adjacent areas studied now cover only part of what is now designated as the San Joaquin Roadless Area.

The study area lies at the crest of the Sierra Nevada and is extremely rugged, with nearly 10,000 ft of total relief, ranging from an altitude of 3200 ft where the San Joaquin River leaves the area to 13,135 ft at Mount Ritter. More than 25 peaks higher than 12,000 ft in elevation lie within or on the boundary of the area. Much of the area at lower elevations is forested, but roughly 50 percent of the study area is above timberline or supports only scattered growth because of precipitous slopes or other adverse conditions. The winter climate of the area is severe; it has one of the thickest annual snow packs in the Sierra.

The Sierra Nevada is a large block of the Earth's crust that has been uplifted on the east along an extensive system of high-angle faults and tilted westward. Most of the central Sierra is composed of Mesozoic granitic plutons that constitute the Sierra Nevada batholith. The batholith was intruded into Paleozoic and Mesozoic sedimentary and volcanic strata, which are preserved in the walls of the batholith and as roof pendants, septa, and inclusions within the batholith. Such strata, now metamorphosed, underlie nearly half of the study area, mostly in a body of rock referred to as the Ritter Range pendant; many small bodies of metamorphic rock are scattered throughout the rest of the predominantly granitic terrane. With few exceptions, the known occurrences of mineralized rock are confined to the metamorphic rocks, and the exceptions appear to be confined to a few granitic rocks older than the bulk of the batholithic rocks in the study area.

MINERAL RESOURCES

The study area is within a region where gold and other metals have been sought extensively, beginning at least as long ago as the mid-1800's; the prospecting accelerated around 1878 when gold was discovered in the Mammoth district, east of the study area. Mines in the Mammoth mining district may have produced as much as $1 million worth of gold, silver, and other metals at then-current prices. The Strawberry mine, adjacent to the south boundary of the study area, produced more than 40,000 short-ton units of tungsten trioxide (WO_3). The host rocks in these two mineralized areas do not extend into the study area.

Many local mineralized areas are present within the study area and about 1200 mining claims have been filed for gold, copper, lead, zinc, silver, molybdenum, tungsten, and iron. About 25 claims were held during the time of investigation; nine have been patented. No

[1]With contributions from Howard W. Oliver and Roy A. Bailey, USGS and Michael S. Miller, C. Thomas Hillman, David S. Lindsey, and Richard W. Morris, USBM.

mineral production has been recorded from prospects within the study area.

Within the study area there are 3 localities with demonstrated resources that are surrounded by areas of probable mineral-resource potential: the Crown Point-Nidever prospect, Minarets magnetite prospect, and Mark prospect. A fourth area, Red Top Mountain, has a probable potential for silver and molybdenum.

The Crown Point-Nidever prospect on Shadow Creek (no. 1 on map) has been explored by extensive trenching and several diamond-drill holes; it has an estimated 9 million tons of demonstrated resources of copper, lead, zinc, and silver in tactite. In addition probable mineral-resource potential occurs in areas extending southeasterly and northwesterly from the tactite, but no resource estimate could be made because the occurrences are too poorly exposed.

An iron-bearing lens on the Minarets magnetite prospect (no. 2) west of Iron Mountain has been explored with two diamond-drill holes and contains an estimated 8.5 million tons of demonstrated iron resources. An area with small, widely scattered magnetite masses that has probable mineral-resource potential surrounds the Minarets prospect.

North-trending gash-fracture veins in metasedimentary rocks on the Mark prospect (no. 3) in the southern part of the area, contain at least 30,000 tons of demonstrated resources of silver and copper. At this locality, copper in the form of chalcocite and bornite occurs as very fine grains disseminated in equally fine grained metasedimentary rock. Locally the sulfide minerals have been deposited as thin stringers and irregular masses along fractures crosscutting the host rock; it was these local high-grade masses that were being explored by prospect pits at the time of the study.

A geochemical survey indicated anomalous silver in a small drainage basin on the northwest side of Red Top Mountain and widespread anomalous molybdenum around the eastern side of the mountain (no. 4). Limited exposures preclude estimation of the size of the area of probable silver resource potential, but it is more than likely small. The area of molybdenum mineralization, seen in many prospects, is considered to have probable resource potential for possibly higher-grade mineralization at depth or of extensive disseminated mineralization.

The areas with mineral-resource potential mentioned above are in the established Minarets Wilderness except for the Minarets magnetite prospect and the Mark prospect, which were in the area designated as the North Fork San Joaquin Roadless Area at the time of the study.

SUGGESTIONS FOR FURTHER STUDIES

Although mineralization of diverse types is widespread within the study area, it is mostly confined to favorable horizons or structures in the metamorphic rocks and areas of significant mineralization are few. The rocks in the area are generally well exposed and all stream-sediment geochemical anomalies recognized during the study were traceable to previously known mineralized areas; the probability of finding additional areas of unrecognized mineralization is considered low. However, of the four localities mentioned, only two have been explored sufficiently to make a reasonable estimate of their resource potential. The presence of molybdenum in the Red Top Mountain area, for example, has long been known, but the extent or grade of mineralization is wholly unknown.

In 1975 the Mark prospect was the only one of the four localities discussed that was currently undergoing exploration. The amount and extent of the low-grade disseminated mineralization in this area, which may be quantitatively more important than the high-grade pockets, can only be determined by an extensive program of both surface and diamond-core-drill sampling. The estimated demonstrated and inferred mineral resources of 30,000 tons includes only the higher-grade material; the probability of adding to this resource base in the prospect area is considered high.

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MIRANDA PINE, HORSESHOE SPRINGS, TEPUSQUET PEAK, LA BREA, SPOOR CANYON, FOX MOUNTAIN, AND LITTLE PINE ROADLESS AREAS, CALIFORNIA

By VIRGIL A. FRIZZELL, JR.,[1] U.S. GEOLOGICAL SURVEY, and

LUCIA KUIZON, U.S. BUREAU OF MINES

SUMMARY

Mineral-resource surveys conducted in 1980–83 by the USGS and USBM indicate demonstrated resources of barite, copper, and zinc at two localities in the La Brea Roadless Area and demonstrated resources of phosphate at a mine in the Fox Mountain Roadless Area. A building stone quarry is present on the southern border of the Horseshoe Spring Roadless Area and an area of substantiated resource potential extends into the area. The Miranda Pine, Tepusquet Peak, Spoor Canyon, and Little Pine Roadless Areas have little promise for the occurrence of mineral resources and there is little promise for the occurrence of energy resources in any of the roadless areas.

CHARACTER AND SETTING

The Miranda Pine, Horseshoe Springs, Tepusquet Peak, La Brea, Spoor Canyon, Fox Mountain and Little Pine Roadless Areas together occupy about 246 sq mi in the Los Padres National Forest, California. For purposes of this report the individual areas will be referred to collectively as the study area.

The study area consists of most of the Sierra Madre Mountains and part of the San Rafael Mountains in the western part of the Transverse Range, and is situated between Santa Barbara and Santa Maria on the south and west and Cuyama Valley on the north. California State Highways 33, 154, and 166 provide access to paved and unpaved roads which in turn allow access to individual roadless areas.

Much of the study area is characterized by steep-walled canyons and sharp ridges. Although summit ridges may locally support coniferous forests and riparian woodlands may line valley bottoms, impenetrable chaparral covers much of the mountain slopes and makes off-trail traverses difficult.

Thick fault-bounded sequences of sandstone, siltstone, shale, and conglomerate underlie nearly all of the study area and are divided on the basis of age into a mostly pre-Miocene section and a mostly Neogene section (Frizzell and Vedder, in press). The pre-Miocene section contains nearly equal amounts of Mesozoic and Cenozoic rocks, which were mostly deposited in submarine fan environments near continental margins. Lesser amounts of Upper Cretaceous and Oligocene nonmarine rocks, which were deposited in alluvial fan, fluvial, or littoral environments, are also present.

Organic-rich siltstone and shale, interbedded sandstone and lesser conglomerate predominate in the Neogene section. These rocks formed mostly from sediments deposited in relatively restricted marine basins where the organic remains of flora and fauna living in the water column constituted a relatively important source of sediment. Mapped with these rocks are lesser amounts of Neogene nonmarine rocks which occur along the southern edge of the Cuyama Valley.

A sliver of igneous rock along the southwest margin of the study area includes Jurassic(?) gabbroic rocks and Tertiary volcanic rocks.

In addition to the geologic mapping, multidisciplinary work in the study area included analysis of mines and prospects, geophysical investigations and organic- and inorganic-geochemical studies.

Placer gold mining by Spanish settlers began both northwest and east of the study area in the early 1800's, and gold and antimony were mined from bedrock lodes to the east of the study area at the end of the 1800's.

[1]With contributions by George E. Claypool, Andrew Griscom, and David B. Smith, USGS, and Dale W. Avery, John R. Benham, Michael C. Horn, Terry R. Neumann, and Robin B. McCulloch, USBM.

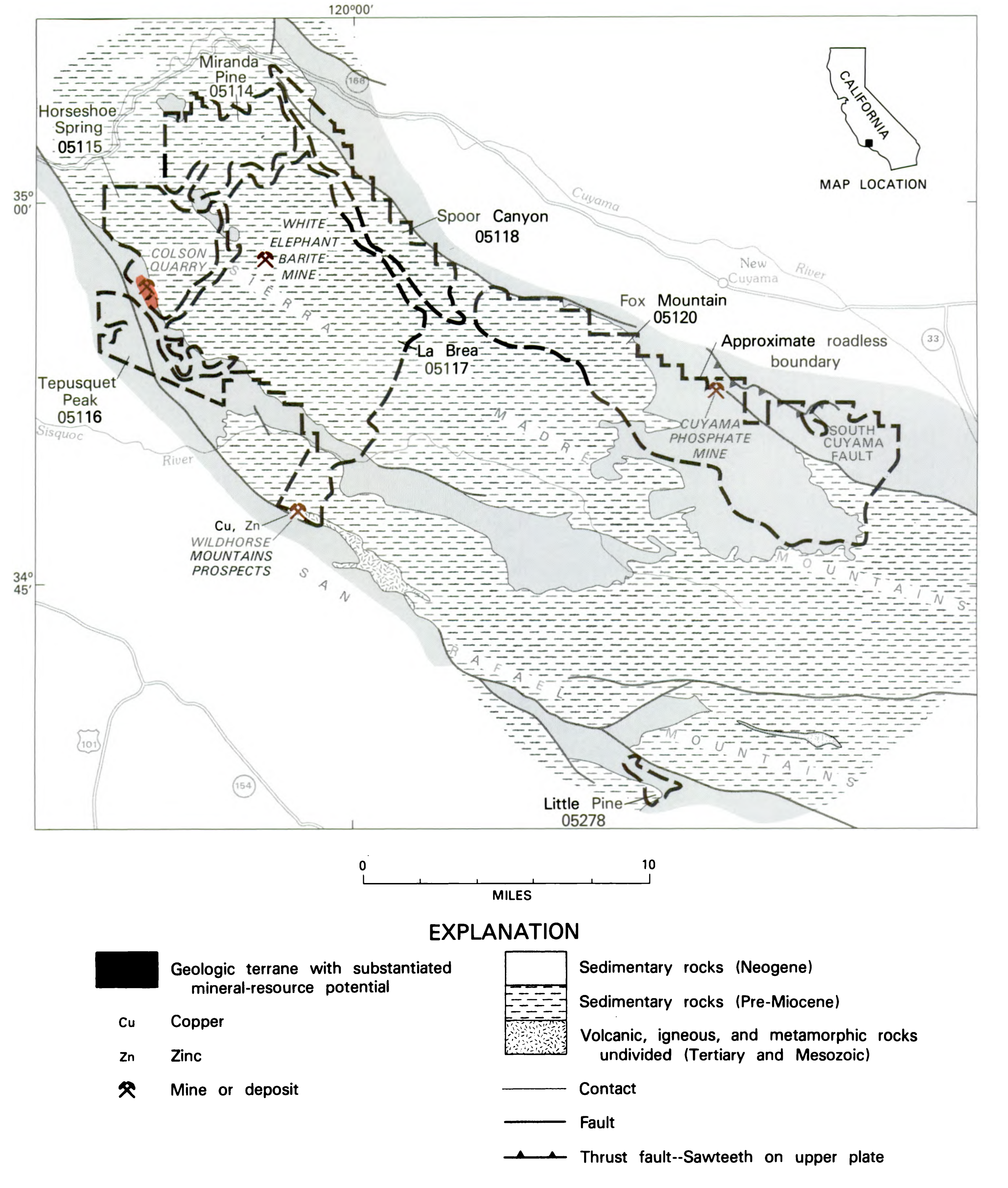

Figure 85.—Miranda Pine, Horseshoe Springs, Tepusquet Peak, La Brea, Spoor Canyon, Fox Mountain, and Little Pine Roadless Areas, California.

Exploration for oil began in the study area just after the turn of the century and the Cuyama Valley oil fields immediately north of the study area began production in the late 1940's. Gypsum was discovered just east of the study area in 1892 and phosphate-bearing rocks were reported in the study area in the 1930's.

Geophysical studies included the compilation and analysis of gravity and magnetic data (Griscom, in press). The northern edge of the Fox Mountain Roadless Area is on the southern margin of a negative gravity anomaly occupying Cuyama Valley. The gravity data do not support the presence of significant amounts of Neogene rocks there, below the South Cuyama thrust. Sediment samples taken from stream deposits, collected for a reconnaissance geochemical study, delineate areas with previously known mineralization (Smith and others, in press). Analyses of fine-grained sedimentary rocks collected for a reconnaissance study of organic matter mostly indicate low quantities of oil- and gas-producing materials.

MINERAL RESOURCES

While our studies, presented in Frizzell and others (in press), indicate that most rocks within the study area probably do not contain petroleum resources or favorable environments for the concentration of metallic minerals, four localities do have demonstrated resources; the Horseshoe Springs Roadless Area has demonstrated building stone resources at the Colson Quarry; the La Brea Roadless Area has two localities, one of demonstrated barite resources at the White Elephant mine and one of copper and zinc resources at the Wild Horse Mountain prospects; and the Fox Mountain Roadless Area has demonstrated phosphate resources at the Cuyama phosphate mine.

The only active mining in the study area is for building stone in the Colson Quarry, one third of which is in the Horseshoe Spring Roadless Area. The mine annually produces 2000 tons of sandstone for flagging and rubble (Horn, 1983). An area of substantiated resource potential for thin-bedded, fine-grained sandstone and interbedded siltstones of the Miocene and Pliocene Monterey Formation similar to that quarried at the mine extends 1 mi northwest and southeast of the site and includes demonstrated resources in excess of 50,000,000 tons of raw material.

Gabbroic rocks on Wildhorse Mountain in the La Brea Roadless Area contain vugs and fractures filled with malachite and azurite. Prospects in a high grade zone contain 1300 tons of demonstrated resources with 1.87 percent copper and 3.13 percent zinc. An additional 5850 tons of demonstrated and inferred resources containing 0.18 percent copper and 1.34 percent zinc are exposed adjacent to the high-grade material (Benham and McCulloch, 1981, p. 6). The patented White Elephant barite deposit (formerly called Eagle) was mined extensively in 1929 and 1930. The barite occurs as veins in Cretaceous sedimentary rocks and about 95,000 tons of 73 percent barite are inferred to remain on the claims (Benham and McCulloch, 1981, p. 7). A high barium content in geochemical samples and high sulfate content in spring waters sampled indicate the possible presence of additional barite veins in the La Brea Roadless Area as well as in other localities, but no resource potential is identified.

The Santa Margarita Formation, in the Fox Mountain Roadless Area, may contain more than 300 million tons of phosphatic pellet-bearing rocks (Fedewa and Hovland, 1981, p. 72), but most of these rocks are covered by thick overburden. The area does, however, contain more than 21 million tons of inferred phosphate resources at the Cuyama phosphate mine having 4.84 percent P_2O_5 (McCulloch and Neumann, 1982, p. 4). Although there has been no mining from leases within the roadless area, similar material was mined north of the area between 1965 and 1970.

Because the study area is predominantly underlain by sedimentary rock and located between the South Cuyama and Santa Maria oil and gas fields, oil and gas resource potential might be expected throughout the study area. Reconnaissance oil and gas studies (Frizzell and Claypool, in press; Howell and Claypool, 1977), however, indicate little promise for the occurrence of petroleum within the pre-Miocene rocks in the study area. Samples from pre-Miocene rocks contain organic matter in quantities and qualities below those necessary to produce significant amounts of hydrocarbons.

Many of the Miocene marine rocks contain sufficient quantities and suitable types of organic matter necessary to generate hydrocarbons. The Miocene rocks exposed at the surface in the Tepusquet Peak, La Brea, and Little Pine Roadless Areas, though, are relatively thin (about 2000 to 4000 feet) and have generally been well breached by erosion. Likewise, the Miocene rocks at the surface in the Fox Mountain Roadless Area are relatively thin and have been well dissected, and, even though similar rocks are projected to occur below the South Cuyama thrust, gravity data do not support their presence in great thicknesses.

SUGGESTIONS FOR FURTHER STUDIES

Additional gravity data and development of gravity models may add to our understanding of Neogene rocks below the South Cuyama thrust and the potential for occurrence of petroleum there. Detailed geological mapping and geochemical sampling may also add to our understanding of the barite occurrence in the La Brea Roadless Area.

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MOKELUMNE WILDERNESS AND ADJACENT ROADLESS AREAS, CALIFORNIA

By EDWIN H. MCKEE,[1] U.S. GEOLOGICAL SURVEY, and

FRANCIS E. FEDERSPIEL, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey in 1979 most of the Mokelumne Wilderness and adjacent roadless areas including Caples Creek, Tragedy-Elephants Back (nos. 4-984 and 5-984), and Raymond Peak (no. 5-985) are considered to offer little promise for discovery of mineral resources. A small area in the northeast part of the Mokelumne Wilderness and parts of the Tragedy-Elephants Back and Raymond Peak Roadless Areas contains a previously known mining district (Summit City) in which small amounts of a number of metallic minerals occur and the area has a probable mineral potential for gold and silver resources. No energy resources were identified in this study.

CHARACTER AND SETTING

The Mokelumne Wilderness and adjacent roadless areas, most of which is directly west of the Sierra crest, comprise 197 sq mi south of Lake Tahoe. The area is dominated by the Mokelumne River canyon, a deep and rugged feature that runs from the Sierra crest westward to the Sacramento Valley. Important mountains in the area include Round Top (10,380 ft), Mokelumne Peak (9332 ft), and Mt. Reba (8758 ft). Two major highways, State Route 88 on the north and State Route 4 on the south side of Mokelumne Canyon provide access to the area. Small roads and trails reach the drainage heads and the rim of the canyon at a number of places but access into and along the canyon is limited to a few trails. The nearest population center is South Shore Tahoe, about 20 mi to the northeast; the small town of Markleeville is about the same distance to the east.

Geologic mapping, geochemical sampling, and mine and prospect evaluation for this study area was done by the USGS and USBM in 1979. A geologic map was published in 1981 (McKee and Howe, 1981); an aeromagnetic map in 1981 (Plouff and McKee, 1981); geochemical maps in 1981 and 1982 (Chaffee and others 1981, 1982) and a mineral-resource potential map and report in 1982 (McKee and others, 1982).

The rocks exposed in the study area are mostly Cretaceous plutons of the Sierra Nevada batholith. These granitic rocks have intruded and metamorphosed volcanic and sedimentary rocks of presumed Jurassic to Cretaceous age and several large, and numerous small, bodies of metamorphic rocks crop out as roof pendants within the granitic rock. Many of the ridges and peaks in the area are capped by Tertiary volcanic and sedimentary rocks, and a few prominent peaks are deeply eroded volcanic necks or complex dike swarms. The prevalent volcanic rock is andesite including lava flows and lahars. The sedimentary rocks contain a large amount of volcanic detritus and in places are almost entirely air fall ash deposits. The great variation in thickness, lenticular nature of units, and facies variations ranging from coarse fan-type deposits to thinly laminated, plant fossil-bearing siltstone indicate that there was considerable topographic relief in the Tertiary at the time these deposits accumulated. The Tertiary deposits and underlying rocks are now deeply eroded reflecting uplift of the Sierra Nevada and dissection by streams and glaciers.

MINERAL RESOURCES

The earliest reported mining activity in the study area centered around the Summit City mining district (northwest and west of Upper Blue Lake) where veins carrying silver minerals were prospected during the early 1860's and gravel along the head of Summit City Creek was worked for placer gold. The rush was short lived, however, and left no record of production.

[1]With contributions by Maurice A. Chaffee, USGS, and Edward L. McHugh, Eric E. Cather, Douglas F. Scott, and Clanton M. Rumsey, USBM.

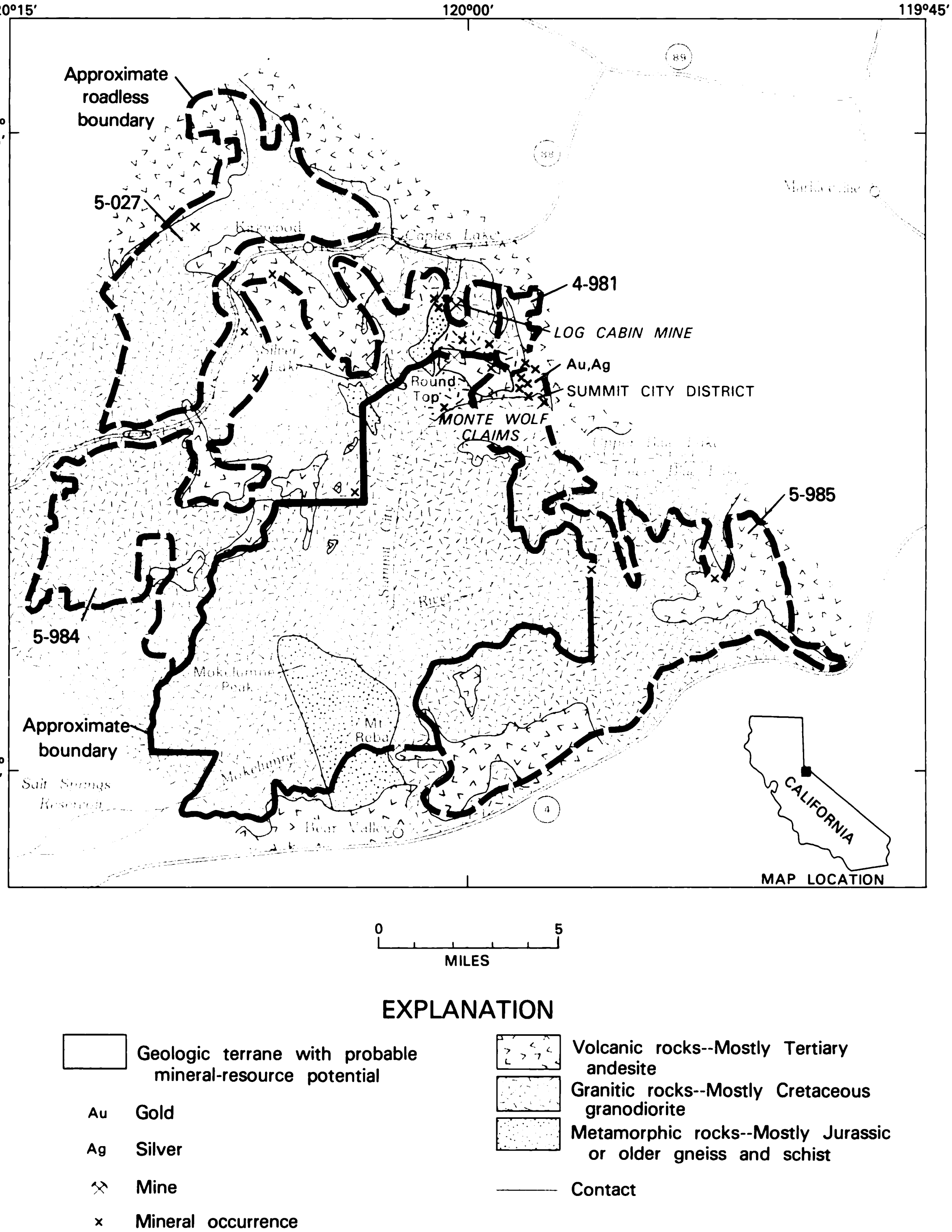

Figure 86.—Mokelumne Wilderness and adjacent roadless areas, California.

The only current mineral interest within the Mokelumne Wilderness is at the Monte Wolf property on the Mokelumne River above the mouth of Summit City Creek. It and several other scattered claims are undeveloped; they show little promise for the discovery of mineral resources.

At least 20 mining claims were located in the Caples Creek Roadless Area (5-027), mainly for uranium, during the 1950's. Interest focused on pegmatite dikes that emitted radiation counts above background levels. None of these occurrences is of high grade and they are not considered as resources. A few claims have been staked on quartz veins and stringers for precious metals but these structures contain no significant amount of metals.

No claims were identified within the Tragedy-Elephants Back Roadless Area (4-984); although a small amount of silver and gold was identified in one silicified zone, the zone is small and the grade is low.

At least 67 claims have been located within the Tragedy-Elephants Back Roadless Area (5-984) area since 1877. Two mines outside, but near the eastern border of the roadless area, have produced some gold, silver, copper, and lead. Neither mine is presently active and there is no evidence that their vein system extends into the roadless area. Geochemical sampling within the roadless area has not revealed significant concentrations of metal. There seems to be little promise for the discovery of mineral resources.

About 60 gold and silver claims and 28 uranium claims have been located in the Raymond Peak Roadless Area (5-985). Most gold-silver claims were at the head of Summit City Creek in the Summit City mining district and were located during the 1860's and early 1900's. None are active today. The uranium claims were explored between 1971 and 1979 mostly by drilling. Some uranium was found and subsequent sampling by the USBM revealed as much as 0.009 equivalent-weight percent of U_5O_8 in an ancient stream channel. No resource potential was identified.

Within the wilderness and adjacent lands only the area around Round Top seems to offer any potential for the occurrence of mineral resources and this area is of moderate interest at best. Geochemical sampling indicates a general enrichment in silver, gold, barium, bismuth, copper, iron, and lead in this vicinity. The area around Round Top is also the area in which most of the previous mining activity occurred and contains the Summit City mining district. The geologic setting, the anomalous metal values, and the particular suite of elements indicate that this is an area of hydrothermal alteration. The concentrations of metals are relatively low, however, in comparison with those detected in or near exposed mineral deposits. In general, average grades are low and metal distribution is erratic in the exposed mineralized quartz veins and shear zones that surround Round Top.

The complex sulfide ores mined from altered Tertiary volcanic rocks from districts east of the roadless areas are not known to occur in similar rocks within the study area. Tactite bodies in pre-Cretaceous rocks from districts east of the area contain scheelite and metallic sulfide minerals, but roof pendants within the Mokelumne Wilderness and adjacent roadless areas are less highly mineralized.

Samples from mineralized zones from several abandoned mines within or near the study area suggest probable potential for local gold and silver resources in quartz-filled shear zones near these sites. The vein systems are not large and the grades are not high.

SUGGESTIONS FOR FURTHER STUDIES

Any further exploration in the Mokelumne Wilderness and adjacent roadless areas should focus on the area around Round Top. The Log Cabin mine outside the roadless area is presently inaccessible but its relatively rich vein system may extend into the roadless area, although no evidence for this was seen. Drilling based on careful geologic mapping is the only feasible method to explore this vein system further.

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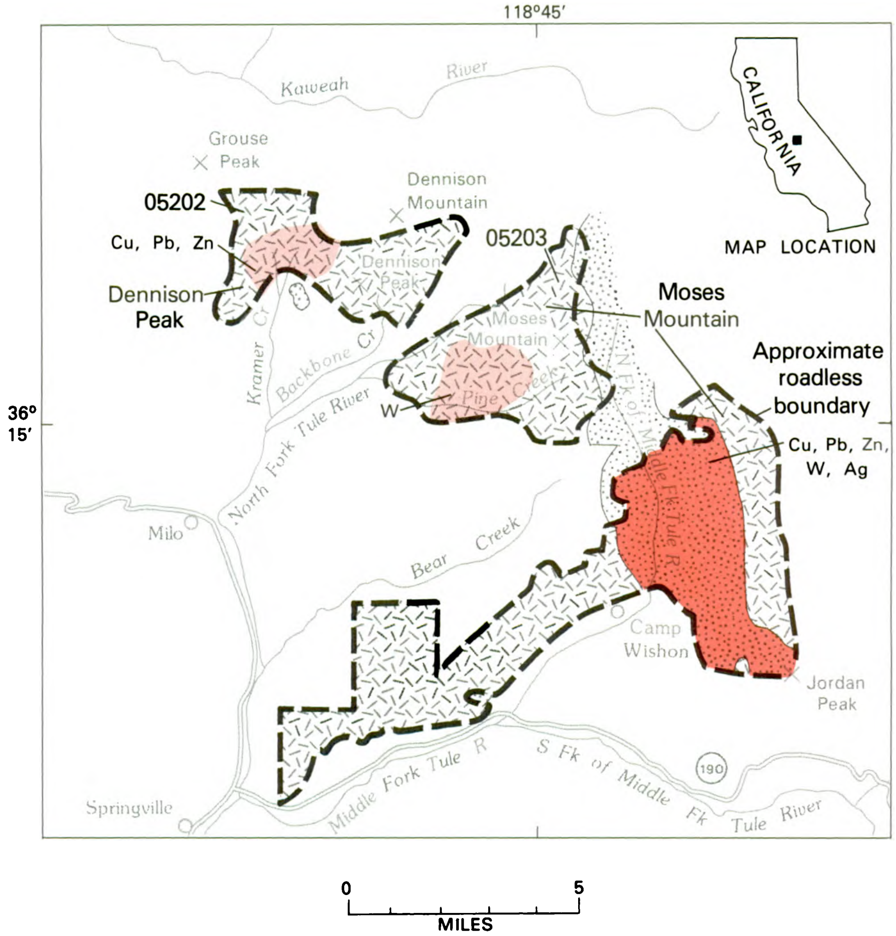

EXPLANATION

Geologic terrane with substantiated mineral-resource potential

Geologic terrane with probable mineral-resource potential

Cu Copper

Pb Lead

Ag Silver

W Tungsten

Zn Zinc

Granitic rocks of the Sierra Nevada batholith (Cretaceous and Jurassic)

Metasedimentary and metavolcanic roof pendant (Middle Jurassic to Upper Triassic)

Contact

Figure 87.—Moses and Dennison Peak Roadless Areas, California.

MOSES AND DENNISON PEAK ROADLESS AREAS, CALIFORNIA

By RICHARD J. GOLDFARB,[1] U.S. GEOLOGICAL SURVEY, and

DAVID A. LIPTON, U.S. BUREAU OF MINES

SUMMARY

A mineral-resource survey was conducted by the USGS and USBM between 1979 and 1982, in the Moses and Dennison Peak Roadless Areas, southeastern Sierra Nevada, California. One area within the Moses Roadless Area is classified as having substantiated mineral-resource potential for small base-metal skarn deposits. Additionally, geochemical data indicate probable potential for small base-metal skarn deposits from one locality within Dennison Peak Roadless Area and for small tungsten skarn deposits from a region within Moses Roadless Area. The geologic setting precludes the presence of energy resources.

CHARACTER AND SETTING

Moses Roadless Area includes 38 sq mi and Dennison Peak Roadless Area 10.5 sq mi in the southern Sierra Nevada of California, southeast of Sequoia National Park. Both roadless areas are contained totally within Sequoia National Forest. They are characterized by extreme relief and dense vegetation. The North Fork of the Tule River and the Dillonwood Sequoia Grove property separate Dennison Peak Roadless Area from the northern part of Moses Roadless Area. Moses Roadless Area is bisected by the Mountain Home State Forest.

Most of the exposed rocks within Moses and Dennison Peak Roadless Areas are Jurassic to Cretaceous plutons of the Sierra Nevada batholith. Granodiorite and alaskite are the most abundant intrusive rock types, but quartz diorite, diorite, and gabbro are also observed. Contacts between plutons are generally sharp but between some bodies agmatitic zones are present.

Metasedimentary and metavolcanic rocks enclosed by plutons of granitic to gabbroic composition underlie about fifteen percent of the combined roadless areas and occur mostly as roof pendants along the North Fork of the Middle Fork of the Tule River and as small septa along the margins of plutons. Rock types in the pendant include thinly bedded quartzite and pelite, podiform limestone, minor basaltic dikes, and, in the eastern portion, abundant porphyritic volcanic rocks that have been regionally metamorphosed to mid- to upper-greenschist facies. Subsequently, thermal metamorphism produced hornfels-grade assemblages adjacent to granitic and granodioritic plutons, and slightly higher grade assemblages near dioritic and gabbroic plutons. The metamorphic rocks are classified as a portion of the Tule River pendant within the Upper Triassic to Middle Jurassic (Saleeby and others, 1978).

MINERAL RESOURCES

Mineralized skarns in the Sierra Nevada province are common in regions characterized by roof pendants and septa of metasedimentary and metavolcanic rocks within the surrounding batholithic terrains. Contact metasomatic deposits of tungsten, lead-zinc-silver, and occasionally copper are found throughout the Sierra Nevada. The Mineral King district, approximately 15 mi northeast of Moses Mountain, contains complex sulfides of copper, lead, zinc, and silver within metasedimentary host rocks. The Pine Tree mine, 8 mi to the east of Moses Mountain and within the boundaries of the adjacent Golden Trout Wilderness, is presently producing minor amounts of scheelite from the Mineral King roof pendant. Additionally, minor scheelite was reportedly taken from the Royal Tungsten, Martin, and Good Hope mines, located within contact zones northwest of Dennison Peak Roadless Area.

One mine and 3 prospects, the Powell mine, the King Solomon prospect, and the Helen-Joyce prospects, are located within the eastern portion of the southern part of Moses Roadless Area (Lipton, 1983; Goldfarb and others, 1983). Very little production has been recorded

[1]With contributions from David Leach, Michael Sawlan, and Suzanne Smaglik, USGS.

from these occurrences. Most of the mineralization is represented by silver, copper, and zinc minerals, and occurs in skarn-type deposits within the metasedimentary rocks in quartz veins or epidote-rich zones within calcareous layers adjacent to granodiorite. The chief gangue minerals are garnet, epidote, hornblende, actinolite, feldspar, calcite, and quartz.

The mineralized area is characterized geochemically by anomalously high amounts of silver, zinc, boron, and bismuth in stream sediment and associated nonmagnetic, heavy-mineral concentrate samples. Although chalcopyrite is reported from some of the known mineral occurrences within the area, the sediment and concentrate samples showed relatively little copper enrichment. On the basis of the abundance of favorable host lithology, geochemical reconnaissance work, and the examination of known prospects, part of the southeastern Moses Roadless Area has substantiated resource potential for small zinc-silver-lead(?) skarn deposits, and to a lesser extent for small copper and iron skarn deposits.

Two other localities within Moses and Dennison Peak Roadless Areas have probable mineral-resource potential. Both localities appear to be underlain by intrusive rocks, but small septa of metamorphic rocks could be present, hidden by the thick soil cover. The anomalous geochemical signatures of the sediment samples from these two localities are quite similar to those indicative of base-metal and tungsten-bearing skarns from elsewhere in the Sierra Nevada.

One of the two areas is found between Backbone and Pine Creeks within the northern part of Moses Roadless Area. Nonmagnetic, heavy-mineral-concentrate samples are enriched in tungsten and bismuth. The concentrations of these elements at this locality are similar in magnitude to those surrounding the Pine Tree mine within the Little Kern River watershed, about 8 mi to the east (Leach and others, 1982). Minor scheelite along contacts between alaskite and small, unexposed metamorphic septa are likely in this part of the Moses Roadless Area.

A very strong geochemical anomaly is located around Kramer Creek, within the western part of Dennison Peak Roadless Area. Stream-sediment and associated heavy-mineral-concentrate samples are enriched in silver, arsenic, gold, lead, and boron. This area is underlain by a mafic granodiorite but lies within 2 mi of the Good Hope mine, characterized by metasomatic scheelite. Based on the geochemical evidence, this area has probable mineral-resource potential for small base-metal-bearing skarn deposits.

SUGGESTIONS FOR FURTHER STUDIES

Future studies of these roadless areas should emphasize detailed mapping of the metamorphic lithologies, to better define the calcareous host rocks favorable for mineralization related to contact metasomatism. The thick soil cover, however, may restrict such mapping in many places. Within the two areas of probable mineral-resource potential, detailed soil geochemistry surveys might aid in the location of the source of the stream-sediment anomalies. It must be noted that all production from the mines and prospects within and adjacent to Moses Roadless Area and Dennison Peak Roadless Area has been quite minor. Hence, future mineral discoveries within these wildernesses are expected to be similar.

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MOUNT EDDY AND CASTLE CRAGS ROADLESS AREAS, CALIFORNIA

By JOCELYN A. PETERSON,[1] U.S. GEOLOGICAL SURVEY, and

DAVID K. DENTON, JR., U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Mount Eddy and Castle Crags Roadless Areas, California, conducted in 1981 and 1982 shows probable mineral-resource potential for chromite and gold on the basis of local occurrences of these minerals and favorable geologic environment within the roadless areas. There is also geochemical evidence for mineralization, but surface evidence is scant. Although asbestos and copper minerals are present in the areas and the geologic environment is favorable for nickel and platinum-group metals, no resource potential for these was identified. No energy resources were identified in the study of the roadless areas.

CHARACTER AND SETTING

The Mount Eddy and Castle Crags Roadless Areas occupy 15 sq mi and 5 sq mi, respectively, in Shasta, Siskiyou, and Trinity Counties, California, approximately 8 mi west of the towns of Mount Shasta City and Dunsmiur. The areas are located in rugged terrane in the easternmost part of the Klamath Mountains where altitudes range from about 2500 ft in the southern Castle Crags Roadless Area to 9025 ft atop Mount Eddy. Interstate 5 passes east of the areas and secondary roads and trails provide access.

The Mount Eddy Roadless Area and the southern Castle Crags Roadless Area are underlain by ultramafic rocks of the Trinity ultramafic sheet, the largest such mass in the United States. This ultramafic body is composed primarily of harzburgite, dunite, and plagioclase lherzolite. Dunite occurs as small pods and large tabular masses. The ultramafic mass has been intruded by large bodies of gabbro, one of which underlies most of the northern Castle Crags Roadless Area, and smaller stocks and plugs of hornblende diorite, prevalent in the northern portion of the Mount Eddy Roadless Area (Quick, 1981; Throckmorton, 1978). Between and extending east of the two parts of the Castle Crags Roadless Area is a large granitic pluton which has formed the striking topography of Castle Crags (Vennum, 1971). Plugs and dikes related to the Castle Crags pluton intrude the ultramafic rocks and gabbro in the northern part of the Castle Crags Roadless Area. All of the units described are considered to be of Paleozoic age although exact times of formation are still unknown. The ultramafic rocks have undergone serpentinization which becomes more prevalent in the southern part of the mapped area. Quartz veining is common in gabbro and hornblende diorite. Faulting within the area strikes west to northwest and is usually characterized by a serpentinized shear zone several feet wide. Asbestos fibers have developed in some of the shear zones.

The Mount Eddy Roadless Area underwent glaciation during the Pleistocene Epoch and remnants of glacial material can be found at altitudes above about 4500 ft. Additionally, spectacular glacial topography was developed around Mount Eddy leaving razor sharp ridges, broad U-shaped valleys, and numerous cirque lakes or tarns. Snow remains at the higher altitudes throughout most of the year.

MINERAL RESOURCES

Ultramafic rocks such as the ones found in the Mount Eddy and Castle Crags Roadless Areas may contain a variety of mineral commodities including chromium, nickel, cobalt, platinum-group elements, and asbestos. Sometimes gold is found in quartz veins coursing through ultramafic rocks. Many of these elements may also be found in lateritic soil overlying ultramafic rocks. Of these commodities chromium (in the mineral chromite) and asbestos have been found in sufficient

[1]With contributions from Mary E. Caress, USGS, and James M. Spear, USBM.

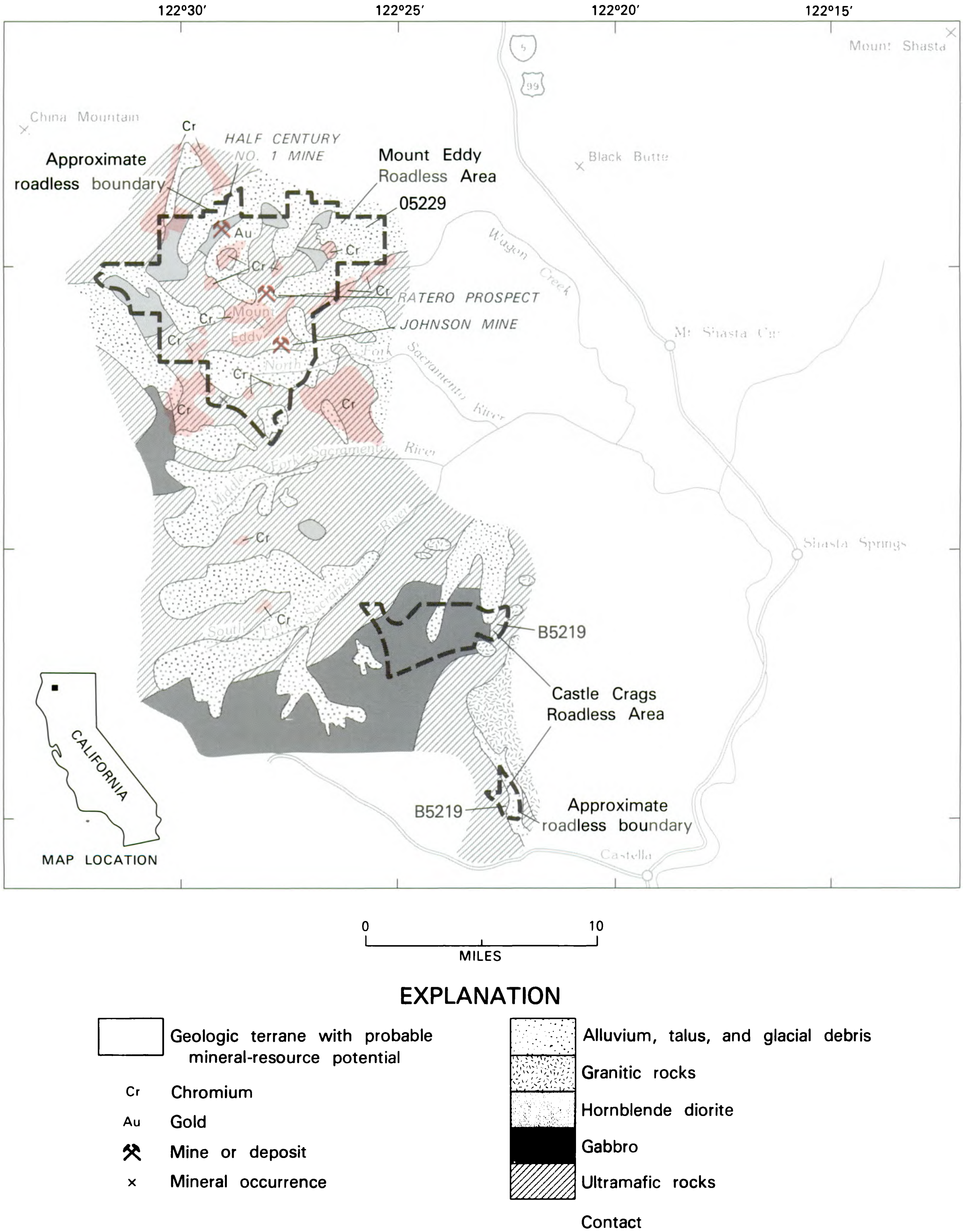

Figure 88.—Mount Eddy and Castle Crags Roadless Areas, California.

amounts to mine in localities within 5 mi of the roadless areas.

One known chromite mine, the Johnson mine, occurs within the Mount Eddy Roadless Area, southeast of Mount Eddy. It produced an unrecorded amount of chromium during the 1940's from a dunite body in a shear zone of serpentinized peridotite. Potential exists for occurrence of chromite resources in the shear zone. A grab sample from the remaining stockpile assayed 39.8 percent Cr_2O_3. The Ratero prospect, northeast of Mount Eddy, contains a chromite pod 16 in. wide exposed for 40 ft in serpentinized peridotite. A sample assayed 38.1 percent Cr_2O_3 and it is estimated that the pod contains 260 tons of demonstrated chromite resources. The Bagley mine about 2 mi north of the Mount Eddy Roadless Area was estimated in 1943 to contain possibly 2500 tons of ore. The deposits occur as banded chromite and dunite or disseminated ore. It is not likely that large surface deposits will be found because the area has been well prospected. Areas of chromite-bearing dunite occur in the Mount Eddy Roadless Area, particularly in the southern part; however, these areas are small and the occurrences low grade. The largest of these, that contain visible chromite, is south-southwest of Mount Eddy. All areas of dunite, however, are considered to have probable potential for chromium because no subsurface exploration has taken place.

Surface exploration for asbestos has also been thorough. Like the chromite deposits, the known asbestos deposits are small. The usual asbestos mineral is chrysotile, a form of serpentine, but one property south of the Castle Crags Roadless Area contains the amphibole asbestos anthophyllite. The asbestos fibers range from brittle to flexible and fiber lengths are 1/16 in. to 3/4 in. Some deposits contain slip-fiber asbestos while others contain cross-fiber asbestos. Within the Mount Eddy Roadless Area and the southern part of the Castle Crags Roadless Area asbestos minerals are frequently seen in talus debris and occasionally in shear zones as small cross-fiber veinlets as much as 1 in. wide and 2 ft long. No potential for asbestos resources was identified in areas having asbestos occurrences.

Geochemical data indicate no anomalous occurrences of the commodities mentioned previously, except for gold (Peterson, 1983; D. K. Denton, Jr., unpub. data, 1983). Stream-sediment data for barium, boron, and mercury indicate the imprint of hydrothermal activity on the gabbro and hornblende diorite units. This hydrothermal event may have also been responsible for forming quartz veins. A small amount of gold was found in two of the stream-sediment concentrate samples. This gold was probably derived from the numerous quartz veins cutting the gabbro, hornblende diorite, and to a lesser extent ultramafic rocks and an analysis of a sample from one of the veins showed 0.271 oz gold/ton. This sample was collected down slope from the Half Century No. 1 prospect, northwest of Dobkins Lake, where the quartz occurs as discontinuous, irregular, vuggy iron-stained lenses averaging 5 in. wide. The quartz contained small amounts of chalcopyrite, bornite, and malachite, and spectrographic analysis of a quartz sample indicated 700 parts per million copper. Another known gold prospect occurs in a quartz vein 2 mi southwest of the northern part of the Castle Crags Roadless Area.

There may be low-grade nickel mineralization in the northern part of the Mount Eddy Roadless Area based on data from dunite samples. As the values are not particularly high (3000 parts per million), however, they may represent background variation. Lacking the presence of nickel-bearing sulfide minerals, a potential for nickel was not identified. Analyses by Quick (1981) of olivine samples show that nickel oxide is present in olivine structures; olivine is a common mineral in the dunite in the Mount Eddy Roadless Area. Nickel-bearing laterite occurrences bordering the Castle Crags Roadless Area are too low grade to constitute a resource.

SUGGESTIONS FOR FURTHER STUDY

The area around and including the roadless areas has been heavily prospected in the past and further exploration offers little promise of finding new surficial deposits. If geophysical methods to detect buried chromite deposits become available, further exploration for chromite may be warranted.

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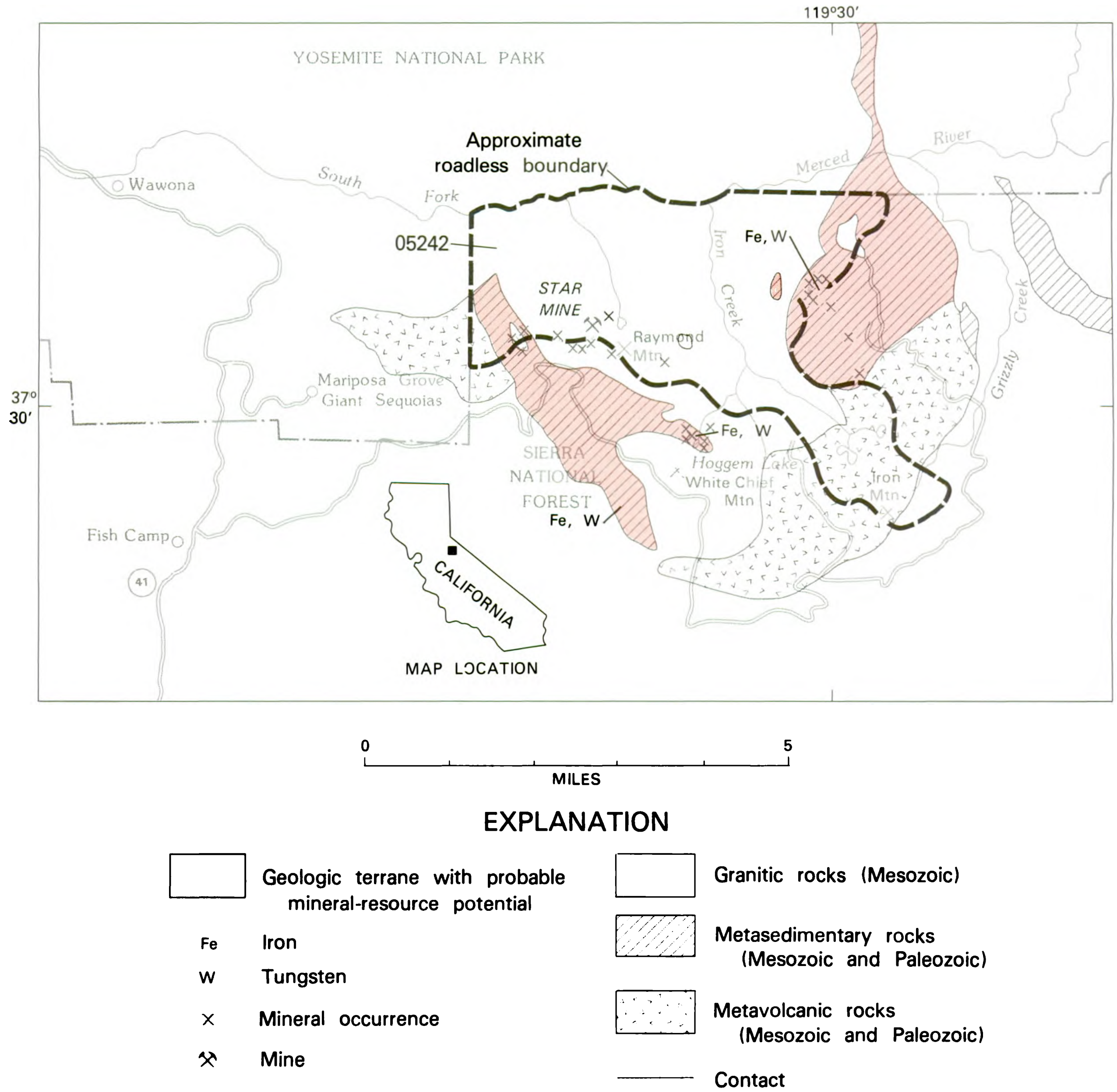

Figure 89.—Mount Raymond Roadless Area, California.

MOUNT RAYMOND ROADLESS AREA, CALIFORNIA

By N. KING HUBER,[1] U.S. GEOLOGICAL SURVEY, and

DONALD O. CAPSTICK, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Mount Raymond Roadless Area in the central Sierra Nevada, California, was conducted by the USGS and USBM during 1980–82. Areas of probable resource potential for tungsten associated with iron-bearing rocks adjacent to the roadless area extend into the eastern and southwestern parts of the roadless area. No energy resource potential was identified in the study.

CHARACTER AND SETTING

The Mount Raymond Roadless Area is in the central Sierra Nevada adjacent to the south boundary of Yosemite National Park. The area is small, but rugged; it encompasses about 10.5 sq mi and has a relief of 4400 ft, culminating at 9165 ft at Iron Mountain. Much of the area at lower altitudes is forested, but the higher parts support only scattered growth because of precipitous slopes or other adverse conditions. The area is accessible by a road from Fish Camp that roughly parallels the roadless area boundary on the south and east. Bedrock is well exposed on ridges and in glacial cirques, but most of the forested area is covered by talus and slopewash and locally by glacial moraine.

The Sierra Nevada is a large block of the Earth's crust that has been uplifted and tilted westward by an extensive system of high-angle faults on its east side. Most of the central Sierra is composed of Mesozoic granitic plutons that constitute the Sierra Nevada batholith. The batholith intruded Paleozoic and Mesozoic strata, remnants of which are preserved as roof pendants, septa, and inclusions within the batholith. Granitic rocks underlie more than 80 percent of the Mount Raymond Roadless Area. Metamorphic rocks are largely confined to the southwest corner and the eastern margin of the area, including a southeastern prong.

[1]With contributions from Maurice A. Chaffee and Andrew Griscom, USGS, and Stephen R. Iverson, USBM.

MINERAL RESOURCES

The Mount Raymond Roadless Area and vicinity have two types of metallic mineral occurrences. One consists of silver-lead-zinc minerals, and the other of various iron minerals. Some of the iron-rich mineral occurrences apparently also include tungsten minerals. Both types of occurrences have a history of prospecting dating back to at least the early 1880's.

Silver, lead, and zinc occur as sulfide minerals in a small complex of alaskite dikes near Raymond Mountain. The known occurrences are discontinuous within the dikes, and are no more than 50 ft in maximum dimension. The only significant surface occurrence was developed as the Star mine in 1888–1889. After three unsuccessful attempts to operate profitably, the mine has remained idle since about 1908. Records of concentrates shipped or metal produced are not available, but production is not thought to have been significant. Although the presence of sulfide mineralization in the Star mine area suggests the area has a substantiated resource potential, this classification would be possible only if significant additional subsurface mineral zones were likely. Due to their character, the surface occurrences do not lend themselves to projection at depth.

Occurrences of iron-rich minerals, particularly magnetite and hematite, are scattered southwest, south, and east of Raymond Mountain. These deposits were prospected during the same period as were the silver-lead-zinc occurrences. Although several patents were granted on these claims during the early 1900's, little has been done to develop them; none of the patented claims are within the roadless area. The iron-bearing zones occur in highly altered metasedimentary rocks of both quartzose and calc-silicate (tactite) types. These occurrences are widespread, but are spotty, variable in size, and have indistinct boundaries. The altered rock is oxidized and disaggregated and it is difficult to determine from natural exposures what metallic minerals other than magnetite and hematite might be present. Panned concentrates of stream-sediment samples from streams draining these areas of altered metasedimentary rock commonly contain anomalous amounts of an element suite (boron, bismuth, molybdenum, tin, tungsten) considered to characterize tungsten mineralization. This suggests that at least some of the iron-rich rocks could contain possibly significant amounts of tungsten (Huber and Chaffee, 1983). All of the area underlain by metasedimentary rock is shown on the map as geologic terrane with probable resource potential for iron and tungsten because some of these rocks are known to contain iron-bearing zones; the iron-bearing zones have not been specifically delineated and much of the metasedimentary terrane probably has no resource potential.

SUGGESTIONS FOR FURTHER STUDY

The geochemical survey was a limited reconnaissance. Nevertheless, anomalous amounts of tungsten and tungsten-related elements in stream-sediment concentrates from streams draining areas of altered metasedimentary rock indicate the presence of tungsten mineralization, although no specific sources have been identified. A more detailed geochemical survey might help to better delineate possible source areas for the anomalous tungsten.

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MOUNT SHASTA WILDERNESS STUDY AREA, CALIFORNIA

By ROBERT L. CHRISTIANSEN[1], U.S. GEOLOGICAL SURVEY, and

ERNEST T. TUCHEK, U.S. BUREAU OF MINES

SUMMARY

The Mount Shasta Wilderness study area was surveyed in 1975. It lies wholly on the slopes and summit area of Mount Shasta and consists almost entirely of the products of geologically young volcanism. Small deposits of volcanic cinders and pumice are present. The volcanic system of Mount Shasta is judged to have probable resource potential for geothermal energy but that potential is least within the wilderness study area boundaries. Because any geothermal energy resource beneath the volcano would lie at considerable depths, exploration or development would be most likely at lower altitudes on the gentler slopes outside the study area.

CHARACTER AND SETTING

Mount Shasta is the largest high conical volcano of the Cascade Range. The volcano rises to 14,162 ft, far above its 3000-ft base and the generally 5000–8000-ft mountains of the region, making it the dominant natural feature of northern California. The communities of Weed, Mount Shasta, and McCloud lie at the base of the mountain, and Interstate Highway 5 and U.S. Highway 97 flank it on the west and north. Other state highways and unpaved roads provide access to the wilderness study area from all sides. The study area occupies mainly the upper slopes of the mountain near and above timberline, which is generally at about 9500 ft; on the northwest, the study area extends to near the level of the Southern Pacific Railroad at about 5000 ft.

The volcanic edifice of Mount Shasta grew by the successive eruptive emplacements of hundreds of lava flows and by associated mudflows and other fragmental deposits in at least four, and probably more, major cone-building episodes. Growth of the volcano has been geologically recent, having occurred within about the past 500,000 years; most of the present edifice has grown since about 250,000 years ago. The two youngest major cone-building episodes occurred within the past 10,000 years. During those last 10,000 years, significant eruptions have occurred on the average of at least once every 800 years; during the past 4500 years they have occurred about once every 600 yrs (Miller, 1980). The youngest known eruptions probably occurred during the latter half of the 18th century. Two areas of small sulfurous fumaroles (steam vents) occur near the summit of the volcano, and one of them includes a small acid hot spring.

Throughout its evolution, during times between the major cone-building episodes, Mount Shasta has erupted dacites, lavas whose compositions are commonly thought to reflect the residence of magmatic liquids at relatively high levels in the Earth's crust for considerable periods of time. Intermittent volcanic eruptions during the generally erosional periods between major cone-building episodes also produced several small cinder cones and moderately extensive deposits of pumice.

An aerial survey of the Earth's magnetic field in the area of Mount Shasta indicates a significant linear structural control for some eruptive vents of the volcano along a north-trending zone through the summit. Interpretation of the magnetic-field variations also indicates that a zone beneath the main summit area of the volcano induces a smaller field intensity than would be expected if the entire volcanic edifice were uniformly magnetized (Blakely and Christiansen, 1978).

MINERAL RESOURCES

Metallic mineral resources are commonly found to be associated with the formerly deeply buried parts of old volcanic systems that may once have been similar to

[1]With contributions from Frank J. Kleinhampl and Richard J. Blakely, USGS, and Fredrick L. Johnson and Martin D. Conyac, USBM.

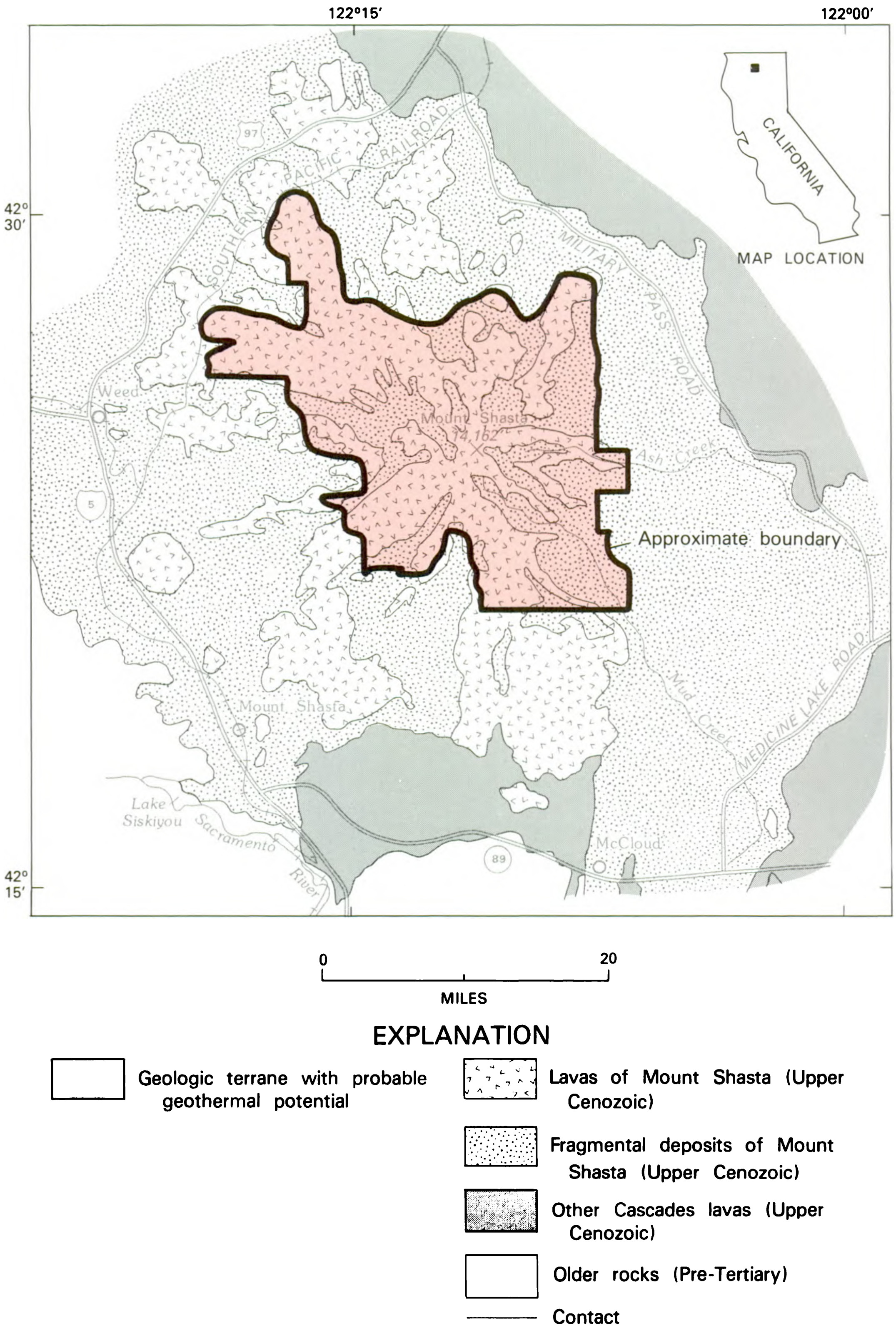

Figure 90.—Mount Shasta Wilderness study area, California.

Mount Shasta. Such metallic deposits, however, generally are accessible to development only after deep erosion has removed much or all of the surficial volcanic edifice, exposing rocks of types that would now lie many thousands of feet below the surface of Mount Shasta. Young volcanoes of this type, even where they have been altered by hydrothermal activity (the hot waters and volcanic gases that can transport metallic constituents in solution), are typically barren of significant mineral deposits. Small areas of intense but localized hydrothermal alteration have been recognized near the original central vents of the four recognized cone segments of Mount Shasta but virtually nowhere else. Metallic trace elements are nowhere found to be significantly above background values (Christiansen and others, 1977). Parts of the wilderness study area have been prospected previously for mineral deposits, and three unworked prospects were located in the area. No resources were found.

Although there are several cinder cones on the lower flanks of the volcano, very few of them occur within the wilderness study area. Minor deposits of cinders and moderately extensive pumice do occur, but they lie on steep slopes and are accessible only with difficulty while more extensive deposits are readily accessible nearby.

A probable resource potential is judged to exist within the study area for geothermal energy. The geologic elements necessary for commercial development of geothermal resources are a source of heat within the Earth, water to provide a medium for the transferral of heat from its source to a point of extraction, and an aquifer or some suitable structure to control the appropriate subsurface movement of this hydrothermal fluid. Several factors suggest that a suitable geothermal heat source exists beneath Mount Shasta: volcanic activity has been intermittent for about 500,000 years, the most recent activity has been within about the past 200 years, magma-filled chambers probably have formed repeatedly at high crustal levels beneath the volcano to produce its dacitic lavas, fumaroles remain active near the summit of the volcano, and the anomalously low magnetic intensity of the summit zone may reflect a high temperature at shallow depth beneath that part of the volcano (Blakely and Christiansen, 1978).

Despite the likely presence of a heat source, several factors are unfavorable for the occurrence of geothermal energy at Mount Shasta. The volcanic edifice itself consists mainly of highly fractured or porous materials that generally retain ground water only poorly, and meltwater from the extensive winter snowfields of the mountain percolate readily downward. Consequently, few permanent streams drain the slopes of the volcano, and only parts of two of them, Mud Creek and Ash Creek on the south and east flanks, maintain substantial year-round flows. Thus, the shallow parts of the volcanic system are readily flushed by downward-percolating cold waters. There are no hot springs other than the small one near the summit, and no other significant manifestations of hot water at shallow depths are known in or immediately around the volcano. Thus, if a hidden geothermal system exists, it would not likely be high within the volcanic edifice itself but rather within the Earth's crust beneath it. It could be investigated only by deep drilling, and such drilling would be difficult or impractical from the high altitudes or the steep and unstable slopes typical of the parts of the mountain where most of the wilderness study area lies.

SUGGESTIONS FOR FURTHER STUDIES

Further studies within the Mount Shasta Wilderness study area are unlikely to reveal significant new information on its mineral-resource potential. The only important potential judged to exist—for geothermal energy—probably is least within the wilderness study area. The potential for geothermal resources, both within the study area and in the larger area around the lower flanks of Mount Shasta, probably can best be evaluated by further work in the surrounding area. Ultimately, only drilling can test the geothermal resource potential definitively, but careful chemical and isotopic studies of surface and subsurface waters around the base of the volcano might shed additional light on the possibility that hydrothermal waters circulate actively beneath and around the volcano.

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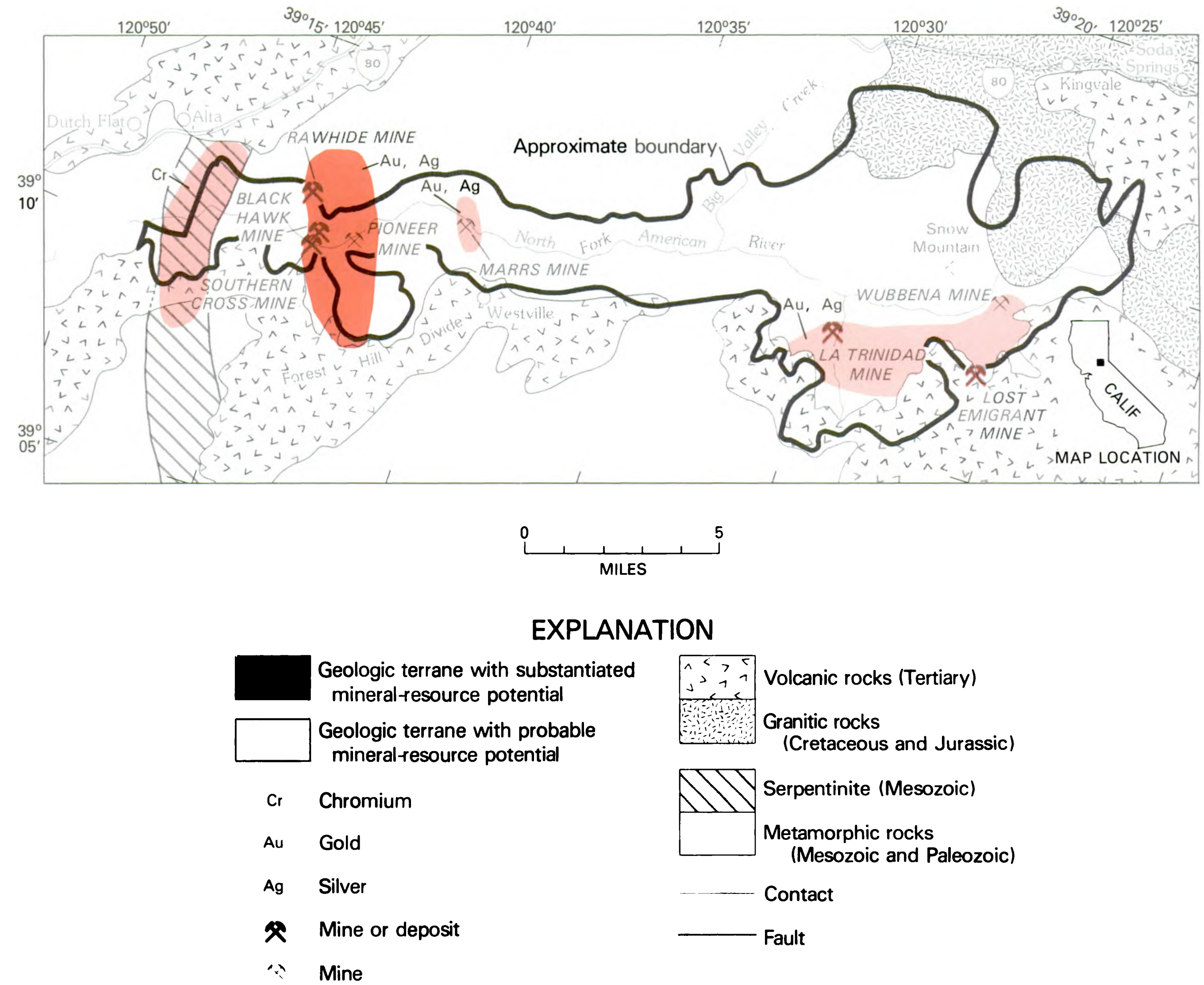

Figure 91.—North Fork of the American River Wilderness study area, California.

NORTH FORK OF THE AMERICAN RIVER WILDERNESS STUDY AREA, CALIFORNIA

By DAVID S. HARWOOD, U.S. GEOLOGICAL SURVEY, and

FRANCIS E. FEDERSPIEL, U.S. BUREAU OF MINES

SUMMARY

Mineral-resource surveys of the North Fork of the American River Wilderness study area, conducted between 1975 and 1979, have identified a zone of substantiated resource potential for gold and silver within the western 6 mi of the area between the Rawhide and Pioneer mines. Zones of probable gold and silver potential occur in the eastern part of the area between the Wubbena and La Trinidad mines and locally around the Marrs mine. A zone with probable chromium potential occurs in the serpentinite belt along the western border of the area. No energy resources were identified in this study.

CHARACTER AND SETTING

The North Fork of the American River Wilderness study area encompasses about 77 sq mi along one of the major drainages on the west slope of the Sierra Nevada located generally between Donner Pass (alt. 7088 ft) and Sacramento, California. From an altitude of 5200 ft at its eastern boundary, the study area extends westward 24 mi down the river canyon to an altitude of 2000 ft just south of the settlements of Dutch Flat and Alta, early gold mining camps of the Mother Lode district. The western two thirds of the area is confined to the extremely steep, brush-covered river canyon, where local relief approaches 3000 ft. The eastern third of the area extends north of the canyon into less steep, relatively open glaciated terrane that provides spectacular vistas of sharp peaks along the Sierran crest, about 4 mi to the east. Interstate Highway 80 generally parallels the North Fork of the American River and passes within a few miles of the northern boundary of the study area at several points between Alta and Soda Springs.

Mineral-resource surveys were conducted in the area intermittently between 1975 and 1979, and a detailed evaluation of the mineral-resource potential has been published by Harwood and others (1982).

The Sierra Nevada is a north-trending uplifted and westward-tilted range bounded on the east by an active fault system that has been the focus of several large earthquakes during historic time. However, this relatively young period of faulting and uplift is only the most recent phase of deformation in a complex geologic history that has shaped the range over the past several hundred million years. One of the most significant events in its geologic history, with respect to the mineral-resource potential of the Sierra Nevada, was the protracted intrusion of large masses of granitic rock into a variety of older sedimentary and volcanic rocks that form the framework of the range. The granite metamorphosed the country rocks and hydrothermal solutions locally deposited gold-bearing quartz veins. Following intrusion of the granitic masses, while the range underwent uplift and erosion, ancient rivers concentrated gold from widely distributed quartz veins into channelized placer deposits. Vast amounts of volcanic rocks, erupted from vents along the eastern range-front fault system, then blanketed the western slope of the Sierra Nevada and covered the ancient placer deposits. As uplift continued, modern rivers cut through the volcanic cover, exhumed the buried placer deposits, and further concentrated the gold from ancient placers into new channel gravels.

After gold was discovered at Sutter's Mill on the South Fork of the American River in 1849, mining activity spread rapidly to all drainages on the west slope of the Sierra Nevada. Initial efforts of the forty-niners were concentrated on panning and sluicing the modern river gravels, but operations progressed rapidly to hydraulic mining of ancient placers, exposed high up on the canyon walls, and eventually to underground mining of lode deposits found primarily in gold-bearing quartz veins and the adjacent country rock.

MINERAL RESOURCES

Because of its proximity to Sutter's Mill, it is not surprising that approximately 1100 lode and 900 placer claims and relocations have been filed in the North Fork of the American River Wilderness study area since 1866. Most historic gold and silver lode production occurred in the western part of the area from the Rawhide, Black Hawk, and Southern Cross mines, which yielded 31,000 troy oz of gold, 4000 troy oz of silver and 19,000 lbs of copper. More than 85 percent of that production came from the Rawhide mine. In addition, the Pioneer mine, located just south of the proposed boundary of the study area, produced 50,000 troy oz of gold and 9000 troy oz of silver between 1899 and 1922.

These mines occur in a north-trending zone of altered rock pervasively cut by quartz veins. Based on past production and the geologic setting, these mines clearly define a zone of substantiated mineral-resource potential for gold and silver. It is estimated that 1.4 million tons of demonstrated lode resources averaging 0.04 to 0.22 oz of gold per ton occur at and near the Rawhide, Black Hawk and Southern Cross mines and that an additional 6 million tons of gold resources may occur in a mineralized zone of substantiated gold and silver resource potential between the Rawhide and Pioneer mines.

The Lost Emigrant, La Trinidad, and Wubbena mines in the eastern part of the study area have produced about 5000 troy oz of gold, 730 troy oz of silver, and 480 lbs of copper since the 1850's. The Lost Emigrant mine has a demonstrated gold resource of 270,000 tons averaging about 0.27 troy oz of gold per ton and La Trinidad mine has a demonstrated gold resource of 150,000 tons averaging about 0.17 troy oz of gold per ton. Based on past production and geologic setting, the area between the Wubbena and La Trinidad mines is considered to have a probable gold resource potential. From bedrock and geochemical sampling, it is estimated that the area around the Marrs mine also has a probable gold resource potential.

About 1000 short tons of chrome were produced from the serpentinite belt at the western end of the study area during World Wars I and II. Much of that production occurred at the surface of the serpentinite belt where the rock was deeply weathered and the chrome-bearing minerals had been naturally concentrated by the weathering process. From this we conclude that the serpentinite belt has a probable chrome resource potential.

SUGGESTIONS FOR FURTHER STUDIES

Clearly the hard work was done by the forty-niners and their followers who found and developed the deposits. Our studies have confirmed what they discovered, but more exploration work, especially at depth, is necessary to completely delineate gold deposits in the area.

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NORTH FORK SMITH RIVER ROADLESS AREA, CALIFORNIA AND OREGON

By FLOYD GRAY, U.S. GEOLOGICAL SURVEY, and

MICHAEL HAMILTON, U.S. BUREAU OF MINES

SUMMARY

Geologic, geochemical, and geophysical investigations and a survey of mines and prospects were conducted in 1980-82 to evaluate the mineral-resource potential of the North Fork Smith River Roadless Area. The North Fork Smith River Roadless Area has probable and substantiated resource potential for nickel, chromium, copper, and mercury and approximately 2300 mining claims exist in or adjacent to the area. The geologic terrane precludes the occurrence of fossil fuel resources.

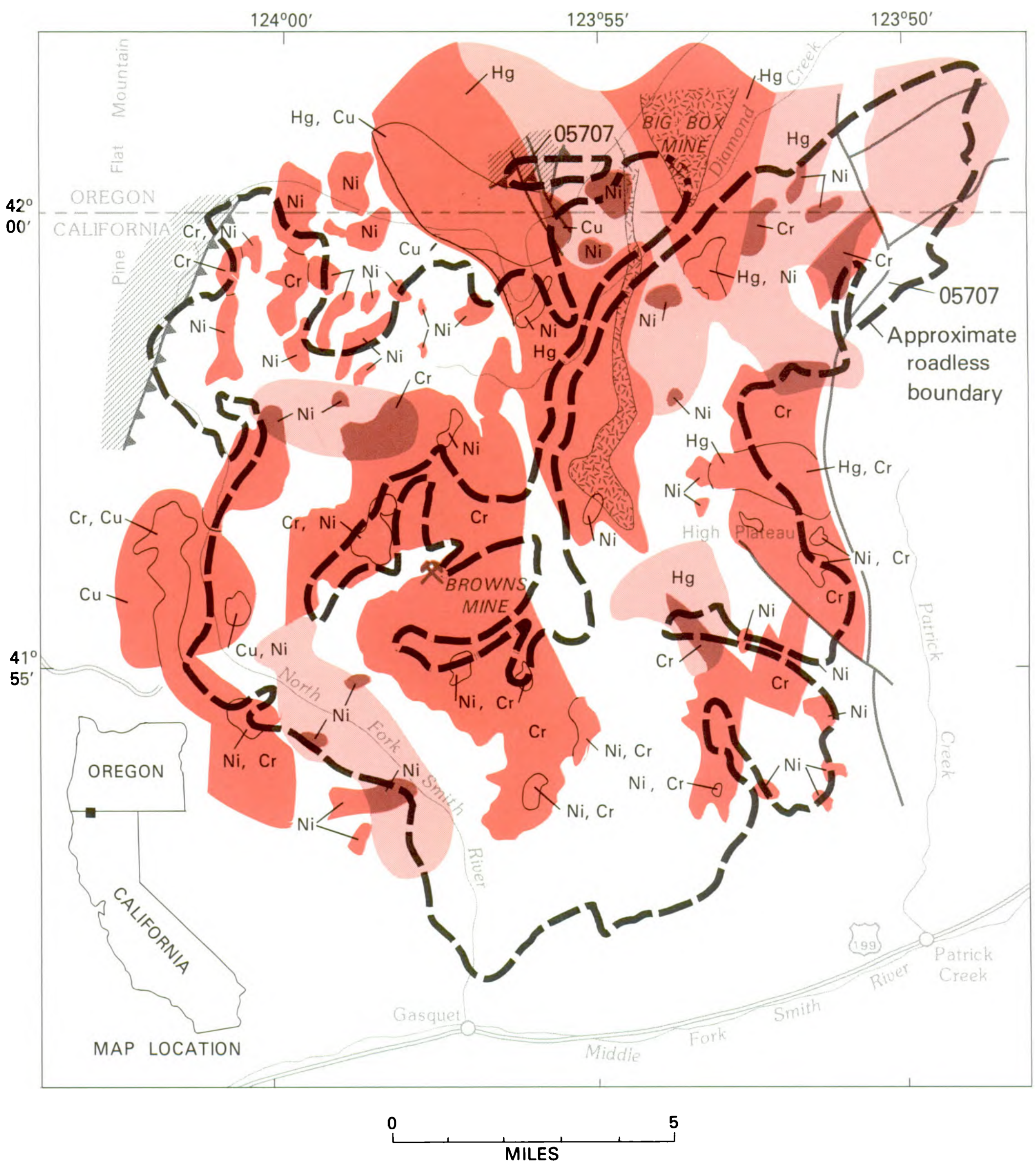
CHARACTER AND SETTING

The North Fork Smith River Roadless Area in Del Norte County, California, and Josephine County, Oregon, is an oval-shaped area of approximately 63 sq mi within Six Rivers and Siskiyou National Forests. It extends from the ridge just west of the North Fork Smith River to Patrick Creek on the east and from the town of Gasquet, California, on the Middle Fork Smith River, north to the Wimer Road, an old stagecoach route running along the Oregon-California border that connected the coastal towns to inland areas. The roadless area can be easily accessed by the Gasquet Mountain road on the western side and by the Old Gasquet Toll Road-Patrick Creek road on the east. Both of the roads intersect with U.S. Highway 199 near Gasquet, California, the Redwood Highway. The roadless area includes rugged, highly dissected plateaus separated by the North Fork Smith River and its tributaries. Although annual rainfall in the area is greater than 150 in., vegetation (mainly Douglas fir, sugar pine, and manzanita) is sparse.

The roadless area is underlain predominantly by ultramafic rock, part of an approximately 310 sq mi area of deep oceanic mantle rocks occurring in southwestern Oregon and northern California called the Josephine Peridotite. The minimum age of the Josephine Peridotite is 157 million years.

All the components of an ophiolite sequence are present, however, faulting between units precludes any estimate of total thickness. The sequence of major components from lowermost to uppermost is peridotite, ultramafic cumulates, layered cumulate gabbro, and massive gabbro. Each component is briefly described to aid in the interpretation of the mineral-resource potential.

The Josephine Peridotite, a harzburgite-dunite tectonite mass, is the lowermost unit exposed and forms the base of an essentially shallow dipping sheet of fault-transported material. Cumulus ultramafic and gabbroic rocks are present in a number of localities near the eastern edge of the roadless area. A massive serpentinite shear zone everywhere marks the contact between these cumulate rocks and the tectonite peridotite. Dunite, a predominantly olivine-rich rock containing podiform masses of chromite ranging in length from several inches to tens of feet, may be found in both the tectonite and cumulate ultramafic rock units. Most of the chromite mines in the North Fork Smith River Roadless Area are located in and adjacent to the contact zone between the peridotite tectonite and cumulate ultramafic rocks. Ultramafic cumulates are overlain by layered cumulate gabbro which grades upward into a massive gabbro unit characterized by abrupt compositional and textural variations, intrusive breccias, and local diabase dikes. Minor volcanic rocks and associated diabase dikes crop out in the northeastern portion of the roadless area and are considered part of the Josephine Peridotite. Two separate intrusive events of possible Cretaceous to Tertiary age are indicated in the roadless area; the younger, a silicic event, is the most pervasive and is accompanied by widespread hydrothermal activity that penetrated the peridotite along shears and fractures. Weathering in tropical to subtropical conditions created soil horizons on exposed peridotite during a protracted period in Eocene to Pliocene time.



EXPLANATION

Geologic terrane with substantiated mineral-resource potential for indicated commodity and probable mineral-resource potential for mercury

Geologic terrane with substantiated mineral-resource potential

Geologic terrane with probable mineral-resource potential for mercury

Cr	Chromium	Hg	Mercury
Cu	Copper	Ni	Nickel

Mine or deposit

Mine

Young intrusive rocks (Tertiary to Cretaceous)

Dothan Formation (Cretaceous and Jurassic)

Josephine Peridoite--ophiolitic rocks (Jurassic or older)

Contact

Fault

Thrust fault--Sawteeth on upper plate

Figure 92.—North Fork Smith River Roadless Area, California and Oregon.

The roadless area was studied for its mineral-resource potential in 1979–82 and the results were published by Gray and others (1983a, b), Page and others (1983), and Griscom (1983). Stream-sediment and whole-rock samples were collected and analyzed from the roadless area. Mining claims and prospects were sampled and evaluated. An areomagnetic survey was flown and compiled in 1979 as part of a larger survey of the entire Josephine Peridotite in Northern California.

MINERAL RESOURCES

The earliest prospecting and mining in the North Fork Smith River Roadless Area began in 1851. Chromite and copper were discovered at approximately the same period in 1853 (Maxson, 1933) and quicksilver deposits were discovered north of Diamond Creek in the 1850's. Chromite was, by far, the most actively mined resource with domestic markets stimulated greatly by World Wars I and II. Currently nickel-laterite soils are being explored as a resource in and adjacent to the roadless area.

The most significant deposits in the roadless area are lateritic soils, developed on peridotite, that contain nickel, iron, chrome, and cobalt. Fresh or partly serpentinized peridotite contains approximately 1500–2000 parts per million nickel, 110–200 parts per million cobalt, 1600–2400 parts per million chromium, and 8–12 percent iron. Weathering of the peridotite removes magnesium, silicon, and calcium and leaves behind a residual soil enriched in the above metals. These deposits are associated with uplifted Eocene to Pliocene erosional surfaces which form as ridge-top, landslide-slump, and continuous-slope laterite surfaces. The thickness of lateritic soil formation ranges from 8 to 12 ft, however soils on the eastern slope of Gasquet Mountain are 15 to 25 feet thick. The nickel content of the soils ranges from 3900 to 16,000 parts per million and the cobalt content ranges from 480 to 1300 parts per million as shown from analyzed samples. Chromium and iron are also present in these soils. Total demonstrated resources of nickel are approximately 16 million tons (minimum) from widely scattered areas of substantiated nickel resource potential. Another 29 million tons of ore exist in areas immediately adjacent to the roadless area.

Chromite with byproduct platinum-group elements also is a resource in the roadless area. Chromite occurs in dunite-rich rocks near the cumulate-tectonite interface. Podiform chromite deposits occur as lenticular bodies, usually complexly folded, and are composed of nearly pure chromite. Small disseminated deposits of chromite consist of grains and schlieren of chromite mixed with dunite. Byproduct platinum-group elements are present in analyzed chromitites from the roadless area and they may enhance the resource potential of these deposits. The largest deposit in the area, on High Plateau (Brown mine) contains approximately 26,000 tons of demonstrated chromite resources. The remaining smaller scattered deposits in the area together only total another estimated 4000 to 5000 tons of demonstrated chromite resources.

Mercury deposits and magnetite veins with copper and minor cobalt occur in silicic intrusive rocks in the roadless area. The intrusive event was accompanied by hydrothermal fluids which may have acted as leaching agents to remove copper, iron, and minor amounts of cobalt from the peridotite body and redeposit them in veins. Mercury mineralization is related to the silicic magmas which ubiquitously intruded the peridotite-tectonite and the mercury occurs as two depositional types. The largest mercury deposit is adjacent to the area at the Webb mine and occurs in highly sheared peridotite approximately 3000 ft west of a major fault contact between the ophiolite and metavolcanic rocks. Numerous small felsitic dikes and stringers intrude the shear zone. Alteration in the mineralized zone consists of thin carbonate veinlets, abundant kaolinization of silicic dike rock, and silicification of the serpentine into silica-carbonate rock as is characteristic of other mercury deposits throughout the Coast Range in California. Finely crystalline cinnabar, metacinnabar, and minor pyrite are found in the silica-carbonate rock as well as on fracture-vein surfaces in brecciated areas. These minerals as well as native mercury occur in clay gouge zones within the roadless area.

The second type of mercury deposit, displayed in the Big Boy group, occurs in hornblende diorite country rock that has been altered by later magmatic activity. The diorite has been thoroughly propylitized with constituent feldspar and hornblende minerals breaking down to kaolinite-sericite aggregates and limonite, respectively. Cinnabar is deposited on fine joint surfaces within the propylitized diorite. The roadless area has probable and substantiated resource potential for small deposits of mercury.

Magnetite deposits with copper and minor cobalt occur as 2- to 15-ft thick replacement veins in serpentine shear zones and are closely associated spatially and temporally with rhyolitic dike rocks. Most of these deposits occur in two areas of substantiated copper resource potential along the west and northwest edge of the roadless area although scattered small deposits occur elsewhere. The veins are composed of dense magnetite grading outward into boxwork open-space-filling hematite that grades into hematite-coated serpentine. Either unaltered serpentine or partly serpentinized peridotite extend outward from this area. The copper minerals chrysocolla and azurite are common within the magnetite zones. Although substantiated, resources of iron, copper and cobalt from the vein deposits are thought to be small.

Small seams of asbestos, primarily slip-fiber chysotile, crop out in partly serpentinized peridotite along the North Fork Smith River Canyon, however, no resource potential was identified within the area.

SUGGESTIONS FOR FURTHER STUDIES

The North Fork Smith River Roadless Area contains a number of exposed mineral deposit types within and adjacent to its environment. However, mineral resource assessment, in a strict sense, requires three-dimensional knowledge of deposits yielding greater information as to shape, structures, as well as, extent, and grade consistency of ore at depth. The copper-cobalt-bearing magnetite veins, in particular, shed little light on their nature beyond small surface exposure. Rhyolitic dikes provided a heat source initiating hydrothermal fluids that deposited metals in shear zones at near-surface conditions. Other elements such as gold, silver, and arsenic may be finely disseminated in such a system and may be detectable only at or near the limits of determination. The veins may be interconnecting at depth and may have different chemical constituents down dip within shear structures reflecting thermal gradients in the hydrothermal system. A drilling and sampling program to intersect these veins at depth would identify grades and structural dimension and characterize thermal conditions of this deposit type.

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ORLEANS MOUNTAIN ROADLESS AREA (B5079), CALIFORNIA

By MARY M. DONATO,[1] U.S. GEOLOGICAL SURVEY, and

J. MITCHELL LINNÉ, U.S. BUREAU OF MINES

SUMMARY

The Orleans Mountain Roadless Area (B5079) has substantiated mineral-resource potential for placer and lode gold. This conclusion is based on a 1979-80 investigation that included geologic mapping, study of known mines, prospects, and mineralized areas, gravity and aeromagnetic surveys, and geochemical sampling. Gravel deposits along the Salmon River contain placer gold. Resources of lode gold exist at mines in the northwest and southwest portions of the roadless area. The geologic terrane precludes the occurrence of fossil fuel resources.

CHARACTER AND SETTING

The Orleans Mountain Roadless Area (B5079) is located in the Salmon Mountains of northern California, and comprises approximately 64.3 sq mi in the Klamath and Six Rivers National Forests. The roadless area is bounded on the northeast by the Salmon River, on the northwest by the Klamath River, and adjoins the Salmon-Trinity Alps Wilderness to the south. It is an area of great relief and rugged terrain, ranging in altitude from approximately 500 ft near Somes Bar to nearly 6200 ft above sea level at Orleans Mountain. Access is provided by California State Highway 96 (Klamath River Highway), the Salmon River road, and by numerous logging roads which skirt the boundaries of the roadless area. In addition, trails and fire breaks facilitate limited access by foot to many parts of the roadless area.

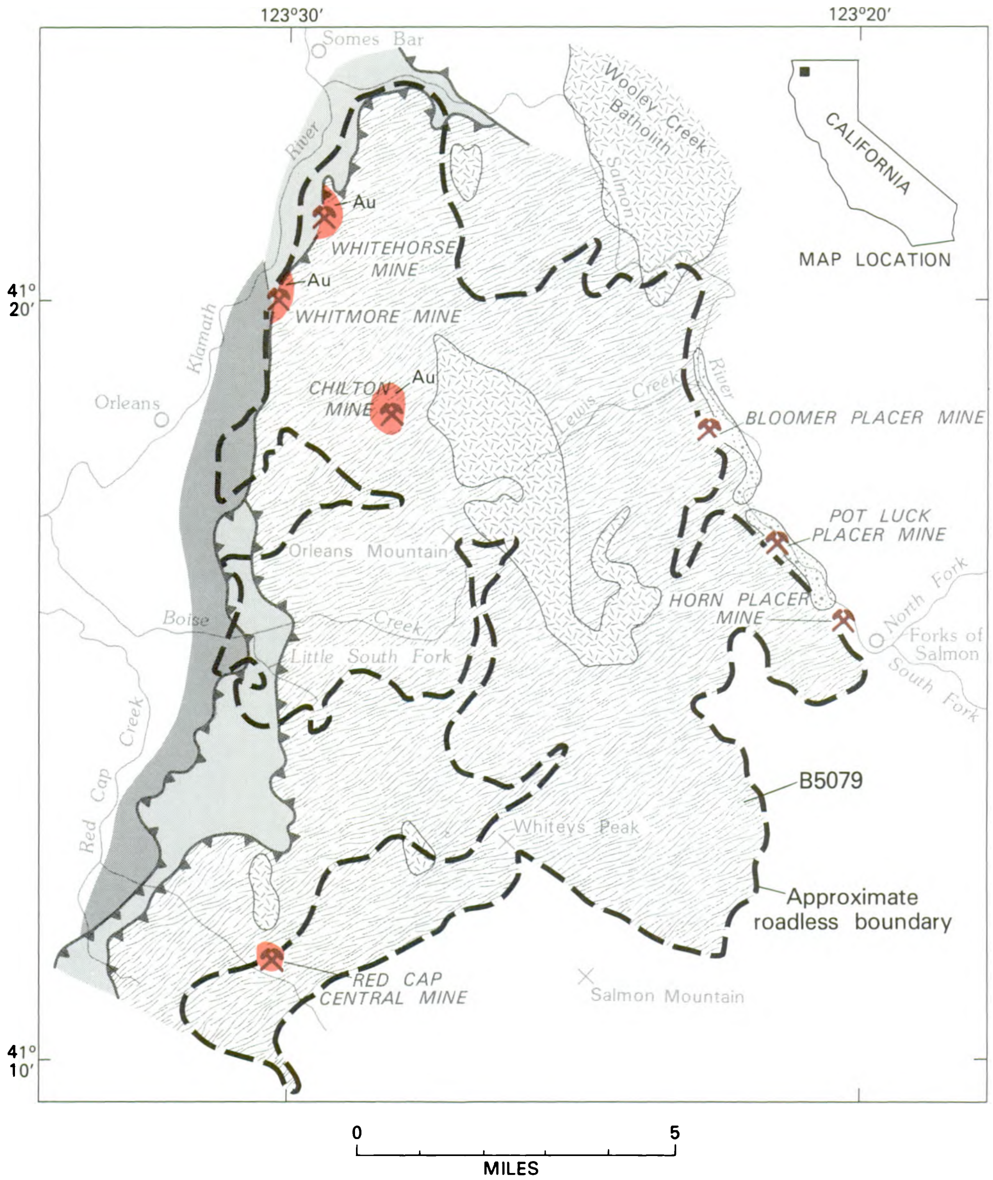
The Orleans Mountain Roadless Area is located in the Klamath Mountains geologic province of northern California. A geologic map has been prepared by the USGS as part of this assessment (Donato, Barnes, and others, 1983). The roadless area is underlain primarily by metamorphic and plutonic rocks of the western Paleozoic and Triassic belt, but rocks belonging to the western Jurassic belt occur along the western margin. Two of the three subdivisions of the western Paleozoic and Triassic belt, the Rattlesnake Creek and Hayfork terranes, are also recognized in this region.

The structurally lowest unit in the roadless area, the Galice Formation, belongs to the western Jurassic belt. The Galice Formation in this region consists mainly of interlayered slate and metagraywacke, although greenstone is abundant locally. The Galice is separated from the overlying rocks by an eastward-dipping regional thrust fault called the Orleans fault, which forms the basal contact of the western Paleozoic and Triassic belt.

The structurally lowest map unit of the western Paleozoic and Triassic belt in this region consists of a serpentinite-matrix melange containing blocks of greenstone, chert, gabbro, and minor limestone, and overlies the Galice Formation along the Orleans fault. These rocks of the Rattlesnake Creek terrane are believed to represent fragments of upper Paleozoic(?) and Triassic oceanic crust. An eastward-dipping sequence of greenschist-facies metasedimentary rocks belonging to the Hayfork terrane overlies the serpentinite-matrix mélange along a shallowly dipping thrust fault. These rocks are predominantly volcanogenic sediments, including feldspathic sandstones, crystal tuffs, and volcanic conglomerates with interbedded siltstone, chert, and siliceous argillite, and are interpreted as an island-arc terrane. Eastward (upsection) the volcanogenic rocks decrease in abundance, giving way to argillite, chert, and chert-limestone-argillite breccia.

Intrusive rocks in the roadless area are mainly dioritic to granodioritic in composition, and include the Wooley Creek batholith, which crops out in the northeastern portion of the roadless area, as well as numerous small dikes and plutons. No evidence of mineralization associated with these intrusive rocks was observed.

[1]With contributions from Robert C. Jachens and David B. Smith, USGS.



EXPLANATION

- Geological terrane with substantiated mineral-resource potential
- Au — Gold
- Mine or deposit
- Alluvium (Quaternary)
- Galice Formation (Jurassic)
- Serpentine-matrix mélange (Triassic and Paleozoic)
- Metamorphosed volcanogenic sedimentary rocks (Triassic and Paleozoic)
- Intrusive rocks
- Contact
- Fault
- Thrust fault--Sawteeth on upper plate

Figure 93.—Orleans Mountain Roadless Area (B5079), California.

The general structural aspect of the roadless area is one of eastward-dipping thrust plates. A major thrust fault, the Orleans fault, is present in the westernmost part of the roadless area, and is locally modified by later high-angle, north-south-trending faults. Thrust faults also form the boundary between the Rattlesnake Creek terrane and the overlying Hayfork terrane. Two of four lode gold mines are located near thrust faults. Although lode gold deposits are more characteristic of Hayfork than Rattlesnake Creek terrane, three lode claims occur in Rattlesnake Creek terrane in or near the roadless area; they are near the thrust fault separating Rattlesnake Creek from Hayfork terrane, which suggests that mineralization may be related to this fault. The majority of lode claims or prospects, however, occur within the metasedimentary units of the Hayfork terrane.

A reconnaissance geochemical study of stream sediments and panned concentrates from the roadless area by the USGS yielded scattered anomalies of elements characteristic of lode and placer gold deposits in streams draining the eastern slope of the Salmon Mountains. This confirmed the previously known potential for lode and placer gold in the area. Gravity and aeromagnetic surveys were also conducted over the roadless area and surrounding areas to supplement the geologic mapping and to aid in the assessment of the mineral-resource potential of the area. The geophysical data have been used to infer the distribution of rock units and the attitudes of boundaries between them, but have generally not been useful in identifying or confirming areas of resource potential in this case.

Three mining districts extend into the roadless area: the Salmon River, Orleans, and Red Cap mining districts. Gold was discovered on the Salmon River in 1849. From 1932 to 1959 the district's production totaled 18,868 oz of gold and 15,981 oz of silver. According to USBM files, the Bloomer, Horn, and Pot Luck placer mines yielded over 12,000 oz of gold and 840 oz of silver before 1920. Small-scale placer mining continues.

The Orleans mining district is in the vicinity of the town of Orleans and covers approximately 100 sq mi. The district's northeast corner overlaps the northwest part of the roadless area. The Whitehorse, Chilton, and Whitmore Creek mines, all lode deposits, lie within the roadless area in the Orleans district. Production of 100 oz of gold and 30 oz of silver came from the Chilton mine between 1927 and 1940, and is the only recorded mineral production from within the roadless area.

The Red Cap mining district is centered around Red Cap Creek and covers approximately 50 sq mi. The southern part of the district overlaps a small part of the roadless area in the vicinity of the Middle Fork of Red Cap Creek, where rocks of the Hayfork terrane are present. Placer mining in the Red Cap district began in the late 1870's along Red Cap Creek near its confluence with the Klamath River. Copper, chromium, gold, and silver lodes also occur in the district outside the roadless area. Within the roadless area, gold and silver occur in quartz veins at the Red Cap Central mine, located in the Hayfork terrane. Underground exploration has been conducted at this mine, but no production is recorded.

MINERAL RESOURCES

The Orleans Mountain Roadless Area has demonstrated and inferred resources of placer gold, and both demonstrated resources and substantiated resource potential for lode gold (Donato, Linné, and others, 1983).

Placer gold occurs in bench placer deposits adjacent to the roadless area between Lewis Creek and Forks of Salmon, near the eastern boundary of the roadless area. These deposits adjoin and extend into the roadless area, but no development has occurred within the roadless area. Three bench placers from 50 to 400 ft above the present river channel are found at both the Bloomer and Horn mines, and one bench placer about 30 ft above the river channel is found at the Potluck mine. These bench placers are often overlain by thick layers of slide material. At several channel sample locations, gold values were found as much as 15 ft above bedrock, indicating that mineral deposition may have occurred as separate events without later reconcentration. Three placer mines occur adjacent to the east border of the roadless area and all have resources that extend into the roadless area. At the Bloomer placer mine, 190,000 cu yd of inferred resources of gold-bearing gravel occur within the roadless area; at the Potluck placer mine, an estimated 700,000 cu yd of inferred resources of gold-bearing gravel occur within the roadless area; and at the Horn placer mine, 40,000 cu yd of demonstrated resources and 20,000 cu yd of inferred resources of gold-bearing gravel are within the roadless area. At all three properties, there is little possibility for the occurrence of additional gold resources.

Lode gold occurs in the roadless area in quartz veins as "free gold," associated with pyrite. These veins strike northeast or northwest and occur in metavolcanic and metasedimentary rocks of the Hayfork terrane. Veins at the Whitehorse and Whitmore Creek mines are probably associated with the Orleans fault.

The Whitehorse, Chilton, and Whitmore Creek mines, all lode deposits, lie within the roadless area; the only mineral production was from the Chilton mine. At these three mines, there is a total of 49,000 tons of demonstrated and inferred resources with grades from 0.06 to 0.62 oz gold/ton. Areas around these properties have substantiated potential for the occurrence of additional resources.

Underground exploration has been conducted at the Red Cap Central mine, located in the Hayfork terrane, but no production is recorded for this prospect. An inferred resource of 13,000 tons containing 0.26 oz gold/ton with some silver is estimated. The possibility for the occurrence of additional resources is high and an area of substantiated gold resource potential extends around the area of the mine.

SUGGESTIONS FOR FURTHER STUDIES

Because lode gold deposits are characteristic of the Hayfork terrane in the southern Klamath Mountains, and most of the Orleans Mountain Roadless Area is underlain by rocks belonging to that terrane, it is possible that additional lode gold deposits are present. The areas with known lode gold resources seem to be more closely associated with faults in the western part of the roadless area than with Hayfork lithologies. Scattered geochemical anomalies found in panned concentrates taken from streams draining the eastern slope of the Salmon Mountains suggest sparse mineralization in Hayfork rocks. Further exploration would be necessary to confirm or disprove the existence of deposits.

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ORLEANS MOUNTAIN ROADLESS AREA (C5079, B5079), CALIFORNIA

By A. S. JAYKO,[1] U.S. GEOLOGICAL SURVEY, and

L. Y. MARKS, U.S. BUREAU OF MINES

SUMMARY

The Orleans Mountain Roadless Area (C5079, B5079) located along the Siskiyou-Trinity County line in the Salmon Mountains of northern California was studied in 1969-70 by P. E. Hotz and others for mineral-resource potential, and reexamined in 1981-82. Several areas with probable gold resource potential were identified based on examination of mines and prospects, analytical values of selected elements, and historical records of gold and silver production. The geologic terrane precludes the occurrence of fossil fuel resources.

CHARACTER AND SETTING

The Orleans Mountain Roadless Area (C5079, B5079) occupies a rugged mountainous area of about 98 sq mi in the central Klamath Mountains 73 sq mi of which have been designated roadless by the USFS. The area is approximately 80 mi northeast of Eureka, California. The area consists of Paleozoic and Mesozoic metamorphic and ultramafic rocks complexly folded and faulted together and intruded by Jurassic granitic rocks (Jayko and Blake, 1983). Mineral occurrences are commonly located in fault zones and along contacts where magmatic fluids migrated.

Extensive geochemical studies and mine prospect examinations were performed by Hotz and others (1972), with additional sampling carried out in 1981. Rock, mine dump rock, stream-sediment, and pan concentrates from stream-sediment samples were analyzed.

Mining activity began in the roadless area at the turn of the century with the first gold production recorded in 1899 and continuing into 1951 (Hotz and others, 1972). Most of the gold and silver production in and immediately adjacent to the roadless area occurred between 1929-39 from nine lode mines and two placers. Of the 30,500 oz of gold produced, 10,000 oz came from the Dorleska mine and 10,000 oz from the Nash placer mine located in Coffee Creek, just outside the roadless area. Forty-eight hundred ounces of silver were produced, of which 2200 oz came from the Grand National mine located approximately 0.25 mi outside the eastern portion of the roadless area and 1400 oz came from the Nash placer. Silver and to a very minor extent lead and copper were recovered as byproducts of gold refining. Nineteen hundred pounds of copper were mined from the Grand National mine and 246 lbs of lead from the Geneva mine. There has been no production recorded from any of the mines during the last 40 years (Hotz and others, 1972).

MINERAL RESOURCES

Gold, silver, and to a lesser extent lead and copper occur in vein systems that cut all the different lithologies in the roadless area. These mineralized vein systems developed in association with late Mesozoic plutonic activity and are commonly located adjacent to, or along, fault zones or contacts between different lithologies.

Three of the areas of probable mineral-resource potential include the Klatt mine, Grand National mine, and Mt. Shasta View prospect, which are closely related to brecciated intrusive contacts between granitic rock and ultramafic country rock. Four other areas of probable mineral-resource potential, located in the south-central portion of the roadless area, include the Dorleska mine, Geneva mine, Packer mine, and Hardscrabble mine which seem to be remotely associated with thrust faults that emplace metamorphic rock against metamorphic rock. One area of probable mineral-resource potential, the Carter prospect, is located entirely within granitic rock. An area with probable placer gold resource potential is along Coffee Creek, just outside the roadless area.

Six of the nine areas identified as having probable mineral-resource potential were previously mined and

[1]With contribution by M. C. Blake, Jr., USGS.

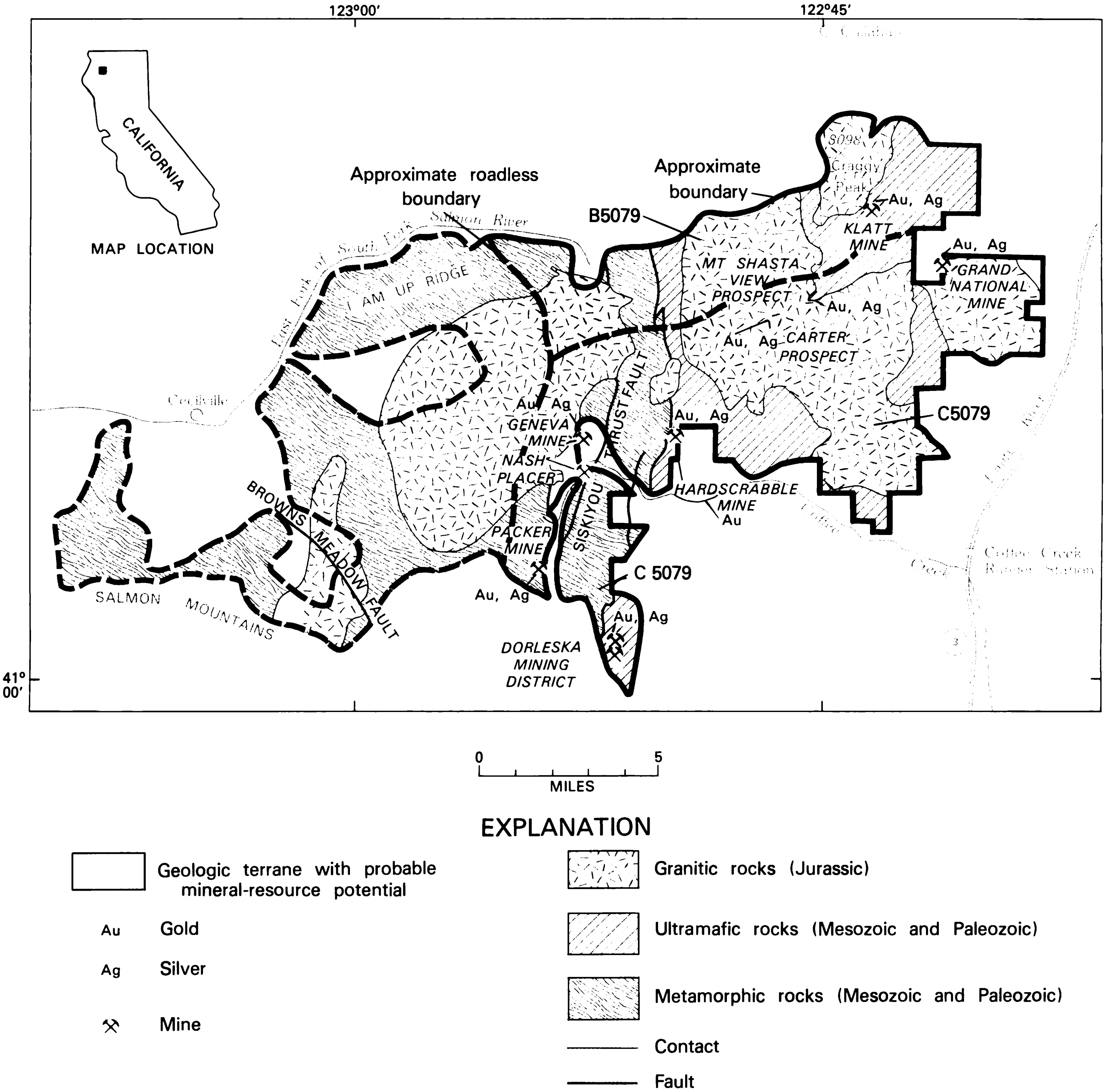

Figure 94.—Orleans Mountain Roadless Area (C5079, B5079), California.

produced 63 to 10,000 oz of gold and as much as 2200 oz of silver, but none of the mines have been active within the last 40 years. Two areas of probable mineral-resource potential, at the Carter and Mount Shasta View prospects, have no record of gold or silver production; the Mount Shasta View, has extensive workings. The mines that are located within the areas of probable mineral-resource potential are presently inactive. The immediate vicinity of the workings was identified as having probable mineral-resource potential based on results from mine and prospect sampling, geochemical sampling of nearby veins, and whole-rock samples which contained anomolous concentrations of selected elements. Additional mineralized vein systems may be present in the vicinity of the known deposits.

The Orleans Mountain Roadless Area contains 56 mines and prospects located entirely within or immediately adjacent (within 0.5 mi) to the roadless area. Only three of these, the Grand National mine, Nash placer, and the Red Rock Mountain prospect (both located 0.25 mi outside the roadless area) are on patented land.

Two small placer mines located within the roadless area produced a total of 680 oz of gold between 1912 and 1937. These placers were on alluvial gravels. The streams that drain the roadless area have been extensively mined and little terrace gravel remains; therefore, the only placer gold resource potential identified is outside the roadless area, along Coffee Creek.

The location of areas of probable mineral-resource potential was based mostly on past mining history and examination of mines and prospects; the results of geochemical surveys verified mine and prospect sample data. If deposits are present they would probably be gold- and (or) silver-bearing quartz vein systems. Recreational placer mining is probably feasible along some of the larger streams.

SUGGESTIONS FOR FURTHER STUDIES

If further work were to be carried out within the roadless area the most promising region to study would be in the area around the Dorleska mining district.

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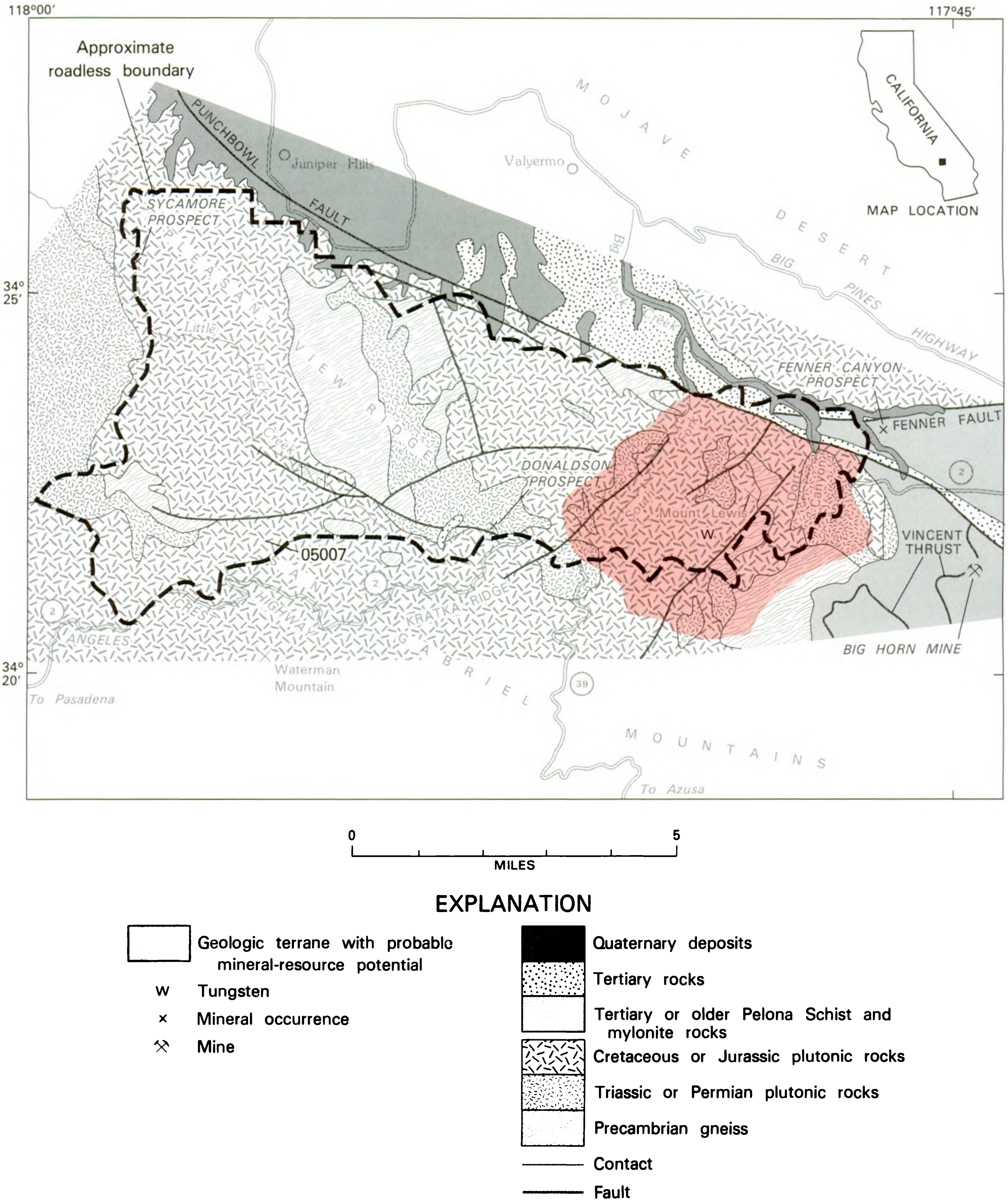

Figure 95.—Pleasant View Roadless Area, California.

PLEASANT VIEW ROADLESS AREA, CALIFORNIA

By BRETT F. COX,[1] U.S. GEOLOGICAL SURVEY, and

DAVID A. LIPTON, U.S. BUREAU OF MINES

SUMMARY

The Pleasant View Roadless Area, located in eastern Los Angeles County approximately 17 mi northeast of Pasadena, California, was studied during 1981–82. The study included a geochemical survey and geologic mapping by the USGS and an examination of mines and prospects by the USBM. There are no known mineral deposits and no evidence of past mineral production from the roadless area. Nevertheless, the geochemistry and mineralogy of stream sediments indicate that occurrences of the tungsten mineral scheelite are present throughout an area of about 8.5 sq mi near the east end of the roadless area. A probable mineral-resource potential for tungsten is assigned to this specific area. No potential for other mineral or energy resources was identified.

CHARACTER AND SETTING

The Pleasant View Roadless Area includes approximately 42 sq mi of rugged terrain on the north slope of the San Gabriel Mountains directly south of the western Mojave Desert region. The maximum altitude of 8396 ft is located at Mount Lewis near the east end of the area. Pleasant View Ridge, with several summit altitudes near 8000 ft, trends northwestward across the western part of the area. Angeles Crest Highway (California State Highway 2) skirts the south boundary, providing access to neighboring ski resorts on Waterman Mountain and Kratka Ridge. Two trails cross the roadless area, connecting Angeles Crest Highway with campgrounds near Big Rock Creek.

Several regionally significant faults are located within or immediately adjacent to the roadless area. The inactive Punchbowl fault follows the foot of the range, nearly coinciding with the north boundary of the roadless area. The recently active San Andreas fault, which lies outside the roadless area, is parallel to and approximately 2.5 mi north of the Punchbowl fault. A third steeply dipping structure, the Fenner fault, is located at the northeast corner of the roadless area between the Punchbowl and San Andreas faults. An ancient gently dipping fault, the Vincent thrust, lies approximately 1 to 3 mi southeast of the roadless area. No mineral resources have been identified along the Punchbowl and Fenner faults near the roadless area, but gold, silver, copper, and lead have been produced at the Big Horn mine, located near the Vincent thrust approximately 2 mi southeast of the roadless area (Ridenour and others, 1982).

Movements on the Vincent, Fenner, and Punchbowl faults have juxtaposed four structural blocks that contain distinct assemblages of rocks. Most of the roadless area is located on the block west of and above the Vincent thrust and south of the Punchbowl fault. The rocks in this region include Precambrian gneiss (metamorphosed sedimentary and granitic rocks) and a diverse assemblage of mafic to silicic Mesozoic plutonic rocks. During or prior to earliest Tertiary time, these gneissic and plutonic rocks were faulted on top of metamorphosed sedimentary and volcanic rocks of the Pelona Schist that form the structural block east of and below the Vincent thrust. Rocks in the upper plate of the thrust were strongly deformed as a consequence of these fault movements. This episode of deformation is represented by a belt of mylonitic rocks located mostly east of the roadless area adjacent to the thrust, and by a broader zone of less intense, heterogeneous deformation, including localized fracturing and foliation, that extends into the roadless area as far west as the western drainage divide of the South Fork of Big Rock Creek. This broader zone of interspersed brittle and ductile deformation west of the Vincent thrust may have been partly responsible for localization of scheelite near the east end of the roadless area.

[1]With contributions from Robert E. Powell, Margaret E. Hinkle, Curtis M. Obi, and Vicki A. Fulkerson, USGS.

Numerous faults of probable Cenozoic age cut the gneissic and plutonic rocks of the roadless area. One of these minor faults located north of Kratka Ridge is cross-cut by a large dike of Tertiary rhyolite. No evidence of mineralization was found associated with the minor faults or rhyolite rock.

Two structural blocks north of the Punchbowl fault extend a short distance into the northeast part of the roadless area. The block between the Fenner and Punchbowl faults consists primarily of metasedimentary and metavolcanic rocks of the Pelona Schist. A minor body of granite either intrudes or is faulted against the schist near the Punchbowl fault; this body is not shown on the map because of its small size. No mineral concentrations have been identified within either the schist or granite. The bedrock block north of the Fenner fault consists mostly of deformed Mesozoic plutonic rocks. Tertiary sandstone, shale, and conglomerate overlie the plutonic and metamorphic rocks both north and south of the Fenner fault, and extensive deposits of Quaternary sand and gravel are present along Big Rock Creek and on alluvial fans near Juniper Hills. The deformed plutonic rocks and overlying sedimentary units do not extend for significant distances into the roadless area, nor do they contain concentrations of metallic minerals.

Rock materials suitable for general construction purposes are present in the roadless area. Deposits of sand and gravel are found in a few places near the north boundary, particularly along tributaries of Big Rock Creek. Some of the gneissic and plutonic rocks within the roadless area could be used for crushed stone or riprap. However, sand and gravel and construction stone of equal or better quality are available in neighboring areas outside the roadless area.

MINERAL RESOURCES

No mineral production has come from within the Pleasant View Roadless Area and there are no patented mining claims or mineral leases. The Big Horn mine, located 2 mi southeast of the roadless area, has produced gold, silver, copper, and lead. It has the only nearby mineral production. The mine penetrates schist directly beneath the Vincent thrust. There is no evidence for similar deposits in the roadless area.

Three prospects are located within or directly adjacent to the roadless area (Cox and others, in press). The Sycamore prospect is located near a sheared intrusive contact between two Mesozoic plutons. A quartz vein at the prospect was analyzed and found to contain traces of silver and gold; the amount of mineralized rock is small and no resources were identified. The Donaldson prospect is located in sheared, brecciated rock adjacent to a minor fault. The Fenner Canyon prospect is located in limonite-stained schist. No evidence of mineral resources was found at either prospect.

Despite the absence of historic mineral production, there is a probable tungsten potential for small deposits in veins in the east part of the roadless area near Mount Lewis. This assessment is based on stream-sediment geochemistry and mineralogy, and comparison with vein occurrences in other parts of the San Gabriel Mountains. Anomalous amounts of tungsten were found (100–300 parts per million (ppm); background values less than the 100-ppm spectrographic detection limit) and grains of scheelite were identified in 11 of 12 panned-concentrate samples collected from tributaries of Dorr Canyon and the South Fork of Big Rock Creek, and from one minor drainage on the north flank of Mount Lewis. Anomalous amounts of barium (7000–10,000 ppm; background values 50–500 ppm) and grains of barite were also found in 11 of these same 12 samples. The drainage area represented by the anomalous samples includes approximately 8.5 sq mi within the roadless area. By contrast, only a few isolated geochemical or mineralogical anomalies for tungsten and barium occur in the 34 sq mi of the roadless area west of the South Fork of Big Rock Creek.

Carbonate rocks, which commonly host metasomatic skarn deposits of scheelite, are not present in the roadless area, and the scheelite may occur instead within veins cutting the gneissic and plutonic rocks, although none were observed. The joint occurrence of barite and scheelite in the same cluster of stream-sediment samples supports the idea of occurrence in veins, because barite is a common vein gangue mineral. Moreover, vein occurrences of tungsten have been reported in similar gneissic and plutonic rocks in neighboring areas of the San Gabriel Mountains (Ridenour and others, 1982; Zilka and Schmauch, 1982). These vein occurrences of tungsten are also located in upper-plate rocks near the Vincent thrust.

The lack of panned-concentrate tungsten anomalies greater than 300 ppm and the inferred occurrence of the scheelite in veins rather than carbonate-hosted skarn bodies suggests that any tungsten concentrations that may exist near the east end of the roadless area probably are not large or particularly rich. Nevertheless, the clustering of tungsten anomalies and the similar geologic setting of vein occurrences in nearby areas indicates that the area surrounding Mount Lewis has probable potential for tungsten resources. No potential for other mineral or energy resources was identified in the area.

SUGGESTIONS FOR FURTHER STUDIES

More detailed field and geochemical studies of veins and stream sediments are needed to fully evaluate the potential for tungsten in the east part of the Pleasant View Roadless Area. Future studies might also test the hypothesis that tungsten concentrations may be related spatially, and possibly genetically, to deformation near the Vincent thrust.

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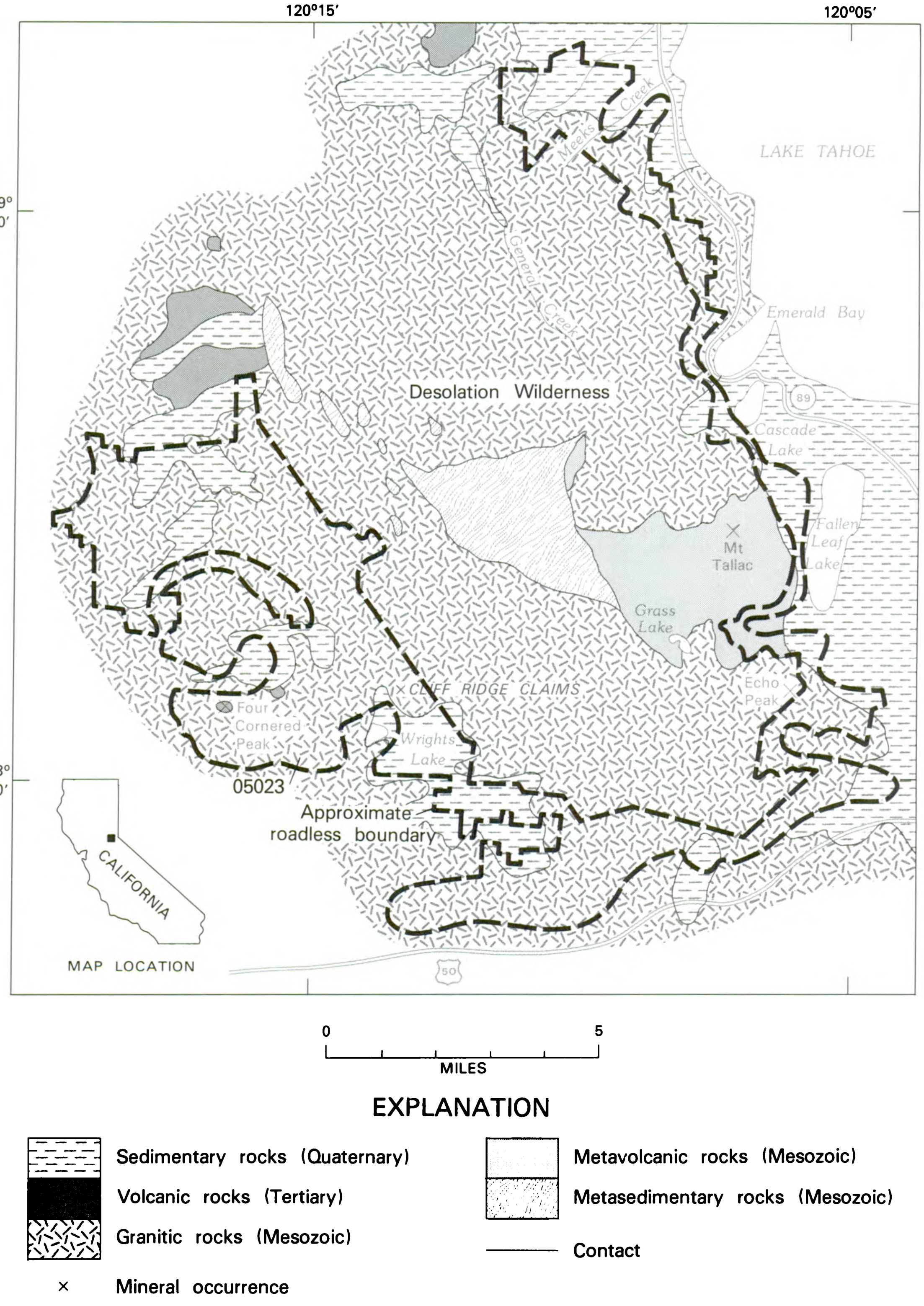

Figure 96.—Pyramid Roadless Area, California.

PYRAMID ROADLESS AREA, CALIFORNIA

By AUGUSTUS K. ARMSTRONG,[1] U.S. GEOLOGICAL SURVEY, and

DOUGLAS F. SCOTT, U.S. BUREAU OF MINES

SUMMARY

A geologic and mineral survey conducted in 1982 indicates that the Pyramid Roadless Area, California, has little promise for the occurrence of mineral or energy resources.

CHARACTER AND SETTING

The Pyramid Roadless Area is adjacent to and partly surrounds the Desolation Wilderness. The roadless area lies near the crest of the Sierra Nevada about 75 mi east of Sacramento, California. The roadless area includes approximately 49 sq mi in El Dorado National Forest and the Lake Tahoe Basin Management Unit of El Dorado County.

The roadless area is dominated by deep rugged canyons that run from the Sierra Nevada crest eastward to Tahoe Basin and westward from the crest to the Sacramento Valley. Altitudes range from about 5500 ft in the bottom of Big Silver Canyon to 8895 ft at Echo Peak along the southeast boundary of the roadless area. U.S. Highway 50 on the south side and California Highway 89 on the east side, provide access to the roadless area; secondary roads and trails reach the roadless area boundaries in a number of places, but access to many areas is limited to a few trails. The nearest population center is South Lake Tahoe, California, about 3 mi east from the eastern edge of the Pyramid Roadless Area. Placerville is about 26 mi to the southwest of the western edge of the roadless area.

All the sedimentary and volcanic rocks intruded by the Sierra Nevada batholith in the Pyramid Roadless Area are thermally metamorphosed. These rocks are mostly biotite-hornblende gneiss and schists, porphyroblastic granitoid rock, and calc-silicate hornfels. Mineral assemblages suggest metamorphism to amphibolite facies or hornblende-hornfels contact facies (Dodge and Fillo, 1967; Loomis, 1964). The prebatholithic metamorphic rocks occur in a roof pendant in the east-central part of the roadless area. Two groups of metamorphic rocks have been recognized, a metasedimentary sequence derived from argillaceous limestones and shales and a conformable overlying metavolcanic sequence. The metasedimentary rocks are fine-grained calc- and quartzo-feldspathic hornfels. Locally, light-colored quartz-rich beds are interlayered with darker mafic hornfels, giving these rocks a banded appearance. The metavolcanic rocks in the roadless area south of Fallen Leaf Lake are dark quartzo-feldspathic hornfels, whose parent rocks probably were andesites or dacites. A broad area just east of the metavolcanic-metasedimentary contact is underlain by metavolcanic breccia. Several masses of dioritic rocks are exposed in the northeastern and southwestern parts of the Pyramid Roadless Area. In some places a complete transition from dark igneous or igneous-appearing rock to metamorphic rocks can be seen. The major rock type of the northeastern, southern, and western parts of the Pyramid Roadless Area is plutonic rock of granitic composition. Within the Desolation Wilderness, eight discrete granitic units were recognized by Dodge and Fillo (1967), but they made no distinctions between individual masses on their geologic map. Loomis (1960, pl. 1) recognized seven distinct granitic plutons within the area of the Pyramid Roadless Area, granodiorite being the most prevalent rock type. The intrusive masses range from alaskite, quartz monzonite to quartz diorite. Quartz, plagioclase, and biotite are major constituents of the granitic rocks. A small mass of noritic rocks was described and mapped near the east side of the roadless area, southwest of Emerald Bay (Loomis, 1963, 1964; and Dodge and Fillo, 1967).

Cenozoic andesite breccias and interbedded epiclastic stream conglomerates and sandstones crop out immediately to the south and southeast of the area, and porphyritic olivine basalt occurs on the northwest side of the roadless area. The west-central part of the area

[1]With contributions from Maurice A. Chaffee, USGS.

contains three peaks, Four Cornered Peak and two unnamed peaks, possibly volcanic necks, which are composed of olivine basalt. Dalrymple (1964) has documented volcanic activity of middle and late Miocene age for many localities in the central Sierra Nevada.

The Quaternary glacial deposits within the Pyramid Roadless Area are glacial moraines, outwash gravels, and lake and stream deposits. A record of the advances and retreats of the Quaternary glaciers is preserved in moraines. Four main advances are known and a fifth minor advance is represented by several rock glaciers that still may be active. Thick deposits of lateral and terminal moraines are found around Fallen Leaf Lake, Cascade Lake, and Emerald Bay and along General and Meeks Creeks in the northeast. Morainic material and outwash gravel are extensive south and east of Wrights Lake.

USBM personnel conducted literature and courthouse record searches and fieldwork to determine the mineral resources of the roadless area. Samples taken from mineralized areas in and adjacent to the roadless area were analyzed by atomic absorption, chemical, and fire-assay methods. All samples were checked for radioactivity with a gamma-ray scintillometer and for fluorescence with an ultraviolet light. Most of the samples were analyzed by semiquantitative spectrographic methods to determine the presence of unsuspected elements.

MINERAL RESOURCES

The Pyramid Roadless Area contains mineral showings, but no mineral-resource potential was identified during our studies. Three granodiorite samples on the west side of the roadless area contained weakly anomalous concentrations of uranium. Two samples of roof-pendant rocks, one metasedimentary rock and one metavolcanic rock, contain low concentrations of copper, and of copper and molybdenum, respectively. The anomalous concentrations in all of these samples probably only represent abnormally high background concentrations for the respective rock types. These analytical results corroborate those of Dodge and Fillo (1967) for the adjacent Desolation Wilderness. They found that, except for rock samples collected from previously known prospects, none of the rock samples contained anomalous concentrations of any elements that might be indicative of hydrothermal mineral deposits.

The Cliff Ridge mining claims, north of Wrights Lake, were located for uranium in 1959 and 1979, respectively. Both claims are on a 4-ft-thick aplite dike that strikes N. 80° W., and dips 66° SW. in quartz monzonite. The dike yields a slightly higher than background count using a gamma-ray scintillometer, but samples from these localities contained no uranium.

Silicified and limonite-stained metasedimentary rocks near a granitic rock contact occur west of Fallen Leaf Lake. These rocks have locally as much as 2 percent disseminated sulfides, but no resource potential was identified.

Three quartz stringers containing molybdenite rosettes and massive arsenopyrite occur in slightly limonite-stained quartz monzonite near Grass Lake. These stringers, 0.25 to 2 in. thick, trend northeast-southwest, and contained from 0.28 to 1.06 percent MoS_2 (molybdenum disulfide). These were not exposed in the roadless area.

SUGGESTIONS FOR FURTHER STUDIES

Although none was identified, the geologic terrane is permissive for mineral occurrences and large-scale, detailed geologic mapping of the areas of metasedimentary and metavolcanic roof pendants in the Pyramid Roadless Area could define a mineral-resource potential for tungsten and precious metals.

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RAYWOOD FLAT ROADLESS AREAS, CALIFORNIA

By JONATHAN C. MATTI,[1] U.S. GEOLOGICAL SURVEY, and

STEPHEN R. IVERSON, U.S. BUREAU OF MINES

SUMMARY

The Raywood Flat Roadless Areas, studied in 1979–82, are situated adjacent to the San Gorgonio Wilderness in the southeastern San Bernardino Mountains, southern California. Geologic, geochemical, and geophysical studies, together with an investigation of mines and prospects, indicate that there is little likelihood for the occurrence of metallic mineral or energy resources in the roadless areas. In the eastern part of the roadless areas, a geochemical survey shows slightly anomalous amounts of lead, copper, molybdenum, tin, and bismuth and suggests that there are small and scattered occurrences of these metals in the bedrock. The inferred mineral occurrences lack the characteristics associated with metal concentrations that would identify resources. Marble and other construction materials occur in the area but, similar commodities occur outside the area, closer to markets.

CHARACTER AND SETTING

The Raywood Flat Roadless Areas consist of a further-planning area and a wilderness-recommendation area that are located in the southeastern San Bernardino Mountains, about 35 mi east of San Bernardino and about 10 mi north of Banning, California. The wilderness-recommendation area (A5–187) constitutes about 35 sq mi; the further-planning area (B5–187) constitutes about 29 sq mi. The roadless areas are situated adjacent to the existing San Gorgonio Wilderness, and consist of rugged mountainous terrain that includes Allen Peak (7747 ft), Little San Gorgonio Peak (9140 ft), Galena Peak (9330 ft), and Kitching Peak (6598 ft). The roadless areas are drained by major streams that include Mill Creek, several tributaries of Oak Glen Creek, San Gorgonio River, and the North and South Forks of Whitewater River. Access to the roadless areas is gained from several entry points. In Mill Creek canyon, a paved road that branches from California State Highway 38 affords access to much of area B5–187; southern parts of the area can be entered via dirt roads that lead from Oak Glen Road, a paved road that follows Oak Glen Creek. Access to area A5–187 can be gained via dirt roads leading up Millard Canyon and its major tributaries, and by permit via a private dirt road that leads up San Gorgonio River.

The Raywood Flat Roadless Areas are underlain mainly by a variety of crystalline bedrock, including plutonic igneous rocks and metamorphic rocks. Valley areas locally are mantled by Quaternary deposits of gravel and sand, and landslides are developed on some hillslopes. Three strands of the San Andreas fault system occur in the vicinity of the Raywood Flat Roadless Areas—the Mission Creek fault, the Mill Creek fault, and the South Branch of the San Andreas fault. The South Branch presently is an active strand of the San Andreas system; the Mill Creek and Mission Creek faults both appear to be abandoned strands. Many miles of right-lateral displacement on the Mission Creek and Mill Creek faults have carried rocks in the Raywood Flat Roadless Areas northwestward to their present location from their original location in the Salton Trough area to the east.

North of the Mission Creek fault, the rocks consist of gneiss and several varieties of granitoid rock. The oldest rocks consist of biotite-rich, compositionally layered Precambrian gneiss. A younger gneiss terrane includes a heterogeneous assemblage of granite and granitic gneiss formed during Mesozoic time as a result of intense thermal and tectonic activity. These events involved partial melting of pre-existing continental crust accompanied by intrusion of granitic plutons and by

[1]With contributions from Brett F. Cox, USGS.

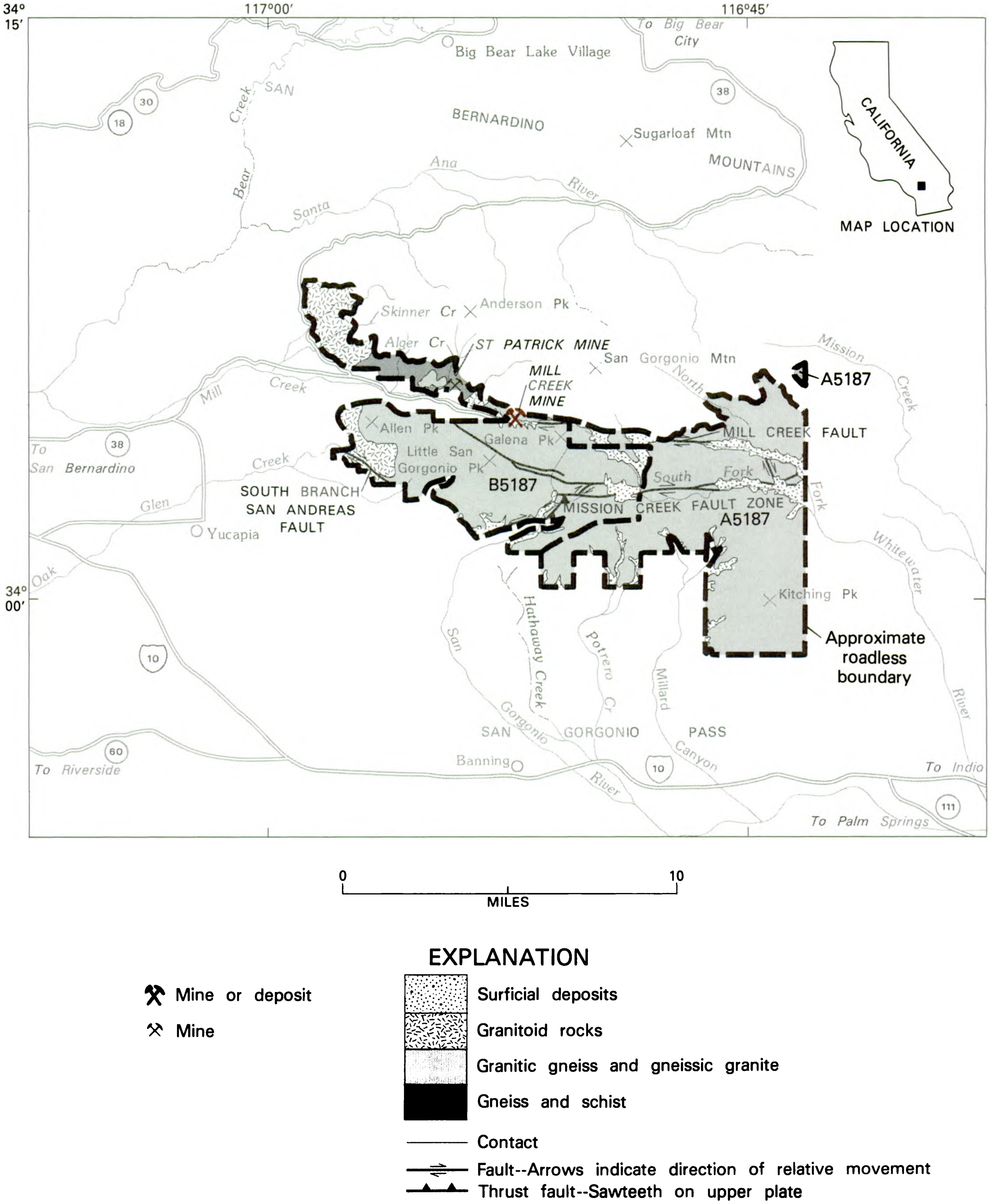

Figure 97.—Raywood Flat Roadless Areas, California.

ductile shearing. These processes probably occurred at intermediate or deep levels in the Earth's crust, and produced fabrics and structures that impart a metamorphic rather than plutonic appearance to the rocks. The Precambrian and Mesozoic gneiss terranes have been intruded by several lithologically distinct varieties of Mesozoic granitoid rock that form plutons of moderate size. Locally, pods of biotite-sillimanite-garnet schist, metaquartzite, and marble occur as metasedimentary inclusions within the foliated and gneissose plutonic rocks.

South of the Mission Creek fault, the rocks consist of two distinct terranes separated by a steeply dipping thrust fault that is part of the region-wide Vincent-Orocopia thrust system. The lower plate of this thrust contains metavolcanic and metasedimentary rocks; the upper plate consists of a lithologically monotonous assemblage that includes foliated granitoid rocks, gneissic granitoid rocks, and pegmatite. Most of these rocks represent deformed granitoid plutons that probably are Mesozoic in age, although bodies of Precambrian gneiss may be present. The rocks of this crystalline terrane have been crushed and sheared during one or more episodes of regional deformation.

Little mineral production has come from the Raywood Flat Roadless Areas and only a few abandoned mines and prospects exist in the areas. Three claims are located within area BS-187. One of these claims produced small amounts of marble (loc. 1, on map), and a second produced small amounts of low-grade uranium-bearing ore (loc. 2).

MINERAL RESOURCES

Geologic, geochemical, and geophysical investigations, together with a review of prospecting and mining activities, indicate little promise for the occurrence of mineral or energy resources in the Raywood Flat Roadless Areas. A reconnaissance geochemical survey of stream sediment in the Raywood Flat Roadless Areas was conducted to identify variations in stream-sediment chemistry that might reflect local concentrations of metals in areas drained by the streams. The patterns of metal distribution indicated by the geochemical survey do not indicate mineralized rock within most of the roadless areas. Most of the analyses fall within ranges that are reasonable for nonmineralized crystalline rocks and derivative stream sediment; few elemental values are anomalous with respect to the average geochemical background for the roadless areas. A single group of stream-sediment samples in the east part of area AS-187 shows low-level geochemical anomalies for lead, barium, bismuth, copper, molybdenum, and tin. These elements commonly are found in veins and replacement deposits of hydrothermal origin. Steep brush-covered topography prevented our examination of much of the bedrock in the areas drained by the streams. Consequently, we have no direct evidence as to the type or scale of mineralization that may have occurred in this vicinity, and the inference that mineral occurrences exist in the drainage basins is based only on results of the geochemical survey. The drainages that yielded anomalous metallic values are fairly small, and the analytical values are not very high. The inferred occurrences of the metals are therefore regarded as probably small and scattered. The anomalies most likely reflect isolated small-scale occurrences in veins or in minerals disseminated in a larger mass of rock. Aeromagnetic and aeroradioactivity surveys similarly fail to provide evidence favorable for the occurrence of metallic resources.

Small amounts of low-grade uranium-bearing rock containing uranothorite were taken from a small abandoned open cut near Alger Creek (loc. 2) (Hewitt and Stone, 1957). The uranothorite is disseminated in three adjacent pegmatite lenses composed of coarse-grained potassium feldspar and quartz and is surrounded by granitic gneiss. The pegmatitic lenses are small, and they contain relatively small amounts of uranium; analyzed samples across a radioactive zone in the largest lens assayed 0.019 and 0.002 percent uranium oxide U_3O_8. No persuasive evidence of uranium concentrations was found by the aerial radioactivity survey (Pitkin and Duval, 1981) or the geochemical survey. The uranium-bearing pegmatites are small and low in uranium content and no potential for resources was identified.

Marble and other construction materials do occur in these roadless areas. Five and a half million tons of demonstrated marble resources are estimated for the Mill Creek mine (loc. 1). Development of marble at this site and of other construction materials (granitic rocks, sand and gravel) in the roadless areas is regarded as unlikely because of relative inaccessibility and greater distance to markets than similar deposits elsewhere in southern California.

SUGGESTIONS FOR FURTHER STUDIES

These studies identified geochemically anomalous drainages in the eastern part of the Raywood Flat Roadless Areas, but were not sufficiently detailed to identify the source of the anomalous metals. We recommend that the area of anomalous stream-sediment samples be studied in detail in order to confirm the extent and geologic setting of mineral occurrences that we infer to exist there.

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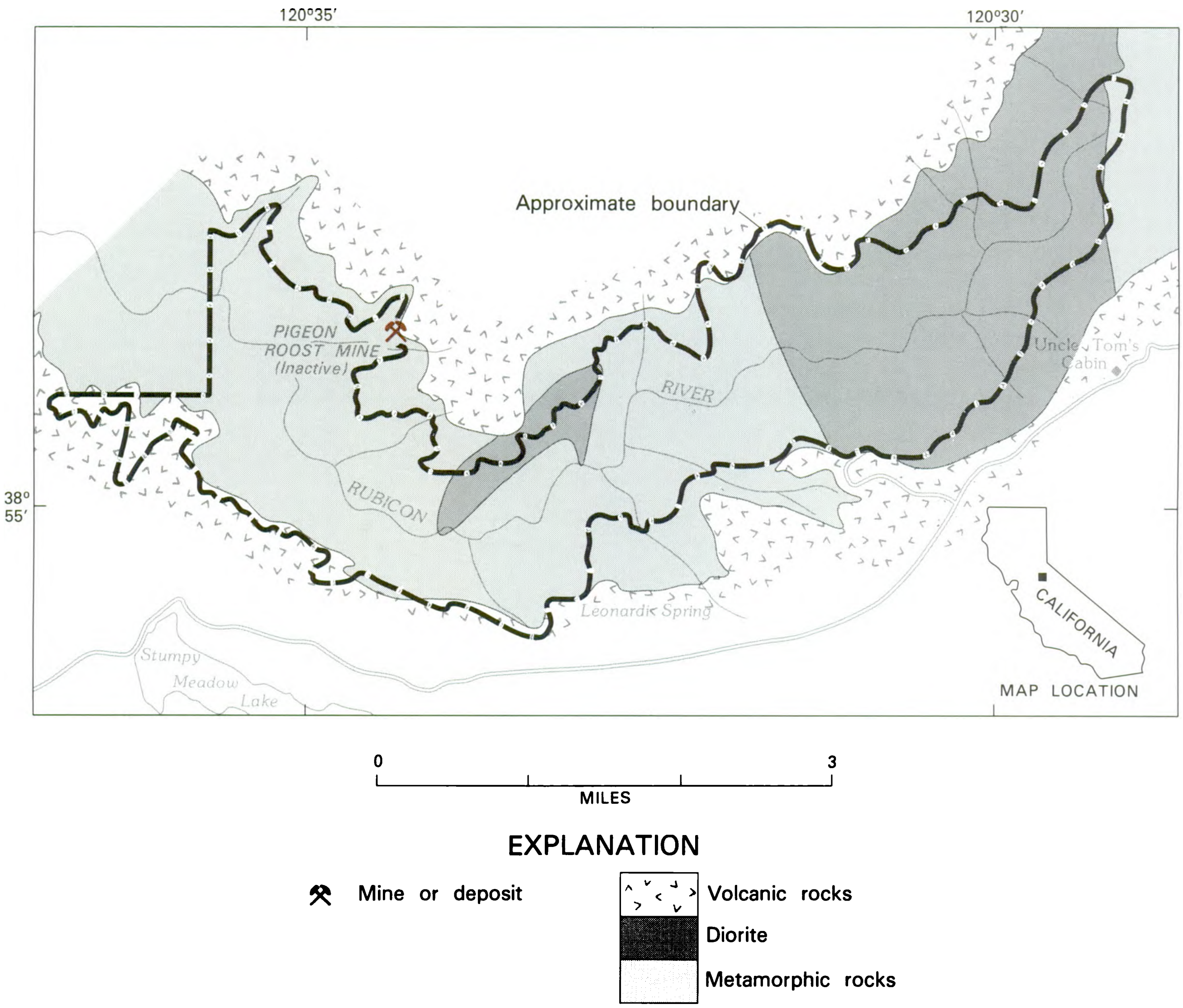

Figure 98.—Rubicon Roadless Area, California.

RUBICON ROADLESS AREA, CALIFORNIA

By DAVID S. HARWOOD, U.S. GEOLOGICAL SURVEY, and

ERIC E. CATHER, U.S. BUREAU OF MINES

SUMMARY

Based on mineral-resource surveys conducted in 1981 and 1982, the Rubicon Roadless Area has little promise for the occurrence of metallic or energy resources. A very small demonstrated gold resource occurs at the Pigeon Roost mine. Glacial deposits, which occur in the eastern part of the area, are too bouldery and too small to be of value as construction materials.

CHARACTER AND SETTING

The Rubicon Roadless Area encompasses about 8 sq mi along the lower reaches of the Rubicon River, a major tributary of the Middle Fork of the American River that drains the west slope of the Sierra Nevada in eastern California. Although the roadless area is small compared to many proposed and established Sierran wildernesses, its proximity to Placerville, 21 mi to the southwest, and to Sacramento, 37 mi to the west, make it a popular retreat for outdoor recreation. Access to the area is provided by a hard-surfaced road that extends eastward from Georgetown, toward Uncle Tom's Cabin. The hard-surfaced road crosses the Rubicon at the east boundary of the roadless area and traverses the north wall of the river canyon and the interfluve between the Rubicon and the Middle Fork of the American River to the north. The USFS maintains a campground at Stumpy Meadow Lake.

The roadless area is generally confined to the steep, wooded canyon walls of the Rubicon River where local relief is as much as 1500 ft. The river has exposed a variety of metamorphic rocks that are intruded by small, isolated plutons of the Sierra Nevada batholith. The Ordovician(?) to Devonian(?) metamorphic rocks and Jurassic and Cretaceous igneous rocks are unconformably overlain by Tertiary volcanic rocks that cap the interfluves north and south of the river. Small deposits of bouldery gravel, which represent outwash from Pleistocene glaciers that capped the higher parts of the Sierra Nevada to the east, are plastered along the canyon walls in the eastern part of the area. Mineral-resource surveys were conducted in the area in 1981 and 1982 and a detailed geologic and geochemical report of the area has been published by Harwood (1983). A detailed evaluation of the mineral-resource potential has been published by Harwood and others (1983).

MINERAL RESOURCES

Gold and silver have been the principal interests of prospectors in the region since the discovery of gold in 1849 at Sutters Mill, which is located only 14 mi west of the study area. Despite the proximity of the classic Mother Lode district to the west, no record of mineral production from the study area was found. Tertiary gravel at the abandoned Pigeon Roost mine contains gold values as high as $138 per cu yd (assuming $400/oz for gold) but the deposit is small and gold values are erratic. It has only a very small demonstrated gold resource. Holocene alluvium in Pigeon Roost Creek below the mine workings contains trace amounts of gold, but these areas are not classified as having a gold resource potential.

SUGGESTIONS FOR FURTHER STUDIES

Further investigations of the roadless area offer little promise for the occurrence of hidden potential mineral deposits.

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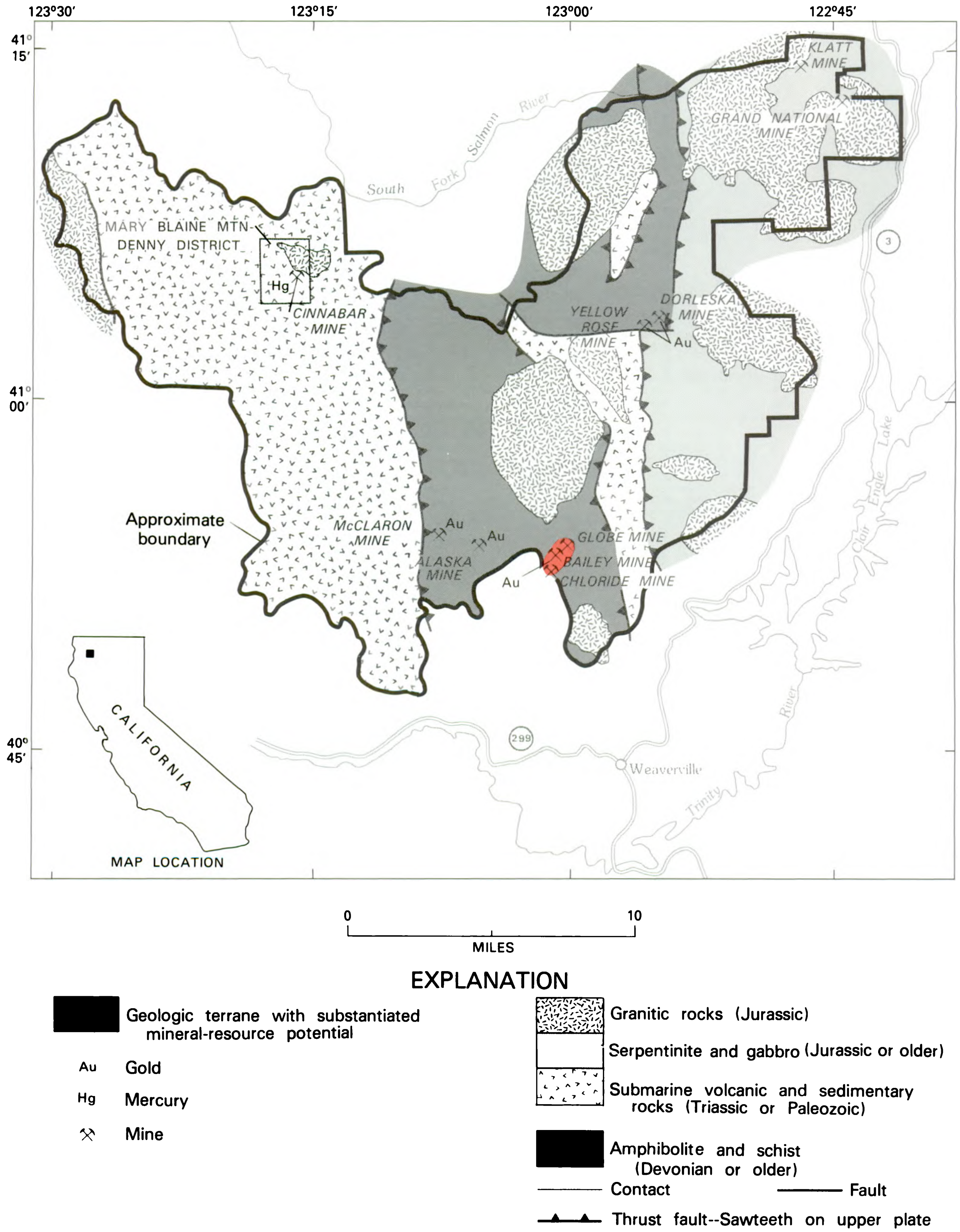

Figure 99.—Salmon-Trinity Alps Wilderness, California.

SALMON-TRINITY ALPS WILDERNESS, CALIFORNIA

By PRESTON E. HOTZ, U.S. GEOLOGICAL SURVEY, and

HORACE K. THURBER, U.S. BUREAU OF MINES

SUMMARY

As a result of field studies in 1968-70 and 1972 it was determined that the Salmon-Trinity Alps Wilderness has an area with substantiated potential for gold resources in known lode deposits. Small amounts of quicksilver have been produced from one mine but there is little promise for the discovery of additional mercury resources. Geochemical sampling showed that anomalously high amounts of several other metals occur in a few places, but there is little promise for the discovery of energy or mineral resources other than mercury and gold.

CHARACTER AND SETTING

The Salmon-Trinity Alps Wilderness in the Klamath Mountains province occupies an area of about 648 sq mi in parts of Trinity, Siskiyou, and Humboldt Counties, northwestern California. The central part of the area is about 45 mi northwest of Redding. The principal town in the region is Weaverville, which is about 15 mi south of the southern boundary of the wilderness, and is the county seat of Trinity County, The area is accessible by subsidiary roads and trails from State Highway 299 on the south and State Highway 3 on the east; the northern part can be reached by spur roads and trails from a county road that follows the South Fork of the Salmon River. The entire region is mountainous and heavily wooded. The relief is great, in many places is 2000-3000 ft, with deep, steep-sided, narrow-bottomed canyons and sharp ridges. Maximum relief in the Trinity Alps is in the central part of the wilderness where the highest point, Thompson Peak, has an elevation of 9002 ft.

The rugged Trinity Alps in the central part of the wilderness are spectacular, where erosion by glaciers has resulted in many U-shaped valleys, lake-filled rock basins, sawtooth ridges, and other scenic alpine features.

The Salmon-Trinity Alps Primitive Area was established prior to the Wilderness Act of 1964. A mineral survey of the primitive area and adjacent lands was made during the field seasons of 1968-70 (Hotz and others, 1972). At the request of the USFS the proposed additions to the primitive area were studied in 1973 (Hotz and others, 1982).

Fieldwork by the USGS included reconnaissance geologic mapping, which consisted of new mapping in the western one fourth of the area and checking and updating existing maps in the rest of the area. Many prospects and abandoned mines were examined by the USBM and other geological features studied. The major effort was the collection of samples for a geochemical survey of the study area. Stream-sediment samples and panned concentrates were taken at regular intervals from the principal streams, and all the common rock types were sampled, including those with visible alteration and other evidence of possible mineralization. The USGS also made an aeromagnetic survey of the area (Griscom, *in* Hotz and others, 1972, p. 45; Hotz 1982, p. 17).

Three north-south-trending belts or packets of rocks occur in the area. Slightly more than one-third of the western part is underlain by an assemblage of weakly metamorphosed sedimentary and submarine volcanic rocks. Meager fossil evidence indicates that these rocks range from middle or late Paleozoic to Jurassic in age. The central part of the area is occupied by older (Devonian), more strongly metamorphosed volcanic and sedimentary rocks which have been transformed to dark amphibolites and schists and impure marble. This belt of older rocks is a folded sheet that overlies rocks of the western belt along an eastward-dipping thrust fault whose surface trace is the belt's western boundary. Along the eastern part of the central belt, the underlying younger, less strongly metamorphosed volcanic and sedimentary rocks of the western belt are exposed in the eroded core of an upwarped (antiformal) fold in the overthrust sheet.

The eastern belt is part of a large body of dark igneous rocks (serpentinite and gabbro) which have been derived from the Earth's mantle and are thrust westward over the metamorphic rocks of the central belt. Several bodies of granitic rock intrude rocks of all three belts; they range from less than 1 mi to as much as 10 mi in their greatest dimension, and only some of the largest are shown on the map. Long, narrow, tabular sheets of serpentinite and gabbro also occur along north-south-trending faults in the eastern part of the western belt, but are not shown on the map.

MINERAL RESOURCES

The area is in a region where gold has been sought extensively and mined from lodes and placer deposits. Discovery of gold on the Trinity River in July 1848 stimulated prospecting in streams of the Trinity River drainage, including streams in the present wilderness. The first "quartz" or lode mines were located in the early 1880's. Total production of gold from lode deposits in and immediately adjacent to the wilderness exceeded $5 million. Placer deposits have a smaller total recorded production, on the order of $500,000, but not all the placer gold produced was recorded.

Gold, the principal mineral resource of the area, is widely distributed, but more occurs in the western half of the area than in the eastern. Lode mines in five districts have produced significant amounts of gold and byproduct silver: the Globe-Bailey-Chloride mine group, the Mary Blaine Mountain-Old Denny district, the Dorleska and Yellow Rose mines, the Alaska and McClaron mines, and the Grand National and Klatt mines. Although deposits in these districts are not exhausted, the resources of all except the area of the Globe-Bailey-Chloride group are small and low grade. Based on available data, the area of the Globe-Bailey-Chloride group has substantiated mineral-resource potential.

Although placer gold was produced from most of the streams in the area, the most productive sections have been essentially worked out. The only placer mining today is confined to small sporadic operations and recreational prospecting.

A few flasks of quicksilver (mercury) were produced from the Cinnabar mine in the Mary Blaine Mountain-Old Denny mining district. This known deposit is small and inaccessible, and additional exploration would be required to determine its extent.

Many gold veins contain a little copper, and a few minor concentrations of copper minerals have been prospected, but no copper resources have been identified.

A few minor occurrences of chromium minerals are known in serpentinite in the eastern part of the area, but there is little promise for the discovery of chromium resources.

The geochemical samples revealed traces of a wide variety of elements in the rocks and stream sediments. Anomalously high amounts of several metals, including copper, lead, zinc, silver, molybdenum, and mercury occur in a few places in the volcanic and sedimentary rocks in the western one third of the area. However, the geochemical sampling program failed to provide any evidence that the area has promise for discovery of energy or mineral resources.

SUGGESTIONS FOR FURTHER STUDIES

It is unlikely that further studies would identify any additional mineral resources in the wilderness area. Additional work would define the mercury potential at the Cinnabar mine.

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SAN GORGONIO WILDERNESS, CALIFORNIA

By BRETT F. COX,[1] U.S. GEOLOGICAL SURVEY, and

NICHOLAS T. ZILKA, U.S. BUREAU OF MINES

SUMMARY

The San Gorgonio Wilderness, located approximately 75 mi east of Los Angeles, California, was investigated by the USGS and USBM using field and laboratory studies during 1978. Several abandoned prospect pits, within and immediately adjacent to the wilderness, mark minor occurrences of metallic minerals, uranium, and marble, but little mineral production has come from the area. Our studies suggest that any undiscovered mineral deposits that may be present in the wilderness probably are small and scattered. Accordingly, we feel that the San Gorgonio Wilderness has little promise for the occurrence of metallic mineral and energy resources.

CHARACTER AND SETTING

The San Gorgonio Wilderness comprises about 55 sq mi of rugged terrain in the southeastern San Bernardino Mountains, and lies within the San Bernardino National Forest. San Gorgonio Mountain, the highest peak in California south of the Sierra Nevada, rises to 11,500 ft near the center of the wilderness. California State Highway 38 skirts the west and north sides of the area, providing access to several vacation resorts near Big Bear Lake.

The San Bernardino Mountains and San Gorgonio Wilderness are situated in the eastern part of the Transverse Ranges, a geologic province bounded by faults that trend east-west across the prevailing northwest-southeast structural grain of California. Even the San Andreas fault system is deflected from its usual northwest-southeast course to a nearly east-west trend where it passes through this region. A major inactive strand of the San Andreas system, the Mill Creek fault, borders the south side of the wilderness. During late Cenozoic time the area of the San Gorgonio Wilderness and other lands north of the Mill Creek fault were moved by faulting, probably tens of miles southeastward relative to land south of the fault.

The geology of the wilderness has been mapped by Morton and others (1980). Southwestern and northern parts of the wilderness are characterized by dark-gray, biotite-rich gneiss which is tentatively assigned a Precambrian age. Light-gray granitic gneiss that may include a mixture of Precambrian and Mesozoic rocks is exposed in the southern and eastern parts of the wilderness. Small bodies of metamorphosed sedimentary rock, including metaquartzite, marble, and skarn, are locally embedded within the granitic gneiss. Several large bodies of undeformed granitic rocks of Jurassic and (or) Cretaceous age, including granodiorite, monzogranite, and quartz monzodiorite, are exposed in the central and western parts of the wilderness. The gneissic and granitic bedrock of the wilderness is covered in a few places by sand and gravel deposited during the Quaternary Period. The largest masses of sand and gravel are contained in glacial moraines deposited along the margins of ancient glaciers that once flowed down the northwest and east flanks of San Gorgonio Mountain (Sharp and others, 1959; Herd, 1980).

Geologic field studies of the wilderness, supplemented by geochemical and geophysical studies, and studies of mines and prospects confirm the existence of small scattered low-grade mineral occurrences. Aerial geophysical studies conducted by members of the USGS include surveys of gamma radiation (Pitkin and Duval, 1981) and geomagnetism (H. W. Oliver, unpub. data). The geophysical surveys do not reveal any abnormal patterns of radioactivity or rock magnetism, and thus provide no indication of mineral deposits.

Investigation of historic mining, prospecting activity, and mineralized areas by the USBM indicates that little mineral production has come from the San Gorgonio

[1]With contributions from Jonathan C. Matti and Howard W. Oliver, USGS.

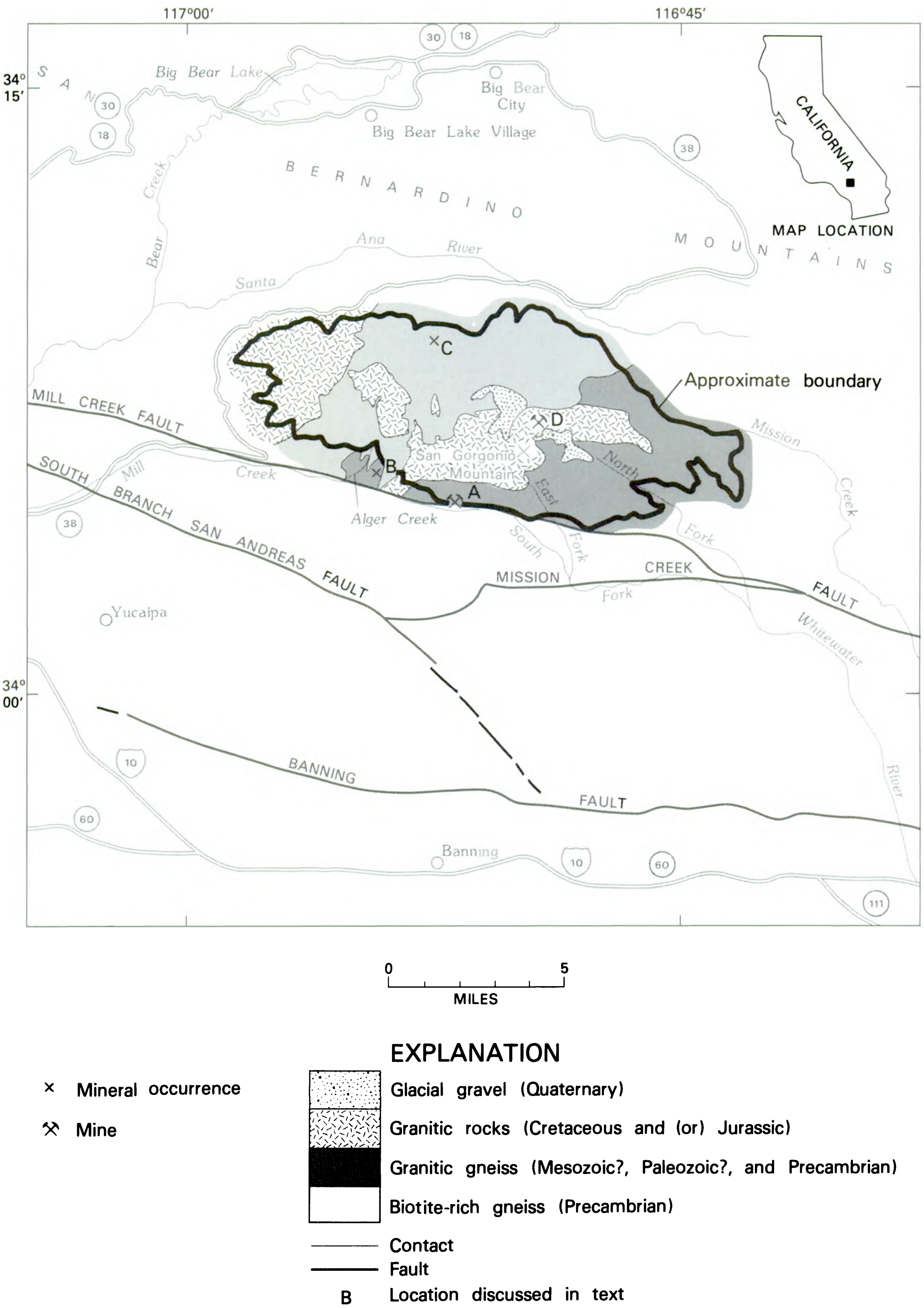

Figure 100.—San Gorgonio Wilderness, California.

Wilderness and that only a few abandoned mines and prospects exist in the wilderness. USFS records, which cover only the last 35 years, show that only three claims are located within or immediately adjacent to the wilderness. Two of these claims produced small amounts of marble (A, on map) and low-grade uranium ore (B), whereas the third claim is apparently located in barren rock (C). Evidence of earlier mining and prospecting activity is limited to a collapsed mine shaft northeast of San Gorgonio Mountain (D). There are no conspicuous signs of mineralization at the ground surface near this shaft, and analyses of mine tailings indicate only trace amounts of gold, silver, and lead.

MINERAL RESOURCES

The San Gorgonio Wilderness holds little promise for the occurrence of metallic mineral or energy resources. Geologic and geochemical studies indicate that geologic terranes potentially favorable for mineral concentrations are small in size, scattered, and lack conclusive evidence that significant mineral enrichment has actually occurred. These geologic terranes include small bodies of metasedimentary rock, quartz veins, zones of iron-stained rock, and pegmatite bodies.

Gold and tungsten occur in mining districts less than 15 mi from the San Gorgonio Wilderness, primarily in large bodies of metasedimentary rock that are surrounded by granitic rock. By comparison, only a few small masses of metasedimentary rock, consisting mainly of marble and skarn, are present in the San Gorgonio Wilderness. These masses of marble and skarn are scattered on the rugged south and east flanks of San Gorgonio Mountain, where most of them are embedded in gneiss rather than in granitic rock. Geochemical data indicate that some molybdenum and tungsten enrichment of the skarn deposits has occurred. There was no visible evidence of metallic mineralization in the few masses of skarn that we examined, although it is possible that small amounts of molybdenum or tungsten minerals are associated with other bodies of skarn that were not examined.

Scattered quartz veins contain trace amounts of several metallic elements, most notably copper, gold, lead, molybdenum, silver, and tin. In addition, south of San Gorgonio Mountain, a zone of iron-stained gneiss along the East Fork of Whitewater River is slightly enriched in barium, chromium, copper, lead, and molybdenum. These geochemical patterns apparently reflect incipient mineralization related to deep-seated hydrothermal processes. However, no evidence was found to indicate that significant concentrations of metals are present in the quartz veins or iron-stained gneiss.

An occurrence of an uranium-bearing mineral, uranothorite, was reported at a small abandoned open cut near Alger Creek (Hewett and Stone, 1957), a short distance south of the San Gorgonio Wilderness (B). The uranothorite is disseminated in three mutually adjacent pegmatite lenses composed of coarse-grained potassium feldspar and quartz and surrounded by granitic gneiss. This occurrence of uranium in pegmatite was investigated because similar pegmatite lenses are common in biotite-rich gneiss and granitic gneiss within the San Gorgonio Wilderness. The pegmatite lenses at the open cut are small, in cross section measuring no larger than 4 ft wide by 50 ft long. They contain relatively small amounts of uranium; samples that we analyzed average only 0.02 percent uranium oxide. No persuasive evidence of significant uranium concentrations was found in the aerial radioactivity survey (Pitkin and Duval, 1981) or the geochemical survey. Therefore we suspect that any undiscovered uranium-bearing pegmatite bodies that may exist in the San Gorgonio Wilderness are small and have a uranium content similar to that of the pegmatite lenses near Alger Creek.

Nonmetallic mineral resources in the San Gorgonio Wilderness include marble, sand and gravel, and granitic rock. Numerous small lenticular bodies of marble, most measuring no more than 50 ft across, are scattered as inclusions in granitic gneiss south and east of San Gorgonio Mountain. A small quantity of marble was quarried at the abandoned Mill Creek mine on the north wall of Mill Creek canyon (A). Glacial moraines on the north and east flanks of San Gorgonio Mountain contain a large volume of loose sand and gravel. Granitic rocks of suitable quality for general construction purposes are extensively exposed near the west end of the wilderness. However, all of these deposits are relatively inaccessible compared to deposits of equal or better size and quality that are widespread in southern California.

SUGGESTIONS FOR FURTHER STUDIES

Current studies indicate that the San Gorgonio Wilderness has little likelihood for the occurrence of metallic mineral or energy resources. Accordingly, we do not believe that further study or investigation of the wilderness would result in identification of other mineral resources. However, in the event that future studies are planned, we recommend the following approaches: detailed mapping and geochemical studies of skarn bodies on the south and east flanks of San Gorgonio Mountain to investigate their potential for molybdenum and tungsten resources; detailed mapping and geochemical studies of iron-stained gneiss along the East Fork of Whitewater River to determine the potential for vein-related or disseminated concentrations of base or precious metals.

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SAN JACINTO WILDERNESS, CALIFORNIA

By BRETT F. COX,[1] U.S. GEOLOGICAL SURVEY, and

MARTIN D. CONYAC, U.S. BUREAU OF MINES

SUMMARY

The San Jacinto Wilderness, located in the San Jacinto Mountains approximately 4 to 11 mi west of Palm Springs, California, was investigated by field and laboratory studies during 1978. The wilderness contains no known mineral deposits and no evidence of past mineral production. Geologic, geochemical, and geophysical studies indicate that the San Jacinto Wilderness has little promise for the occurrence of mineral or energy resources.

CHARACTER AND SETTING

The San Jacinto Wilderness lies within San Bernardino National Forest in Riverside County, and includes two separate parcels located north and south of Mt. San Jacinto State Park. The two parcels cover approximately 34 sq mi. The north parcel occupies the precipitous northern face of 10,800-ft San Jacinto Peak, and consequently is relatively inaccessible. Interstate Highway 10 and California State Highway 111 are located a few miles north and northeast of the north parcel. A high plateau and adjacent ridges in the southern parcel are accessible by trails that originate near California State Highway 243 at the mountain village of Idyllwild. This trail system also connects with an aerial tramway in Mt. San Jacinto State Park.

The San Jacinto Wilderness lies near the northern end of the Peninsular Ranges of southern California, a geologic province that is dominated by plutonic igneous rocks of Mesozoic age (Morton and others, 1980). Crystalline bedrock is exposed in most parts of the two parcels except for a few areas that are underlain by small deposits of Quaternary gravel. Roughly 85 percent of the bedrock consists of plutonic igneous rocks of Mesozoic age; the remaining 15 percent consists of metasedimentary rocks of Paleozoic and (or) Mesozoic age.

Compositionally uniform hornblende-biotite tonalite is the predominant rock type in the north parcel. Two narrow bodies of quartz diorite with abundant mafic inclusions are surrounded by the tonalite. A heterogeneous assemblage of plutonic rocks is exposed directly east of the tonalite body in the south parcel and at the east end of the north parcel. This assemblage consists mainly of leucocratic rocks including granodiorite, monzogranite, and quartz monzonite, but subordinate amounts of mafic quartz diorite and gabbro are present locally in the north parcel.

Metasedimentary rocks are located mainly in the eastern half of the south parcel and directly east of the north parcel. In both areas, but especially in the latter area, the metasedimentary rocks have been complexly intruded by leucocratic granitic rocks of the heterogeneous plutonic assemblage. The metasedimentary rocks include biotite-rich gneiss and schist, micaceous quartzite, and minor amounts of marble and calc-silicate hornfels. These rocks are isoclinally folded and contain scattered quartz veins and abundant dikes and lenticular segregations of pegmatitic granite.

Geologic field studies were supplemented by geochemical and geophysical studies. A reconnaissance geochemical survey of bedrock and stream sediments was conducted to search for characteristic associations or anomalous abundances of elements that might be caused by concealed mineral deposits. Geophysical studies were conducted only in the southern parcel; these include an aeromagnetic survey (U.S. Geological Survey, 1979) and a north-south gravity profile (H. W. Oliver, unpub. data, 1982). The north parcel was excluded from these two surveys because of steep topography.

The history of mineral exploration and the present status of claims and prospects in the San Jacinto Wilderness and vicinity were investigated by the USBM. No mineral production has come from the wilderness and only 6 small blocks of inactive, unpatented claims existed in the area at the time of this study. No workings were found on any of the claims, and samples collected on the claims lack evidence of metallic minerals.

[1]With contributions from Jonathan C. Matti and Howard W. Oliver, USGS.

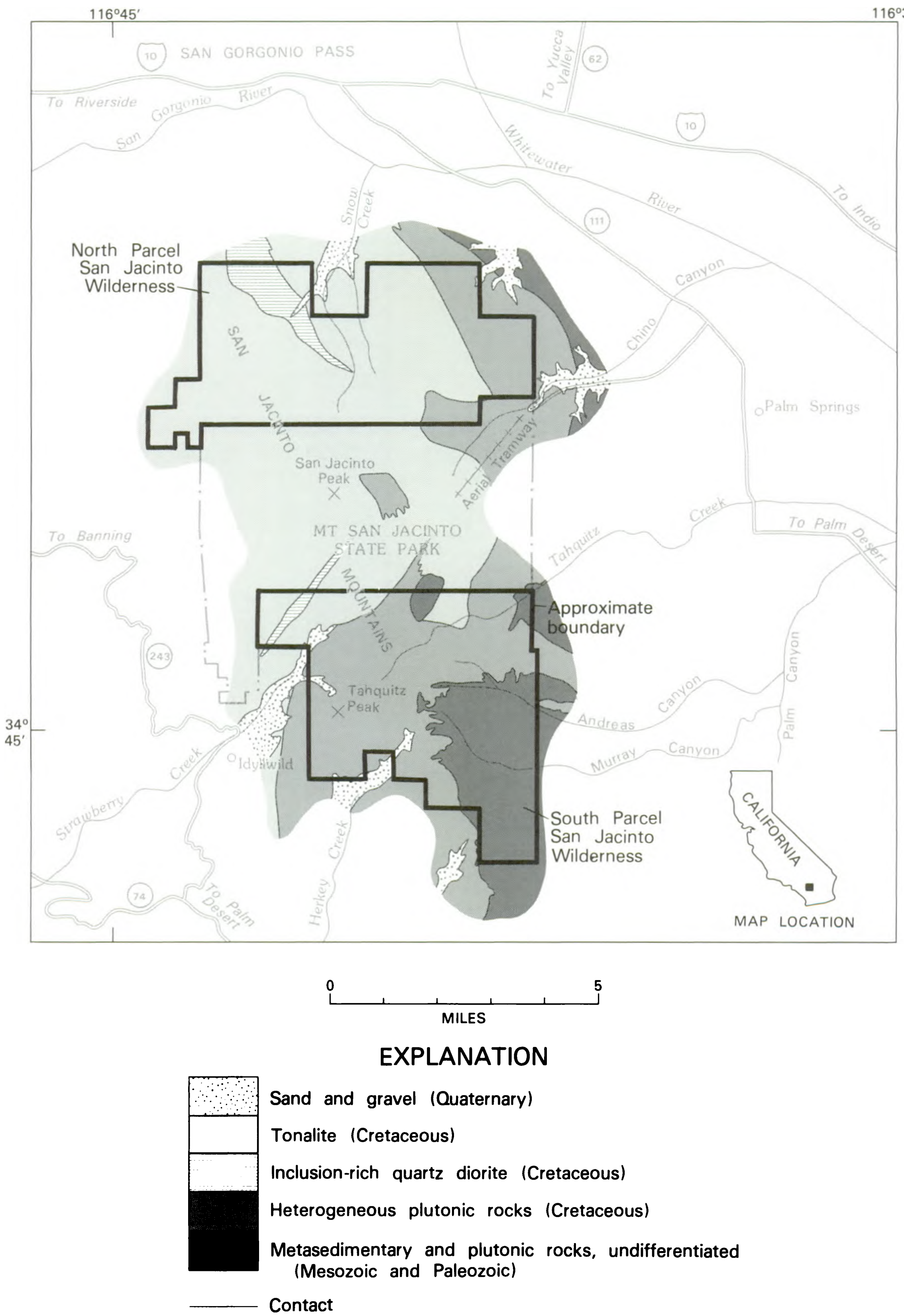

Figure 101.—San Jacinto Wilderness, California.

Mineral resources in nearby areas outside the wilderness are limited, consisting of limestone and marble, sand and gravel, and minor amounts of gold.

MINERAL RESOURCES

Our studies indicate that the San Jacinto Wilderness has little promise for the occurrence of mineral resources. Most parts of the wilderness lack geologic environments that are suitable for the occurrence of mineral deposits. The north parcel and western half of the south parcel are underlain by plutonic igneous rocks that lack mineralized veins or dikes, or any other features of potential interest. The plutonic rocks themselves might be utilized as construction materials, but this is unlikely because similar deposits outside the wilderness are of equal or better quality, more accessible, and closer to existing markets.

Geologic environments potentially favorable for the occurrence of mineral deposits are limited to the belt of metasedimentary rocks in the eastern half of the south parcel, particularly those parts of this belt that lie near intrusive contacts with plutonic igneous rocks. Elsewhere in the Peninsular Ranges, deposits of metallic minerals are locally concentrated where similar metasedimentary rocks have been intruded by Mesozoic plutons. However, during the geologic field studies no evidence of significant mineralization in the belt of metasedimentary rocks was identified.

Geochemical data indicate that the metasedimentary rocks and their derivative stream sediments in the eastern part of the southern parcel locally contain above-average amounts of several elements, including boron, barium, cerium, chromium, copper, lanthanum, molybdenum, nickel, tin, tungsten, and zinc; but the maximum concentrations of these elements are low in comparison to values that have been reported in geochemical surveys of districts with known mineral deposits. The slight mineral enrichment of metasedimentary rocks indicated by the geochemical survey probably reflects weak metasomatism of country rock during the intrusion of plutonic igneous rocks, and no potential for resources was identified.

Geophysical surveys of the south parcel also provide no indication of concealed mineral deposits. The aeromagnetic map (U.S. Geological Survey, 1979) shows remarkably little variation in magnetic intensity and thus indicates there are no significant mafic igneous intrusions or concentrations of iron-rich magnetic minerals in the south parcel. The north-south gravity profile extending through the western part of the south parcel between Idyllwild and San Jacinto Peak confirms the relatively homogeneous nature of the plutonic rocks in this area and indicates there are no buried rock bodies with abnormally high or low density near the line of the survey.

SUGGESTIONS FOR FURTHER STUDIES

On the basis of our studies further exploration of the wilderness is not warranted. However, if future studies of plutonism and related processes of mineralization are conducted in the San Jacinto Mountains and vicinity, the metasedimentary rocks and bordering intrusive contacts in the south parcel of the wilderness might merit further examination. In particular, such future studies might further evaluate the origin and significance of minor stream-sediment geochemical anomalies for tungsten, cerium, and lanthanum detected in our panned-concentrate samples collected near the heads of Murray and Andreas Canyons.

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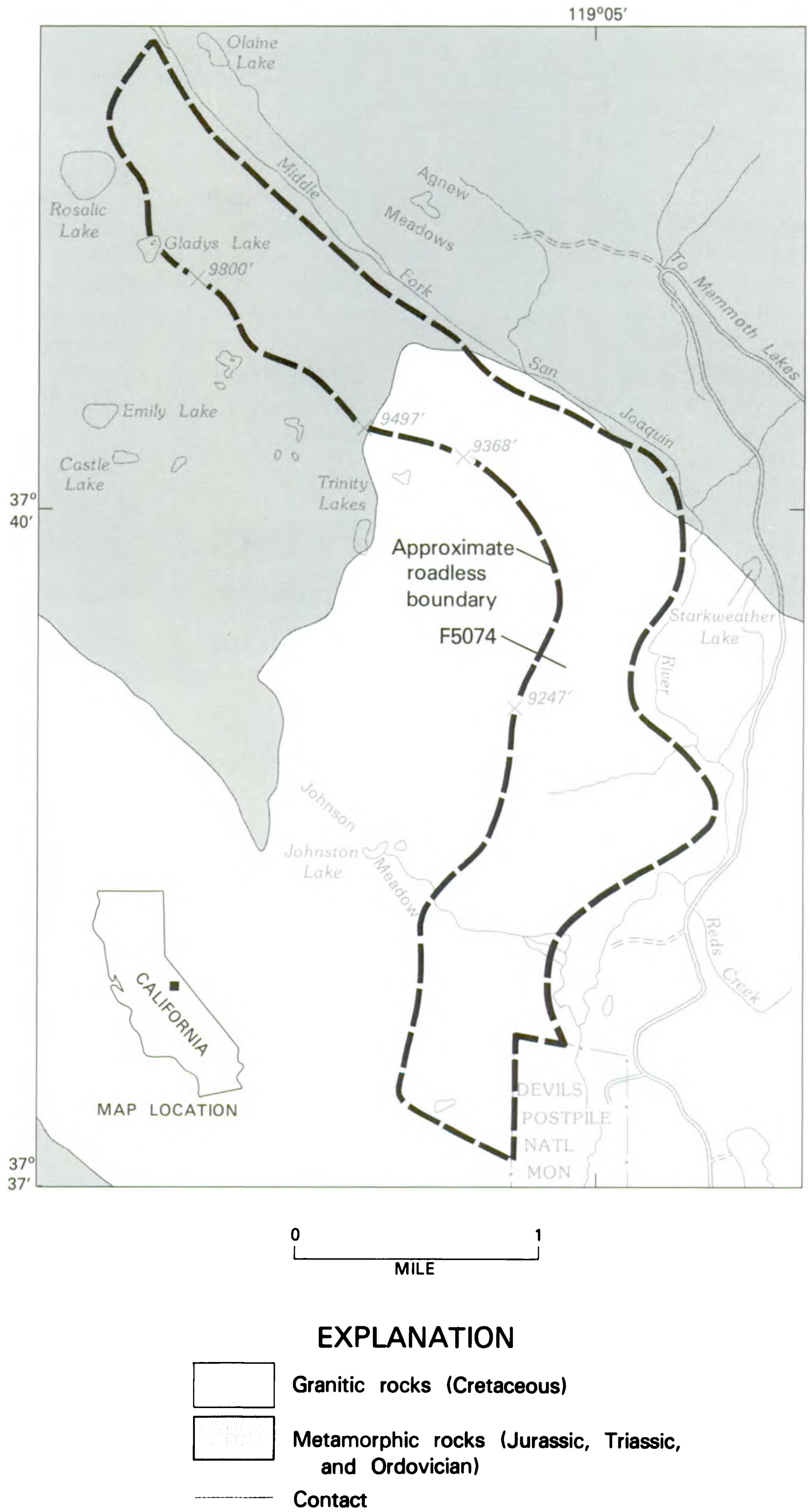

Figure 102.—San Joaquin Roadless Area, California.

SAN JOAQUIN ROADLESS AREA, CALIFORNIA

By EDWIN H. MCKEE, U.S. GEOLOGICAL SURVEY, and

DONALD O. CAPSTICK, U.S. BUREAU OF MINES

SUMMARY

The results of geologic, geochemical, and mining-activity and production surveys in 1981 in the central part of the San Joaquin Roadless Area indicate little promise for the occurrence of metallic-mineral or energy resources in the area. Sand, gravel, and pumice exist in the area but occurrences are small and isolated and farther from major markets than similar deposits outside the roadless area. Rocks in the area are exhibited in exposures of unaltered and nonmineralized granitic and metavolcanic rock along the steep western wall of the glacially carved valley of the Middle Fork of the San Joaquin River. Drainage in the area consists of seeps along fractures in the cliff or small cascading streams, a hydraulic setting not favorable for the development of placer deposits. No mines or prospect workings were found in the roadless area. Alteration zones within the granitic and metamorphic rock that crop out within the area are small, isolated, and consist only of limonitic staining and bleached quartzose rock.

CHARACTER AND SETTING

The San Joaquin Roadless Area is composed of three noncontiguous areas on the eastern side of the Sierra Nevada in Madera County, California. The central part of area F5047 was classified by the USFS as a further planning area and was studied by McKee and Capstick (1982). The area is located about 5 mi northwest of Mammoth Lakes, California, and is contiguous with the Devils Postpile National Monument on the south and the Minarets Wilderness on the west. The roadless area comprises about 3 sq mi along the western of the Middle Fork of the San Joaquin River. Altitudes range between about 7560 ft above sea level along the river, to about 9800 ft on the western crest of the area. Access to within 1 mi of the eastern edge of the area is provided by the road from Mammoth Lakes to Devils Postpile National Monument.

The geology of the roadless area is shown on the geologic map of the Devils Postpile 15-minute quadrangle, mapped by Huber and Rinehart (1965). Most of the area is underlain by Mesozoic granitic rock that intrudes regionally metamorphosed older Mesozoic volcanic rocks. A small amount of Pleistocene andesite similar to that of the Devils Postpile crops out in the area.

The northern part of the roadless area contains a metavolcanic sequence comprised of crystal-lithic tuff, tuff breccia, tuffaceous sandstone, and lava flows. These dominantly pyroclastic rocks are mostly rhyolite to dacite in composition but some basalts and andesites are present. The age of these rocks is considered by Huber and Rinehart (1965) to be Triassic(?) or Jurassic on the basis of fossils found about midway in the stratigraphic sequence. The lower part of the sequence may be as old as Permian (Huber and Rinehart, 1965).

The southern part of the roadless area is comprised of granitic rock. These rocks range in composition from granodiorite to alaskite but have an average composition of quartz monzonite. K-Ar age determinations on biotite from this unit yield a Cretaceous age of about 85 million years.

Andesite flows almost contiguous with the flows that form Devils Postpile crop out on the eastern edge of the roadless area. The andesite is medium-gray, aphanitic, and locally contains plagioclase and olivine phenocrysts. Well-developed platy and columnar joints characterize the unit.

MINERAL RESOURCES

The area lies along the steep western face of the Middle Fork of the San Joaquin River Canyon and is underlain by unaltered and nonmineralized granitic and metavolcanic rock. No mining claim monuments or definite signs of mining or prospecting activity were found within the roadless area. Placer deposits in the unconsolidated alluvium of the Middle Fork valley are not known although the river has undoubtedly been prospected many times by pan techniques. Sand, gravel, and pumice were found in the area, but occurrences are small and distant from forseeable markets. The geologic setting precludes the presence of oil and gas resources.

Geochemical sampling of stream sediment to define element anomalies in eroded material from erosion basins is of limited value in this roadless area. The only drainage in the area that is actively eroding bedrock and transporting sediment is the Middle Fork of the San Joaquin River, along the eastern boundary of the area. Almost all eroded material carried by the Middle Fork is from outside the roadless area, the amount of sediment added to the Middle Fork from the roadless area is negligible. Samples of stream sediment, nonmagnetic heavy-mineral concentrates, and rocks were spectrographically analyzed for 31 elements and show no anomalous amounts of any metallic element.

SUGGESTIONS FOR FURTHER STUDIES

Further study of the roadless area offers little promise for the identification of hidden mineral deposits.

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SAN RAFAEL PRIMITIVE AREA, CALIFORNIA

By H. D. GOWER,[1] U.S. GEOLOGICAL SURVEY

SUMMARY

No mineral-resource potential was identified by the USGS and USBM in 1965 during studies of the San Rafael Primitive Area, located at the southern end of the Coast Ranges of California. No petroleum has been produced from the area and there is little promise for the occurrence of energy resources. Limestone occurs in the area but also is found in abundance outside the area.

CHARACTER AND SETTING

The San Rafael Primitive Area includes about 220 sq mi in the Los Padres National Forest in the San Rafael and Sierra Madre Mountains in the southern part of the Coast Ranges of California. The mountainous and rugged area, about 13 mi north of Santa Barbara and 25 mi southeast of Santa Maria, is characterized by sharp ridges and steep-walled canyons. Layers of resistant rock crop out along the ridges and canyon walls and form cliffs from 100 to more than 400 ft high. Most of the slopes and ridges are densely covered by brush that is nearly impenetrable.

The San Rafael Primitive Area is underlain by Cretaceous and Tertiary sedimentary rocks that are about 22,000 ft thick. These rocks are mainly sandstone, conglomerate, siltstone, and shale, but they include some siliceous shale and minor amounts of limestone. Most of the rocks are of marine origin. The only igneous rocks in the area are two small intrusions. The sedimentary rocks are moderately to intensely faulted and folded, because deformation occurred after each episode of sedimentation recorded by the Cretaceous, Eocene, and Miocene rocks. As a result, the older rocks are generally more steeply dipping and faulted than the younger ones, and unconformities separate the main sedimentary sequences. Most major faults and folds trend N. 60°–80° W., following the general alinement of the southern Coast Range structures. In fact, some of the larger faults in the area are among the major structural elements of the Coast Range fault system.

The San Rafael Primitive Area was studied in 1965 by means of ground traverses, helicopter overflights, and aerial photographs. Additional studies included geochemical analyses of stream sediments and bedrock samples, as well as fossil identifications. After the initial studies in 1965, the boundaries of the San Rafael Primitive Area were modified to include additional lands to the north and southwest and to exclude one small part of the original area. Further studies were conducted late in 1965 to include the new areas, and the results were published the following year (Gower and others, 1966).

[1]Abstracted from a report by Gower and others (1966) by Susan Tufts, with contributions from J. G. Vedder, USGS.

MINERAL RESOURCES

No mineral-resource potential was identified in the San Rafael Primitive Area, although the southern Coast Ranges of California elsewhere contain important deposits of petroleum, mercury, diatomite, and other mineral commodities. These commodities are localized in specific geologic environments of limited extent, and their occurrence is dependent on certain geologic factors. In general, the San Rafael Primitive Area lacks the geologic conditions associated with known major mineral deposits.

There is no record of exploratory drilling for petroleum and natural gas within the San Rafael Primitive Area, although the primitive area is flanked at distances of several miles on the north, west, and southeast by producing oil fields. Test holes in adjacent areas were not productive, although minor amounts of petroleum were present in Miocene and possibly older rocks. Despite the fact that marine sedimentary rocks of Miocene age, which have been prolific producers of petroleum in nearby oil fields, underlie about 25 percent of the primitive area, they are thin and lack potential trap structures, except on a relatively small scale on the north limb of the Hurricane Deck syncline. Even there

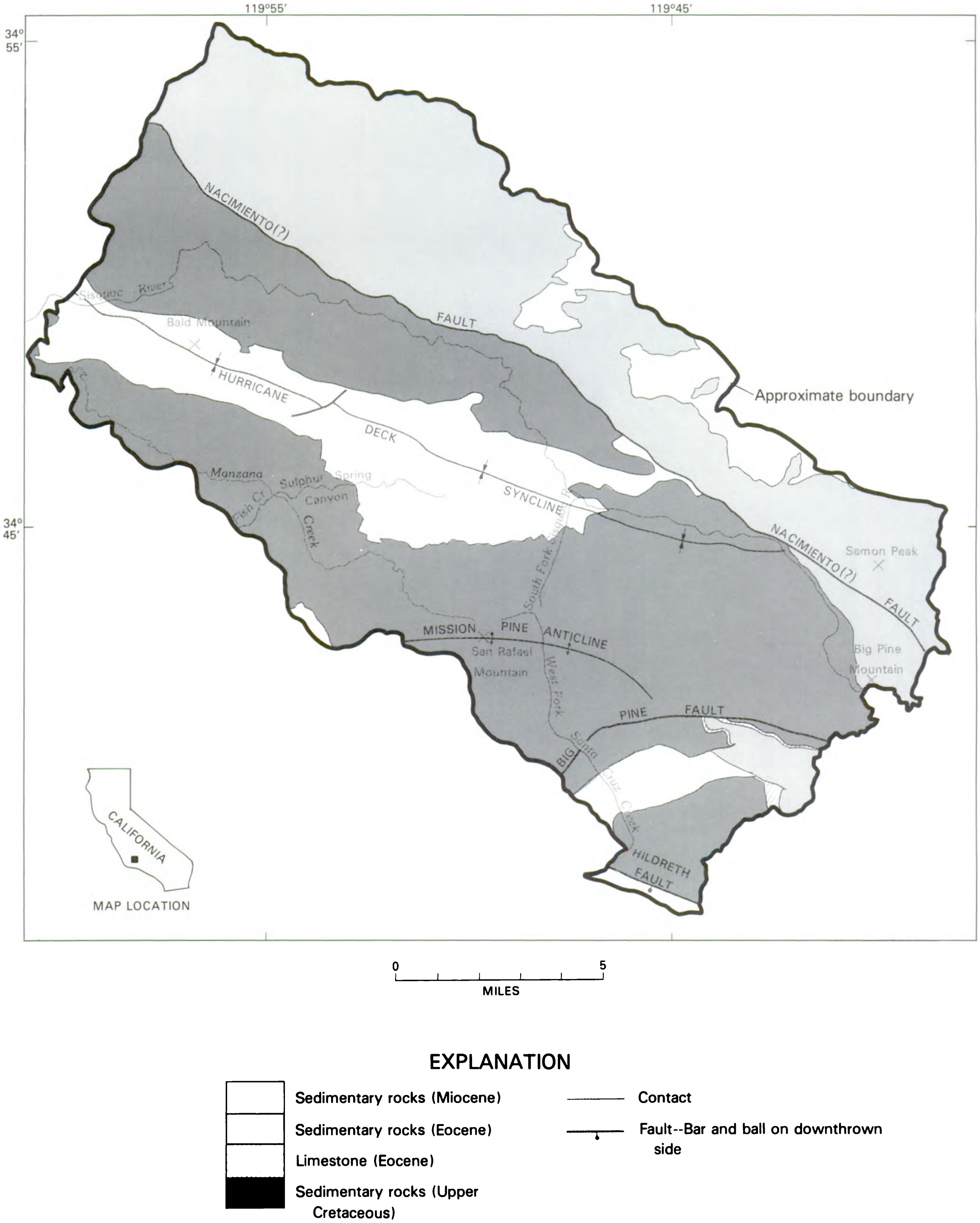

Figure 103.—San Rafael Primitive Area, California.

the existence of petroleum accumulations is doubtful, because most of the potential reservoir rocks lie above the drainage level of the Sisquoc River. The other 75 percent of the primitive area is occupied by rocks of Late Cretaceous and Eocene age, which have produced little or no petroleum in nearby areas. The largest of the possible structural traps for petroleum in the primitive area is the Mission Pine anticline, a broad east-plunging fold that is cut by several north-trending faults and terminates against a branch of the Big Pine fault near McKinley Mountain, just outside the southwestern border of the primitive area. Possible entrapment of petroleum could take place next to the fault near McKinley Mountain or along any of the faults that cut the crest of the fold. However, there is little promise for the occurrence of petroleum because this large structure involves only Cretaceous rocks, which have not been productive nearby. Elsewhere in the primitive area, Cretaceous, Eocene, and Miocene rocks have been folded into several small anticlines, but these folds generally lack apparent structural closure.

Although the San Rafael Primitive Area is bordered on the southwest by the once-productive Cachuma quicksilver (mercury) district, the carbonate-altered host rock of Late Jurassic to Early Cretaceous age for these deposits and closely associated serpentine intrusions are not known in the primitive area. Geochemical studies of stream sediments and bedrock samples indicate a weak mercury anomaly in Sulphur Spring Canyon near the southwestern border of the area, but the mercury content of the richest rocks samples is only about one-thousandth of that of most mercury ores.

Because of the presence of favorable host rocks for uranium, a scintillometer survey was taken after publication of the initial report on the area (H. E. Clifton, written commun., 1966). Readings were taken at several locations across the contact of Miocene and Cretaceous rocks, but none of the readings were sufficiently above the background levels for these rocks to indicate any uranium resource potential.

Limestone of possible commercial use occurs in the southeastern part of the primitive area, but other areas outside the primitive area contain resources of limestone that are easier to obtain and closer to markets.

Five mineral claims, or groups of claims, are recorded from the San Rafael Primitive Area, but no discovery pits were recognized in the field, although one prospect not previously recorded was found along the Sisquoc River in the central part of the primitive area. This prospect consists of an adit 15 ft long driven in Upper Cretaceous sandstone; no evidence of mineralization was seen. There is no record of any mineral production within the primitive area.

SUGGESTIONS FOR FURTHER STUDIES

Inasmuch as sampling and analytical techniques have improved significantly since this study was completed (1965), a restudy of the area using new methodology is possibly warranted.

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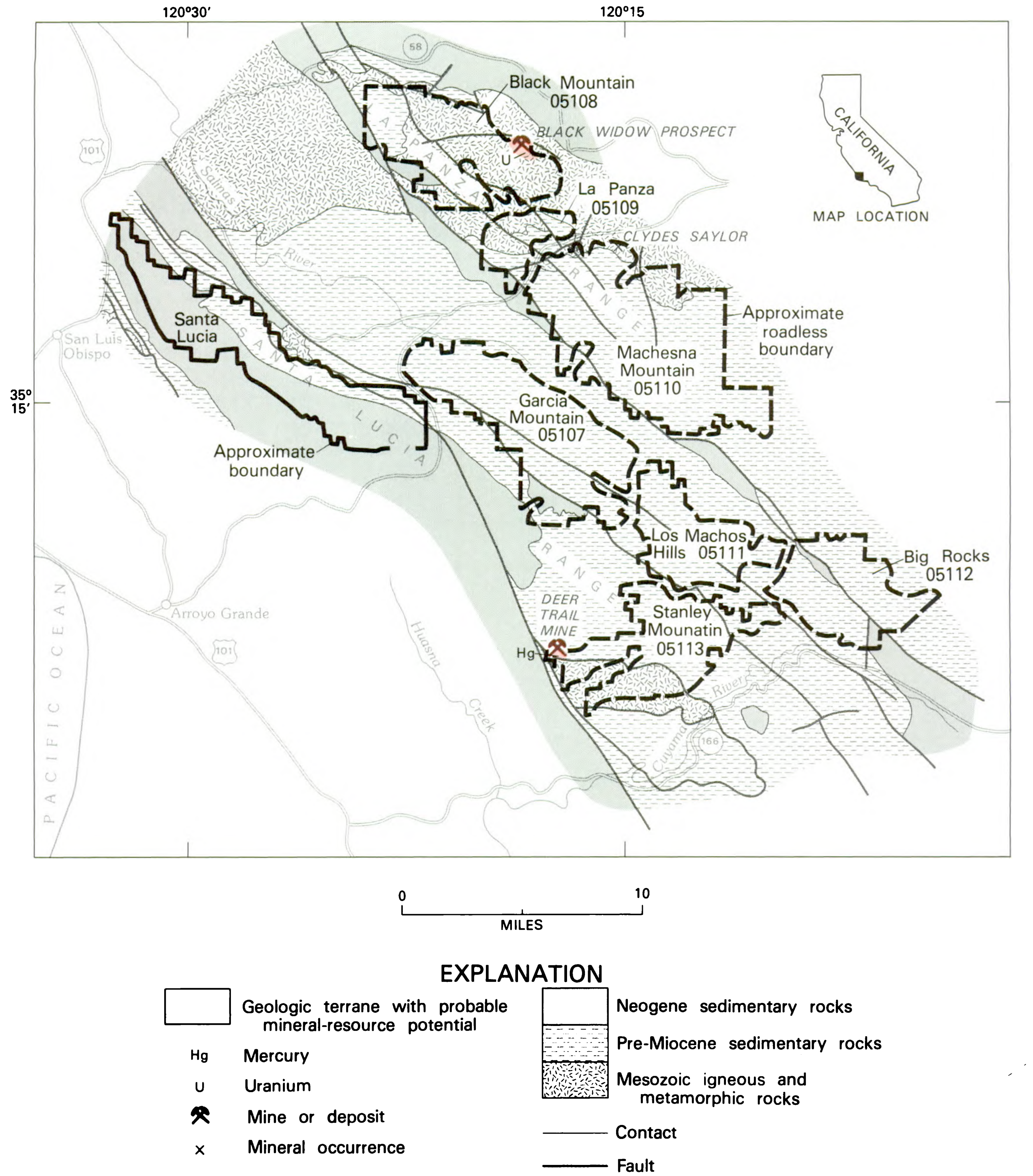

Figure 104.—Santa Lucia Wilderness, and Garcia Mountain, Black Mountain, La Panza, Machesna Mountain, Los Machos Hills, Big Rocks, and Stanley Mountain Roadless Areas, California.

SANTA LUCIA WILDERNESS, AND GARCIA MOUNTAIN, BLACK MOUNTAIN, LA PANZA, MACHESNA MOUNTAIN, LOS MACHOS HILLS, BIG ROCKS, AND STANLEY MOUNTAIN ROADLESS AREAS, CALIFORNIA

By VIRGIL A. FRIZZELL, JR.,[1] U.S. GEOLOGICAL SURVEY, and

LUCIA KUIZON, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral-resource evaluation conducted in 1980–83, a small area in the Black Mountain Roadless Area has a probable mineral-resource potential for uranium, and a small area in the Stanley Mountain Roadless Area has probable potential for low-grade mercury resources. Although petroleum resources occur nearby in rocks similar to those found in the study area, no potential for petroleum resources was identified in the wilderness or any of the roadless areas. No resource potential for other mineral resources was identified in any of the areas.

CHARACTER AND SETTING

The Santa Lucia Wilderness Area and Garcia Mountain, Black Mountain, La Panza, Machesna Mountain, Los Machos Hills, Big Rocks, and Stanley Mountain Roadless Areas together occupy an area of about 218 sq mi in the Los Padres National Forest, California. For purposes of this report the individual areas will be referred to collectively as the study area.

The study area is in the southern part of the Coast Ranges and western part of the Transverse Range near San Luis Obispo and Santa Maria, California. California State Highways 58, 101, and 166 connect to paved and unpaved roads that allow access to the study area.

The study area is characterized by steep-walled canyons and sharp ridges. Although summit ridges locally support coniferous forests and riparian woodlands line valley bottoms, impenetrable chaparral covers much of the mountain slopes and makes off-trail traverses difficult.

Thick fault-bounded sequences of sandstone, siltstone, shale, and conglomerate and igneous and metamorphic rocks are present in the study area (Frizzell and Vedder, in press). Cretaceous biotite granite and pre-Cretaceous metasedimentary rocks underlie part of the La Panza Range, and Jurassic oceanic volcanics and related sedimentary rocks and serpentinized peridotite occur in the southern part of the study area. Mesozoic through Cenozoic sedimentary rocks underlie the remainder of the study area and are divided on the basis of age into pre-Miocene sedimentary rocks and Neogene sedimentary rocks.

Pre-Miocene sedimentary rocks consist chiefly of interbedded sandstone, siltstone, shale, and conglomerate. These rocks range in age from Late Jurassic to Oligocene, but most are Late Cretaceous. They were deposited mainly in deep marine environments but local nonmarine strata are included. Mapped with these rocks are small areas underlain by the Franciscan assemblage, a unit of highly sheared and chaotically mixed sedimentary and less abundant igneous rock.

Organic-rich siltstone and shale, interbedded sandstone and lesser conglomerate predominate in the Neogene section. These rocks formed mostly from sediments deposited in relatively restricted marine basins where the organic remains of flora and fauna living in the water column constituted a relatively important source of sediment. Lesser amounts of Neogene nonmarine rocks are also present.

In addition to geologic mapping, multidisciplinary work in the study area included evaluation of mines and prospects, geophysical investigations, and organic and inorganic geochemical studies.

[1]With contributions by George E. Claypool, Andrew Griscom, and David B. Smith, USGS, and David J. Barnes, David K. Denton, Jr., Leon E. Esparza, Peter N. Gabby, David A. Lipton, and Charles E. Sabine, USBM.

Mercury deposits were discovered just north of the Santa Lucia Wilderness in 1872 and just north of Stanley Mountain in 1915. Uranium minerals and minor uranium production were reported in the study area in the 1950's. Producing oil and gas fields are situated nearby, but exploration has not been successful in the study area.

Geophysical studies include the compilation and analysis of aerial gravity and magnetic data (Griscom, in press). The gravity data indicate that the Miocene marine rocks in the southern two-thirds of the Santa Lucia Wilderness occupy a basin on trend with the Huasna basin to the southeast but those rocks are isolated from the Huasna basin by a ridge of pre-Miocene rocks. Analytical results from stream-sediment samples only delineate areas with previously known mineralization (Smith and others, in press). Analyses of fine-grained sedimentary rocks collected for a study of organic matter mostly indicate low quantities of oil and gas producing materials.

MINERAL RESOURCES

Our studies (Frizzell and others, in press) indicate that most rocks within the study area do not appear to have been favorable hosts for the concentration of metallic minerals or petroleum resources. However, the Black Mountain Roadless Area has an area of probable potential for low-grade uranium resources and the Stanley Mountain Roadless Area has an area of probable potential for low-grade mercury resources.

Although there are no producing mines in the study area, nearly all the separate roadless areas have had placer and lode claims for gold or uranium located in them, and some of these claims are still current. Spanish settlers found gold in alluvial deposits, and placer gold has been produced in small quantity within the Black Mountain, La Panza, and Machesna Mountain Roadless Areas. While these and other units of the study area still contain numerous localities underlain by terrace and alluvial deposits, our studies show that gold contents are low (Frizzell and others, in press; Barnes, 1981; Kuizon, 1983b; Denton, 1982). This and the generally small volumes of these deposits preclude any significant placer-gold resource potential within the study area.

Approximately 69 lode claims for uranium are located in the Black Mountain Roadless Area. Metasedimentary rocks (biotite schist, gneiss, and marble) which have been intruded by granitic rocks, locally give scintillometer readings four to five times background. The Black Widow prospect occurs in an area of probable uranium resource potential and has probably produced 400 lbs of U_3O_8. This and nearby prospects contain demonstrated and inferred low-grade resources of about 156,000 tons of uranium-bearing rock averaging 0.02–0.18 percent U_3O_8 (Gabby, 1981, p. 9).

Samples collected from the Clyde's Saylor prospect in the Machesna Mountain Roadless Area contain very low quantities of U_3O_8, as well as minor gold and silver (Kuizon, 1983b), but no resource potential was identified.

Cinnabar, an ore mineral of mercury, is locally found near major faults. The Deer Trail mercury mine, just outside the Stanley Mountain Roadless Area, is located on a fault and contains cinnabar-filling fractures in brecciated calcite. The mine produced 200 flasks of mercury prior to 1951, and contains inferred resources of about 32,000 tons having 1.71 lbs of mercury per ton (Kuizon, 1983c). Areas adjacent to the mine but inside the roadless area have a probable potential for low-grade mercury resources.

Because the study area is predominantly underlain by sedimentary rock, is located near the Arroyo Grande and Santa Maria oil and gas fields, and because petroleum lease applications have been filed on lands in the area, oil and gas resource potential might be expected. Reconnaissance oil and gas studies (Frizzell and Claypool, in press; Howell and Claypool, 1977), however, indicate that this is not the case. Samples from pre-Miocene rocks collected for the studies cited above contain organic matter in quantities below that necessary to produce significant amounts of hydrocarbons. Furthermore, the organic matter is terrestrial woody material, rather than the type that normally produces oil.

Miocene marine rocks, which are about 5000 ft thick, underlie the southwestern two-thirds of the Santa Lucia Wilderness and are a northwestern continuation of rocks that underlie the minimally petroleum-producing Huasna basin. The rocks contain sufficient quantities and suitable types of organic matter necessary to generate hydrocarbons, but the section here is relatively thin and has been well breached by erosion. Thus, although these Miocene marine rocks are the most likely to contain petroleum, no resource potential for petroleum was identified in the study area.

SUGGESTIONS FOR FURTHER STUDIES

Detailed geologic mapping and geochemical sampling in the vicinity of the Black Widow prospect and Deer Trail mine probably would increase knowledge about distribution and modes of occurrence of uranium and cinnabar in those areas, respectively.

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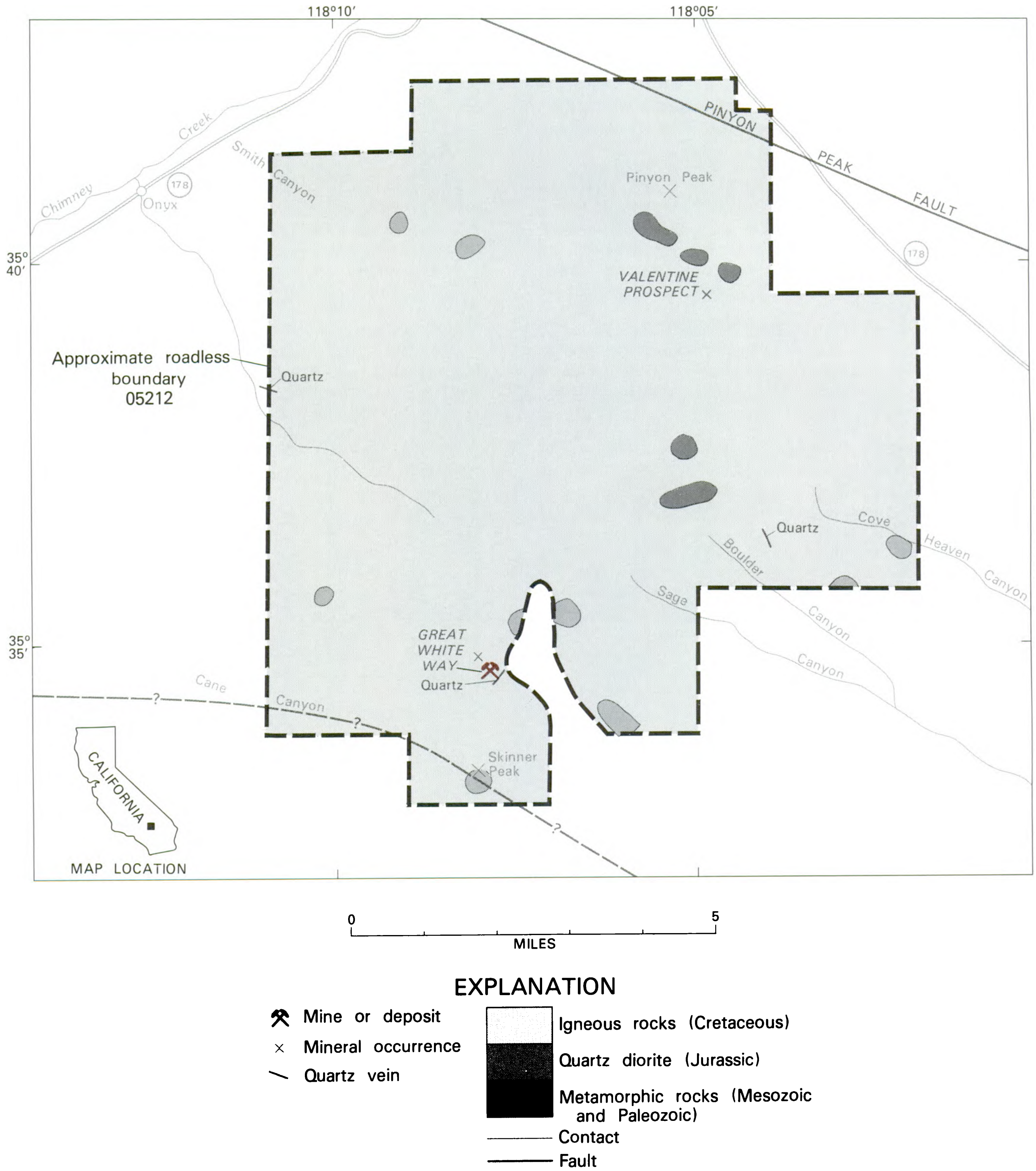

Figure 105.—Scodies Roadless Area, California.

SCODIES ROADLESS AREA, CALIFORNIA

By JOCELYN A. PETERSON,[1] U.S. GEOLOGICAL SURVEY, and

DONALD O. CAPSTICK, U.S. BUREAU OF MINES

SUMMARY

Geologic and geochemical studies carried out during 1980 and 1982 by the USGS and USBM in the Scodies Roadless Area indicate little promise for the occurrence of metallic mineral resources within the area. Tungsten has been mined from tactite in pre-Cretaceous roof pendants in the Weldon tungsten district a few miles to the west and in the Indian Wells Canyon district to the northeast. Small outcrops of similar roof pendants occur in the Scodies Roadless Area, but no tungsten resource potential was identified. Three quartz veins occurring within the roadless area may be utilized for decorative stone. One, the Great White Way, has demonstrated resources of quartz. Because of their small size and remoteness no quartz resource potential was identified in the other veins.

CHARACTER AND SETTING

The Scodies Roadless Area occupies about 75 sq mi in Sequioa National Forest about 60 mi east-northeast of Bakersfield in Kern County, California. It lies in the Sierra Nevada at altitudes ranging from 3500 to 7155 ft. Unpaved roads from Onyx, Weldon, and from California State Highways 178 and 14 provide access into the roadless area.

Most of the roadless area is an elevated plateau that has been cut by a few streams to form steep-walled canyons. The plateau supports pine forests and sagebrush, whereas the south and east parts of the roadless area, which are not on the plateau, contain desert shrubs and Joshua trees. Field work for geochemical, geologic, and mineral-occurrence information pertinent to the mineral resources of the area was carried out during 1980 and 1982 by the USGS and the USBM.

The Scodies Roadless Area lies at the southern end of the Sierra Nevada where granitic plutons have intruded and metamorphosed sedimentary rocks. In this area most of the metasedimentary rocks have been removed by erosion; remnants occur as small roof pendants suspended in the granitic rocks. The metasediments consist of quartzite, mica schist, phyllite, and marble. Locally the marble has been converted to a tactite containing coarse-grained epidote, garnet, and wollastonite (Harner and others, 1983). One of these tactites in the northeast part of the roadless area has been prospected for tungsten.

Three major igneous units occur within the area. The oldest of these is a diorite that crops out in small isolated areas predominantly in the southern part of the Scodies Roadless Area. The other two igneous units, a granodiorite and an alaskite, are intimately mixed and may be separate facies of the same intrusion. The granodiorite is more abundant than the alaskite.

Dikes that are younger than the major igneous units are abundant in the area and transect all major units. One set of dikes is aplitic, the other a coarse-grained pegmatite. Also within the area are three large quartz veins; one vein, near the southeast corner of the roadless area, has been prospected.

Two northwest-striking faults cross the northeastern and southwestern corners of the area.

MINERAL RESOURCES

The presence of tactite and quartz veins in the roadless area would seem to provide favorable conditions for the occurrence of mineral deposits, particularly because tungsten has been mined from tactites in the Weldon tungsten district a few miles to the west and in the Indian Wells Canyon district to the northeast. Gold has also been mined from quartz veins in the Indian

[1]With contributions from Joy L. Harner and James F. Seitz, USGS.

Wells Canyon district. Despite these seemingly favorable geologic environments for mineral deposits within the Scodies Roadless Area, the favorable areas are small and few and no areas of resource potential were found.

Geochemical evaluation of rock and stream-sediment samples indicated weakly anomalous amounts of gold, silver, and lead in the northern part of the roadless area and anomalous lead in the southeastern part of the area. Because the anomalies were weak and because the lead anomalies were not associated with other anomalies expected of hydrothermal lead deposits, they are considered to represent fluctuation in background levels rather than mineralization.

A tactite in a roof pendant in the northeast part of the roadless area (Valentine claims) was prospected during the early 1940's for tungsten. No record of production was found and no tungsten resource potential was identified in this study.

A large quartz vein occurs near the southern boundary of the roadless area and is the site of the Great White Way prospect, where quartz, without visible metallic mineralization, was prospected during the late 1950's. The vein contains a demonstrated resource of an estimated 22,000 tons of white massive quartz which could be used for decorative stone. However, the quartz vein is small and remote and the prospect is not active at present. Two smaller quartz veins occur elsewhere in the area, but no decorative stone or other resources were identified.

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SESPE-FRAZIER, DIABLO, MATILIJA, DRY LAKES, SAWMILL-BADLANDS, CUYAMA, ANTIMONY, AND QUATAL ROADLESS AREAS, CALIFORNIA

By VIRGIL A. FRIZZELL, JR.,[1] U.S. GEOLOGICAL SURVEY, and

WILLIAM N. HALE, U.S. BUREAU OF MINES

SUMMARY

Studies by the USGS and USBM conducted from 1980 to 1983 indicate that the Sespe-Frazier Roadless Area contains demonstrated resources of gold, gypsum, phosphate and bentonite; deposits in the Cuyama Roadless Area have demonstrated resources of gypsum; mines in the Antimony Roadless Area have demonstrated resources of antimony, gold, silver, and marble; and the Quatal Roadless Area has demonstrated resources of bentonite. The Sespe-Frazier Roadless Area has substantiated potential for geothermal resources suitable for direct-heat purposes, probable and substantiated potential for oil and gas resources, and probable potential for gold resources. Small areas of probable resource potential for antimony and gold were identified in the Antimony Roadless Area.

CHARACTER AND SETTING

The study area, consisting of the Sespe-Frazier, Diablo, Matilija, Dry Lakes, Sawmill-Badlands, Cuyama, Antimony, and Quatal Roadless Areas, occupies about 872 sq mi in the Los Padres National Forest, California. For purposes of this report the roadless areas will be referred to collectively as the study area. The study area is in the western part of the Transverse Range of California between the Santa Barbara area, on the Pacific Ocean, and the San Joaquin Valley. Interstate Highway 5 and California State Highways 33 and 126 join paved and unpaved roads that allow access to the study area.

Much of the study area is characterized by steep-walled canyons and sharp ridges. Although summit ridges may locally support coniferous forests and riparian woodlands may line valley bottoms, impenetrable chaparral covers much of the mountain slopes and makes off-trail traverses difficult. Pre-Tertiary igneous and metamorphic rocks underlie the northeastern third of the study area (Frizzell and Vedder, in press). They consist of Precambrian metasedimentary rocks and granitic gneisses, metasedimentary rocks of unknown age, and Mesozoic granitic rocks.

Most of the rest of the study area is underlain by highly folded sedimentary rocks ranging in age from Late Jurassic to Oligocene. They comprise a thick, heterogenous, incomplete marine section of interbedded sandstone, siltstone, shale, and conglomerate, with local nonmarine interbeds.

Neogene sedimentary rocks include organic-rich siltstone and shale, interbedded sandstone, and lesser conglomerate. These rocks formed mostly from sediments deposited in relatively restricted marine basins where the organic remains of flora and fauna living in the water column constituted a relatively important source of sediment. Neogene nonmarine rocks occur mostly in the Cuyama Badland, Lockwood Valley, and along the eastern boundary of the study area in the Ridge Basin.

In addition to geologic mapping, work in the study area included evaluation of mines and prospects, geophysical investigations, and organic- and inorganic-geochemical studies. Geophysical studies (Griscom, in press) included the compilation and anlaysis of gravity, magnetic, and radiometric data. Analytical data from stream-sediment samples, collected for a reconnaissance geochemical study (Smith and others, in press), delineate areas with previously known mineral-resource potential, but failed to identify additional areas.

The study area has a long and varied history of mining and exploration. Placer gold was mined from Piru Creek in the Sespe-Frazier Roadless Area in the 1840's and lode gold was discovered therein in the late 1800's.

[1]With contributions by George E. Claypool, Andrew Griscom, and David B. Smith, USGS, and D. E. Graham, Lucia Kuizon, Robert H. Lambeth, Warren D. Longwell, Terry R. Neumann, William H. White, and R. A. Winters, USBM.

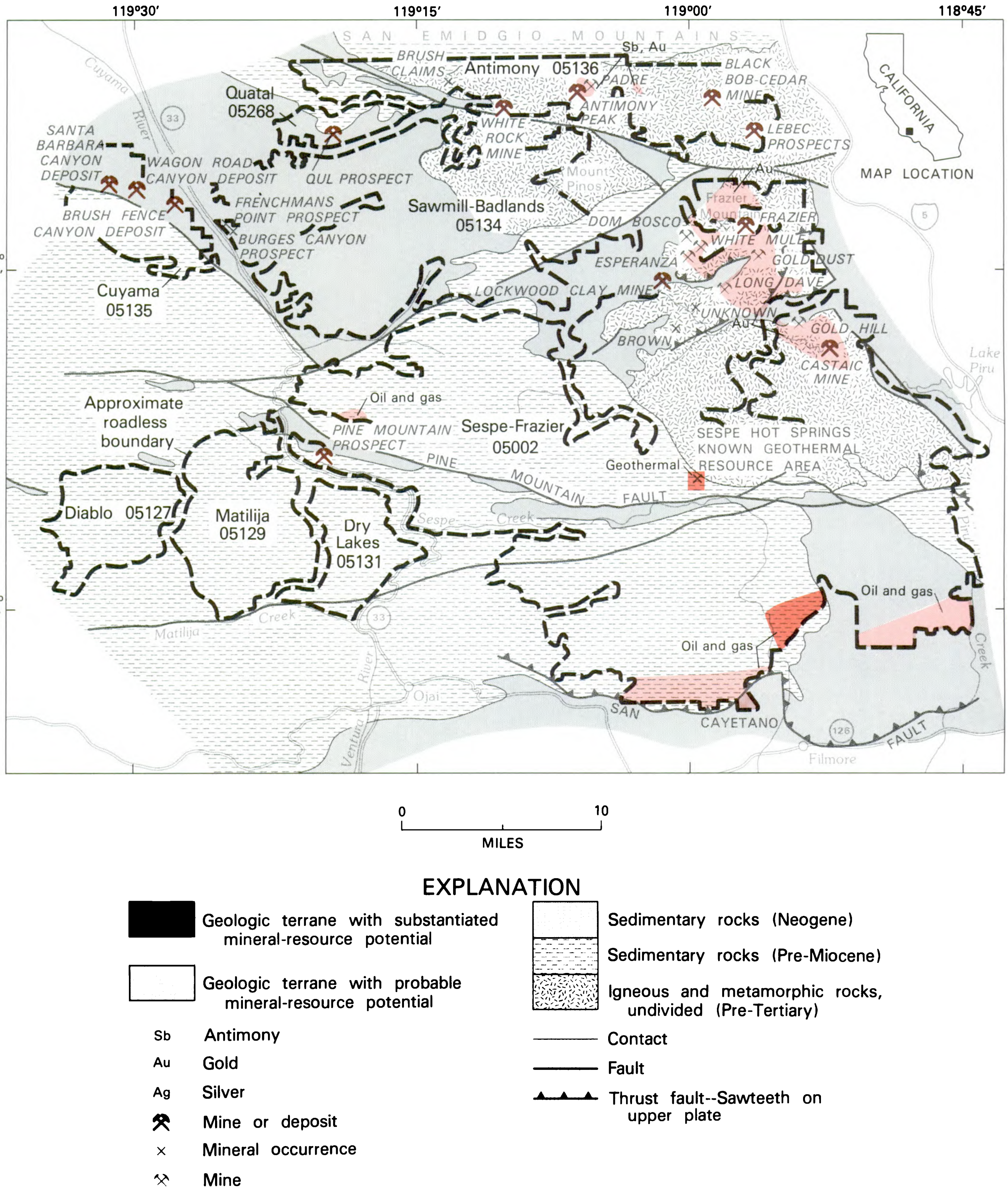

Figure 106.—Sespe-Frazier, Diablo, Matilija, Dry Lakes, Sawmill-Badlands, Cuyama, Antimony, and Quatal Roadless Areas, California.

At about the same time, lode gold was found in the Antimony Roadless Area where antimony had been discovered earlier. Exploration for oil and gas began in the southern part of the Sespe-Frazier Roadless Area in 1887. Uranium was reported in the Antimony and Sawmill-Badlands Roadless Areas in the early 1950's. Marble has been mined in the Cuddy Valley region south of the Antimony Roadless Area since the late 1800's. Gypsum was discovered in the Cuyama Roadless Area in 1892, and subsequently in other localities in the study area. The Pine Mountain phosphate prospect in the Sespe-Frazier Roadless Area was explored in the 1960's.

MINERAL RESOURCES

Our studies (Frizzell and others, in press) indicate that the Sespe- Frazier Roadless Area has demonstrated resources of lode gold, gypsum, phosphate, and bentonitic clay and geothermal resources; that the Cuyama Roadless Area has demonstrated resources of gypsum; that the Antimony Roadless Area has mines containing demonstrated resources of antimony, gold, silver, and marble; and that the Quatal Roadless Area has demonstrated resources of bentonite.

Spanish settlers produced gold from placer deposits in the Sespe-Frazier Roadless Area. This and other roadless areas still contain numerous localities underlain by terrace and alluvial deposits that contain placer gold (Frizzell and others, in press; Hale and others, 1983; White, 1982a,b; Longwill, 1982). Because these deposits generally contain small volumes and have low gold content, as determined from this study, no probable placer gold resources exist within the study area.

Over 400 mining claims have been filed in the Sespe-Frazier Roadless Area since 1885 and gold was produced in or near the area until 1941. Demonstrated resources of about 8000 tons of 0.38 oz/ton gold are present at the Castaic mine. Other prospects or mines in this part of the roadless area contain smaller amounts of inferred resources of gold. The area around these mines is considered to have a probable resource potential for gold.

The Lockwood Clay mine has 7.2 million tons of demonstrated resources of bentonitic clay of which about 4.7 million tons occur within the Sespe-Frazier Roadless Area. Bentonitic clay has been produced from this deposit since 1954. Demonstrated bentonite resources from the Neogene Lockwood Clay (QUL Prospect) also exist in the Quatal Roadless Area (White, 1982b, p. 14).

The Miocene Santa Margarita Formation contains gypsum- and phosphate-bearing beds inside and north of the Sespe-Frazier Roadless Area, south of Pine Mountain. About 51 million tons of phosphate-bearing rock averaging 10 percent P_2O_5, and 8 million tons of gypsum, averaging 76 percent $CaSO_4$, occur within the Sespe-Frazier Roadless Area.

Several deposits in nonmarine rocks in the Cuyama Roadless Area contain demonstrated gypsum resources (Kuizon, 1981); the Santa Barbara Canyon deposit has 30,000 tons averaging 83 percent $CaSO_4$; the Wagon Road Canyon deposit has 276,000 tons averaging 85 percent $CaSO_4$; and the Brush Fence Canyon deposit has 61,000 tons averaging 90 percent $CaSO_4$. Two prospects in the Sawmill-Badlands Roadless Area, the Frenchmans Point and Burges Canyon prospects, also contain gypsum but no tonnages are available (Longwill, 1982).

The strongest geochemical anomalies occur in sediment samples from streams draining areas around Antimony Peak. The patented Antimony Peak mine produced 600 tons of ore (5 tons at the Padre mine) and contains 470,000 tons of demonstrated and inferred resources averaging 1.0 to 2.7 percent antimony (Kuizon, 1982). Geochemical and geologic evidence indicate a probable gold and antimony resource potential for nearby areas. The Black Bob and Cedar mines produced 358 oz gold, 367 oz silver, and 673 lbs of lead. They contain 1600 tons of demonstrated resources averaging 0.13 oz gold/ton and 0.5 oz silver/ton and 11,000 tons lesser grade material. Metasedimentary rocks occur as scattered roof pendants near Brush Mountain, and although samples of metasandstone at the Brush claims contain minor amounts of U_3O_8 and gold and anomalous concentrations of other metals, the data are insufficient to define the metallic resource potential for the area of these metasedimentary rocks.

Marble and dolomitic marble occur as roof pendants in granitic rocks. The Lebec prospects contain about 51 million tons of demonstrated and inferred marble resources averaging 32.2 percent CaO and 2.8 percent MgO. The White Rock mine has produced 300,000 tons and contains 34 million tons of demonstrated and inferred marble resources averaging 32.4 percent CaO and 24.8 percent MgO (Kuizon, 1982).

The study area contains several thermal springs along the southern parts of the Dry Lakes (White, 1982a) and the Matilija (Lambeth, 1982) Roadless Areas, and, notably, at Sespe Hot Springs, an area of substantiated geothermal resource potential that is a Known Geothermal Resource Area.

Reconnaissance oil and gas studies (Frizzell and Claypool, in press; Howell and Claypool, 1977) indicate that undiscovered petroleum resources are not likely in the pre-Miocene sedimentary rocks. These rocks generally contain organic matter in quantities and qualities below those necessary to produce significant amounts of hydrocarbons, and they also generally have poor reservoir characteristics.

The Neogene marine rocks in the southern parts of the Sespe-Frazier Roadless Area, however, do contain sufficient quantities and suitable types of organic matter necessary to generate hydrocarbons. Furthermore, they, and the Eocene marine and Oligocene nonmarine rocks which underlie them there, probably contain undiscovered oil. An elongate east-west negative gravity anomaly confirms the presence of Neogene rocks below the San Cayetano thrust where oil may be present. Part of the Sespe oil field extends into the Sespe-Frazier Roadless Area near the San Cayetano thrust and has a substantiated oil and gas resource potential. Two areas of probable oil and gas resource potential occur in the southern part of the Sespe-Frazier Roadless Area east and west of the Sespe oil field. Another negative gravity anomaly north of the Pine Mountain phosphate prospect indicates that about 4500 ft of Neogene rocks are present below the Pine Mountain fault. An area of probable oil and gas resource potential exists around the anomaly.

SUGGESTIONS FOR FURTHER STUDIES

Additional gravity data and development of gravity models may further our understanding of the rocks and petroleum potential below the San Cayetano and Pine Mountain faults. Detailed geologic mapping and geochemical sampling is required to better assess the resource potential of the Antimony and Sespe-Frazier Roadless Areas.

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SHEEP MOUNTAIN WILDERNESS STUDY AREA AND CUCAMONGA WILDERNESS AND ADDITIONS, CALIFORNIA

By JAMES G. EVANS,[1] U.S. GEOLOGICAL SURVEY, and

JAMES RIDENOUR, U.S. BUREAU OF MINES

SUMMARY

A mineral survey conducted in 1975–76 indicates areas of probable and substantiated tungsten and gold resource potential for parts of the Sheep Mountain Wilderness Study Area and an area of probable tungsten and gold resource potential in the Cucamonga Wilderness and additions. The rugged topography, withdrawal of lands from mineral entry to protect watershed, and restricted entry of lands during periods of high fire danger have contributed to the continuing decline in mineral exploration. The geologic setting precludes the presence of energy resources.

CHARACTER AND SETTING

The Sheep Mountain Wilderness Study Area and Cucamonga Wilderness and additions encompass approximately 104 sq mi of the eastern San Gabriel Mountains, Los Angeles and San Bernardino Counties, California. The Sheep Mountain Wilderness Study Area is 27 mi northeast of the Los Angeles Civic Center. Uplift of the range has resulted in the carving of deep canyons into the crystalline rocks, with 8000 ft of relief in the Sheep Mountain Wilderness Study Area and 4000 ft in the Cucamonga Wilderness and additions. Old Baldy summit, at 10,000 ft altitude, is the highest point in the range and is visible from the heavily populated lowlands. Spectacular views across the Los Angeles Basin to Catalina Island and across the Mojave Desert can be seen from the high ridges. Some of these vistas and parts of the study area and wilderness can be seen at close range from several paved roads that provide access to the eastern San Gabriel Mountains. These include State Highway 39, State Highway 2, which forms part of the north boundary of the Sheep Mountain area, Glendora Ridge Road, which forms part of the south boundary of the same area, and San Antonio Canyon Road, which lies between the two areas and ends at a ski lift that provides further access to the area between Old Baldy and Thunder Mountain.

Mining activity in the region began in the 1840's and has continued intermittently. Most activity has involved recovery of placer gold from recent streambed or old perched stream channel deposits. The richest placer deposits were in the East Fork San Gabriel River south of the Sheep Mountain Wilderness Study Area. The search for sources of placer gold in the late 1800's led to discovery of several lode mines.

Scheelite ($CaWO_4$) was discovered in Cattle Canyon, in the Sheep Mountain Wilderness Study Area, in the 1950's and has been worked intermittently since then, mostly by handpicking the high-grade pieces of rock from talus and alluvium.

Geochemical studies of the areas in 1975–76 included stream-sediment sampling of fine silt and pan concentrates, and collection of rock samples from mineralized outcrops, mines, and prospects. These samples were analyzed for gold, tungsten, and several other elements by the USGS and USBM. The results of these analyses along with a discussion of the geology were published in Evans and others (1977, 1982). The mineral-resource evaluation of the areas is based on these analyses and on geologic models of the deposits. An aeromagnetic study of the areas was also performed.

The hard crystalline rocks that underlie the study area and wilderness range widely in age from Proterozoic to Miocene. They show evidence of a complex history involving the processes of sedimentation, intrusion of granitic magma in several widely spaced pulses, thermal metamorphism due to the great depth of burial as well as contact with hot magma, and dynamic metamorphism under varying conditions of strain. The major structure of the area is the nearly flat lying Vincent thrust, which separates two distinct terranes: schist in

[1]With contributions from Leroy Pankratz, USGS, and Steven W. Schmauch and Nicholas T. Zilka, USBM.

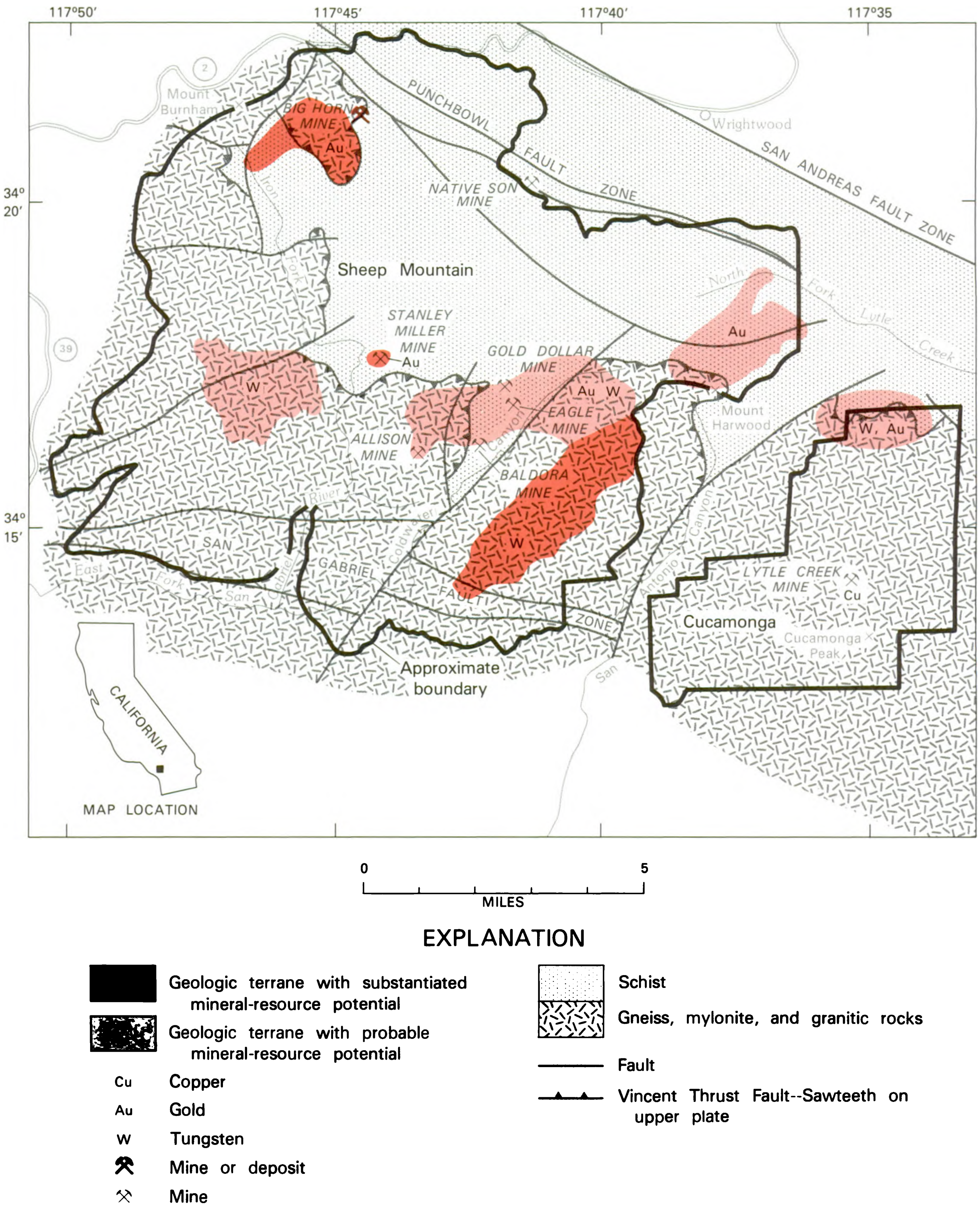

Figure 107.—Sheep Mountain Wilderness Study Area and Cucamonga Wilderness and Additions, California.

the lower plate and gneiss, mylonite, and granitic rocks in the upper plate. The mylonite comprises a zone adjacent to the thrust of intensely sheared, nearly homogenized rock derived from parts of the gneiss, granitic rocks, and schist. A final pulse of granitic magma was emplaced after development of the thrust and mylonite. Since then, and continuing to the present, the range has been extensively uplifted. In addition, steep faults in the area have had predominantly horizontal slip, most notably along the San Gabriel and Punchbowl fault zones, which are splays of the regional San Andreas fault zone, located 1 mi north of the Sheep Mountain Wilderness study area. Recent erosion has created the very great relief of the range.

MINERAL RESOURCES

Placer samples taken from the East Fork San Gabriel River in this investigation contained very little or no gold. Mines located during the search for the lode sources of the gold are in the schist and in the mylonite above the schist. The Big Horn mine, in the northwest part of the Sheep Mountain Wilderness Study Area has the largest recorded production and estimated demonstrated resources. It lies along the Vincent thrust, a structure which must have localized mineralizing solutions. The other lode gold mines in the Sheep Mountain Wilderness Study Area lie in a band between Iron Mountain and West Baldy, in an area in which geochemical sampling indicates a probable potential for additional gold resources. Another area northeast of Old Baldy has probable potential for gold resources based on stream-sediment samples.

Tungsten (scheelite) deposits in alluvium and talus in Cattle Canyon were derived from veins, pods, and disseminations in fractures in the gneiss and granitic rock of the canyon walls. The area has a substantiated tungsten resource potential. Abundant evidence for similar kinds of deposits was found in Devil Gulch and the area is assessed a probable tungsten resource potential. Tungsten mineralization accompanies gold mineralization in the area of probable resource potential between Iron Mountain and West Baldy. A probable resource potential for low-grade tungsten and gold in the cataclastic rocks above the Vincent thrust fault exists in the northern part of the Cucamonga Wilderness and additions.

In general, the rocks of the study area and wilderness show few indications of extensive mineralization; where gold or tungsten was found, the occurrences are restricted to narrow veins or zones. Much of the gold in the placer deposits of the East Fork San Gabriel River may have been derived from very small lode deposits which remain undiscovered today. In addition, the aeromagnetic data do not indicate any mineral-resource potential in the area. The geologic setting of the area precludes the presence of energy resources.

SUGGESTIONS FOR FURTHER STUDIES

Additional study of the study area and wilderness offers little promise for identification of hidden mineral resources.

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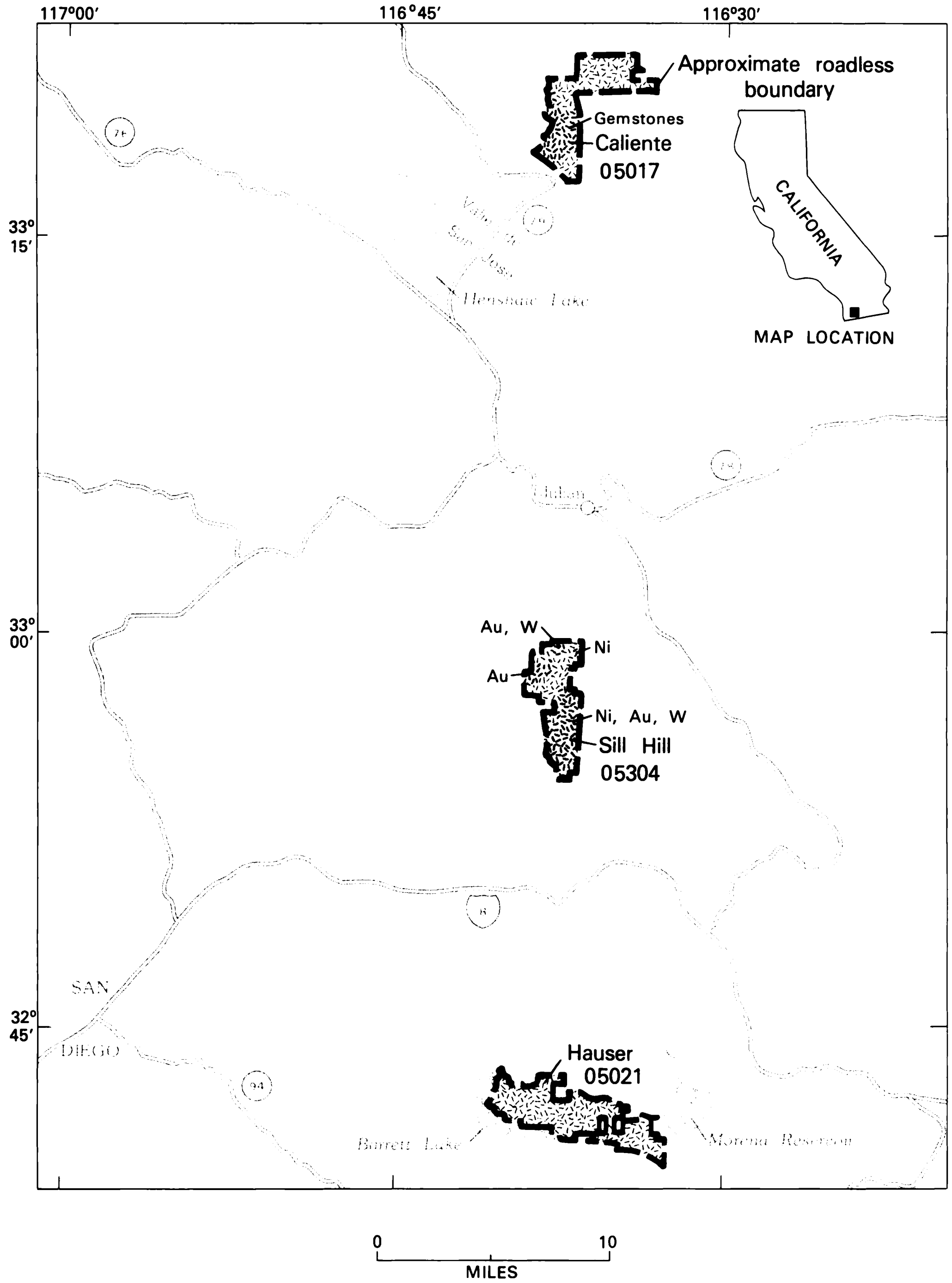

EXPLANATION

Geologic terrane with probable mineral-resource potential

Plutonic igneous rocks

Au Gold

Ni Nickel

W Tungsten

Figure 108.—Sill Hill, Hauser, and Caliente Roadless Areas, California.

SILL HILL, HAUSER, AND CALIENTE ROADLESS AREAS, CALIFORNIA

By VICTORIA R. TODD,[1] U.S. GEOLOGICAL SURVEY, and

THOMAS J. PETERS, U.S. BUREAU OF MINES

SUMMARY

Probable resource potential for metallic minerals and gemstones was identifed during mineral-resource surveys in the Sill Hill, Hauser, and Caliente Roadless Areas, California, by the USGS and USBM in 1980 and 1981. Parts of the Sill Hill Roadless Area have a probable potential for gold, tungsten, and nickel and by-product copper. Part of the Caliente Roadless Area has a probable potential for tourmaline, beryl, quartz, and possibly other specimen minerals and gemstones. No mineral-resource potential was identified in the Hauser Roadless Area, although potash feldspar is abundant as a rock-forming constituent in two parts of the area. The Caliente Roadless Area lies less than 1 mi from an area of hot springs activity which may be part of a low-grade geothermal resource area, but no geothermal resource potential was identified in this or any of the other areas. No resource potential for nuclear energy was identified in this study and the geologic terrane precludes the occurrence of hydrocarbon resources.

CHARACTER AND SETTING

The Sill Hill, Hauser, and Caliente Roadless Areas occupy about 8.0, 12.5, and 9.0 sq mi, respectively, of the Cleveland National Forest in San Diego County, California. Products of the mineral-resource survey include a detailed geologic map of the areas (Todd, in press), and a detailed evaluation of the mineral-resource potential (Todd and others, 1983).

The Cleveland National Forest is in the Peninsular Ranges, the mountainous spine that extends for hundreds of miles from southern California into Baja California, Mexico, and separates the Pacific coastal lowlands on the west from the Colorado Desert on the east. The Cleveland National Forest is characterized by a Mediterranean climate and rugged, chapparal-covered slopes below conifer-forested peaks more than 1 mi high. Total relief in the three roadless areas ranges from about 2200 to 3400 ft.

The Sill Hill, Hauser, and Caliente Roadless Areas are underlain by Cretaceous plutonic igneous rocks of the Peninsular Ranges batholith, rocks which form much of the crystalline bedrock of the Peninsular Ranges. The batholith is composed of a variety of plutons that intruded metamorphosed Paleozoic to Cretaceous sedimentary and volcanic rocks, remnants of which are exposed between the plutons. Patches of upper Cenozoic stream deposits unconformably overlie the uplifted and deeply eroded batholith in all three roadless areas. Faults of various ages have formed along and across the steep layering in the batholithic rocks. In the Caliente Roadless Area, some of these faults cut Quaternary stream deposits.

MINERAL RESOURCES

Mineral occurrences within and near the Sill Hill Roadless Area indicate that parts of the area have a probable resource potential for gold, tungsten, nickel, and copper. The northwest part of the roadless area lies within the Boulder Creek gold district and has a probable gold resource potential. Although the Boulder Creek deposits are low grade, gold deposits in the Julian mining district, 6 mi to the north-northeast, produced $5,000,000 worth of gold in the late 19th and early 20th centuries. Deposits contained entirely or partially within metasedimentary schist have been much more productive than deposits contained in fractured, sheared, or metamorphosed granitic rock. The scarcity of schist in the Boulder Creek district may be a factor contributing to the low grade of the deposits there. A

[1]With contributions from Robert E. Learned, USGS, and Ronald T. Mayerle, USBM.

prospect in the east-central part of the Sill Hill Roadless Area contains scheelite ($CaWO_4$) in a small contact-type deposit. The Friday Nickel prospect, 4.5 mi northeast of the roadless area, contains nickel, with accessory copper and cobalt, in sulfide minerals in a gabbro pluton. Similar occurrences can be extrapolated to the eastern and southern parts of the Sill Hill Roadless Area, which are underlain by the same gabbro pluton.

Chemical analysis of stream-sediment samples from the Sill Hill Roadless Area show anomalous concentrations of chromium, nickel, and vanadium associated with gabbro plutons; gold anomalies associated with quartz veins in granitic plutons; and lead, tin, tungsten, and nickel anomalies associated with contact-type occurrences between small calc-silicate metasedimentary inclusions and intrusive rocks.

Results of this mineral-resource investigation indicate that the Sill Hill Roadless Area has a probable resource potential for gold, tungsten, nickel and by-product copper. Occurrences of gold, nickel, and tungsten are known in and around the roadless area. Areas underlain by metasedimentary rocks have resource potential for gold deposits similar to those in the Julian mining district and for small low-grade tungsten resources in sparse calc-silicate rocks. That part of the Boulder Creek mining district which lies within the Sill Hill Roadless Area has probable gold-resource potential. Areas underlain by gabbro have a probable resource potential for nickel and the gabbro could be an exploration target.

In the Caliente Roadless Area the inactive Cryo-Genie mine in the southwest part of the area has produced small amounts of specimen and gemstone tourmaline and beryl from a pegmatite dike. The Crest Gem mine, 0.5 mi northwest of the area, was the largest local producer of tourmaline in the early 1900's; the mine presently yields several thousand pounds of quartz crystals and a few beryl crystals annually. A prospect in the southwestern part of the roadless area has minor scheelite in a contact-type deposit. Several small, low-grade contact-type scheelite deposits occur in this part of San Diego County. The nearest tungsten mine, and once the largest producer in the county, is the inactive Pawnee mine, 6.5 mi northwest of the Caliente Roadless Area, which has produced small amounts of tungsten trioxide (WO_3) on an intermittent basis since 1917. An unnamed prospect in the northwest corner of the roadless area is in an inclusion of slightly radioactive metasedimentary rocks contained in granitic intrusive rocks and has minor uranium oxide.

Analysis of stream-sediment samples from the Caliente Roadless Area show generally high concentrations of boron, fluorine, uranium, yttrium, lanthanum, scandium, thorium, and zirconium, probably reflecting the presence of abundant tourmaline-bearing granitic pegmatite dikes and leucogranite plutons in the area. Generally high and locally anomalous concentrations of lead, and anomalous tungsten in one sample may reflect the presence of small contact-type occurrences in the area. Molybdenum, silver, copper, zinc, and arsenic anomalies probably represent small mineralized areas in metasedimentary rocks cut by, and possibly hydrothermally altered by, granitic pegmatite and quartz dikes.

The results of this mineral-resource investigation indicate a probable resource potential for mineral specimens and semiprecious gemstones of tourmaline, beryl, quartz, and possibly other minerals. Rare occurrences of tungsten, uranium, and placer gold in the roadless area and stream-sediment sample analyses showing anomalous values for some metals are not considered to indicate a mineral-resource potential for these elements.

No evidence of mining activity exists within the Hauser Roadless Area. The Pacific mine, a potash feldspar deposit located 0.2 mi east of the roadless area, was a principal source of feldspar in California and at least one pegmatite body that is structurally and mineralogically similar to the Pacific deposit was noted within the Hauser Roadless Area. No resource potential for feldspar was identified; other more accessible sources are available outside the roadless area within the Peninsular Ranges.

Several hot springs occur south of the Caliente Roadless Area, but no evidence of hot spring activity exists within the roadless areas. No potential for geothermal, hydrocarbon, or nuclear energy resources was identified in any of the three roadless areas.

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SNOW MOUNTAIN WILDERNESS STUDY AREA, CALIFORNIA

By ROBERT D. BROWN, JR.,[1] U.S. GEOLOGICAL SURVEY, and

FRANCIS E. FEDERSPIEL, U.S. BUREAU OF MINES

SUMMARY

The Snow Mountain Wilderness study area, located about 120 mi north of San Francisco and on the divide between the Sacramento and Eel Rivers, contains some of the highest terrain in the Coast Ranges. Its mineral-resource potential was evaluated in 1977 by interpreting data from geologic field studies, from an aeromagnetic survey, from geochemical sampling of stream sediments, rocks, and springs, and from the examination and sampling of prospects. These investigations indicated that there was little promise for the occurrence of mineral or energy resources within the wilderness.

CHARACTER AND SETTING

The Snow Mountain Wilderness study area occupies about 50 sq mi in northern California. The outline of the study area, its elevation, and many of its landforms are closely related to its geology. Snow Mountain and St. John Mountain, the most prominent landmarks in the study area, stand more than 6500 ft above sea level; the total relief is about 5200 ft. Roads lead to the area from Willows and Maxwell in the Great Valley and from Upper Lake near Clear Lake.

Bordered by steep slopes and dissected by deep narrow canyons, the area's rugged surface and elevation have kept it remote and roadless in comparison with other parts of the Coast Ranges. The proposed boundary of the wilderness follows a major low-angle thrust fault. Flat or gently dipping for much of its extent, this fault separates volcanic rock from the underlying weakly metamorphosed sedimentary rock. The thrust block of volcanic rock above the fault stands high because it resists erosion more effectively than do other rock types in the vicinity.

The volcanic rocks are of Late Jurassic age and consist chiefly of flows of finely crystalline pillow basalt with beds of sandstone, mudstone, and radiolarian chert and a few thin sills of diabase. Most of these rocks accumulated in deep water during an episode of submarine volcanism; many subsequently have been chemically altered.

These rocks are faulted over physically deformed and weakly metamorphosed sedimentary rocks that underlie much of the northern Coast Ranges and that are commonly assigned to the Franciscan Complex. Originally mudstone, siltstone, and sandstone, these sedimentary rocks now exhibit an intensely sheared fabric. They contain a few thin flows of intensely altered pillow lava, evidence that they accumulated in a marine environment, probably during Late Jurassic and Cretaceous time.

A belt of sheared and crushed rock as much as 820 ft thick separates the volcanic rock above the thrust fault from the physically deformed sedimentary rock below. The sheared and crushed debris is chiefly sedimentary rock, but it contains some resistant masses derived from the volcanic thrust block and a few exotic rock types derived from much deeper levels of the Earth's crust. Most of the prospects and claims in the study area are in this belt of rocks or another that is similar but structurally lower.

Serpentinite, in tabular masses and in lenses, occurs both along thrust faults and along high-angle faults. The most extensive serpentinite body follows a northwest-trending fault along the Middle Fork of Stony Creek.

Unconsolidated deposits cover a small amount of the study area. They include glacial and glaciofluvial deposits, landslide debris, terrace deposits, and alluvium.

To evaluate the mineral-resource potential, both existing and new data were collected and interpreted (Brown and others, 1981). New work, done in 1977 for the evaluation, included geologic field studies in the west half of the area; the interpretation of data from an earlier aeromagnetic survey; geochemical interpretation based on the analysis of samples of stream sediment,

[1]With contributions from by David J. Grimes, Reinhardt Leinz, and Andrew Griscom, USGS, and Andrew M. Leszcykowsky, USBM.

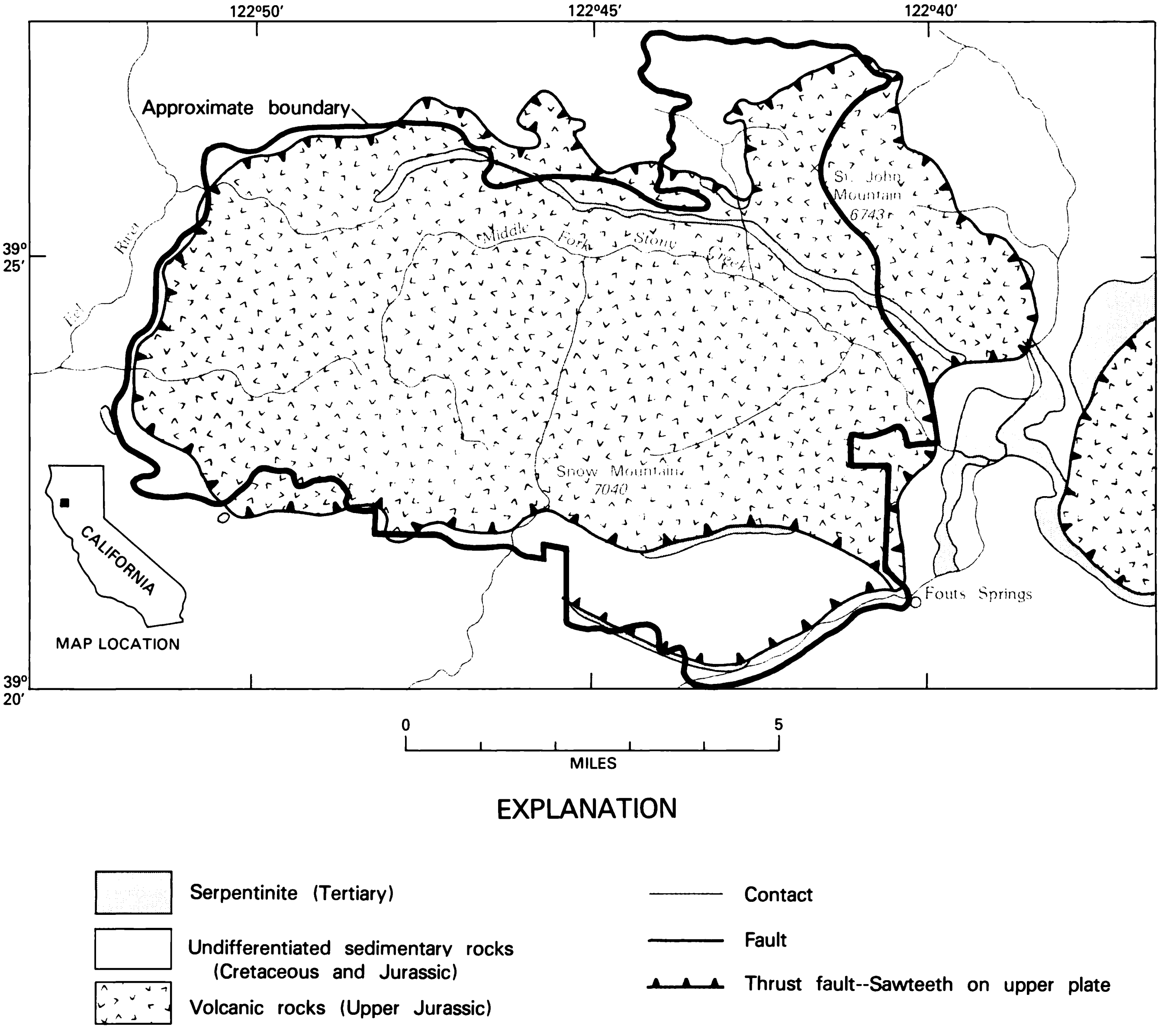

Figure 109.—Snow Mountain Wilderness Study Area, California.

rocks, and springs; and the examination and sampling of prospects.

MINERAL RESOURCES

The geology, as well as records of past mineral exploration and production, gives clues regarding the mineral-resource potential. Chromium, copper, manganese, and mercury have been mined from similar rocks in other parts of the Coast Ranges. At the Geysers, a steam field in the northern Coast Ranges, geothermal power is produced in a somewhat similar geologic setting. The potential for these and other resources in the study area have been evaluated by analyzing and interpreting the geologic, geochemical, and aeromagnetic data; the results disclosed that there is little promise for the discovery of mineral or energy resources. Variations in geochemical properties and anomalies in the aeromagnetic data can be explained by normal chemical and physical properties of the rock units within the area; nowhere do the geochemical or magnetic data indicate unusual concentrations of mineral commodities.

These findings are consistent with the history of exploratory activity; the little previous prospecting done in the Snow Mountain Wilderness study area has not revealed commercial mineral deposits. According to courthouse records, only 19 lode claims have been located in, or adjacent to, the study area. Most of the claims were for manganese. Samples from manganese-bearing chert beds east of the area contain as much as 33.6 percent manganese. These deposits have been mined, mainly during World Wars I and II. Chert with manganese-oxide coatings on bedding and fracture surfaces occurs in the study area, but the size and grade of these deposits are not sufficient for them to be considered a resource. Serpentinized peridotite crops out on some claims in the area, but analyzed samples contained insufficient chrome and nickel to be considered as resources. In the eastern part of the study area, one claim has been located for onyx and another for nephrite jade. No semiprecious gemstones were found during this investigation.

Mineral springs formerly exploited at a spa near Fouts Springs no longer appear to have much resource value. Volcanic rocks and diabase suitable for crushing and for use in construction cover much of the study area; they have not been commercially exploited.

SUGGESTIONS FOR FURTHER STUDIES

Current appraisals of the mineral-resource potential of the Snow Mountain Wilderness study area do not encourage further study. New discoveries of unforeseen resources in other parts of the California Coast Ranges or in similar geologic settings elsewhere could prompt renewed study of Snow Mountain, but the nature of such studies cannot be determined now.

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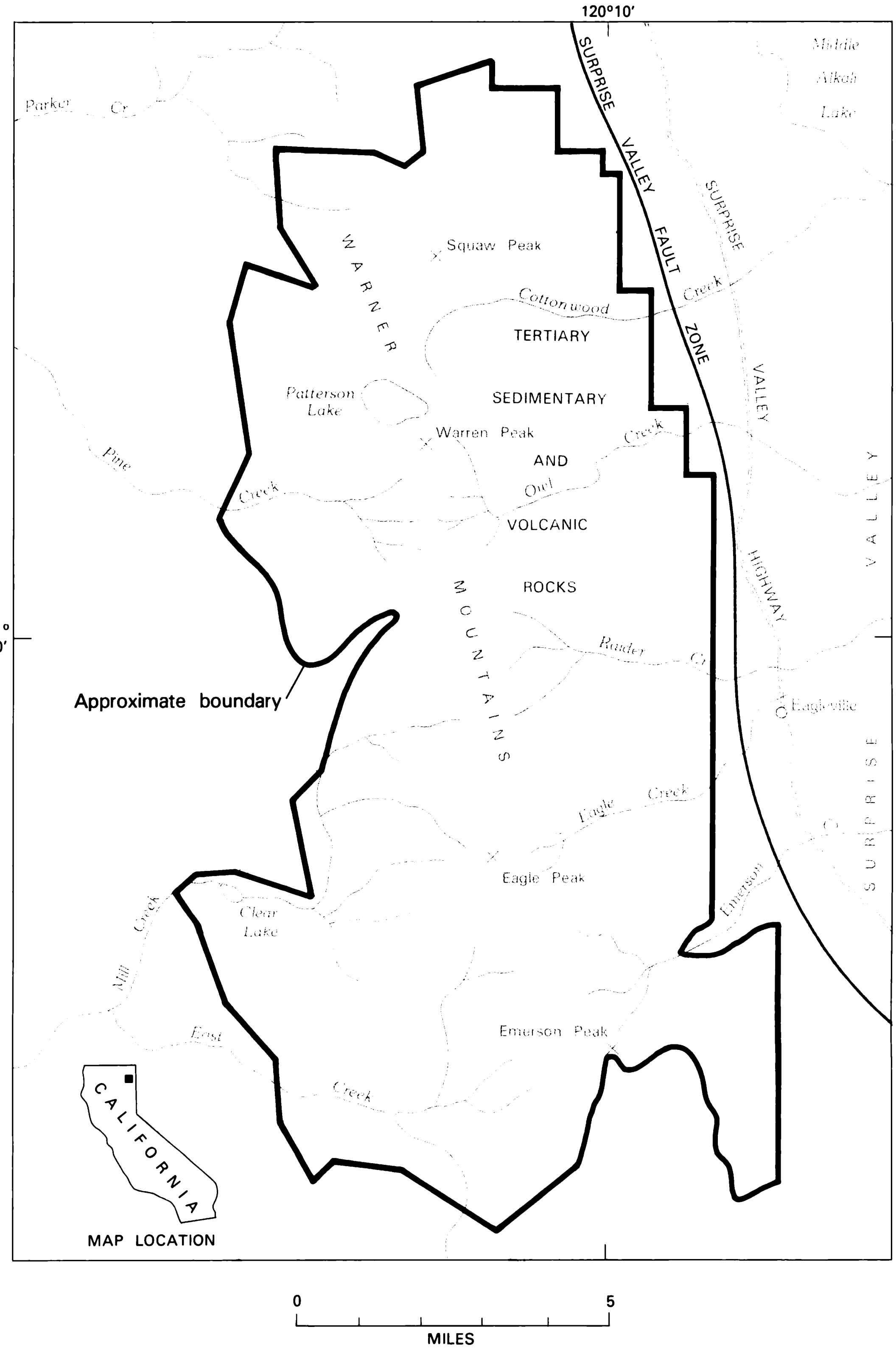

Figure 110.—South Warner Wilderness, California.

SOUTH WARNER WILDERNESS, CALIFORNIA

By WENDELL A. DUFFIELD, U.S. GEOLOGICAL SURVEY, and

ROBERT E. WELDIN, U.S. BUREAU OF MINES

SUMMARY

A mineral appraisal carried out in 1972 and 1973 utilized geologic, geochemical, and geophysical data and an examination of mining claims in the South Warner Wilderness, California. Results of this study indicate that little promise for the occurrence of mineral resources exists within the area. Small veins of optical quality calcite occur on the east side of the area but, are not considered a resource.

CHARACTER AND SETTING

The South Warner Wilderness is in northeast California, about 6 mi west of Nevada and 40 mi south of Oregon. The wilderness is more or less rectangular and measures about 7 mi east-west and 16 mi north-south. The area encompasses about 109 sq mi centered along the crest of the Warner Mountains, a north-trending range that rises to a maximum elevation of 9900 ft at Eagle Peak in the south part of the wilderness.

The Warner Mountains are at the west edge of the Basin and Range physiographic province and provide a classic example of Basin and Range fault-block mountain structure. Offset along the Surprise Valley fault zone at the east edge of the Warner Mountains has resulted in a minimum vertical uplift of the mountains relative to the adjacent valley of 12,000 ft in about the last 13 million years; some of this fault movement has occurred within the last 10,000 years. Fault offset on the west edge of the range has been considerably less, with the result that originally flat lying rock strata are tilted westward about 25 degrees. This tilted, fault-block structure produces a rather gentle, heavily forested western slope to the range and a steep, deeply incised eastern face that presents characteristics of badlands terrane.

The wilderness is underlain primarily by a conformable sequence of Tertiary sedimentary and volcanic rocks whose ages range from somewhat greater than 32 million years old to about 13 million years old. Approximately the lower half of this sequence consists of conglomerate and mudflows that represent deposits derived from the flanks of major andesite stratovolcanoes in adjacent but unidentified areas. The upper half of the sequence consists of lava flows, pyroclastic flows, and beds of volcanic ash deposited as air-fall debris. This younger half of the sequence includes rock types that cover the entire spectrum of chemical composition from basalt through andesite to rhyolite.

During parts of Quaternary time (the last 1.8 million years) glaciers were present in the highest parts of the range; these left small volumes of glacial deposits such as moraines, sand and gravel, and also carved out a glacial cirque within which Patterson Lake, the largest, highest and most beautiful of the lakes in the wilderness, is located. With the melting of glaciers, Surprise Valley filled with water to a depth of at least 500 ft. Several high-level, wave-cut beach lines and alluvial cones of stream gravel banked against the walls of the valley provide graphic evidence of the former deep lake.

Essentially the entire sequence of Tertiary rocks has been subjected to mild alteration by circulating hydrothermal fluids. This has resulted in the deposition of some secondary minerals such as zeolites, calcite, silica, and celadonite, a clay-like mineral that imparts a pale-green tint to many of the rocks. During the mineral-appraisal study all rock types were sampled, as were sediments from all principal streams; chemical analyses of the samples indicate unmineralized, ordinary crustal material. An aeromagnetic survey similarly indicates that ordinary unmineralized crustal rocks underlie the area.

MINERAL RESOURCES

The only commodity ever produced commercially from within the area of the wilderness was calcite of optical quality (Duffield and Weldin, 1976). Production came from a few small veins that crop out locally in the east face of the range. Such deposits have not been mined for many years; they are too small, and synthetic materials now serve most uses once provided by optical calcite.

The deposits of stream gravel that lie adjacent to the wilderness on the east are used locally for concrete aggregate and road construction. Parts of some gravel deposits are very near the wilderness boundary, but it is unlikely that their possible future exploitation would extend within the area.

Sources of geothermal energy may exist in Surprise Valley near the east boundary of the wilderness. Surface indications of this resource are in the form of hot springs localized along the Surprise Valley fault zone. However, if geothermal energy proves to be a viable commodity in Surprise Valley, development will almost certainly be along the fault zone, or further east, well outside the wilderness area, in the thick sequence of sedimentary debris that partly fills the valley.

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SUGARLOAF ROADLESS AREA, CALIFORNIA

By ROBERT E. POWELL,[1] U.S. GEOLOGICAL SURVEY, and

HARRY W. CAMPBELL, U.S. BUREAU OF MINES

SUMMARY

On the basis of geologic, geochemical, and geophysical investigations by the USGS in 1981-82 and a survey of mines, quarries, and prospects by the USBM in 1981, the Sugarloaf Roadless Area, California, has little promise for the occurrence of metallic mineral or energy resources. Units of carbonate rock and graphitic schist have demonstrated resources of magnesian marble and graphite. Sand, gravel, and construction stone other than carbonate rock are present in the roadless area, but similar or better quality materials are abundant and more accessible outside the area.

CHARACTER AND SETTING

The Sugarloaf Roadless Area, California, located in the central San Bernardino Mountains of San Bernardino County, encompasses about 14 sq mi within the San Bernardino National Forest. Sugarloaf Mountain (9952 ft), at the center of the roadless area, lies about 6 mi southeast of Big Bear City and 21 mi east-northeast of San Bernardino. Several investigators have previously mapped the geology in the roadless area (Vaughan, 1922; Dibblee, 1964; Cameron, 1982; Sadler, 1982). This report summarizes results presented by Powell and others (1983).

The oldest rocks in the Sugarloaf Roadless Area consist of Precambrian metasedimentary and metaplutonic gneiss that is unconformably overlain successively by uppermost Precambrian and Paleozoic quartzite, schist, and carbonate rock. The quartzite consists of a lower unit of laminated gray quartzite and an upper unit of light-colored quartzite in which bedding is commonly obscured. Aluminous phyllite and schist, graphitic schist, and micaceous siltite occur generally above quartzite and beneath carbonate rock, although the rock types are complexly interlayered in detail. Carbonate rock consists of generally light gray crystalline dolomite and limestone (marble). Mafic and felsic Mesozoic plutonic rocks intrude the Precambrian gneiss and overlying metasedimentary units. Intrusive units include hornblende-biotite gabbro and diorite, hornblende-biotite monzodiorite, granodiorite, and tonalite and biotite monzogranite. Miocene arkosic sandstone and conglomerate, with intrusive and extrusive basalt units, occur south of the Santa Ana fault.

Faults that developed along the unconformity between Precambrian gneiss and the overlying sedimentary units, and perhaps within the metasedimentary section, have been deformed successively by east-west-trending and northwest-plunging fold-sets. The Cenozoic Santa Ana fault trends roughly east-west across the southern part of the roadless area, dips 60-65° to the north, and exhibits both reverse and left-lateral separation. Extensive landsliding has occurred throughout the Sugarloaf Roadless Area.

In addition to the geologic investigation, a reconnaissance geochemical survey was conducted for 32 elements to determine spatial variations in stream-sediment chemistry that might reflect local concentrations of ore minerals. Aeromagnetic and gravimetric geophysical surveys also were conducted in the Sugarloaf Roadless Area and their results compared to those of the geologic and geochemical surveys for evaluation of the mineral-resource potential.

MINERAL RESOURCES

Mining and quarrying within the Sugarloaf Roadless Area began with the discovery of graphite deposits in Green Canyon and near the confluence of Cienaga Seca Creek and the Santa Ana River. Crushed magnesian marble from the Green Canyon Quarry on the north flank of Sugarloaf Mountain was marketed as roofing

[1]With contributions from Jonathan C. Matti, Brett F. Cox, and Eduardo A. Rodriguez, USGS.

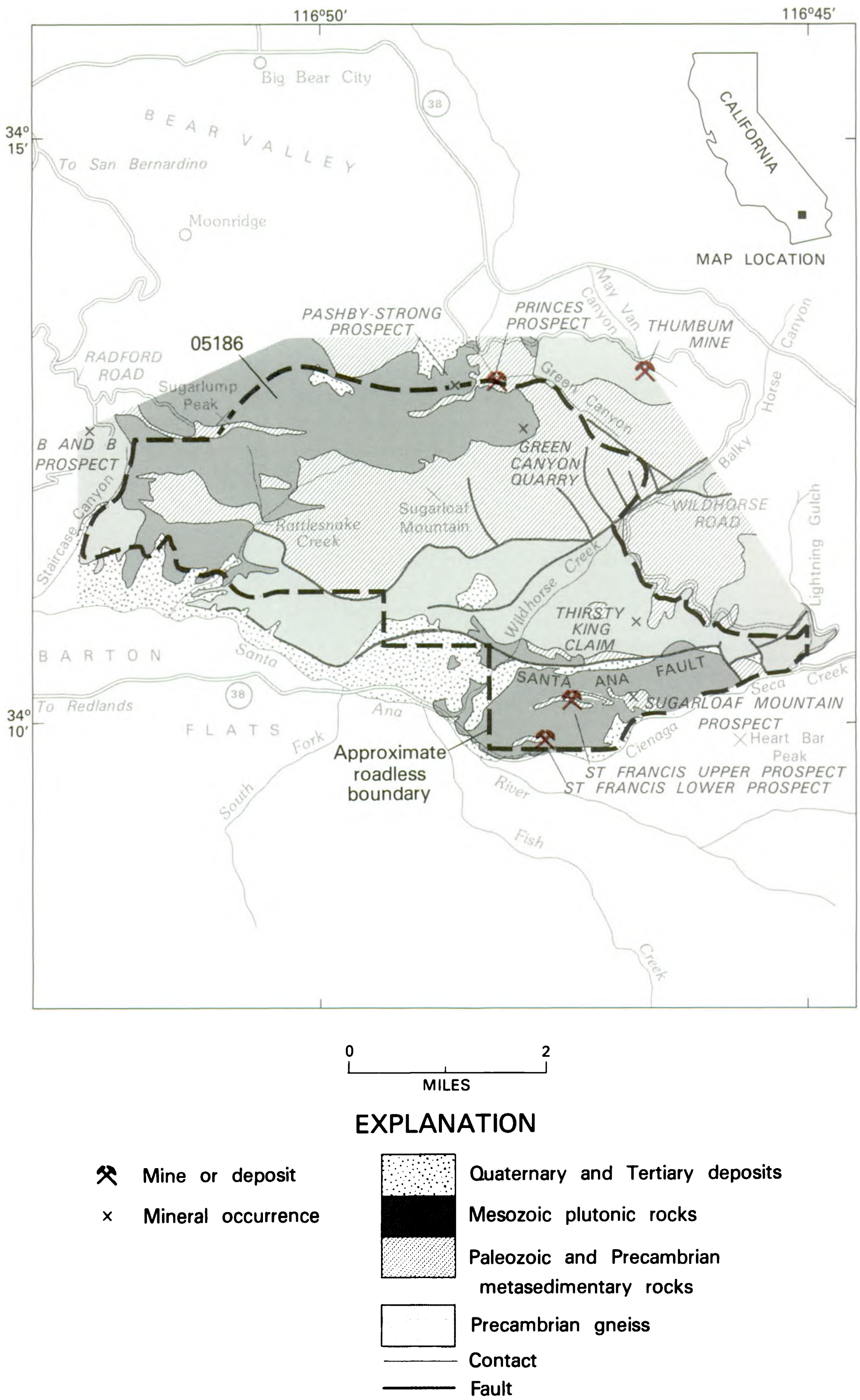

Figure 111.—Sugarloaf Roadless Area, California.

granules in 1960 (Dibblee, 1964). Uranium deposits in the vicinity of the roadless area came under scrutiny in the 1950's; the Thumbum mine was located in 1953 about 1 mi northeast of the roadless area; the Rocky Point (B and B) claim was located in 1954, about 0.5 mi west of the area; and the Thirsty King claim was located in 1955 in the southeastern corner of the area. The first commercial shipment of uranium from California was produced in July 1954 from the Thumbum mine (Troxel and others, 1957).

In the survey of mines, quarries, and prospects within the Sugarloaf Roadless Area, prospects in carbon-rich beds within the schist unit were determined to have low-grade graphite resources. The St. Francis upper prospect contains an estimated 10,000 tons of demonstrated amorphous graphite resources averaging 12 percent fixed carbon and 30,000 tons of inferred graphite resources of similar grade. The St. Francis lower prospect contains an additional 15,000 tons of demonstrated, and 56,000 tons of inferred amorphous graphite resources averaging 11 percent fixed carbon. The Princes prospect, which straddles the boundary of the roadless area, contains about 130,000 tons of demonstrated, and 100,000 tons of inferred amorphous graphite resources averaging 7 percent fixed carbon. Resources inside the roadless area at this prospect amount to 100,000 tons of demonstrated, and 63,000 tons of inferred graphite resources. Most uses of amorphous graphite require upgrading to 90 percent graphite, which involves a costly process of concentration.

Magnesian marble is abundant at prospects in the carbonate unit that crops out on the north flank of Sugarloaf Mountain and above Cienaga Seca Creek. Magnesian marble resources at the Green Canyon Quarry and the Sugarloaf Mountain prospect are suitable for use as industrial aggregate and agricultural soil conditioners, but have too much magnesium, silica, and loss on ignition to be suitable for cement production. Most of these resources have been claimed at various times since the 1940's, but superior deposits closer to markets are already developed.

Stone other than magnesian marble is abundant, but similar deposits are equally abundant and more accessible outside the area. Sand and gravel, largely confined to relatively narrow active streambeds, are not a significant resource.

Resources are not estimated for hydrothermal uranium deposits that may be associated with pegmatite at prospects within the Precambrian gneiss; surface exposures were not observed during this study, and, according to earlier descriptions, underground ore bodies are erratically distributed and irregular in size and shape (Rohtert, 1981; Warne and Reeves, 1957). At the Thumbum mine, outside the Sugarloaf Roadless Area, very low grade supergene deposits contain an estimated 320,000 tons of demonstrated, and 620,000 tons of inferred resources averaging 0.01 percent U_3O_8. No uranium resources are identified at the B and B and Thirsty King prospects.

Within the Sugarloaf Roadless Area, no appreciable mineral concentrations have been observed along faults or intrusive contacts, in pegmatites in the Precambrian gneiss, in stratigraphic zones within the metasedimentary units, or in skarns. A show of gold (traces in three grab samples) and silver (0.16 oz/ton in one grab sample) occurs in the contact zone between carbonate rocks and monzodiorite at the Pashby-Strong prospect, but concentrations are so low that no resources could be estimated. Neither hydrothermal veins nor extensive areas of clay or limonitic alteration has been found, although retrograde metamorphic alteration is pervasive.

None of the elemental concentrations in stream-sediment samples of the roadless area indicates a mineral occurrence large enough to be a target for further exploration. Most of the analyses fall within ranges that are reasonable for sediment derived from nonmineralized igneous rock, carbonate rock, and sandstone. The few values that exceed geochemical background are probably related to greater-than-normal abundances of disseminated non-ore minerals or traces of ore minerals rather than to mineral deposits. The principal magnetic and gravity anomalies in the roadless area correspond, respectively, with lithologic units of high magnetic susceptibility and of inferred high density relative to surrounding units, rather than to mineral deposits.

SUGGESTIONS FOR FURTHER STUDIES

Further study holds little promise for identification of unknown hidden mineral deposits within the Sugarloaf Roadless Area. However, because the roadless area lies within a crystalline province characterized by high background concentrations for several elements (including molybdenum and tin) that tend to be concentrated with volatile constituents in late-stage plutonic differentiates and potentially with ore-fluids related to the differentiates, investigations of the regional geochemical and petrologic setting may yield insight into the processes of mineralization that have operated and where deposits are likely to occur.

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SWEETWATER ROADLESS AREA, CALIFORNIA AND NEVADA

By GEORGE L. KENNEDY,[1] U.S. GEOLOGICAL SURVEY, and

ROBERT H. LAMBETH, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys of the Sweetwater Roadless Area, located on the east side of the central Sierra Nevada in California and Nevada, were conducted in 1978–82. On the basis of these investigations, the roadless area has probable and substantiated resource potential for gold, silver, copper, iron, molybdenum, and tungsten. If undiscovered resources are present, they are likely to be of the epithermal-vein and disseminated precious-metal (silver, gold), disseminated molybdenum porphyry, or contact-metasomatic (iron, copper, molybdenum, tungsten, gold) types. The geologic terrane precludes the occurrence of fossil fuel resources.

CHARACTER AND SETTING

The Sweetwater Roadless Area comprises approximately 113 sq mi of Toiyabe National Forest in Mono County, California, and Lyon and Douglas Counties, Nevada. The roadless area, encompassing most of the Sweetwater Mountains, lies on the east side of the Sierra Nevada 20 mi northwest of Mono Lake and 40 mi southeast of Lake Tahoe. The area is highlighted by a series of spectacular barren peaks, from East Sister in the north to Mount Jackson in the south, and is underlain by bleached or brightly colored Mesozoic basement rocks and Tertiary volcanics. Altitudes range from 11,673 ft on Mt. Patterson to 6160 ft near Devils Gate on the East Walker River. Vegetation types vary from semiarid to alpine. Access to the area is from U.S. Highway 395 on the southwest and west, Risue Road on the north, Nevada Highway 22 on the northeast, and California Highway 182 on the southeast. Bridgeport, California, 3 mi southeast of the roadless area, is the nearest populated area.

The mineral-resource evaluation of the roadless area was based on geologic mapping, geochemical analyses of rock, stream-sediment, and nonmagnetic heavy-mineral-concentrate samples, aeromagentic and gravity surveys, and an examination of mines, prospects, and mineralized areas (Brem and others, 1983; Brem, 1983; Lambeth and others, 1983).

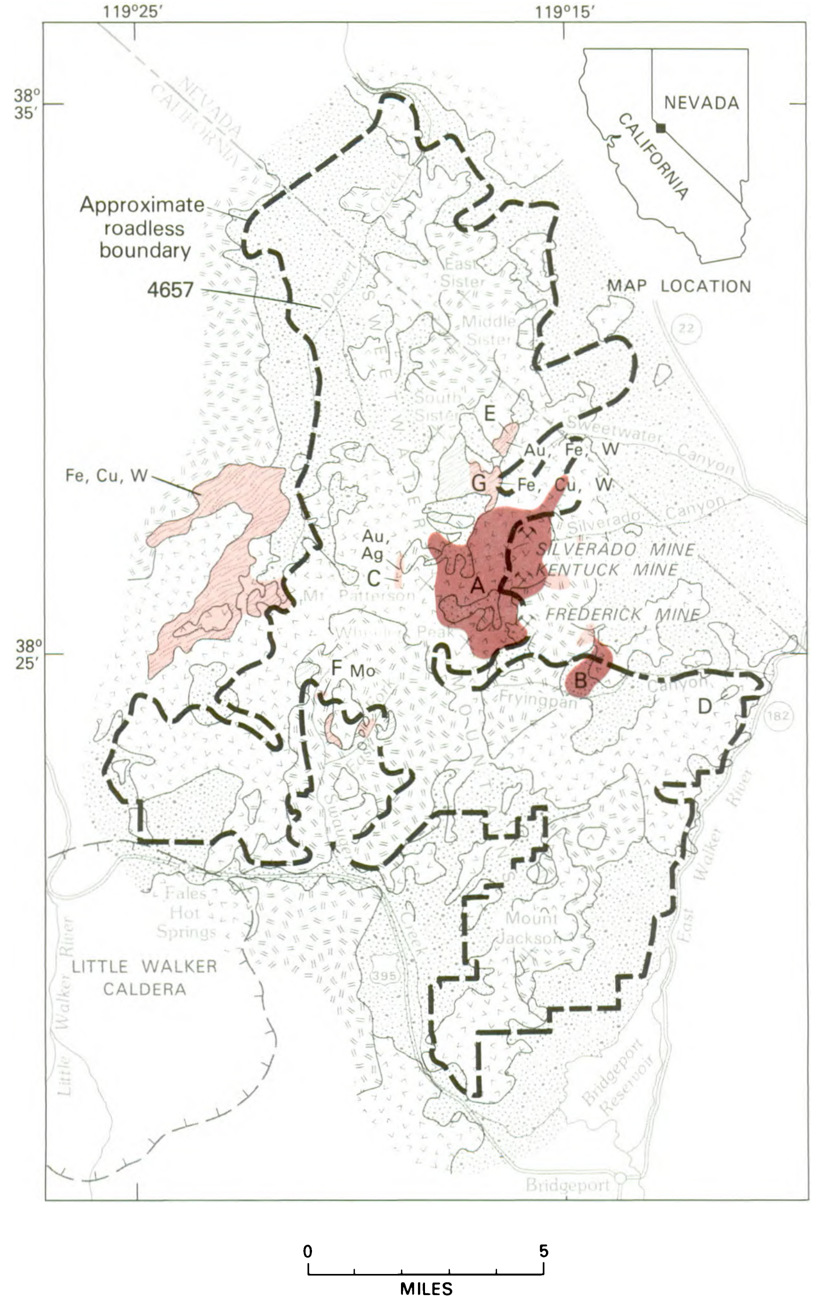
The Sweetwater Mountains are underlain by a Mesozoic basement complex of dominantly silicic granitic rocks and minor amounts of metamorphic rocks. An extensive cover of Tertiary volcanic rocks and Tertiary(?) and Quaternary surficial deposits make up the remainder of the area. Mineralized areas are associated with hydrothermally altered Cretaceous granite and Tertiary rhyolite, and thermally metamorphosed and metasomatized roof-pendant rocks.

Metamorphosed volcanic and marine tuffaceous sedimentary rocks of Mesozoic age occur in small roof pendants and septa scattered throughout the roadless area. Granitic rocks related to the Sierra Nevada batholith are exposed over about one-fifth of the roadless area and represent a sequence of predominantly Upper Cretaceous intrusions. Multiple intrusive episodes of alteration and mineralization are associated with the most extensive plutons.

Nearly half of the roadless area is covered by Miocene volcanic rocks of varying compositions and provenance. The most extensive units, from oldest to youngest, are as follows: andesite of the Relief Peak Formation; rhyolitic hypabyssal intrusive rocks, lava flows and tuff breccias from Sweetwater volcanic center; and latite flows and tuffs of the Stanislaus Group from Little Walker caldera. Hydrothermal alteration and mineralization associated with rhyolitic volcanism has affected rhyolitic and all underlying rocks.

The remainder of the roadless area is covered by Tertiary(?) and Quaternary surficial deposits of varied origins. Fluvial gravels of uncertain age at the north

[1]With contributions from G. F. Brem, M. A. Chaffee, and D. Plouff, USGS, and H. W. Campbell, D. F. Scott, and J. O. Spear, USBM.



EXPLANATION

(solid)	Geologic terrane with substantiated resource potential for gold and silver and probable resource potential for molybdenum
(open)	Geologic terrane with probable mineral-resource potential

Cu	Copper	Mo	Molybdenum
Au	Gold	Ag	Silver
Fe	Iron	W	Tungsten
⚒	Mine		

Surficial deposits (Quaternary and Tertiary?)

Volcanic rocks (predominantly Miocene)

Plutonic rocks (predominantly Mesozoic)

Metamorphic rocks (predominantly Mesozoic)

——— Contact

B Area discussed in text

Figure 112.—Sweetwater Roadless Area, California and Nevada.

and south ends of the mountain range may be related to Tertiary(?) uplift of the Sierra Nevada. Younger fanglomerate and alluvium, associated with changes in drainage patterns, and normal faulting along the east side of the range indicate Quaternary uplift and westward rotation of the Sweetwater Mountains block.

Prospecting in the Sweetwater Mountains probably began in the late 1850's or early 1860's. Following the discovery of silver, an area on the east side of the roadless area was organized into the Patterson mining district, eventually encompassing about 2000 staked claims. The district had three major periods of production, in the early 1880's, in the early 1900's, and again in the 1930's. Total production, mostly from the Silverado, Kentuck, and Frederick mines located just east of the roadless area, is estimated to be 3,400,000 oz silver, 3000 oz gold, and 35,000 lbs copper. Only limited, mainly unrecorded, production has come from workings within the roadless area. No mines in the district are currently in production, but about 300 claims are kept active by mining companies; most are east of the roadless area between Sweetwater and Fryingpan Canyons.

MINERAL RESOURCES

On the basis of the mineral-resource investigations, parts of the Sweetwater Roadless Area have probable and substantiated resource potential for epithermal-vein or disseminated silver and gold, probable resource potential for disseminated molybdenum, and probable resource potential for contact-metasomatic iron, copper, tungsten, and gold in metamorphic rocks.

Two areas (A and B, on map) have a substantiated resource potential, and one area (C) has probable resource potential for epithermal-vein or disseminated silver and gold. Precious-metal deposits in all three areas occur in sheared, intensely silicified, argillized or sericitized rhyolitic rocks erupted from the Sweetwater volcanic center.

Area A is the largest, contains most of the old silver mines in the Patterson mining district, and lies east of the mountain crest between Sweetwater and Fryingpan Canyons. The area extends eastward beyond the roadless area, where it is transected by Silverado Canyon. Precious-metal-bearing veins occur in north-trending shear zones in intensely altered rhyolite; disseminated precious-metal deposits are likely, particularly near vein deposits with previous mineral production. Vein minerals that may be found here include precious- and less abundant base-metal sulfides, native precious metals, or precious-metal tellurides in quartz-adularia gangue and rhyolite breccia. Fluorite and heubneritie have been found near the Kentuck mine, and several probable breccia pipes and dikes are also present. Extensive mineralization in vein and altered country rock is indicated by assays of numerous vein, dump, and rock samples. However, the podiform nature of vein deposits, extensive talus cover, and sporadic occurrence of disseminated precious-metal mineralization generally precludes calculation of resources.

Area B, near Fryingpan Canyon, has substantiated resource potential for gold and silver, and is underlain by intensely silicified rhyolitic rock. Precious-metal vein deposits have been developed in a small mine with no known production, and disseminated deposits have been prospected for in the altered rhyolitic host rock. Gold distribution patterns are also indicative of a disseminated gold-silver deposit of hot-spring origin. Area C, west of Mt. Patterson, has probable resource potential for gold and silver. A small mine with no known production is developed here in a silicified shear zone in rhyolitic intrusive rock. Area D, near the eastern tip of the roadless area, is characterized by bleaching and weak gold and silver geochemical anomalies in leached andesite. No resource potential was identified.

In Area E, north of Sweetwater Canyon, gold in association with magnetite occurs in small silicified shear zones in metavolcanic roof-pendant rocks that have been intruded by granitic rocks. Area E has probable resource potential for contact-metasomatic gold, as well as iron and tungsten.

Molybdenum occurs in the roadless area in two geologic environments of different ages; disseminated in highly altered volcanic rock, and (or) as molybdenite-bearing quartz veinlets in altered granitic rock. Molybdenum mineralization of highly altered rhyolitic rocks of the Sweetwater volcanic center is evident in three areas (A, B, C), all coincident with areas of precious-metal mineralization of the same general age. Resource potential for areas A and B is probable. Although molybdenum occurs in area C, no resource potential was identified. Geochemical analyses indicate that selected vein and altered rock samples are anomalously high in molybdenum, and heavy-mineral-concentrate samples are moderately to strongly anomalous in the molybdenum-tungsten, base-metal, and hydrothermal-alteration element suites.

In Area A, the geochemical anomalies, the complex rhyolitic intrusive sequence, the breccia pipes and dikes, pervasive silicic and phyllic to argillic alteration, fluorite and heubnerite occurrences, and gravity and aeromagentic lows indicate that the Tertiary mineralization could have produced a disseminated molybdenum porphyry system at depth. Molybdenum in the system could have been derived from remobilization of molybdenum in Cretaceous granitic rocks, or less likely, from a Cretaceous episode yielding coarse molybdenite.

The combined geologic, geochemical, and geophysical characteristics suggest probable resource potential for a possible molybdenum porphyry system at depth.

Coarse- to medium-grained molybdenite or its weathering products occur in quartz veinlets in altered granitic rocks at four places, three east of the roadless area between Silverado and Fryingpan Canyons, and a fourth (F) in the upper Swauger Creek drainage, only partly inside the roadless area. Sericite associated with molybdenite in Silverado Canyon has yielded a Late Cretaceous age (Brem, 1983), indicating a Mesozoic molybdenum mineralization event. The widely spaced areas of mineralization and alteration, and the absence of appropriate host rock, suggest that the resource potential for a Mesozoic molybdenum system is probable.

Iron-copper deposits in the form of metasomatic magnetite-serpentine rock with traces of copper-bearing sulfides or alteration products crop out near Sweetwater Canyon (G) and in a large metamorphic roof pendant just west of the roadless area. Although a test batch of reportedly high grade ore was taken from Sweetwater Canyon, large near-surface deposits are unlikely because of the limited amounts of appropriate host rocks. Moderate amplitude magnetic and gravity anomalies suggest that the metamorphic bodies are of sufficient size to contain larger buried mineral deposits. Nevertheless, the mineral-resource potential for iron and copper-bearing bodies is only probable in area G, and west of the roadless area. A third, small body of metamorphic rock occurs in the upper Swauger Creek drainage, outside of the roadless area.

Tungsten mineralization may occur in contact metasomatic skarn mineral deposits developed in carbonate facies of the metamorphic rocks near Sweetwater Canyon (area G), and in two areas outside of the roadless area, in the large roof pendant to the west and in the upper Swauger Creek drainage. These areas have probable resource potential for deposits of tungsten on the basis of weakly anomalous concentrations of elements related to tungsten mineralization, and the limited outcrop area of favorable host rocks.

SUGGESTIONS FOR FURTHER STUDIES

Identification of additional precious-metal resources in the roadless area will require intensive further investigation because vein deposits are generally high grade pods in otherwise barren veins, and disseminated deposits are sporadic in occurrence. In addition, the extent of a possible buried molybdenum porphyry system in the roadless area can only be determined by extensive additional investigations.

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THOUSAND LAKES WILDERNESS, CALIFORNIA

By ALISON B. TILL,[1] U.S. GEOLOGICAL SURVEY, and

EDWARD L. MCHUGH, U.S. BUREAU OF MINES

SUMMARY

A mineral survey conducted by the USGS and USBM in 1979 of the Thousand Lakes Wilderness in northern California indicated little promise for the occurrence of mineral resources. Volcanic stone and cinders occur, but similar materials are found in abundance outside the wilderness. The wilderness is in the Cascade Volcanic Province, a setting locally favorable for geothermal resource potential. No geothermal potential was identified in the wilderness; subsurface potential cannot be evaluated without regional studies and drilling.

CHARACTER AND SETTING

Thousand Lakes Wilderness, an area of about 25.5 sq mi, is located about 50 mi east of Redding and 12 mi south of Burney, in eastern Shasta County, California. The wilderness is part of Lassen National Forest, and is roughly 5 mi from north to south and 6 mi from east to west. The wilderness is on the crest of the Cascade Mountains and is dominated by a deeply eroded composite volcano. This volcano is the major volcanic edifice between Lassen Peak and Mount Shasta. Crater Peak, Magee Peak, and Fredonyer Peak are all on the volcano which will be called Crater-Magee volcano in this report. North and east of Crater-Magee volcano is the Thousand Lakes valley, which is at the center of the wilderness. Many small lakes are scattered in the valley between altitudes of 5600 and 8677 ft. Small Pleistocene shield volcanoes and Holocene flows and cinder cones are on the north and east sides of the wilderness. The Thousand Lakes valley is forested; peaks above the valley floor are generally free of vegetation.

Thousand Lakes Wilderness is in the southern part of the Cascade Volcanic Province (Macdonald, 1966), a belt of Tertiary to Quaternary volcanic centers that extends from southern British Columbia to northern California. The wilderness is 60 mi southeast of Mount Shasta and 18 mi northwest of Lassen Peak.

The bedrock in the wilderness is composed of volcanic rocks of Tertiary and Quaternary age. The oldest rocks exposed are pyroxene andesite of late Pliocene age (Macdonald, 1963). The pyroxene andesite is composed of a thick sequence of flows, is regionally extensive, and is considered the basement rock of the area. Younger (Pleistocene) shield and composite volcanoes overlie these flows. In the Thousand Lakes Wilderness, andesitic lavas of Crater Peak, Magee Peak, Fredonyer Peak, Freaner Peak, and Logan Mountain rest on the pyroxene andesite. Several faults in a north-northwest trending system of vertical to steeply dipping faults subsequently cut the flows in the northern and eastern part of the wilderness. During Holocene time, basalt and andesite flows emanated from cinder cones spaced along the fault system. These young flows occupy valleys along the east side of the wilderness. The youngest flow, the Devil's Rock Garden, extends across the south boundary of the wilderness.

MINERAL RESOURCES

No metallic mineral deposits are known in the Thousand Lakes Wilderness; nonmetallic deposits, consisting mainly of stone and cinders occur in the wilderness. A geochemical study revealed no significant anomalous values of metallic elements. An aeromagnetic survey showed no anomalies that suggest the existence of mineral deposits.

No mining claims or prospects exist within the wilderness. No nearby metallic mineral deposits occur in the type of rocks found within the wilderness. Gold and silver were produced before 1934 from altered Cenozoic rhyolitic tuff at Hayden Hill, 50 mi northeast of the wilderness. The more mafic Cenozoic rocks within

[1]With contributions from Clayton M. Rumsey, USBM.

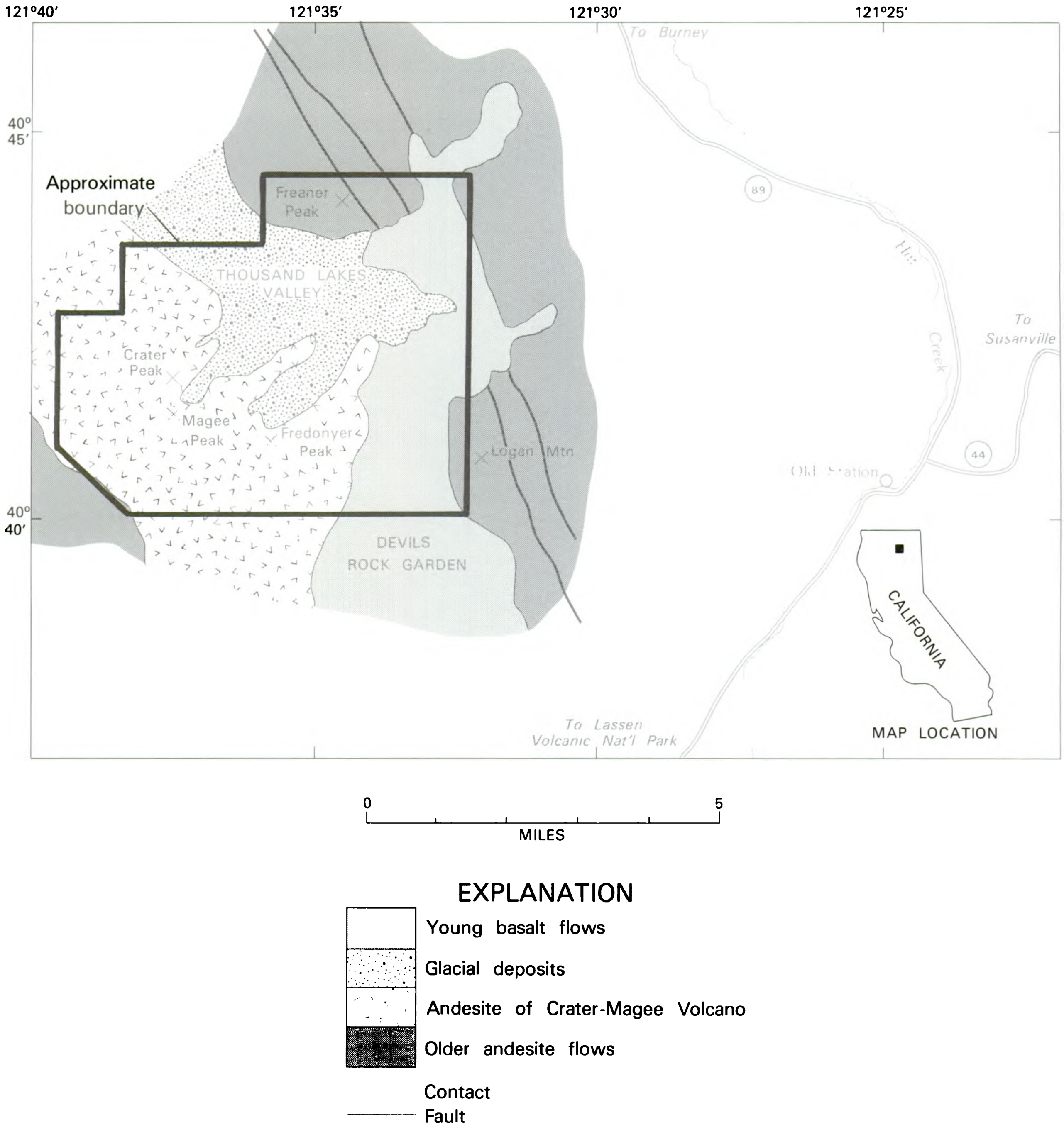

Figure 113.—Thousand Lakes Wilderness, California.

the wilderness contain no analogous alteration. Gold, silver, copper, lead, and zinc have been mined from Mesozoic metavolcanic and sedimentary rocks 15–20 mi to the west, but similar mineralized rocks do not occur within the wilderness. Coal, diatomite, and sulfur were also produced in the region but are not found in the wilderness.

The Thousand Lakes Wilderness is in a region recognized as having potential for geothermal resources (U.S. Geological Survey, 1978). Hot springs are known some 10 mi north along the Pit River, and south of the wilderness. To the south, geothermal activity occurs at several places within Lassen Volcanic National Park. The Morgan Springs Known Geothermal Resource Area (KGRA) along the south side of the park is 17 mi south of the wilderness. No geothermal resource potential was identified in the wilderness and further study and drilling would be required to fully identify any geothermal potential.

Mineral resources within the Thousand Lakes Wilderness are limited to volcanic stone and cinders. Large volumes of good quality basaltic cinders occur throughout the area and cinders from nearby sources have been used in road building, for railroad ballast, and as lightweight aggregate. The hard, dense, and partly vesicular dark-gray andesite at Freaner Peak, Logan Mountain, and Devil's Rock Garden could provide large volumes of stone for construction. Plentiful and more accessible deposits of both volcanic stone and cinders, however, are available at several developed sites within 20 mi of the wilderness closer to markets (Lydon and O'Brien, 1974, p. 144–147).

SUGGESTIONS FOR FURTHER STUDIES

Further study of the wilderness is not likely to identify metallic mineral or fossil fuel resource potential; the regional geologic setting, however, is favorable for geothermal resources. No surface indications of geothermal resources exist in the wilderness, so regional studies and drilling would be necessary to identify the potential.

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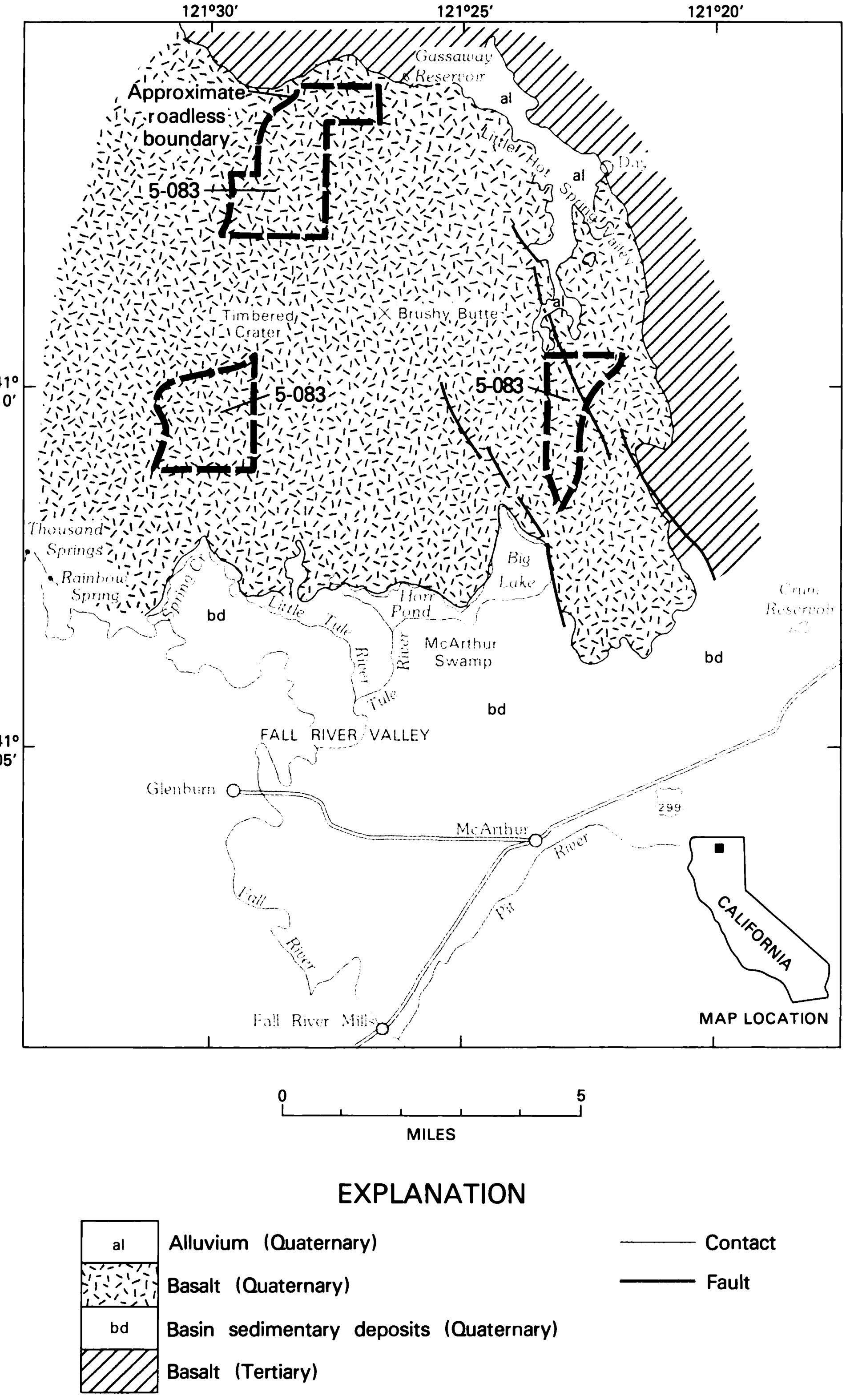

Figure 114.—Timbered Crater Roadless Area, California.

TIMBERED CRATER ROADLESS AREA, CALIFORNIA

By JOCELYN A. PETERSON,[1] U.S. GEOLOGICAL SURVEY, and

LEON E. ESPARZA, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Timbered Crater Roadless Area conducted in 1979 indicated that the area has little or no promise for the occurrence of energy and mineral resources. Lava flows in the southern two segments of the roadless area contain large quantities of rubble that could be used in local construction projects. Further exploration in the area is unlikely due to the unfavorable geologic setting.

CHARACTER AND SETTING

The Timbered Crater Roadless Area occupies three small segments of land totaling about 7 sq mi in Siskiyou and Shasta Counties, 75 mi northeast of Redding, California. The area is about 20 mi south of the Medicine Lake Highland, the source for some of the lava flows found in the area. The towns of Fall River Mills and McArthur lie about 8 mi south of the roadless area along U.S. Highway 299. Altitudes in and near the area range from about 3300 ft to 3981 ft and the area is characterized by rough often barren lava flows.

The Fall River valley in which the Timbered Crater Roadless Area is located is a structural graben about 30 mi long and 15 mi wide in the vicinity of the study area (Peterson and Martin, 1980). The southern part of the graben is filled by lake sediments. Further north in the graben these sediments are covered by Quaternary basalt flows. Springs emanate from the southern toes of these basalts, 1–2 mi south of the roadless area.

The Quaternary basalts are divided into three groups based on age and source area, but they all have similar trace-element chemistry and petrography (Peterson, 1980; Peterson and Martin, 1980); these basalts have been combined into one unit for this report but are briefly described. The oldest group consists of possible Pleistocene basalt flows erupted from Timbered Crater which now are covered by a deep red soil and heavy vegetation. The second group of flows had its origin in the Medicine Lake Highland area sometime in the Holocene. The lava was apparently very fluid and able to flow down the pre-existing graben. The youngest basalt group consists of a small Holocene shield complex that erupted from several vents in the vicinity of Brushy Butte between the three segments of the roadless area.

MINERAL RESOURCES

Between the late 1940's and 1971, flat lava decorative stone was removed from the vicinity of the Timbered Crater Roadless Area but further removal was banned by the U.S. Bureau of Land Management and USFS to protect local archeological sites. Recorded production of flat lava in the vicinity was 1700 tons, but twice that amount may actually have been removed. Geochemical and geophysical data (Peterson, 1980; Griscom, 1981) do not indicate the presence of any metallic commodities. Warm springs northeast of the area may indicate some geothermal potential but recorded temperatures are inadequate for power production.

Based on the above discussion, it is concluded that the Timbered Crater Roadless Area has little promise for the discovery of energy and mineral resources. Some basalt rubble is present that could be used in the construction industry.

SUGGESTIONS FOR FURTHER STUDIES

It is unlikely that further studies in the area would discover any additional mineral resources.

[1]With contributions from Linda M. Martin, USGS, and Gary J. Cwick, USBM.

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TIOGA LAKE, HALL NATURAL AREA, LOG CABIN-SADDLEBAG, AND HORSE MEADOWS ROADLESS AREAS, CALIFORNIA

By J. F. SEITZ, U.S. GEOLOGICAL SURVEY, and

F. E. FEDERSPIEL, U.S. BUREAU OF MINES

SUMMARY

Studies in 1979 of the geology and mineral resources of the Tioga Lake, Hall Natural Area, Log Cabin-Saddlebag, and Horse Meadows Roadless Areas indicate that parts of the Log Cabin-Saddlebag and Hall Natural Roadless Areas have a substantiated resource potential for gold and (or) silver resources, and a probable potential for tungsten and molybdenum resources. Tioga Lake Roadless Area has little likelihood for the occurrence of mineral resources and the Horse Meadows Roadless Area has a probable potential for low-grade tungsten, gold, and (or) silver resources. In the Log Cabin-Saddlebag Roadless Area, the principal mineralized areas are on the east flank of Mt. Warren in the vicinity of the Log Cabin mine and on the ridge between Saddlebag Lake and Warren Creek. In the Hall Natural Roadless Area the principal mineralized zone is at the site of the long defunct Great Sierra mine west of Tioga Lake. The geologic terrane in the roadless areas precludes the occurrence of organic fuel resources.

CHARACTER AND SETTING

The roadless areas described in this report are adjacent to each other in the eastern part of the Sierra Nevada range, Mono County, California. They lie immediately east of Yosemite National Park where they extend from the crest of the Sierra east to the vicinity of Mono Lake. Altitudes in the glaciated and rugged terrain range from 6815 to 12,588 ft above sea level. California State Highway 120 provides access to the areas, entering from the west at Tioga Pass and from the east in the canyon of Lee Vining Creek. Two of the areas lie south of the highway and the other two immediately north of it.

The Tioga Lake Roadless Area covers 1.25 sq mi and lies adjacent to and northeast of Tioga Pass. The Hall Natural Area covers 9 sq mi and extends west from Tioga Lake to the crest of the range and northward to the upper basin of Saddlebag Lake. Its west margin is composed of a series of cirques culminating in the peaks of Mount Conness and North Peak. The Log Cabin-Saddlebag Roadless Area, largest of the group with 23 sq mi includes the Saddlebag Lake area and Mount Warren and extends east from the Hall Natural Area to Mono Lake. It is bordered on the south by Lee Vining Creek and on the north by Lundy Lake and the Hoover Wilderness. The fourth roadless area, Horse Meadows, covers 9 sq mi south of Lee Vining Creek. It is covered mostly by glacial moraines and has a less rugged topography than the other roadless areas of this group.

The geology of the areas is dominated by a series of plutons that enclose roof pendants of metavolcanic and metasedimentary rocks. The larger plutons are of Cretaceous age and form the west margin of the areas. They are bordered on the east by a belt of metamorphic rocks 13,000 ft thick whose protolithic ages are Paleozoic, Permian, Triassic, and Jurassic. East of this in the area of Mount Warren and Mono Dome are six separate plutons of Triassic and Cretaceous ages. These are bordered on the east by a smaller roof pendant composed of Paleozoic metasedimentary rocks. Bedding and foliation in the metamorphic rocks follow a northwest trend throughout. The principal faults, mostly located in the Saddlebag Lake basin, follow this same trend with the exception of a northeast-trending fault or fault system located along the course of Mill Creek.

Mining activity began in this region in the late 1850's. Gold- and silver-bearing quartz veins were mined outside the roadless areas at the Log Cabin and May Lundy mines. Both mines were being reopened at the time of

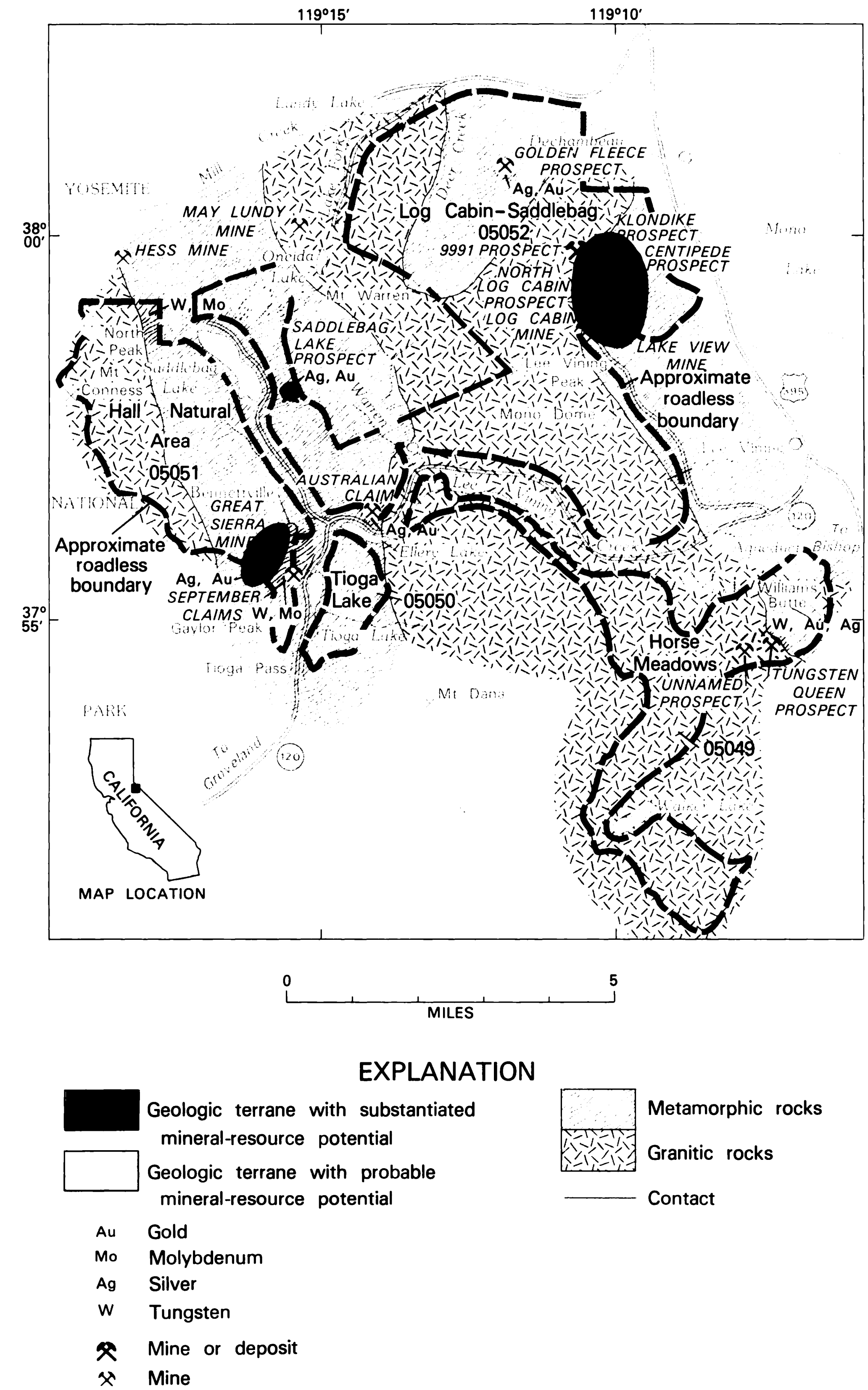

Figure 115.—Tioga Lake, Hall Natural Area, Log Cabin-Saddlebag, and Horse Meadows Roadless Areas, California.

this study. The Hess mine, also outside the areas, contains small amounts of tungsten and molybdenum in calc-silicate metasedimentary rocks.

More than 100 claims in these roadless areas have been recorded since 1880. None are placer claims. The Australian claim, on the south boundary of the Log Cabin-Saddlebag Roadless Area, was patented in 1912.

Mining records and previous reports indicate most mining activity was undertaken in the early 1900's and 1930's. During the mineral-resource survey in 1979, 21 adits (17 of which were caved), 15 shafts (12 of which were caved), and numerous trenches and pits were found. Present mining activity is limited to assessment work by local miners; no large-scale mining or prospecting was noted in the roadless areas.

MINERAL RESOURCES

All known mineral deposits and zones of mineralization within the roadless areas are located in the metamorphic rocks of the roof pendants or along the contacts between the roof pendants and the bodies of intrusive rock. In places where fracturing of the slates and quartzites in the metamorphic rocks has provided channels, sulfide-bearing quartz veins have penetrated the country rock. Some of these veins are massive and others comprise a fine network.

Gold and silver minerals occur in hydrothermally altered and silicified shear zones in Paleozoic metasedimentary and metavolcanic rocks that contain limonite-stained vuggy quartz and disseminated pyrite. Tungsten minerals occur locally in calc-silicate rocks along Paleozoic metasedimentary and Cretaceous intrusive rock contact zones.

Rock, stream-sediment, and nonmagnetic heavy-mineral concentrate samples were prepared and analyzed for the geochemical study of the Tioga Lake, Hall Natural Area, Log Cabin-Saddlebag, and Horse Meadows Roadless Areas.

An aeromagnetic survey was flown of the four roadless areas to determine if any significant magnetic iron-ore deposits exist and to delineate areas with chromium and nickel on the basis of associations with highly magnetic mafic intrusions. A significant magnetic anomaly in the shape of an elongate magnetic high was identified along the south flank of the ridge connecting Mono Dome and Lee Vining Peak in the Log Cabin-Saddlebag Roadless Area. This magnetic high is primarily associated with two igneous plutons, the granodiorite of Mono Dome and the quartz monzonite of Williams Butte. The high also extends northwestward into the Hoover Wilderness where it terminates over a small body of gabbro about 1 mi west of Lee Vining Peak. Additional work was done to evaluate whether or not the magnetic high was related to mineral resources. Ground magnetic intensity and rock susceptibility measurements were made along several profiles across the aeromagnetic high to look for the source of the anomaly. The results indicate that the high is not related to mineralization, but is only the expression of the granodiorite of Mono Dome, which is an unusually high magnetic rock.

The rock samples were collected primarily to provide information on the normal, or background, chemical composition of the rock units present in the roadless areas; consequently, only the stream-sediment and concentrate analyses are discussed here.

Geochemical anomalies were identified from samples of both stream sediment and heavy-mineral concentrates collected from several parts of the Log Cabin-Saddlebag Roadless Area and from samples collected from the southern part of the Hall Natural Area. The most significant anomalies are in drainage basins that originate in the Hoover Wilderness and continue into the Log Cabin-Saddlebag Roadless Area. The geochemical anomalies consist of the elements copper, lead, zinc, silver, gold, and tungsten, which form a suite that is commonly associated with contact-metasomatic sulfide deposits that may contain base and precious metals and (or) tungsten. Some of the anomalies may be, at least in part, the result of contamination from mining activity upstream from various samples sites. The geochemical anomalies occur along streams draining areas of locally hydrothermally altered metamorphic rocks, including both metasedimentary and metavolcanic units, and suggest that undiscovered contact-metasomatic deposits of base and precious metals and (or) tungsten may exist within the Log Cabin-Saddlebag Roadless Area or the Hall Natural Area. Major faults are known in some of the anomalous areas; these faults may serve as favorable sites for undiscovered mineral deposits.

Demonstrated resources in the roadless areas are estimated at about 640,000 tons of gold- and silver-bearing material. Approximately 38,000 tons of the demonstrated resources, possibly averaging as much as 0.04 oz gold/ton and 0.2 oz silver/ton, are in two areas of substantiated resource potential in the Log Cabin-Saddlebag Roadless Area; one on the east side at the 9991, Centipede, Klondike, and North Log Cabin prospects, and one on the west side at the Saddlebag Lake prospect.

Resources in and near these prospects are in northerly trending, steeply dipping shear zones that range from 1 to 3 ft thick. Zones at the Centipede, North Log Cabin, and Saddlebag Lake prospects contain limonite-stained metasedimentary rocks and quartz veins with as much as 5 percent disseminated sulfides (mainly pyrite). Zones at the 9991 prospect contain limonite-stained quartz diorite and quartz veins with as much as 3 percent disseminated pyrite.

Two additional prospects, the Australian and Golden Fleece, are each in a small area that has a probable potential for gold and silver resources. Resource estimates could not be made for these prospects because the underground workings were caved and mineralized zones were covered with talus.

About 600,000 tons of demonstrated resources possibly averaging 0.01 oz gold/ton and 1.2 oz silver/ton are in the Hall Natural Area at the Great Sierra mine in an area of substantiated mineral-resource potential.

Mineralization occurs in shear zones in metasedimentary rocks that are 6 to 40 ft thick, strike N. 20–30° W., dip steeply northeast, and contain brecciated metasedimentary rocks and quartz veins with arsenopyrite, pyrite, chalcopyrite, and sphalerite.

The north and south parts of the Hall Natural Area also have a probable resource potential for tungsten and molybdenum resources. Southern extensions of the Hess mine may underlie the north part of the area and in the south part of the area small tactite deposits occur on the September claims.

Records of mining or prospecting are not available for Horse Meadows Roadless Area, but the area containing the Tungsten Queen prospect southwest of Williams Butte has a probable potential for low-grade tungsten resources. A probable potential for low-grade gold and silver resources exists at the unnamed prospect to the west.

No resources were identified in the Tioga Lake Roadless Area.

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TUOLUMNE RIVER ROADLESS AREA, CALIFORNIA

By JOY L. HARNER,[1] U.S. GEOLOGICAL SURVEY, and

PAUL C. HYNDMAN, U.S. BUREAU OF MINES

SUMMARY

On the basis of mineral-resource surveys in 1975 and 1982, the western part of the Tuolumne River Roadless Area has a substantiated potential for the occurrence of gold and silver resources and has numerous mines and prospects with demonstrated or inferred gold resources. The gold is localized in high-grade shoots within quartz veins in the Calaveras Complex of metasedimentary rocks and as placer gold in Tertiary and recent river beds. The Tuolumne River bed has a probable placer gold resource potential. Limestone and dolomite deposits occur within the roadless area, and similar deposits are found outside the area. There is little promise for the occurrence of energy resources in the roadless area.

CHARACTER AND SETTING

The Tuolumne River Roadless Area is approximately 13 mi long and 5 mi wide, encompassing about 28.5 sq mi in the western Sierra Nevada, and is located about 10 mi west of the Yosemite National Park. Groveland is situated just south of the roadless area along California State Highway 120. Altitudes range from 800 to 3880 ft above sea level. The major river in the roadless area is the Tuolumne, which drains the Hetch Hetchy Reservoir 15 mi to the east. The Tuolumne River has been popular for river rafting between Lumsden Bridge on the eastern edge of the roadless area and Wards Ferry 17 mi downstream to the west. The Clavey River, which joins the Tuolumne River from the north is the largest tributary. The roadless area consists of gently rolling uplands cut by deep (2000 ft) steep-walled river and stream canyons. Vegetation includes evergreens, deciduous oaks, manzanita and grasslands, with conifers and digger pines above 2000 ft. Access to the roadless area is provided by unpaved and unimproved roads from Highway 120 to the south and from Tuolumne City near Highway 108 on the north, trails, and the Tuolumne River which is navigable through the roadless area by raft and kayak.

The Tuolumne River Roadless Area is located in the western Sierra Nevada, where a metamorphic belt flanks the west side of the Sierra Nevada batholith. The roadless area is crossed by the East Belt, a mineralized zone which parallels the famed Mother Lode Belt about 10 mi to the west, and which extends from the Stanislaus River southeast across the Tuolumne River Valley to approximately the south boundary of the roadless area. In width it extends from about the mouth of the South Fork of Tuolumne River west for about 10 mi.

Rocks of the roadless area include predominantly the Calaveras Complex of metasedimentary rocks of Paleozoic age (Schweikert and others, 1977), diorite and granitic intrusive rocks of Mesozoic age, numerous dikes and veins of probable Mesozoic age, and volcanic rocks of Tertiary age.

The term Calaveras was originally applied to the Calaveras Formation and included all metamorphic rocks of Paleozoic age in the western Sierra Nevada. The Calaveras Complex is now restricted by Schweickert and others (1977) as a northwest-trending metamorphic belt bounded by a fault zone on the west, and by the Sierra Nevada batholith on the east, stretching from Placerville to the Merced River area with extensions of the belt south of the Merced River in roof pendants at least as far south as the Tule River. The Calaveras Complex is a steeply dipping northwest-trending complex of metasedimentary rocks that include mica schist, phyllite, metachert, quartzite, and limestone. It is divided in the roadless area into three major units: an argillite-phyllite unit, a chert unit, and a quartzite unit. The limestone is primarily within the argillite unit, and occurs as southeastern extensions of much larger marble

[1]With contributions from James F. Seitz, USGS.

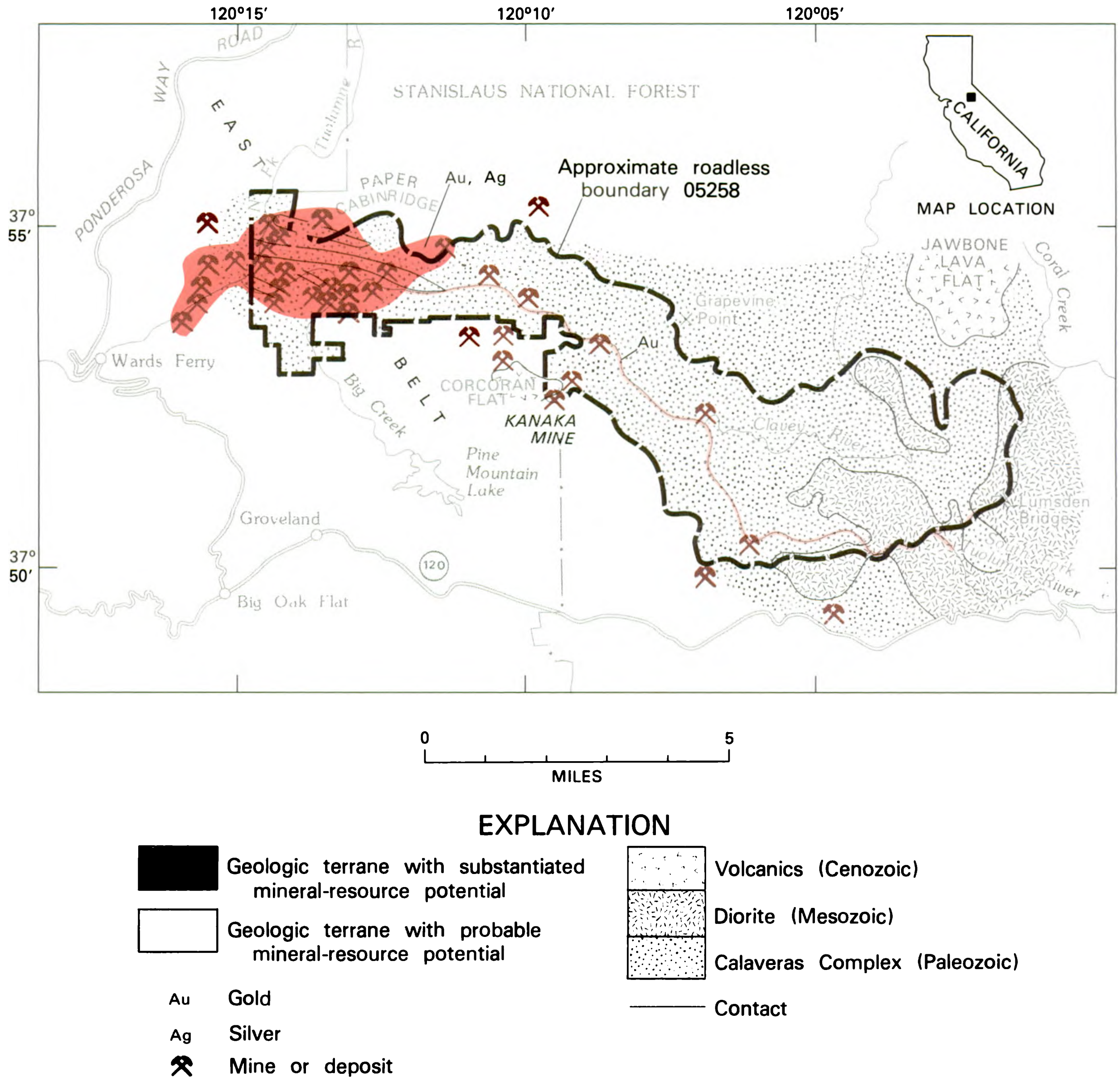

Figure 116.—Tuolumne River Roadless Area, California.

masses to the west and north; minor outcrops also occur within the chert unit. Each of the units of the Calaveras Complex is composed of chiefly the rock type for which it is named, with lesser amounts of interbedded rocks of the other two types. Contacts run northwest, and the limestone bodies trend slightly more east-west.

The diorite, with compositional variations to granodiorite, occurs in the eastern end of the roadless area, and is the westernmost extension of the Mesozoic intrusives that make up the Sierra Nevada batholith. Textures are fine to medium grained, equigranular, and foliated near the contacts with the metamorphic rocks. Mixed rocks of the plutonics and the metasediments, including breccias with diorite enclosing quartzite blocks, also occur near the contacts.

Dikes and veins of pegmatite, aplite, quartz, and basalt composition occur throughout the roadless area. The dikes represent several ages of emplacement as they exhibit complex crosscutting relationships.

The volcanics are remnants of Tertiary flows (20 to 30 million years old) that once covered much of the area near the present Tuolumne River. The flows commonly cap gold-bearing Tertiary stream gravel. Volcanic rocks are located in two places near the roadless area boundary; on Corcoran Flat and on Jawbone Lava Flat.

A geochemical survey of the area was completed by the USBM during their study in 1975 for the Wild and Scenic Rivers appraisal; sediments were sampled along the Tuolumne River and in each of its significant tributaries.

Geophysical maps were compiled from gravity and aeromagnetic surveys to aid in geologic mapping and mineral appraisal (Don Plouff, unpub. mapping, 1982).

MINERAL RESOURCES

Gold is the principal mineral commodity in the Tuolumne River Roadless Area. It occurs in the East Belt in quartz veins and in silicified portions of shear zones and in placers. In some of the vein deposits silver, lead, copper, and zinc are associated with the gold. Placer gold occurs in Tertiary river gravels on the rims of the Tuolumne River Canyon and in Holocene gravels and in the present river bed.

Gold in the roadless area occurs in both lode and placer deposits. The lode deposits occur as ribbon quartz veins and stringers, with disseminated pyrite, within shear zones in pyritic phyllite or marble. The highest gold values occur in shoots, reportedly as wide as 50 ft, that are at an angle to the dip of the veins. Lead and zinc occurring in galena and sphalerite usually accompany the higher concentrations of gold. The gold-bearing zones generally strike east-west but some strike north and northeasterly.

The Tertiary placer deposits, situated mostly on the south rim of the Tuolumne River Canyon, were capped by lava flows and preserved during subsequent uplift and erosion during the Sierran orogeny. Gold in the placer deposits of the present river have as their sources the Tertiary placers as well as the gold-bearing veins of the East Belt.

In the geochemical study, detectable amounts of gold and silver were found in all stream-sediment samples. However, only one location contained an anomalously high concentration of gold, and only four contained anomalously high concentrations of silver.

The geophysical study showed narrow magnetic highs that extend nearly 2 mi southeast from the Kanaka mine. The magnetic highs probably reflect magnetite-bearing veins or dikes that follow the regional geologic trend.

Since the 1870's when county records were established, more than 1500 lode and 300 placer claims have been recorded, mainly in the western half of the roadless area. An unknown number, probably quite large, were located between 1850 and 1870. Within the roadless area, 12 lode claims, and placer claims covering 571 acres, have been patented. A total of about 100 shafts, adits, and pits were examined in the roadless area, and another 50 workings were examined that are near the area. An estimated 940,000 troy oz of gold has been produced in the East Belt, of which about 86,000 oz was from mines in and near the roadless area (Julihan and Horton, 1940, p. 18). Complete mine production records are not available.

Twenty lode properties within the roadless area have demonstrated and (or) inferred gold and, in some properties, silver resources. Nine lode properties adjacent to the roadless area also have demonstrated and (or) inferred resources of gold and, locally, silver. Four placers within the roadless area, and one placer adjacent to it have demonstrated gold resources; one placer within the area and three placers adjacent to the area, have inferred gold resources. Several other lode and placer properties within and adjacent to the roadless area may also have low-grade gold resources. The Tuolumne River bed is a possible area for suction dredging for the recovery of gold and has a probable placer gold resource potential. Localized fissures in bedrock may yield very coarse gold nuggets. Some large, high-calcium marble deposits extend into the roadless area from the west. These occurrences, however, are far from present or potential markets and similar material is found outside the area. There is little possibility for the occurrence of fossil fuel and geothermal resources in the roadless area.

SUGGESTIONS FOR FURTHER STUDIES

Additional rock sampling in the area of substantiated gold resource potential would help define the gold resources of the roadless area and possibly identify other occurrences.

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VENTANA WILDERNESS, CALIFORNIA

By R. C. PEARSON,[1] U.S. GEOLOGICAL SURVEY, and

P. V. FILLO, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Ventana Primitive Area (now the Ventana Wilderness) was made in 1966–67. On the basis of known mineral occurrences and our geologic and geochemical studies, this part of the Coast Ranges of central California contains little evidence for the existence of mineral resources. Small bodies of good quality marble are scattered through parts of the wilderness. Because of their small size these marble occurrences are not considered as having resource potential.

CHARACTER AND SETTING

The Ventana Wilderness is in the Santa Lucia Range southeast of Monterey and Carmel, California. Its central part is drained by the Big Sur River, and its western boundary is generally along the coast ridge, a few thousand feet above the rugged and scenic Pacific coast. The area is characterized by northwest-trending, steep-sided, sharp-crested ridges that are separated by youthful V-shaped valleys. Many of the streams flow in narrow canyons with steep to vertical walls, waterfalls, and deep plunge pools.

The Santa Lucia Range is part of a northwest-trending fault-bounded block of crystalline rocks. Sedimentary and probably volcanic rocks have been metamorphosed and are now schists and gneisses that have been intruded by plutonic igneous rocks that range from gabbro to granite. Younger unmetamorphosed sedimentary rocks, chiefly sandstone, siltstone, and claystone, lie on the crystalline rocks and are preserved as slices and blocks along and between faults. The block of crystalline rocks, which is over 300 mi long, is bounded by major faults: the San Andreas on the northeast and the Sur-Nacimiento on the southwest. Both of these are outside the Ventana Wilderness, but the principal faults within the area also trend northwest and account for the northwest pattern of ridges and valleys that make up the area. Generally lesser faults of other trends are also abundant.

Because the area is heavily vegetated, the rocks in the wilderness are weathered and the soil is thick, and the country is difficult to traverse on foot, much reliance was placed on geochemical sampling to assess the mineral resources. So far as known, no mining has been done, although 2 lode claims and 18 placer claims were filed many years ago and some prospecting has been done according to reports.

[1]With contributions from P. T. Hayes, USGS.

MINERAL RESOURCES

The southern Coast Ranges of California have produced substantial quantities of petroleum, mercury, and dolomite, and lesser amounts of chromite, manganese, asbestos, diatomite, limestone, and copper. All these commodities, except dolomite, limestone, and copper were derived from geologic terranes different from the crystalline rocks that dominate the Ventana Wilderness and, hence, they are not likely to occur here. The sedimentary rocks are not preserved in sufficient thickness to provide traps for petroleum. Dolomite has been quarried extensively about 40 mi northeast of the wilderness. Elsewhere, limestone has been exploited on a small scale, and negligible amounts of copper have been mined. Uranium, molybdenum, and mercury prospects are within a few miles of the wilderness but no significant prospects are known in the area.

The geochemical studies generally confirm the scarcity of mineralized rock in the area as determined by the absence of mining and minimal observable evidence of mineralized rocks. Although a few samples of pyritic and graphitic schist and gneiss were highly anomalous in vanadium and molybdenum, and small amounts of copper and zinc, no resource potential was identified.

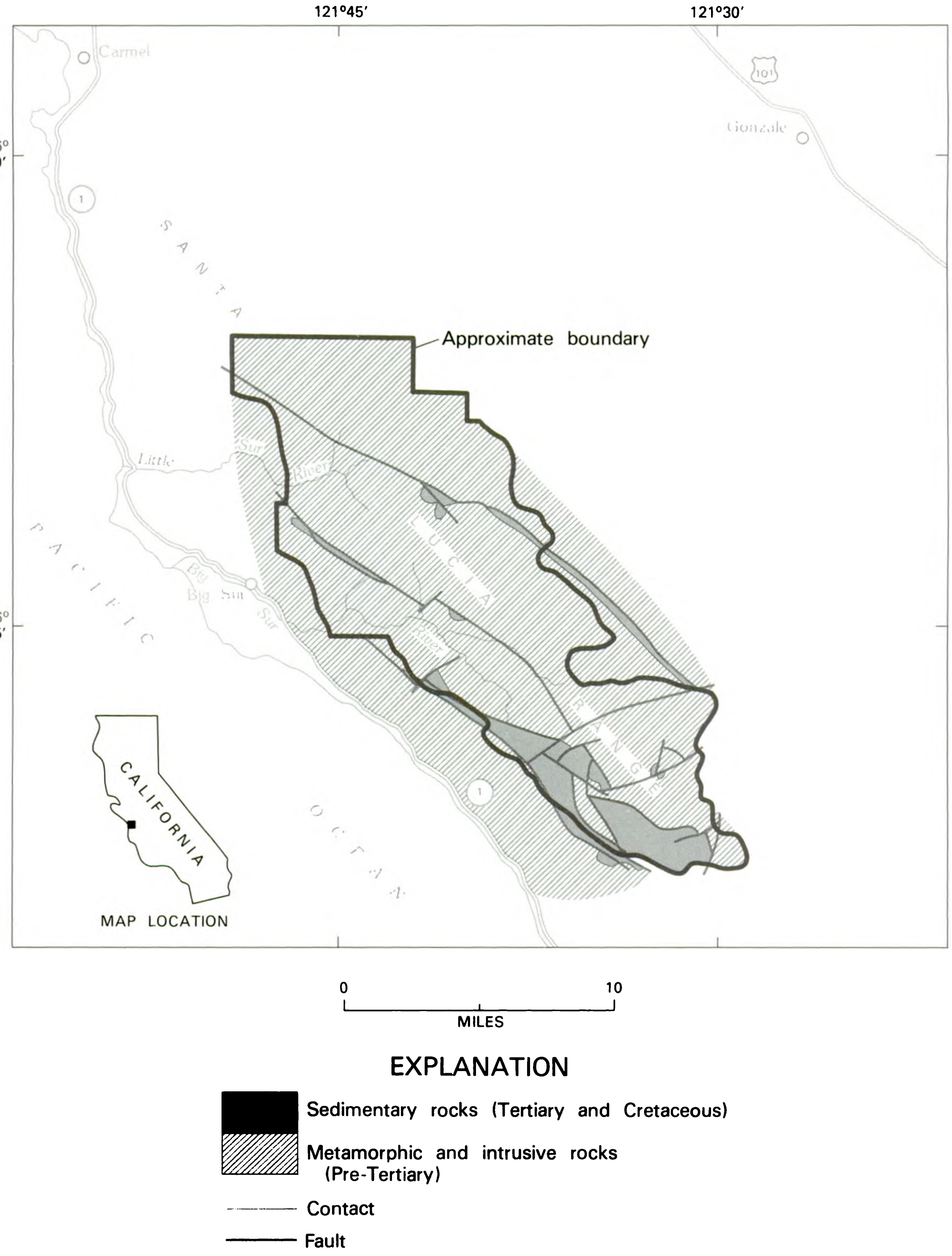

Figure 117.—Ventana Wilderness, California.

Thin layers and small pods of limestone have a composition suitable as a source of lime, but the marble bodies are small, in very rugged terrain, and are remote from transportation.

SUGGESTIONS FOR FURTHER STUDIES

Detailed mapping and sampling of the sulfide-bearing gneiss and schist will be needed to determine the grade and extent of these rocks and the possibility that they, in fact, could represent significant resources.

When the mineral survey of the Ventana Wilderness was made in 1966–67, no consideration was given to the possiblity of geothermal energy. The numerous thermal springs in and near the area suggest a high geothermal gradient and that geothermal-energy resources should be investigated.

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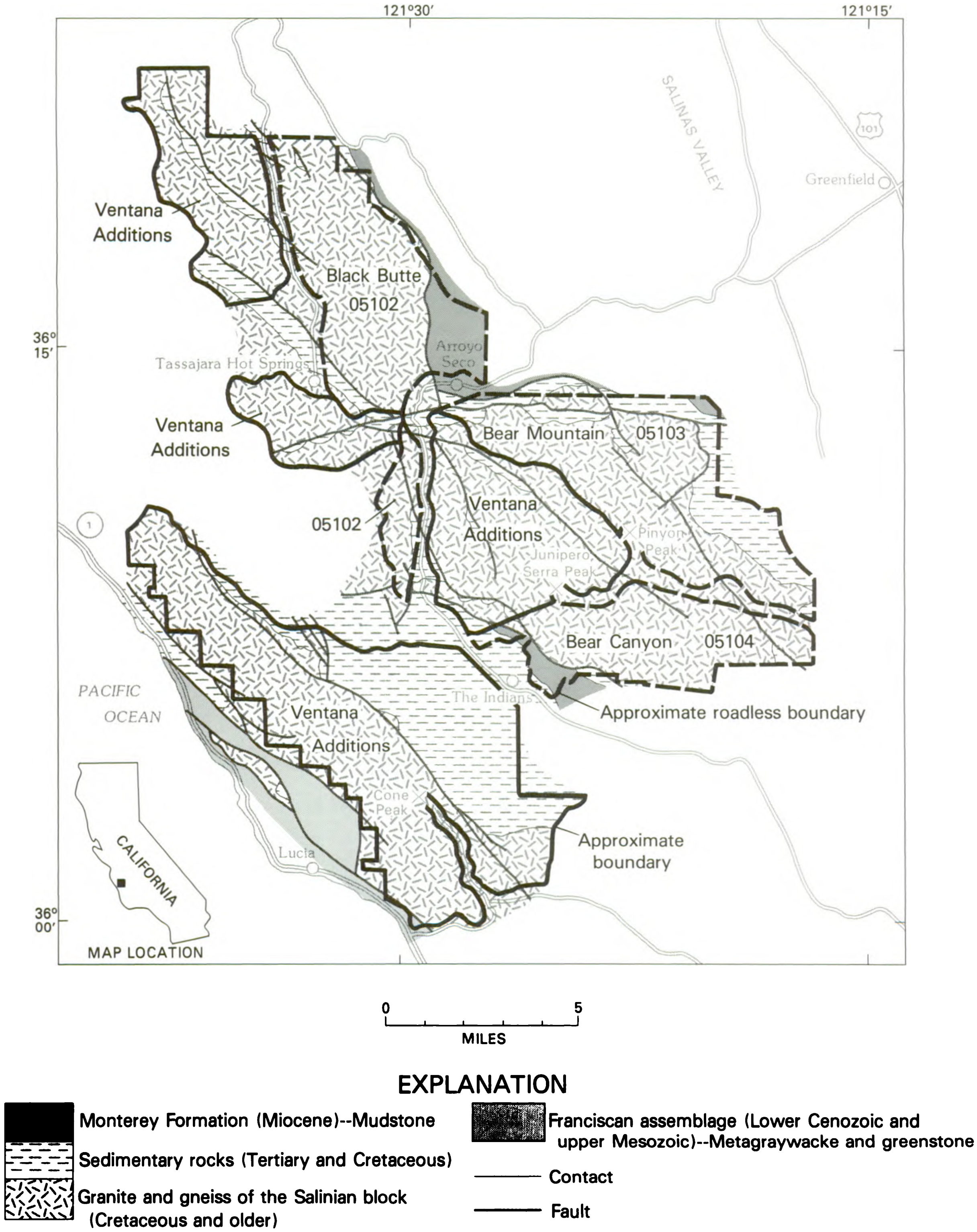

Figure 118.—Ventana Wilderness Additions and the Black Butte, Bear Mountain, and Bear Canyon Roadless Areas, California.

VENTANA WILDERNESS ADDITIONS, AND THE BLACK BUTTE, BEAR MOUNTAIN, AND BEAR CANYON ROADLESS AREAS, CALIFORNIA

By VICTOR M. SEIDERS,[1] U.S. GEOLOGICAL SURVEY, and

LEON E. ESPARZA, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey conducted in 1980–82, the Ventana Wilderness additions and adjacent roadless areas offer little promise for the occurrence of mineral or energy resources. There has been virtually no history of mining in the area and very little mining has been done in geologically similar regions nearby. Oil and gas are produced from the Monterey Formation nearby, but the small areas of Monterey rocks in the area appear to lie beyond the limits of productive sandstone.

CHARACTER AND SETTING

The Ventana Wilderness additions and adjacent roadless areas, hereafter referred to as study area, occupy an area of about 181 sq mi in the Los Padres National Forest. The study area is in the Santa Lucia Range, a part of the Coast Ranges of California, and lies between the Salines Valley on the east and the Pacific Ocean on the west. Paved roads reach the area from U.S. Highway 101 on the east and a road just south of the area crosses the range and connects with the Coast Highway (California State Highway 1). The area has rugged relief and dense vegetation. Cone Peak, only 3.2 mi from the ocean, has an altitude of 5155 ft. Junipero Serra Peak, with an altitude of 5862 ft, is the highest point in the Santa Lucia Range. Much of the study area is covered by brush, with stands of oak, madrone, and pine in more moist locations and at higher altitudes. Redwoods grow in valleys near the coast. The large Marble Cone fire of 1977 burned much of the study area north of The Indians, temporarily eliminating a great deal of nearly impenetrable brush. Annual precipitation ranges from more than 100 in. near the coast to about 20 in. inland, falling mainly between December and April.

A mineral survey of the Ventana Primitive Area was carried out by the USGS and the USBM and a report was published (Pearson and others, 1967). The Ventana Wilderness, as established in 1978, expanded the original primitive area. The adjacent Black Butte, Bear Mountain, and Bear Canyon Roadless Areas were established and a mineral survey of the additions to the Ventana Wilderness and the adjacent roadless areas was conducted in 1980–82 (Seiders and others, 1983).

Most of the rocks of the study area are part of a large fault-bounded terrane of central California known as the Salinian block. The basement of the Salinian block consists of high-grade metamorphic rocks of unknown age, chiefly gneiss, intruded by large masses of Cretaceous and older igneous rock, chiefly granite and granodiorite. The basement rocks are unconformably overlain by sedimentary rocks of Cretaceous and Tertiary age. The rocks are largely sandstone, mudstone (shale), and conglomerate. The youngest unit of the sedimentary sequence of the area is a mudstone rich in organic material known as the Monterey Formation. The west edge of the Salinian block is a complex fault system that just reaches the west edge of the study area. West of the fault zone are low-grade metamorphic rocks of the upper Mesozoic and lower Cenozoic Franciscan assemblage. These rocks are chiefly metagraywacke and shale, with subordinant greenstone, and minor serpentinite.

MINERAL RESOURCES

The Coast Ranges of central California have been the site of a considerable and varied mineral production but there has been no significant activity within the study area. Mercury has been obtained from mining districts located within 65 mi of the study area, and small quantities of chromium and gold have been produced nearby.

[1]With contributions from Charles Sabine, J. M. Spear, Scott Stebbins, and J. R. Benham, USBM.

However, nearly all the metallic mineral deposits have been found in rocks of the Franciscan assemblage. Rocks of the Salinian block, which underlie nearly all of the study area, have produced no significant metallic mineral deposits. Although Monterey County records indicate 107 claims located in the study area, none are currently active and very little evidence remains of past activity. Geochemical study of stream-sediment samples (Seiders and others, 1983) showed anomalous values of certain elements in 9 samples, but most of these anomalies appear to correlate with rocks in the area containing relatively high values of these elements. Field examination and chemical analyses of rock samples revealed little evidence of metallic mineralization. One rock sample contained anomalous amounts of silver, arsenic, bismuth, copper, and lead but no anomaly was defined from sediment samples taken from streams draining the area. The area of mineralization does not seem to be large, and no resources were identified. A unit of graphitic, pyritic gneiss in the northwestern part of the study area shows anomalous values of vanadium, molybdenum, copper, and silver. Flour gold was detected in some placer samples. However, no resource potential for metallic mineral deposits was identified.

Deposits of crystalline limestone occur in the metamorphic rock sequence of the Salinian block but they are small in extent and inaccessible. Sand and gravel occur in alluvium and alluvial terraces but the deposits are small and remote from markets. Larger deposits occur just outside the study area. In the past, diatomite has been mined from the Monterey Formation in nearby areas but there has been no production since 1942. No similar deposits are known to occur in the study area. Phosphate rock has been reported to occur as thin beds in the Monterey Formation in the study area. However, based on available data, no resource potential for phosphate or other nonmetallic mineral deposits was identified.

Considerable oil and gas is obtained from the Salinas Valley east and southeast of the study area. Most production is from sandstones in the Monterey Formation. The oil fields are located along a northwest-trending zone where sandstone, which is the reservoir of the oil, interfingers with the petroliferous mudstone that is the source of the oil. This zone is entirely east of the study area. Some sandstone also occurs in the Monterey Formation southeast of the study area near a small basement high, the Lockwood high, but so far there has been very little production. The Monterey Formation within the study area contains organic-rich mudstone but appears to lack the productive sandstones. Sedimentary rocks that underlie the Monterey have not been productive in nearby areas nor do they show any favorable indications of oil and gas in the study area. Therefore no resource potential for oil and gas was identified.

Hot springs of moderate discharge occur just outside the study area at Tassajara Hot Springs and on the coast 9 mi northwest of Lucia. The springs are utilized as hot baths. No hot springs are known in the study area and little promise can be held for geothermal energy.

SUGGESTIONS FOR FURTHER STUDIES

Quantitative data on the abundance of phosphate in the Monterey Formation would be useful in evaluating its potential for future use. Exploration for oil and gas in the Monterey Formation in adjacent areas could provide new data that could modify this current assessment of the oil and gas potential in the study area.

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WEAVER BALLY ROADLESS AREA, CALIFORNIA

By M. C. BLAKE, JR., U.S. GEOLOGICAL SURVEY, and

T. J. PETERS, U.S. BUREAU OF MINES

SUMMARY

A mineral survey in 1982 indicates that an area of less than 1 sq mi in the northern part of the Weaver Bally Roadless Area has a substantiated mineral-resource potential for gold and silver; a much larger area has a probable mineral-resource potential for the same elements. The geologic terrane precludes the occurrence of fossil fuel resources and there is little promise for the occurrence of additional metallic, energy, or nonmetallic resources in the roadless area.

CHARACTER AND SETTING

The Weaver Bally Roadless Area includes approximately 22 sq mi in the Shasta-Trinity National Forest, Trinity County, California. The area abuts the southern boundary of the Salmon-Trinity Alps Wilderness and is characterized by steep and rugged topography, largely covered by conifer forest with areas of chapparal. Access is by USFS roads and 4-wheel drive and foot trails. A northern segment of the area was examined during an evaluation of the mineral resources of the Salmon-Trinity Alps Wilderness (Hotz and others, 1972).

Most of the area is underlain by the Salmon Hornblende Schist (Davis and others, 1965), which ranges from a very fine grained metavolcanic rock to a coarse-grained metagabbro. The schist is host for most gold-bearing quartz lodes in the roadless area. The lodes occur along shear zones that strike northeast, dip steeply southeast, and are generally coplanar with foliation (Cox, 1967, p. 47).

The hornblende schist is intruded by a granodiorite stock near Monument Peak, and also contains many, small unmapped dikes and sills of dacite porphyry and alaskite that may be offshoots of the larger Monument Peak pluton. The dikes and sills are locally altered and cut by iron-stained quartz veins. These altered intrusives appear to be the source of the geochemical anomalies reported by Hotz and others (1972).

Both stream sediments and rocks were sampled for geochemical analysis. All of the anomalous values of gold, silver, and other metals were found in rock samples; no anomalous values were identified in stream sediments. A geologic map of the area has been published (Blake, in press).

MINERAL RESOURCES

A substantiated mineral-resource potential was identified in an area encompassing the Globe Consolidated Group (Globe-Bailey-Chloride mines) at the north end of the roadless area. Production between 1891 and 1953 from these mines totaled more than 100,000 oz of gold and about 26,000 oz of silver (Hotz and others, 1972, p. B114–119). There has been no significant production since 1916. Additional demonstrated resources of an estimated 11,627 tons remain at the Globe mine, averaging 0.56 oz gold/ton. The Globe workings were largely inaccessible at the time of this study. If gold-silver ratios follow past production, resources will also contain by-product silver. The Bailey workings are inaccessible; accessible portions of the Chloride mine contain only minor amounts of gold-bearing quartz, but the grade is encouraging.

Other gold-bearing quartz lodes in the roadless area and vicinity with demonstrated gold resources include the Mason-Thayer mine, the Meckel-Fields mine, and the Arbuckle mine. Assay results from 12 other lode prospects in the roadless area do not indicate demonstrated resources, but exposure at many prospects is limited.

Free gold was found in pan concentrates from 10 of 11 known placer prospects in the roadless area. Placer mining is limited to recreational dredging in stream beds because of the lack of gravel bars. Suction dredges were operating at two prospects at the time of this study.

Based on the gold resources at the Globe mine plus additional gold-bearing quartz veins at four other prospects, and a high gold geochemical anomaly in altered dacite porphyry along Weaver Bally Mountain, the

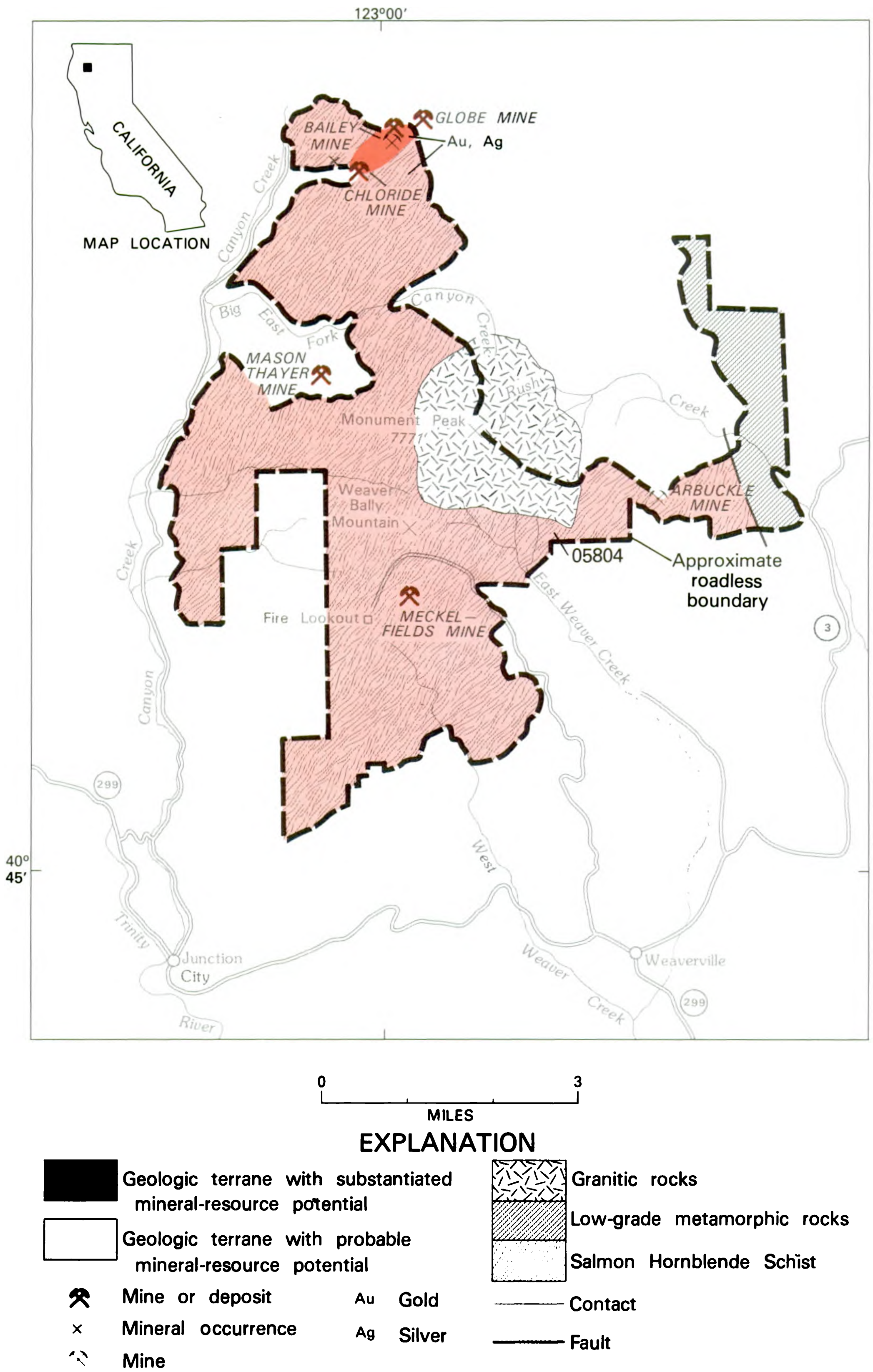

Figure 119.—Weaver Bally Roadless Area, California.

entire area underlain by the Salmon Hornblende Schist is considered to have a probable mineral-resource potential for lode gold and disseminated gold in dacite porphyry. Placer mining will be limited to recreational dredging because of the absence of significant gold-bearing gravel bars.

SUGGESTIONS FOR FURTHER STUDY

Detailed studies, including further geochemical sampling and drilling could be done in the region of the Globe mines. In addition, the outcrops of dacite porphyry dikes and sills and associated hydrothermal alteration should be mapped in detail.

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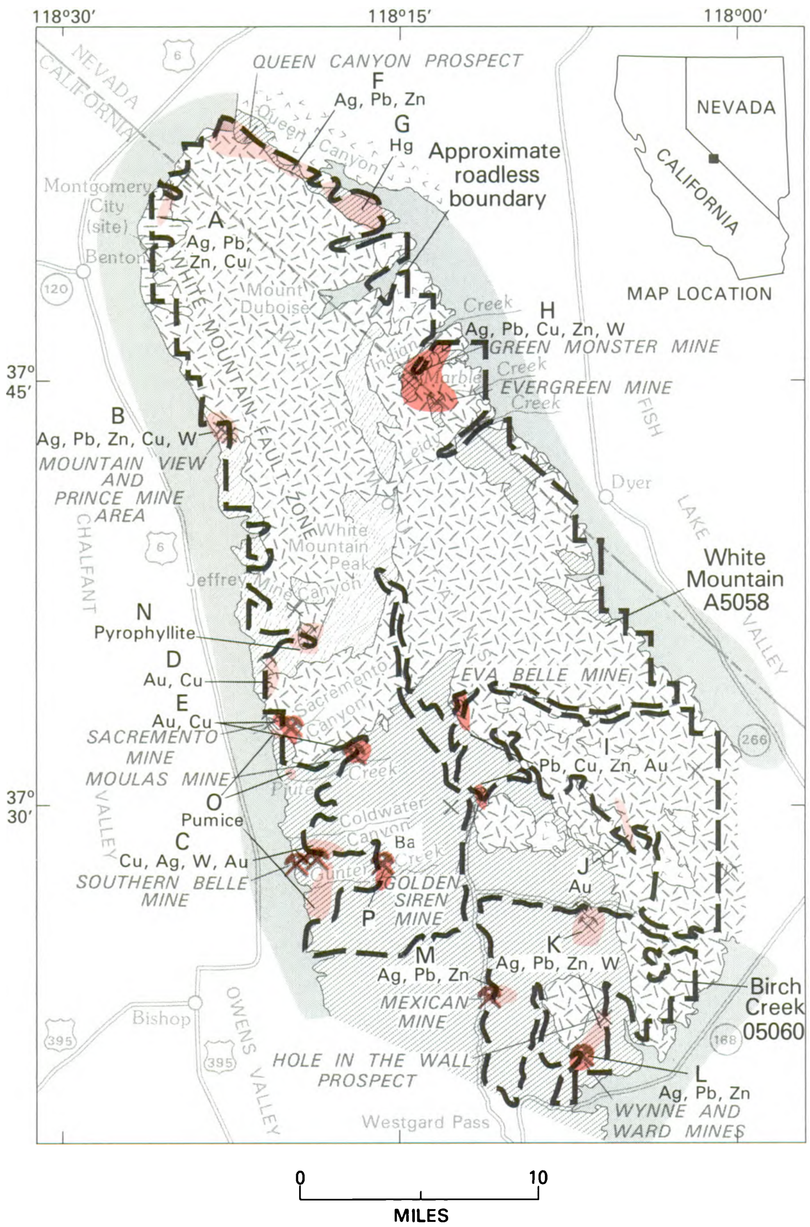

EXPLANATION

Geologic terrane with substantiated mineral-resource potential

Geologic terrane with probable mineral-resource potential

Cu	Copper	Ag	Silver
Au	Gold	W	Tungsten
Pb	Lead	Zn	Zinc
Hg	Mercury		

Mine or deposit

Mineral occurrence

Mine

Sedimentary deposits (Quaternary)

Volcanic rocks (Cenozoic)

Plutonic rocks (Mesozoic)

Metamorphosed sedimentary and volcanic rocks (Pre-Jurassic)

Marble (Jurassic to Paleozoic)

Sedimentary rocks (Paleozoic and Proterozoic)

Contact

B Area discussed in text

Figure 120.—White Mountains and Birch Creek Roadless Areas, California and Nevada.

WHITE MOUNTAINS AND BIRCH CREEK ROADLESS AREAS, CALIFORNIA AND NEVADA

By MICHAEL F. DIGGLES,[1] U.S. GEOLOGICAL SURVEY, and

STEVEN W. SCHMAUCH, U.S. BUREAU OF MINES

SUMMARY

The mineral survey of the White Mountains and Birch Creek Roadless Areas, conducted in 1980 and 1981 indicates that there is probable and substantiated resource potential for gold, silver, lead, copper, zinc, tungsten, and mercury as well as barite and pyrophyllite. Pumice resources occur in several areas in the White Mountains Roadless Area. There is little promise for the occurrence of energy resources in the areas.

CHARACTER AND SETTING

The White Mountains and Birch Creek Roadless Areas occupy 243 and 88 sq mi, respectively, in the rugged, steep White Mountains about 15 mi northwest and west of Bishop, California. They are bounded on the west by Owens and Chalfant Valleys and on the east by Fish Lake Valley. Access is provided by secondary roads off of U.S. Highways 395 and 6, California State Highway 168, Nevada State Highway 3A, and from the White Mountains road. The geology of the roadless areas was mapped by McKee and others (1982). Geochemical and geophysical studies by the USGS and evaluation of mines, prospects, and other known mineral deposits by the USBM were conducted in 1980, 1981, and 1982. A summary of the results of these studies and an evaluation of the mineral-resource potential is presented in Diggles and others (1983).

The two roadless areas are underlain mostly by granitic rocks of the Inyo batholith which is an eastern extension of the Sierra Nevada batholith. The plutons intrude country rocks consisting of Late Proterozoic through Cambrian carbonate, sandstone, and shale; Ordovician argillite, chert, and shale; and metavolcanic and metasedimentary rocks of probable late Paleozoic to early Mesozoic age. Late Tertiary rhyolitic tuffs, flows, and dome rocks and local olivine basalt occur mostly in the northern part of the area.

The structural history of the roadless areas is marked by four periods of deformation. Prior to emplacement of the batholithic rocks, a thrusting event placed younger Cambrian strata over older rocks. The Cambrian and older rocks are found elsewhere in conformable sequences. Late Paleozoic to early Mesozoic metamorphosed volcanic and sedimentary rocks were deformed elsewhere and moved to their present location, possibly as a thrust sheet or accreted crustal fragment prior to intrusion of the oldest Mesozoic plutons. Local deformation is related to the emplacement of the plutonic rocks, and Tertiary through Holocene Basin and Range faulting is responsible for the present steep topography.

Mining activity in the two roadless areas dates back to the early 1860's. The principle commodities mined from the White Mountains Roadless Area have been silver, gold, lead, copper, and zinc as well as pyrophyllite, pumice, barite, and andalusite. Silver, lead, and zinc have been produced from the Birch Creek Roadless Area. The USBM evaluated 133 properties in and near the White Mountains Roadless Area; within this area at least 20 mines have produced metallic or nonmetallic minerals. Thirty-nine properties in and near the Birch Creek Roadless Area were studied; three properties within the area have produced small amounts of metallic minerals.

MINERAL RESOURCES

Four areas within the White Mountains and Birch Creek Roadless Areas were identified as having substantiated metallic mineral-resource potential (areas E, H, I, and L, on map). One area has a substantiated nonmetallic mineral-resource potential (area P).

Area E, along the west side of the White Mountains

[1]With contributions from Richard L. Rains, USBM.

Roadless Area, consists of two small areas between Sacremento Canyon and Piute Creek. The Sacremento mine, within the roadless area, and the Moulas mine, just outside the roadless area have both produced small amounts of gold and copper. Geochemical anomalies (Diggles, 1983) and the small production indicate this area has substantiated potential for copper and gold resources.

On the east side of the White Mountains Roadless Area, east of Fish Lake valley, the Indian-Marble Creek area (H) has substantiated mineral-resource potential as attested to by a rich mining history. The Green Monster mine produced silver, copper, lead, and zinc from 1938 to 1953. The Evergreen mine produced silver, lead, zinc, and tungsten from tactite in the contact zone between Mesozoic intrusives and Late Proterozoic carbonate and clastic rocks. Geochemical anomalies in this area (Diggles, 1983) provide additional evidence for the mineral potential of area H. Area I consists of two small areas, and is a contact zone between Mesozoic granitic plutons and calcareous country rock that contains two mines, the Eva Belle on the north, and the Golden Siren, on the south, both of which have produced lead, copper, zinc, and gold. Geochemical anomalies for lead, copper, and zinc (Diggles, 1983) provide additional evidence for an area of substantiated mineral-resource potential. Area P, the Gunter Creek area, includes two mines which have produced barite from veins, and stream-sediment samples from this area contained anomalous levels of barium. The area has a substantiated resource potential for barite.

In the Birch Creek Roadless Area, the Wynne and Ward mine has demonstrated resources of silver, lead, and zinc and is surrounded by an area of substantiated silver, lead, and zinc resource potential (area L). Nine areas (A, B, C, D, F, G, J, K, and M) have probable resource potential for metallic mineral resources. Two additional areas (areas N and O) have a probable potential for nonmetallic mineral resources.

Within the White Mountains Roadless Area, in area A, the Montgomery City townsite area, numerous claims were located for silver in the White Mountain fault zone. Silver occurs in short veins made discontinuous by faults. Silver, lead, zinc, and copper geochemical anomalies were found. There is a probable resource potential for small deposits containing these metals. Similarly, about 9 mi south along the fault zone, in the Mountain View and Prince mine area (B), geochemical samples contained low but anomalous levels of silver, lead, zinc, copper, and tungsten. There is a probable resource potential for small deposits of these metals in quartz veins.

Geochemical samples collected in area C, the Gunter-Coldwater Canyon area, were anomalous in copper, silver, and tungsten. Outside, but near the White Mountains Roadless Area, the Southern Belle mine yielded small amounts of gold. Copper staining can be seen in the area. A probable resource potential for small deposits of these metals is indicated. Area D contains several gold and copper prospects, as well as anomalous amounts of copper in geochemical samples and has a probable mineral-resource potential.

At the north end of the White Mountains Roadless Area, adjacent to the mining area of Queen Canyon (area F) geochemical sampling showed silver, lead, and zinc anomalies. In the past, the Queen Canyon mine produced small amounts of silver and the area has probable mineral-resource potential. To the east, adjacent to areas of active cinnabar prospecting, area G has a probable resource potential for mercury in Tertiary silicic volcanic rocks. Tertiary stream gravels capped by ancient basalt flows yielded minor amounts of placer gold in area J. There is a probable resource potential for gold in small placer deposits extending north into the roadless area.

In the Birch Creek Roadless Area, the contact zone between Cretaceous quartz monzonite and Proterozoic calcareous rocks, contains two areas (K, M) of probable resource potential for metallic mineral resources. Area K contains the Hole-in-the-Wall prospect and has probable resource potential for small deposits of lead, silver, zinc, and gold. Area M contains the Mexican mine and has probable resource potential for silver, lead, and zinc deposits in replacement bodies in dolomite and limestone. Both areas have probable resource potential for tungsten in tactite.

Pyrophyllite and andalusite have been produced and are present in several deposits in the White Mountains Roadless Area and area N has probable resource potential. North of this area there are rutile occurrences in Jeffrey Mine Canyon. Further studies by the USGS are being conducted to determine if these occurrences constitute a titanium resource. There currently is no identified titanium resource potential at this site. Pumice is present at the U.S. Gypsum, Hidecker, and White Gull prospects in area O in the White Mountains Roadless Area. This area has probable potential for small pumice resources.

SUGGESTIONS FOR FURTHER STUDIES

Recent USBM and USGS studies indicate several areas in the White Mountains Roadless Area should be considered for further study. In area E, the Moulas and

Sacremento mines, and in area C, the Southern Belle mine should be drilled to prove and extend limits of gold mineralization. Drilling is also needed to better define the silver-bearing mineralized zones at the Evergreen, Green Monster, and Mollini mines, all in area H. Geochemical sampling could better define areas of silver-bearing rock occurring at the nearby Silver Consolidated nos. 1-10 property.

Drilling programs could be initiated on the Wynne and Ward and the Mexican mine properties in the Birch Creek Roadless Area to establish limits of mineralization. Geochemical results in areas K and L were sufficiently anomalous to justify additional geochemical sampling using more sensitive analytical techniques.

Metasedimentary rocks in Jeffrey Mine Canyon along the range front of the White Mountains Roadless Area contain known rutile occurrences at the site of the Champion mine. Geochemical studies and (or) a drilling program could help define the possibility of a titanium resource.

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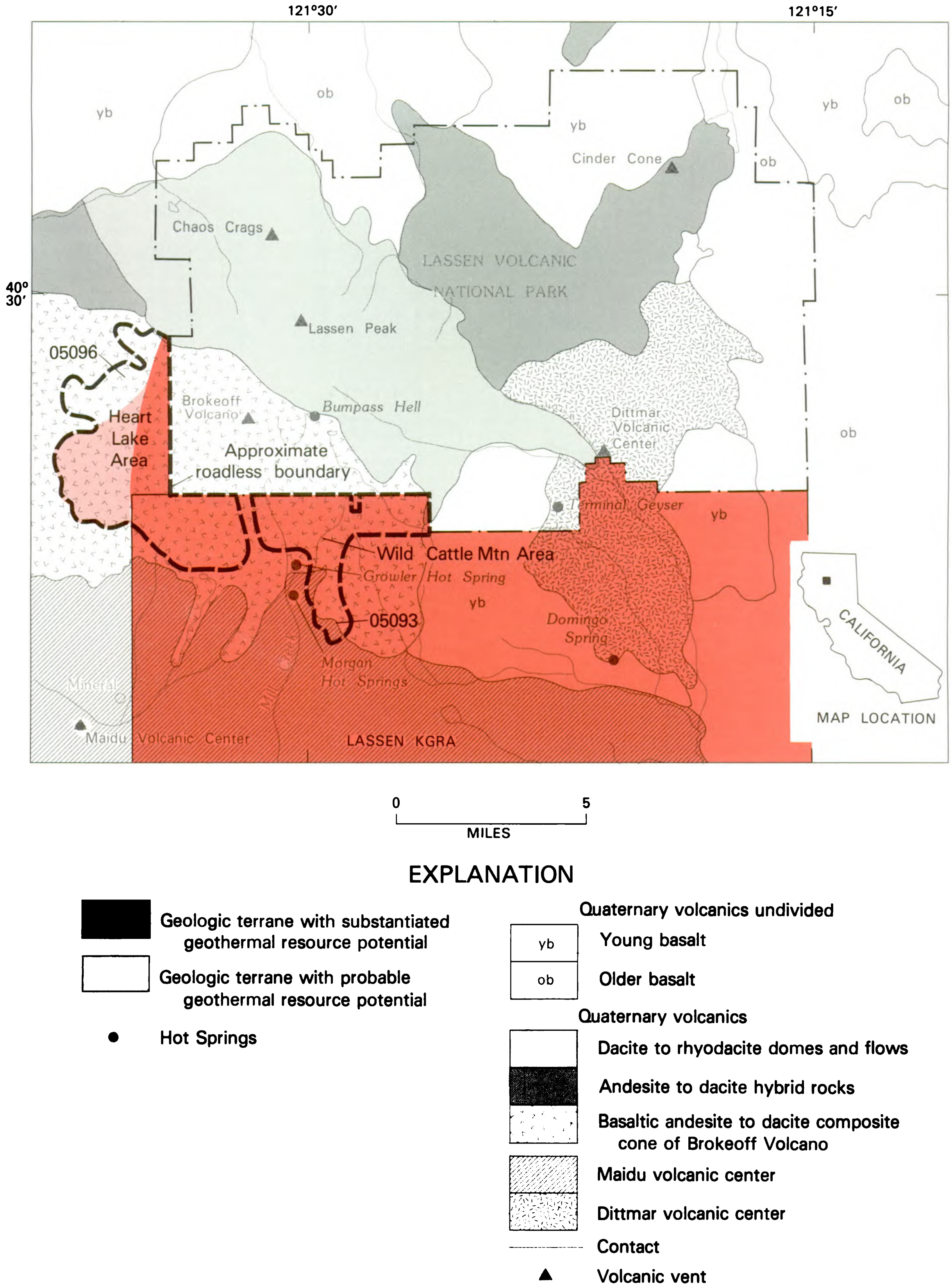

Figure 121.—Wild Cattle Mountain and Heart Lake Roadless Areas, California.

WILD CATTLE MOUNTAIN AND HEART LAKE ROADLESS AREAS, CALIFORNIA

By L. J. PATRICK MUFFLER,[1] U.S. GEOLOGICAL SURVEY, and

DAVID K. DENTON, JR., U.S. BUREAU of MINES

SUMMARY

The results of geologic, geochemical, and geophysical surveys in Wild Cattle Mountain and Heart Lake Roadless Areas in 1982 indicate little promise for the occurrence of metallic, nonmetallic, or fossil fuel resources. However, Wild Cattle Mountain Roadless Area and part of Heart Lake Roadless Area lie in Lassen Known Geothermal Resources Area, and noncompetitive geothermal lease applications have been filed on much of the rest of Heart Lake Roadless Area outside the KGRA. Both areas are adjacent to Lassen Volcanic National Park. Geochemical and geologic data indicate that the thermal manifestations in the Park and at Growler and Morgan Hot Springs just southwest of Wild Cattle Mountain Roadless Area are part of the same large geothermal system. Consequently, the entire Wild Cattle Mountain Roadless Area and part of the Heart Lake Roadless Area have a substantiated geothermal resource potential; the rest of the Heart Lake Roadless Area has a probable geothermal resource potential.

CHARACTER AND SETTING

Wild Cattle Mountain and Heart Lake Roadless Areas are in the southernmost part of the Cascade Range of northern California; the areas are about 45 mi east of Redding, and are in Lassen National Forest. The roadless areas, which were studied by Muffler, Clynne, and Cook (1982), and Denton and Graham (1982) are contiguous to the north and east with Lassen Volcanic National Park (LVNP) and lie partly within the Lassen Known Geothermal Resources Area (Lassen KGRA). Wild Cattle Mountain Roadless Area comprises 8.5 sq mi at altitudes between 4960 and 7680 ft, and Heart Lake Roadless Area comprises 14 sq mi at altitudes between 5600 and 7555 ft. Access to the areas is along a network of USFS gravel roads from California Highways 36 and 89.

Wild Cattle Mountain and Heart Lake Roadless Areas lie on the southeast and southwest flanks, respectively, of Brokeoff Volcano, an eroded andesitic composite volcano formed between 0.6 and 0.35 million years ago. Remnants of Brokeoff Volcano are overlain on the northeast by an extensive field of upper Pleistocene and Holocene dacites and andesites; historic volcanic eruptions occurred in 1915–1917 at the summit of Lassen Peak and in 1851 at Cinder Cone.

To the south, the Brokeoff Volcano overlaps older volcanic rocks of the Maidu Volcanic Center, formed 1.8 million years to 0.8 million years ago, which in turn overlaps the Pliocene Tuscan Formation, a sequence of andesitic breccias and flows that crops out extensively on the northeastern side of the Sacramento Valley. The nature of the basement under the central and northeastern parts of the Maidu Volcanic Center is uncertain; Cretaceous marine sedimentary rocks (the Chico Formation) and Mesozoic granitic and metamorphic rocks are exposed sporadically in canyons to the south, and Mesozoic granitic and metamorphic rocks crop out extensively in the northernmost Sierra Nevada 19 mi to the southeast (Lydon and others, 1960). These granitic and metamorphic rocks probably underlie the volcanic rocks of the region around LVNP to appear again to the northwest in the Klamath Mountains.

Regional geologic structure south and southeast of LVNP is dominated by northwest-trending high-angle faults, none of which are expressed in the young volcanic rocks of the Wild Cattle Mountain and Heart

[1] With contributions from Michael A. Clynne and Amy L. Cook, USGS.

Lake Roadless Areas. North of LVNP, faulting trends northerly; this direction is also expressed by a line of small basaltic cinder cones just east of the Wild Cattle Mountain Roadless Area.

All of Wild Cattle Mountain and Heart Lake Roadless Areas has been glaciated, and till of Tahoe and Tioga ages (Pleistocene) cover most of both roadless areas.

MINERAL RESOURCES

No metallic mineral or fossil fuel resources are known in either the Wild Cattle Mountain or Heart Lake Roadless Areas, and geochemical analyses of stream sediments revealed no anomalously high metal values.

The region around Lassen Volcanic National Park (LVNP) has long been recognized for its geothermal potential (Renner and others, 1975; Brook and others, 1979), and an area of 141 sq mi just south of LVNP is classified as a Known Geothermal Resources Area (KGRA) (Godwin and others, 1971). This classification was based on the extensive vapor-dominated thermal manifestations to the north in LVNP and on the boiling silica- and chloride-bearing thermal waters at Morgan and Growler Hot Springs.

Geologic observations, thermodynamic considerations, and extensive geochemical data on thermal waters and gases suggest that the fumarole areas within LVNP amd the hot springs at Morgan and Growler Hot Springs are parts of a single large geothermal system whose focus and major thermal upflow is under Bumpass Hell in LVNP (Muffler, Nehring, and others, 1982). Cold meteoric water percolates into Brokeoff Volcano in LVNP, flows underground, and is heated by a cooling igneous intrusion related to the silicic volcanic activity of the past 0.25 million years. Geothermal liquid at approximately 235°C at depth boils to form an overlying vapor-dominated reservoir, steam from which leaks upward to feed the fumaroles in LVNP. Part of the geothermal water flows laterally to the south to feed the Morgan and Growler Hot Springs and to the southeast where it is encountered in the Walker "O" No. 1 well at Terminal Geyser.

This model for the Lassen geothermal system is consonant with the data on mercury and other trace elements in the superficial deposits (soils, muds, and alteration halos) of LVNP and vicinity (Varekamp and Buseck, 1983). In particular, the mercury anomaly that extends southerly down Mill Creek appears to be due, at least in part, to the addition of mercury accompanying steam that boils off the hot thermal water moving to the south from the center of the geothermal system.

Nine shallow heat-flow holes have been drilled in Lassen KGRA (Mase and others, 1980). High gradients at depth in several holes suggest that thermal water may extend under much of the northern part of Lassen KGRA, which includes all of the Wild Cattle Mountain Roadless Area, and the southeastern one-third of the Heart Lake Roadless Area. This suggestion is supported by the detection of a minor thermal component in chemical analyses of cold waters from Domingo Spring (Thompson, 1982).

Several types of geophysical surveys have been conducted in Lassen KGRA (Christopherson, 1980; Christopherson and others, 1980; Christopherson and Pringle, 1981; Fraser, 1983). These surveys all display a complex pattern of resistivity reflecting primarily near-surface variations in lithology, porosity, and temperature. The known thermal areas in and adjacent to LVNP all show up as resistivity lows. Other conspicuous resistivity lows, however, may merely indicate near-surface porous aquifers in alluvium, glacial deposits, and young basalts.

In summary, geologic, geochemical, and geophysical evidence indicates a single geothermal system centered on the Bumpass Hell area of LVNP. The system consists of a vapor-dominated reservoir within LVNP and hot-water outflow to the south along Mill Creek and to the southeast to Terminal Geyser. The high thermal gradients at depths greater than 300 ft in several heat-flow holes suggest that this lateral flow of hot water may not be confined only to the valleys extending south and southeast from Brokeoff Volcano. Instead, the entire Wild Cattle Mountain Roadless Area could be underlain by thermal waters, and the area have a substantiated potential for geothermal resources.

The evidence for possible geothermal resources under Heart Lake Roadless Area is scanty, particularly pertinent geophysical and drill-hole data. The area is indeed adjacent to the southwest part of LVNP, and lateral flow of thermal water from the main upflow zone at Bumpass Hell is possible. Although there are no thermal manifestations in or immediately adjacent to the roadless area, a heat-flow hole just south of the area does show a high temperature gradient at depths greater than 518 ft. Accordingly, the southern part of Heart Lake Roadless Area has a substantiated potential for geothermal resources, and the rest of the roadless area has a probable geothermal resource potential.

SUGGESTIONS FOR FURTHER STUDIES

Hydrologic modeling, gas and water geochemistry, and repetitive gravity surveys are being performed by the USGS for the U.S. National Park Service in order to predict and evaluate possible effects on LVNP of geothermal development in the Lassen KGRA. Evaluation of geothermal resources probably will not be advanced by further surface surveys but will require deep exploratory drilling.

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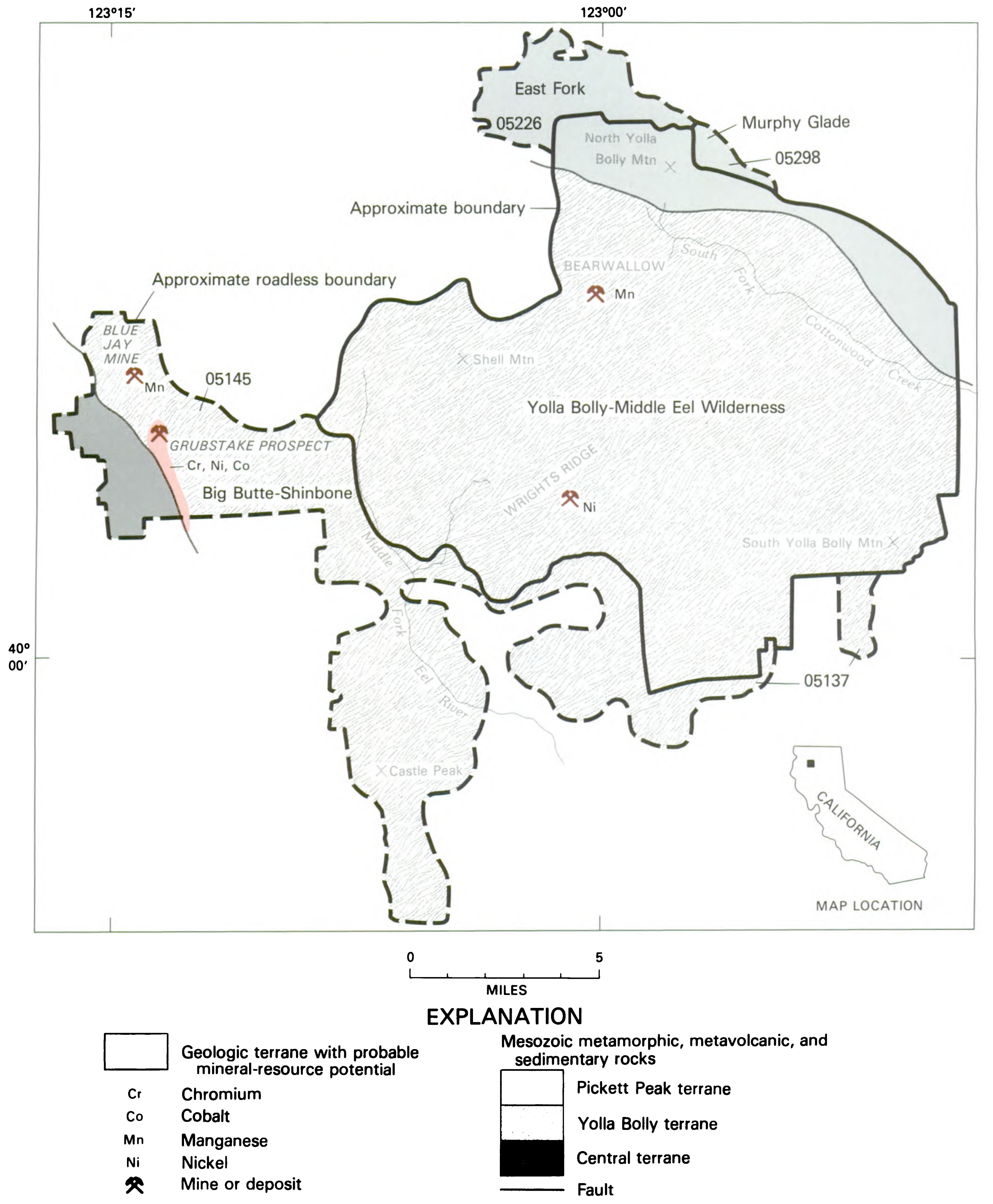

Figure 122.—Yolla Bolly-Middle Eel Wilderness and Big Butte-Shinbone, East Fork, Murphy Glade, and Wilderness Contiguous Roadless Areas, California.

YOLLA BOLLY-MIDDLE EEL WILDERNESS AND BIG BUTTE-SHINBONE, EAST FORK, MURPHY GLADE, AND WILDERNESS CONTIGUOUS ROADLESS AREAS, CALIFORNIA

By M. C. Blake, Jr.,[1] U.S. Geological Survey

A. M. Leszcykowski, U.S. Bureau of Mines

SUMMARY

A mineral survey by the USGS and USBM in 1979–81 of the Yolla Bolly-Middle Eel Wilderness identified a mine with inferred resources of manganese and an occurrence with inferred resources of nickel. The adjacent Big Butte-Shinbone Roadless Area to the west has an area of probable potential for the occurrence of chromium-nickel-cobalt resources and mines with demonstrated and inferred resources of manganese and chrome-nickel-cobalt. The known deposits are small and low grade. The East Fork, Murphy Glade, and Wilderness Contiguous Roadless Areas are considered to have little promise for the occurrence of mineral resources. The geologic terrane precludes the occurrence of fossil fuel resources.

CHARACTER AND SETTING

The Yolla Bolly-Middle Eel Wilderness and adjacent roadless areas lie along the crest of the northern Coast Ranges in Trinity, Tehama, and Mendocino Counties, northern California and together will be referred to as the study area. The area encompasses about 260 sq mi and includes the highest peaks in the entire Coast Ranges, with nearly 6000 ft of relief between South Yolla Bolly Mountain and South Fork of Cottonwood Creek.

All of the rocks in the wilderness and roadless areas are assigned to the Franciscan assemblage which in this area is of Mesozoic age. We have subdivided this assemblage into three tectonostratigraphic terranes based on lithology, age, structure, and metamorphic history.

The Pickett Peak terrane consists of quartz-mica schist, metagraywacke, and minor metabasalt. The Central terrane is a tectonic melange characterized by large blocks of resistant basalt, chert, and sandstone in a highly sheared shaly matrix. Geologic mapping and geochemical sampling suggests that there is little promise for the occurrence of mineral resources in these terranes, within the study area.

Geologic and geochemical studies suggest that the sedimentary rocks of the third terrane, the Yolla Bolly terrane, consisting of interbedded graywacke-type sandstone and radiolarian chert, were deposited on the ocean-floor in an area undergoing rifting, perhaps similar to the present-day Gulf of California. During rifting, small sills of diabase and gabbro intruded the overlying sedimentary rocks and produced local hydrothermal alteration. Subsequently these rocks were folded and thrust faulted and small bodies of serpentinite were tectonically emplaced within and along the faulted boundaries of the Yolla Bolly terrane.

MINERAL RESOURCES

The study area was prospected and claims staked in the region as early as 1899, but no mining occurred until World War I when a few tons of chromite-bearing rock were mined and stockpiled at the Grubstake prospect, in one of the serpentinite bodies along the western margin of the Yolla Bolly terrane. Mining activity was renewed during World War II with the discovery of the Blue Jay manganese deposit in radiolarian chert that had been intruded and hydrothermally altered by a diabase sill. Production from this mine and a few others outside the study area continued intermittently

[1]With contributions from A. S. Jayko, USGS, and W. D. Longwill and Michael Gobla, USBM.

through the Korean war. About 2400 tons of demonstrated and inferred resources averaging 9.5 percent manganese remain at the Blue Jay mine. Geologic studies and geochemical sampling indicates another locality with inferred manganese resources near Bearwallow. The geologic occurrence is identical to that of the Blue Jay mine and approximately 10,000 tons of inferred resources averaging about 21 percent manganese are estimated in the pods exposed on the surface.

Two other deposits associated with serpentinite were also evaluated. One is near the previously mentioned Grubstake prospect, where a red laterite soil, formed from weathering of the serpentinite, contains demonstrated resources of about 9700 tons averaging 1.25 percent chromium oxide (Cr_2O_3), 0.45 percent nickel, and 0.03 percent cobalt. Weathered serpentinite extends to the south and the area is considered to have probable resource potential for similar contents of chromium, nickel, and cobalt. Weathered serpentinite also occurs on Wright's Ridge, where the inferred resource is approximately 2,400,000 tons of laterite averaging about 1.00 percent nickel.

SUGGESTIONS FOR FURTHER STUDIES

The manganese occurrences in the central part of the Yolla Bolly terrane have been exceptionally well exposed by glacial erosion. The relationship between the radiolarian chert, the diabase intrusives, and the manganese are little understood. Further studies in these well-exposed areas could lead to a better understanding of the genesis of manganese deposits of this type.

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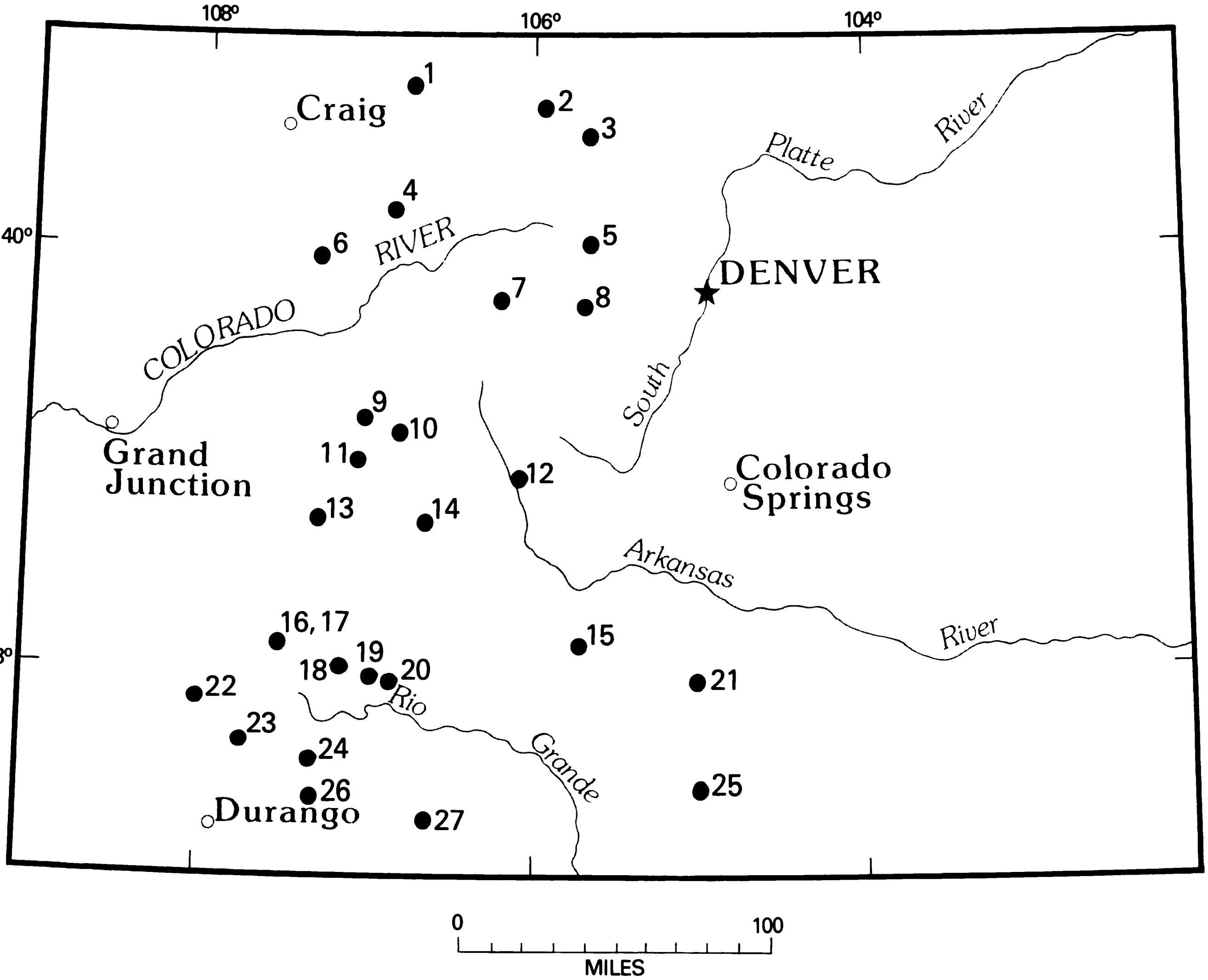
C O L O R A D O



Location of areas studied.

COLORADO

Map No.	Name of Area
12	Buffalo Peaks Wilderness Study Area
18	Cannibal Plateau Roadless Area and Powderhorn Wilderness study area
27	Chama-Southern San Juan Mountains Wilderness study area
3	Comanche-Big South, Neota-Flat Top, and Never Summer wilderness study areas
7	Eagles Nest Wilderness
6	Flat Tops Primitive Area
14	Fossil Ridge Wilderness Study Area
21	Greenhorn Mountain Wilderness Study Area
10	Hunter-Fryingpan Wilderness and Porphyry Mountain Wilderness study area
5	Indian Peaks Wilderness
19	La Garita Wilderness
9	Maroon Bells-Snowmass Wilderness and additions
1	Mount Zirkel Wilderness and vicinity
11	Oh-Be-Joyful Wilderness Study Area
26	Piedra Wilderness Study Area
2	Rawah Wilderness
15	Sangre de Cristo Wilderness Study Area
4	Service Creek Roadless Area
25	Spanish Peaks Wilderness Study Area
16	Uncompahgre Primitive Area
17	Uncompahgre Primitive Area, contiguous study areas
8	Vasquez Peak Wilderness study area, and St. Louis Peak and Williams Fork Roadless Areas
24	Weminuche Wilderness
13	West Elk Wilderness
23	West Needle Wilderness Study Area
20	Wheeler Wilderness Study Area
22	Wilson Mountains Wilderness

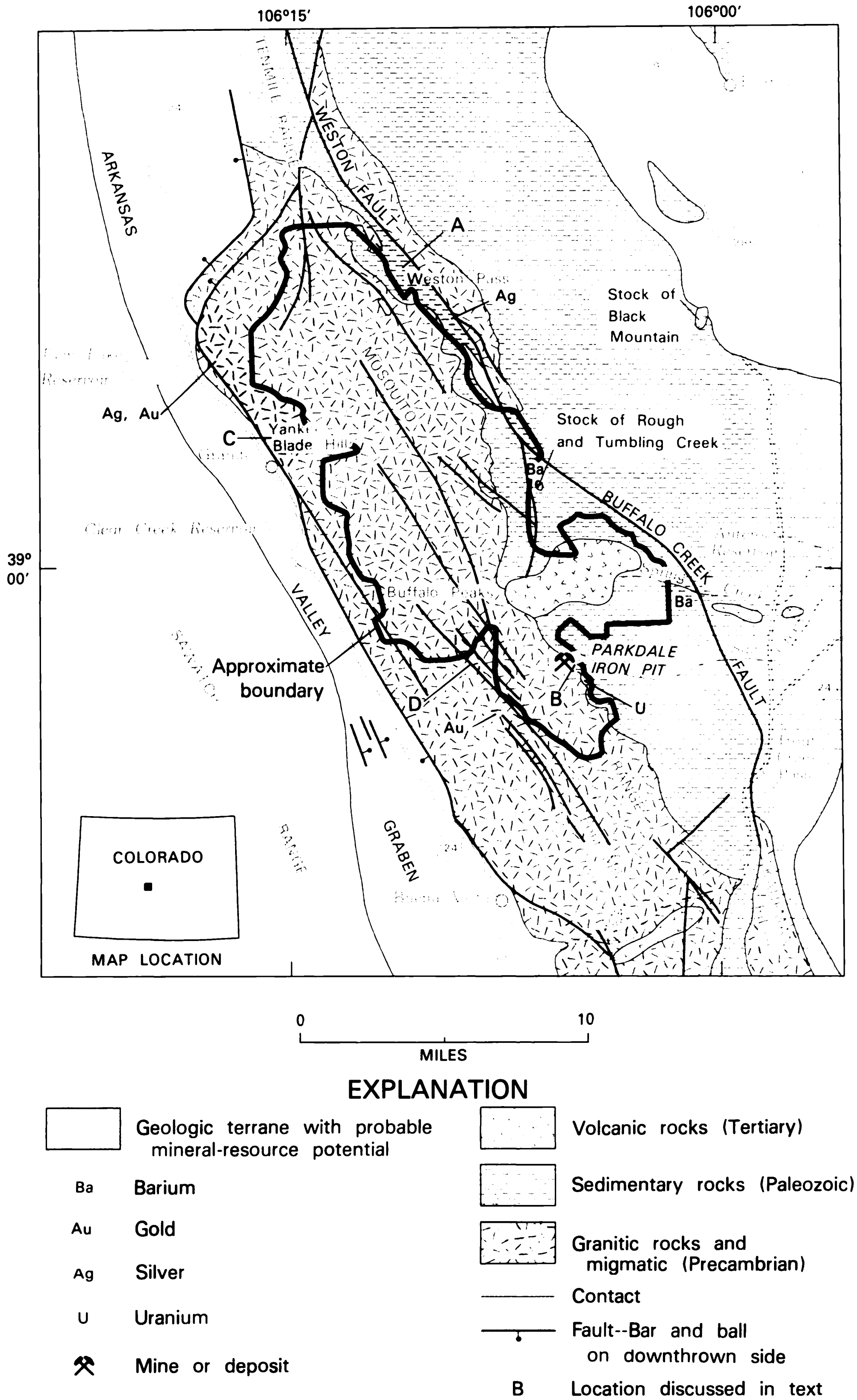


Figure 123.—Buffalo Peaks Wilderness Study Area, Colorado.

BUFFALO PEAKS WILDERNESS STUDY AREA, COLORADO

By D. C. HEDLUND,[1] U.S. GEOLOGICAL SURVEY, and

R. H. WOOD, U.S. BUREAU OF MINES

SUMMARY

The USGS and the USBM conducted field investigations in 1981-82 to evaluate the mineral-resource potential of the Buffalo Peaks Wilderness Study Area, Colorado. On the basis of this study there is a probable mineral-resource potential for silver vein and bedding replacement deposits along the Weston Pass fault zone, for hydrothermal vein-type uranium deposits in the vicinity of the Parkdale iron pit, and for gold vein deposits in the parts of the Granite and Four Mile districts that are within the wilderness study area. A probable barite resource potential occurs at Rough and Tumbling Creek and near Spring Creek on the east side of the study area. There is little promise for the occurrence of energy resources.

CHARACTER AND SETTING

The Buffalo Peaks Wilderness Study Area occupies about 89 sq mi within the Mosquito Range of central Colorado, about 110 mi southwest of Denver and near Buena Vista. The study area is along a moderately high major divide that separates the Arkansas River and its tributaries on the west from South Park and the tributaries of the South Platte on the east. Altitudes range from 12,892 ft on South Peak near Weston Pass (alt. 11,921 ft) to 13,326 ft on the volcanic flows of West Buffalo Peak. The Arkansas River valley is along a major rift structure that separates the Sawatch Range on the west from the Mosquito Range to the east; altitudes along the valley range from 8200 to 8880 ft.

The study area is reached on the north from the secondary USFS Road 425 from U.S. Highway 285 on the east, over Weston Pass, and into Big Union Creek to the west. To the south the study area is accessible from the Otero Aqueduct line and the Lenhardy cutoff road. U.S. Highway 24 along the Arkansas River provides access to the Buffalo Meadows trail head along Fourmile Creek. The Low Pass Gulch road just north of Granite leads to the gold mines of Yankee Blade Hill and other mines of the Granite district.

The high glaciated Mosquito Range is structurally a part of the N. 30 W.-striking east flank of the large, faulted Sawatch anticline. This anticline probably existed by about 70 million years ago and grew laterally as well as vertically from Late Cretaceous through the early Tertiary. Precambrian igenous and metamorphic rocks comprise the core of the anticline, and remnant east-dipping Paleozoic strata along the east side of the Mosquito Range are parts of the eastern limb.

Precambrian rocks underlie more than three quarters of the study area and include a gneissic sequence of predominantly migmatite that is intruded by porphyritic granodiorite and by a still younger biotite granite. The Paleozoic section, about 8500 ft thick, is locally capped by the mid-Tertiary volcanic rocks of Buffalo Peaks.

All of these rocks are within an uplifted and tilted fault block that is bounded by the Weston and Buffalo Creek faults to the east and the faults of the Arkansas valley graben to the west. Displacement along these faults probably occurred repeatedly through a long period beginning in the late Precambrian, and recurring in the late Paleozoic, Laramide and Pliocene-Miocene.

Mineral surveys of the Buffalo Peaks Wilderness Study Area were made in 1981-82 by the USGS and USBM and the results published by Hedlund and others (in press).

MINERAL RESOURCES

There are no active mines within the study area, but there are four inactive mining districts that extend into

[1]With contributions from G. A. Nowlan, USGS.

the study area. There is a probable mineral-resource potential in areas associated with these districts and they are in order of decreasing potential: the Weston Pass district (Behre, 1932) with its silver-bearing base-metal vein and bedding replacement deposits; the Salt Creek subdistrict and its vuggy uraniferous jasperoid deposits; the peripheral parts of the Granite district and the quartz-pyrite-gold-tourmaline veins; and the Four Mile district with quartz-pyrite-gold veins along north-northwest-striking faults. There is a probable mineral-resource potential for barite near the rhyolite stock of Rough and Tumbling Creek and within faulted upper Paleozoic strata along the Buffalo Creek fault near Spring Creek. A geochemical sampling survey of G. A. Nowlan (written commun., 1982) has indicated anomalous barium (2000 to 10,000 parts per million) and lead (1500 ppm) in analyzed panned concentrates from stream sediments at these localities.

The lower Paleozoic strata along the Weston fault and its various branch faults are highly broken and fractured. In places the faults are mineralized with zinc, lead, and silver, especially where the host rock is the Mississippian Leadville Limestone (A, on map). Many of the mineralized fractures are silicified and vuggy and locally grade outward into bedding replacement deposits. The Ruby-Cincinnati, Collin-Campbell, Gates, and other abandoned silver-producing mines in the vicinity of Weston Pass are just outside of the study area, but many of the vein systems can be projected to the southeast within the study area along zones of intense faulting.

The uraniferous jasperoids of the Parkdale iron pit in the Salt Creek district (B) are just within the study area, but several other smaller deposits occur outside of the boundary. C. M. Armstrong (written commun., 1977, 1978) estimated demonstrated resources of about 4000 tons of uraniferous jasperoid per vertical foot within an area of 1200 by 40 ft. However, the exposed thickness is only about 3 or 4 ft and the uranium content is low, 80 ppm (parts per million) uranium by fissure-track methods (R. A. Zielinski, oral commun., 1983). Equivalent U_3O_8 values of 36, 135, 241, 243, 287, and 288 ppm are reported for some jasperiods. Other elements include 20 percent iron; 5000 ppm manganese; 150 ppm vanadium; 2000–3000 ppm zinc; 30–50 ppm lead; 5–55 ppm copper; 30–50 ppm nickel; and 30–50 ppm cobalt; 12 analyses for gold indicate less than 0.005 oz gold/ton and silver values ranging from less than 0.2 to 0.3 oz silver/ton. The jasperoid is interpreted as a hydrothermal vein deposit that was localized in the Cambrian Sawatch Quartzite by hydrothermal fluids migrating upward along fractures in the underlying Precambrian granite.

The area of quartz-pyrite-gold-tourmaline veins in the Granite district (C) has a probable mineral-resource potential, but most veins are outside of the study area. The gold veins of the district commonly occur as a series of closely spaced veins (18–19 veins in a 2000 ft interval) that strike N. 55–70 E. on Yankee Blade Hill. Significant production of gold (24,000 oz) has come from the Belle of Granite mine (J. C. Hersey, written commun., 1982) and the district has yielded an estimated 65,000 to 97,000 oz of gold. The veins are characterized by intensive chloritic and silicic wall rock alteration, the presence of anomalous boron (200 ppm), a relatively low base-metal content, a gold-to-silver ratio of 2.4:1, and a spatial association with rhyolite dikes at some of the mines. The gold content of the veins ranges from about 0.2 oz/ton to about 1.4 oz/ton, whereas the silver values range from about 0.09 oz/ton to about 0.8 oz/ton. The veins are probably Laramide in age and contemporaneous with 65.3 million year old rhyolite dike intrusives (R. F. Marvin, H. H. Mehnert, and E. L. Brandt, written commun., 1983).

Most of the quartz-pyrite-gold veins of the Four Mile district (D) are outside of the study area and generally have low gold values, 0.04 to 0.08 oz/ton.

SUGGESTIONS FOR FURTHER STUDIES

Further study of the area offers some promise for the identification of concealed mineral deposits, especially along the Weston fault system. A geochemical gold anomaly in stream sediments in the Buffalo Meadows area and barium anomalies in the vicinity of the rhyolite stock east of Rough and Tumbling Creek and along Spring Creek warrant further geologic and geochemical studies. The mineral resources of the Granite district, outside of the study area, also deserve further study.

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CANNIBAL PLATEAU ROADLESS AREA AND POWDERHORN WILDERNESS STUDY AREA, COLORADO

By WILLIAM N. SHARP, U.S. GEOLOGICAL SURVEY, and

M. E. LANE, U.S. BUREAU OF MINES

SUMMARY

The Cannibal Plateau Roadless Area and the adjoining Powderhorn Wilderness study area are on the Gunnison-Hinsdale County boundary, approximately 50 mi southwest of Gunnison and a few miles east of Lake City. Part of the area has been known as the Powderhorn Primitive Area. The mineral-resource potential, assessed by the USGS and the USBM in 1979–81, involved a basic geologic study, a geophysical survey, and a geochemical survey. No mining districts exist within the two areas, but the Lake City mining district adjoins the Cannibal Plateau Roadless Area area at the southwest edge. The mineral-resource survey indicates that the southwest part of the Cannibal Plateau Roadless Area has probable mineral-resource potential, for gold, silver, and molybdenum. There is little promise for the occurrence of mineral and energy resources for the remainder of the areas.

CHARACTER AND SETTING

The Cannibal Plateau Roadless Area, about 46 sq mi, and the adjoining Powderhorn Wilderness study area of approximately 80 sq mi, lie on the northern flank of the San Juan volcanic field, an extensive region underlain by a thick accumulation of Tertiary volcanic rocks and together will here be referred to as the study area. Stratovolcanoes, intermediate in composition, and 35–30 million years (m.y.) old, are overlain by a widespread ash-flow-tuff field that accumulated 30–22 m.y. ago. The sources for the ash-flow-tuff sheets are marked by clusters of volcanic subsidence structures (calderas) outside the study area; the western San Juan caldera complex is southwest, and the central San Juan caldera complex is south and southeast. Flood-basalt lava flows deposited after the period of ash-flow eruptions and caldera subsidence cap the high ridges in and near the study area. To the north, near Powderhorn, erosion has cut through the volcanic cover to expose Precambrian crystalline rocks, which are believed to underlie most of the study area at depth. In the study area the erosion surface between the Precambrian basement and the volcanic cover appears to dip a few degrees southwest, so that in combination with rising topography southward, the Tertiary volcanic pile increases in thickness from approximately 1500 ft in the northeast to 5000 ft in the southwest.

The older stratovolcanoes in the vicinity of the study area consist of dark andesitic flows, flow breccias, and volcanic conglomerates that crop out along cliffs on the west side of the plateaus of the study area, and form the hills of the northwest terrane of the study area and beyond. The overlying younger more silicic ash-flow tuffs, derived from caldera sources to the southwest and southeast, form widespread sheets of moderately to densely welded rocks that are exposed along extensive cliffs flanking valley walls on the south and east sides of the study area and along the deep, linear valleys that drain northward. Dark flood-basalt lava flows conspicuously capping the high plateau and associated ridges are part of the Miocene and Pliocene Hinsdale Formation, which consists of a bimodal assemblage of basalt lava flows and rhyolite lava flows and pyroclastic rocks.

Several small plugs, marking former volcanic vents, cut the older lava flows and breccias of intermediate composition around the periphery of the study area. The Trout Creek plug, near the north edge of the study area, and the Larsen Creek plug, just west of the valley of the Lake Fork Gunnison River, are examples. Several rhyodacitic dikes cut the volcanic edifices around these plugs. Hydrothermal activity during or after intrusion

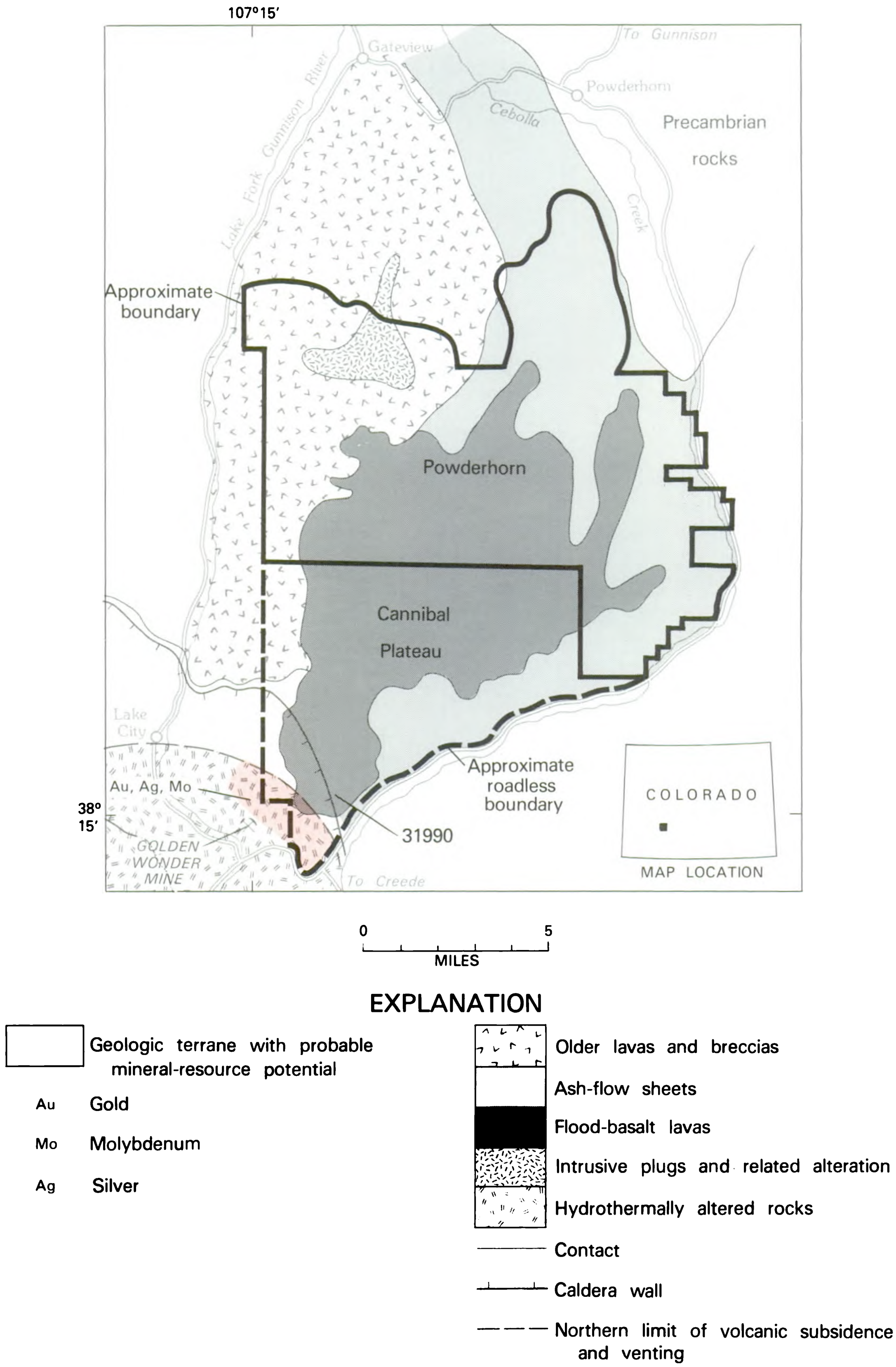

Figure 124.—Cannibal Plateau Roadless Area and Powderhorn Wilderness study area, Colorado.

commonly altered rocks adjacent to the intrusive centers, as well as the related dikes. Several late faults cut the volcanic rocks; along some of these faults the rocks are locally altered and show minor enrichment in several metals.

The southwest corner of the study area is essentially part of the older Uncompahgre and younger Lake City volcanic calderas as shown by the caldera wall lines. This part of the study area is the most geologically complex because it is near large subsidence structures and is the site of extensive rock alteration and vein-forming processes related to the episodes of volcanism.

No mining has been done within the study area; minor prospecting has been done around the Trout Creek plug and at the southwest corner of the study area in the altered terrane associated with the Lake City caldera. However, mines near Lake City are on fissure veins near the boundary of the study area. The Golden Wonder mine and others produced silver and gold sporadically until 1900, and the mines have been promoted, maintained, and reassessed for production since then until the present time.

MINERAL RESOURCES

The study area is underlain entirely by volcanic rocks of Tertiary age along the northern side of the San Juan volcanic field. Despite the proximity of the study area to known mineralized districts near Lake City on the southwest and Powderhorn on the north and northeast, no evidence was seen in the geologic, geochemical, or geophysical surveys to indicate that any significant mineral occurrences exist within the study area except at the southwest edge near Lake City (Sharp and others, 1983). Surface geology does not indicate exposed centers of mineralization elsewhere within the area, and no geologic environments were interpreted that might indicate hidden centers of this kind. Virtually all geochemical sampling results (Sharp and Lane, 1983) can be explained by sources in different bedrock terranes; anomalous metal concentrations that might indicate proximity to mineral deposits were detected only in the southwest edge of the study area near Lake City. Results of aeromagnetic (Martin and Sharp, 1983) and gravity surveys generally can be explained by the known or reasonably inferred distribution of bedrock types, without invoking special circumstances that might specifically indicate mineral potential.

Although several periods of mineralization can be documented in the volcanic rocks exposed in mining areas near Lake City to the southwest, these episodes have affected rocks only within the area of the caldera that is in the southwest corner of the Cannibal Plateau Roadless Area near Slumgullion Pass. None of these episodes has affected rocks within the Powderhorn Wilderness study area. The altered and mineralized rocks related to these periods of mineralization, sampled during the present study, did show anomalous concentrations of several metals (Sharp and Lane, 1983; tables 5 and 6); gold and silver have been mined in this terrane near the study area. These altered and mineralized rocks do overlap the boundary of the study area; and, as part of the Lake City-Uncompahgre caldera complex, this part of the study area is considered to have probable mineral-resource potential. Also, there is a probable resource potential for other metals such as molybdenum, disseminated in subvolcanic porphyries commonly associated at depth with silicic volcanism. No evidence was seen, however, that the altered and mineralized rocks extend northward or farther into the study area than the caldera rim.

Many small mines and prospects in the Precambrian rocks near Powderhorn, north of the study area, were established to explore for base and precious metals, thorium, niobium, titanium, and rare-earth elements. Similar mineral occurrences could well underlie the volcanic rocks exposed in the Powderhorn Wilderness study area. If so, however, they would be at depths of 1500 to 5000 ft and would have no geologic, geochemical, or presently determinable geophysical expression. Under these circumstances, such deposits would be very unattractive targets for exploration and consequently are not shown on the map.

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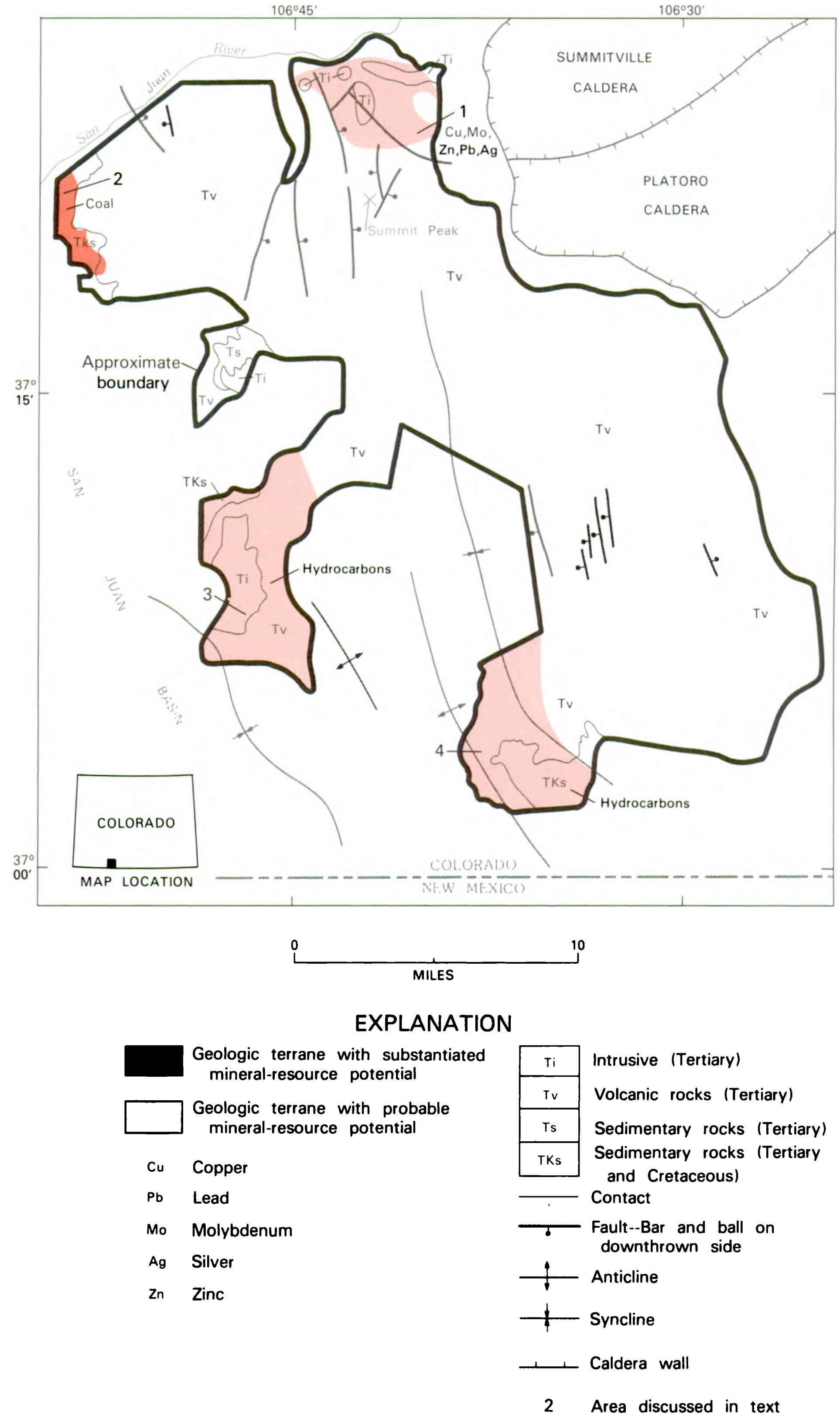

Figure 125.—Chama-Southern San Juan Mountains Wilderness study area, Colorado.

CHAMA-SOUTHERN SAN JUAN MOUNTAINS WILDERNESS STUDY AREA, COLORADO

By MAURICE R. BROCK, U.S. GEOLOGICAL SURVEY, and

ALEC E. LINDQUIST, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Chama-southern San Juan Mountains Wilderness study area in 1975 revealed demonstrated coal resources in an area of substantiated coal resource potential and areas of probable resource potential for petroleum and metals including molybdenum, copper, zinc, lead, and silver.

CHARACTER AND SETTING

The Chama-southern San Juan Mountains Wilderness study area, a rugged mountainous tract of 315 sq mi that lies astride the Continental Divide in south-central Colorado, was studied in 1975 and the results published in 1977 (U.S. Geological Survey and U.S. Bureau of Mines, 1977). The Chama part of the study area, which adjoined the southern San Juan Mountains study area in the original study area proposal, was deleted from the proposal prior to commencement of this study; therefore, this investigation covers only the southern San Juan Mountains area. The west boundary of the study area lies about 8 mi east of the city of Pagosa Springs and its southernmost limit is about 2 mi north of the New Mexico border. Summit Peak (altitude 13,300 ft) is the highest of the many peaks in the area which exceed 11,000 ft.

The southern San Juan Mountains contain a thick sequence of volcanic rocks that are the southeastern part of a very large volcanic field covering several thousands of square miles of the San Juan Mountain region. The wilderness study area lies within the southeastern part of this volcanic field where the preserved thickness of the sequence exceeds 4000 ft. The rocks, which include volcaniclastic debris, lava, and ash-flow tuff, originated from several eruptive centers in the region beginning in Oligocene time. Some of the centers are located near the northeast boundary of the area. The gently dipping volcanic strata are well exposed in the precipitous cliffs of numerous peaks and in the many miles of arcuate escarpments that were carved by glaciers along the high flanks of the Continental Divide. The volcanic rocks have been intruded by small plutons and many dikes of granitic and dioritic composition all of which are only slightly younger than the eruptive rocks (Lipman, 1975).

The layered volcanic rocks rest unconformably upon sedimentary rocks of earlier Tertiary and Late Cretaceous age that are poorly exposed in the lower flanks of the mountains. The Cretaceous and underlying upper Paleozoic rocks have been folded and extensively faulted. These rocks rest upon a Precambrian basement complex of gneisses, schists, and metaquartzite as determined from the few deep drill holes which have bottomed in basement rocks and as extrapolated from outcrops beyond the boundaries of the area. The volcanic and sedimentary rocks are locally covered by glacial till of two distinct generations: an older ice-cap glaciation that blanketed much of the San Juan Mountains in late Pleistocene time, and a younger, more localized, valley glaciation. Most of the till has been removed by erosion or buried by landslides.

MINERAL RESOURCES

Field investigations consisted of geologic studies closely coordinated with geochemical and geophysical investigations by the USGS, as well as a thorough search of mine production records and on-site study of several small mines and prospects within the study area by the USBM. The metals investigations were concentrated in the northern half of the study area which contains many porphyritic intrusive rocks of the type commonly associated with sulfide-bearing ore deposits. Geochemical samples were collected throughout the area; however, most were obtained from in or near the hydrothermally altered and mineralized ground in terrane that borders several mining districts that are centered only a few miles north and northeast of the wilderness study area. The oil and gas studies focused on the sedimentary rock terrane located in the southeastern part of the study area, which is located near two small oil and gas fields. Airborne and surface geophysical surveys, including aeromagnetic and gravity surveys, assisted in evaluation of these terranes for their metalliferous and oil and gas potential. The coal deposit was evaluated on the basis of its geologic setting and on meager information contained in the available production records.

The only recorded production of coal and metalliferous sulfide ores is from mines located beyond the boundaries of the study area. Beds of low-sulfur bituminous coal in the basal 65 ft of the Fruitland Formation of Cretaceous age have been mined intermittently since the early part of this century along the west boundary of the area near its northwest corner (area 2 on map). Thickness of individual coal beds is as much as 10 ft. The interval containing the coal crops out several places within a 4-mi-long area that contains five mines. The coal beds dip between 10° and 15° eastward beneath the western boundary of the study area. The deposit contains a demonstrated coal resource of 8 million tons in an area of substantiated coal resource potential, of which about 90 percent occurs within the wilderness study area. Resource estimates are based on a single 4.5-ft-thick bed dipping at 10° to a depth of 1000 ft beneath the surface. The area of substantiated coal resource potential is several times that of the demonstrated resource tonnage.

The northernmost part of the area has been explored for base and precious metals periodically since 1882. The area contains a large body of altered and iron-stained rock that is a western extension of a 20-mi-long mineralized belt which includes numerous mining districts. Mineralization in these districts is related to the emplacement of numerous plutons in middle Tertiary time in and near the Platoro and Summitville calderas. Mining records indicate there has been no production from the few mines located within the wilderness study area, but mines in the nearby districts have yielded several million dollars in precious and base metals. Geologic, geochemical, and geophysical studies of about 10 sq mi of the most intensely altered ground within the study area (area 1), suggest a probable resource potential for a large porphyry deposit containing copper and molybdenum with zinc, lead, and silver.

The wilderness study area is located about 50 mi northeast of the major oil and gas fields in the San Juan Basin in New Mexico and Colorado. Two small oil fields lie near the southern boundary of the area. The larger of these, the Gramp's field, lies 3 mi south of the boundary; the other, the Chromo field, is about 7 mi south of the area. Two parts of the study area (areas 3 and 4) contain structures and strata similar to that in the nearby oil fields, and there is a probable resource potential for one or more oil pools within those areas.

SUGGESTIONS FOR FURTHER STUDIES

The coal deposit that underlies the northwestern part of the study area at its westernmost extension requires further study for a more accurate determination of the coal resources that underlie the area. A drilling program consisting of six to eight holes to depths of 500–600 ft, located along the north-south trend of area 2 should provide needed information on the continuity and thickness of the contained coal beds. Drilling also is required to determine depth, magnitude, and tenor of the postulated porphyry deposit containing copper and molybdenum in the northernmost part of the study area. Geophysical surveys and detailed geologic mapping in advance of drilling are needed in the areas delineated as having potential for oil and gas resources.

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COMANCHE-BIG SOUTH, NEOTA-FLAT TOP, AND NEVER SUMMER WILDERNESS STUDY AREAS, COLORADO

By R. C. PEARSON[1], U.S. GEOLOGICAL SURVEY, and

L. L. PATTEN, U.S. BUREAU OF MINES

SUMMARY

A mineral-resource assessment was made in 1975–77 of three wilderness study areas adjacent to the north and west sides of Rocky Mountain National Park in north-central Colorado. The three areas have since been incorporated into the wilderness system. Gold, silver, and uranium prospects in major faults near the Comanche-Big South wilderness study area suggest the possibility that these commodities may also occur along numerous similar faults within the study area, but the lack of evidence for mineralized rock at the surface suggests little chance for deposits along these structures. The Neota-Flat Top wilderness study area shows no evidence of being mineralized and little likelihood for the occurrence of mineral resources. The Never Summer wilderness study area has strong geologic, geochemical, and geophysical evidence indicating probable resource potential for molybdenum deposits. The nature of the geologic terrain precludes the occurrence of organic fuels.

CHARACTER AND SETTING

The Comanche-Big South, Neota-Flat Top, and Never Summer wilderness study areas are in north-central Colorado, adjacent to the north and west sides of Rocky Mountain National Park and 25–50 mi west of Fort Collins. The three areas correspond to parts of National Forest areas that were recommended as suitable for wilderness classification in 1979; in 1980 they were incorporated into the wilderness system as the Comanche Peak, Neota, and Never Summer Wildernesses.

The Comanche-Big South wilderness study area occupies about 68 sq mi of mountainous terrain in the north-central Front Range. Comanche Peak (12,702 ft) is the northernmost peak of the Mummy Range, a subsidiary group of mountains within the much larger Front Range. The area is drained to the west, north, and east by tributaries of the Cache la Poudre River that approximately marks the west and north boundaries of the study area. Above timberline, around Comanche Peak, the country is dominated by rock, tundra, and several glacial cirques; the zone below timberline is heavily forested and covered by a thick mantle of soil; and the lower slopes, especially along the Cache La Poudre River, make up a steep-sided rocky canyon. In addition to the small glaciers that existed around Comanche Peak, a large glacier moved north out of the park and down the Cache la Poudre River to Home at the northern tip of the area. It deposited bouldery moraines along the valley sides and scoured the canyon walls.

The rocks of the Comanche-Big South wilderness study area are almost entirely gneisses and granites of Precambrian age. The gneisses represent old sedimentary and volcanic rocks that were metamorphosed and folded before being intruded by the granites. All the Precambrian rocks were broken by east- to northeast-trending faults, parts of a regional fault system that crosses the Front Range. A few small dikes of Tertiary age have been intruded along faults.

The Neota-Flat Top wilderness study area, about 12 sq mi, lies southwest of the Comanche-Big South wilderness study area and is separated from it by a corridor 2–3 mi wide that is traversed by the Long Draw road. The area consists of three short glaciated valleys separated by generally bare flat-topped ridges. Most of the study area is formed of nearly flat lying volcanic rocks about 28 million years old that were deposited on Precambrian gneisses continuous with those in the Comanche-Big South wilderness study area.

[1]With contributions from W. A. Braddock and V. J. Flanigan, USGS.

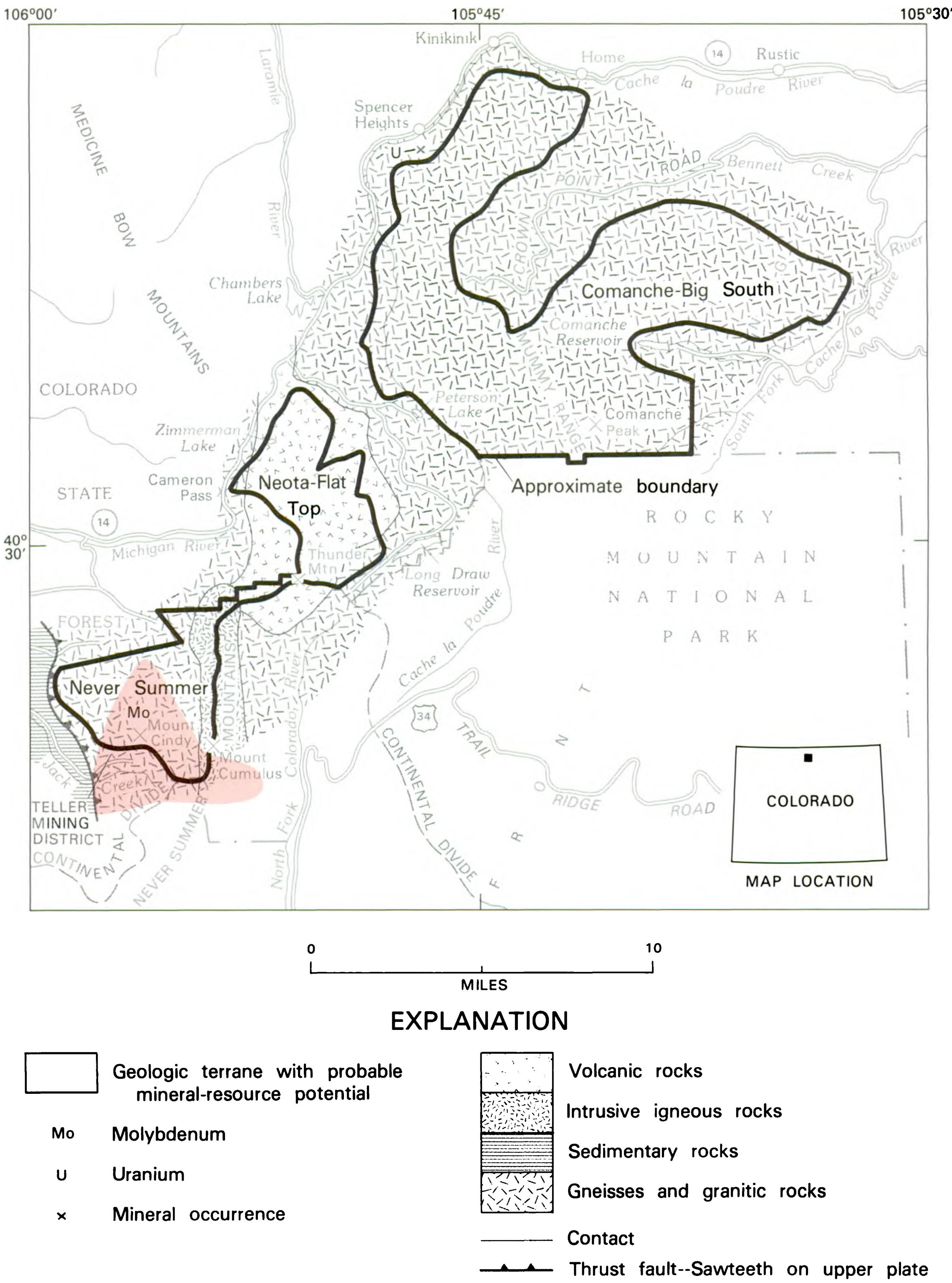

Figure 126.—Comanche-Big South, Neota-Flat Top, and Never Summer wilderness study areas, Colorado.

The Never Summer wilderness study area of 17 sq mi occupies the west flank of the Never Summer Mountains; it is bounded on the north by Colorado State Forest and on the east by Rocky Mountain National Park. It consists chiefly of parts of two glaciated valleys that drain westward into the Michigan River. The east edge of the study area is extremely steep, and the sharp crest of the range can be traversed on foot only with great difficulty. Access is by logging roads up Jack Creek and by several trails.

The Never Summer wilderness study area is geologically more diverse than the Neota and Comanche-Big South wilderness study areas. Most of it is underlain by a part of a huge slab of Precambrian gneisses that was thrust westward out over sedimentary rocks about 50–60 million years ago. The sedimentary rocks and overlying gneisses were arched and intruded by granite and related rocks about 28 million years ago. Mineralization associated with this granite was widespread and recognized by early prospectors.

The geology of the three study areas was mapped, stream-sediment and rock samples were collected and analyzed, and aeromagnetic and gravity maps were compiled and interpreted. Information on mining claims was compiled, and prospect pits, mine workings, and veins were mapped and sampled.

Small amounts of gold and silver have been mined from small districts northeast of the Comanche-Big South wilderness study area and adjacent to the Never Summer wilderness study area. The Teller district in the Jack Creek valley includes the southern part of the Never Summer wilderness study area. The Teller district, which was probably discovered in the late 1870's, is reputed to have been a silver district, but no records of mineral production have been found. It was explored in the 1970's for molybdenum.

MINERAL RESOURCES

Little evidence of mineralization was found in the Comanche-Big South wilderness study area and there is little likelihood for the occurrence of mineral resources in the study area. A uranium prospect near the north boundary south of Spencer Heights lies outside the study area but claims have been staked that extend into the study area. This uranium prospect was discovered in 1954, explored in the late 1950's by means of a shaft, and explored further in the 1970's by drilling. Insufficient mineralized rock was found to constitute an ore body. The uranium is localized along a major fault zone similar to numerous other such zones that cross the study area; uranium could occur along any of them, however no resource potential was identified. Base and precious metals in veins north and northeast of the Comanche-Big South wilderness study area are likewise associated with the major fault zones or with young intrusive rock. While the possibility of such deposits cannot be dismissed entirely—because of the presence of the fault zones—no indications were found in our studies nor, apparently, by the early prospectors.

Although the volcanic rocks in the Neota-Flat Top wilderness study area are geochemically anomalous in molybdenum, tin, and zinc, they were not concentrated to form mineral deposits. No records of mining claims or indications of prospecting were found, and there is little likelihood of the occurrence of mineral resources.

The Never Summer wilderness study area contains several north-trending veins that have been prospected, and small amounts of ore may have been shipped from some of them, although no record of such shipments could be found. These veins are too small—rarely wider than a few inches—and the ore minerals of silver, lead, zinc, molybdenum, and copper, are too sporadic in the veins for them to be considered as containing resources. They do indicate, however, leakage from mineralization associated with an inferred buried granite body, that may have concentrated molybdenum at depth. In Jack Creek valley, about 1 mi south of the study area, a molybdenum prospect was drilled in the 1970's, and mining claims have been staked for molybdenum northward into the study area. Another block of claims has been staked for molybdenum in the eastern part of the Never Summer wilderness study area. On the basis of highly anomalous geochemical samples, a negative gravity anomaly, and widespread visible evidence of weak mineralization, a part of this study area is considered to have probable resource potential for molybdenum. If molybdenum ore bodies are present, they will probably be at depths of more than a few hundred feet.

SUGGESTIONS FOR FURTHER STUDY

An area of general favorability for molybdenum ore bodies has been defined in the Never Summer wilderness study area. More precise delineation of the areas of potential might result from more detailed geologic and geochemical studies and by use of ground geophysical techniques.

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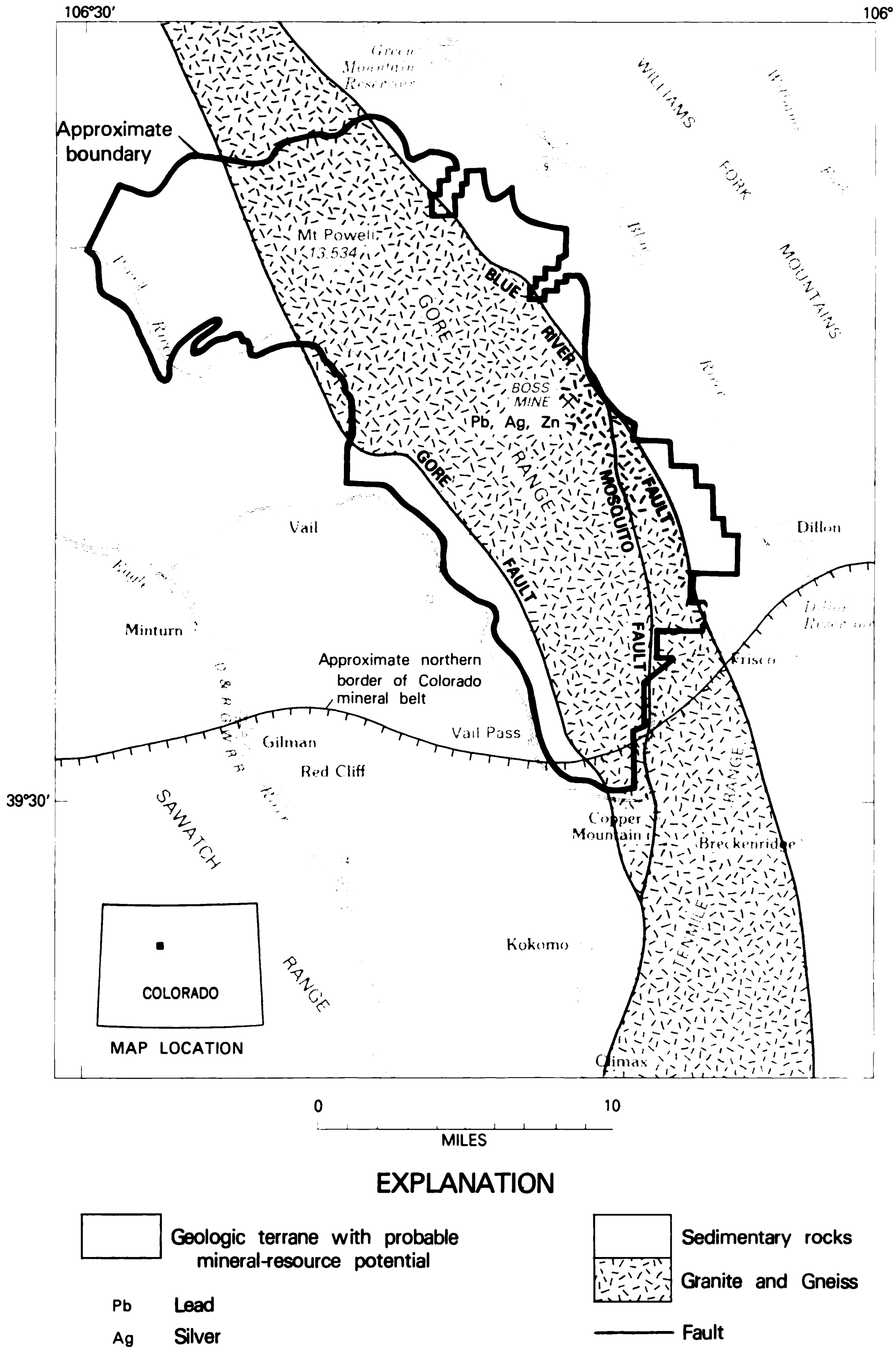

Figure 127.—Eagles Nest Wilderness, Colorado.

EAGLES NEST WILDERNESS, COLORADO

By OGDEN TWETO,[1] U.S. GEOLOGICAL SURVEY, and

FRANK E. WILLIAMS, U.S. BUREAU OF MINES

SUMMARY

On the basis of a geologic and mineral survey in 1969, a primitive area that constitutes the nucleus of the Eagles Nest Wilderness was appraised to offer little promise for the occurrence of mineral or energy resources. Among the additional areas later incorporated in the wilderness, only a strip near a major fault west and northwest of Frisco and Dillon is classed as having probable mineral-resource potential. If mineral deposits exist, they probably are of the silver-lead-zinc or fluorspar types. Because of land development for recreational housing near the border of the wilderness, exploration is unlikely in the foreseeable future.

CHARACTER AND SETTING

The Eagles Nest Wilderness occupies an area of about 210 sq mi in the mountainous region of north-central Colorado, about 60 mi west of Denver. The wilderness is centered over a spectacularly rugged segment of the Gore Range, which towers to a crestline at altitudes of 12,500 to 13,500 ft. Imposing views of the range are seen by the traveler as he approaches the town of Dillon from the east via Interstate 70, or as he follows Colorado Highway 9 along the Blue River northwest of Dillon. Interstate 70 crosses the Gore Range near the southern end of the wilderness at Vail Pass (alt. 10,600 ft). In that vicinity, the wilderness impinges on the vaguely defined border zone of the Colorado mineral belt, a northeast-trending belt that embraces almost all the mineral mining districts of central Colorado. Several of the nearest towns in the region, such as Dillon, Frisco, Breckenridge, Kokomo, Climax, Gilman, and Red Cliff, were established long ago as mining centers in this belt. Vail and Copper Mountain are comparatively new settlements devoted to the skiing and recreational industries, as also, nowadays, is Breckenridge.

The nucleus of the Eagles Nest Wilderness was an established primitive area when the Wilderness Act was passed in 1964. As provided in that act, a mineral survey of the area was made in the summer of 1969, and the results were published early in 1970 (Tweto and others, 1970). When the Eagles Nest Wilderness was established several years later, the boundaries were extended outward from the original primitive area, more than doubling the size of the area. Most of the added territory had been included in the 1969 survey, but some of it was examined only in reconnaissance. Consequently, the appraisal of some of the added territory remains tentative, and further examination of it is to be desired.

The high and rugged part of the Gore Range and wilderness consists of hard and resistant granite and gneiss of ancient (Precambrian) age. These rocks lie within a gigantic uplifted block that is bounded on its northeast and southwest sides by, respectively, the Blue River and the Gore faults. Movements that displaced the rocks bordering these faults occurred repeatedly through a very long period of time, the latest major movements being in geologically recent time only a few million years ago. At that time the block of granite and gneiss between the two faults was reelevated at least 3000 ft above its surroundings, and the present rough topography was later sculptured in it by intense glacial erosion. In contrast to the uplifted block, the territory on each side consists of sedimentary rocks, which in most places are thickly mantled by bouldery glacial deposits. On the east side of the range, the sedimentary rocks are comparatively young and thin above the basement of granite and gneiss. On the west side, by contrast, the sedimentary rocks are older and much thicker, reaching more than 10,000 ft in thickness. Although the Colorado mineral belt is characterized by younger intrusive igneous rocks, such rocks are absent in the adjoining wilderness except some minor dikes near the north end.

[1]With contributions from Bruce Bryant, USGS.

MINERAL RESOURCES

The wilderness, and particularly its southern part, would seem likely to contain mineral deposits by virtue of its location. Not only is it adjacent to the mineral belt, but it contains part of the network of master faults to which mineralization in the region seems related. The Mosquito fault, which enters the area from the south, evidently was a localizing factor for the Kokomo zinc-lead district, the great Climax molybdenum deposits, and farther south, the Leadville silver-lead-zinc district. The Mosquito fault ends against the Blue River fault, which to the southeast passes through the Breckenridge and upper Blue River mineralized area, and to the northwest contains the silver deposits of the Boss mine. The Gore fault, which diverges northwestward from the Mosquito fault, possibly was a factor in the zinc-silver-lead mineralization at Gilman, the connection between the fault and the deposits near Gilman being a northeast-trending shear zone in the deep basement.

Despite these features of the setting, little evidence of mineral deposits was found. Rocks between the Blue River and Gore faults are broken by many lesser faults and shear zones. Some of these fractures contain small veins of quartz or carbonate minerals but little evidence of metallic minerals. Nonetheless, a geochemical survey revealed numerous anomalous values for one or more of several different elements in these small veins. In the absence of visible metallic mineral matter, or of rock alteration other than chloritic, the anomalies do not offer promise. They are regarded as "smoke" that found its way into the fracture system from a great distance or great depth, unaccompanied by power to alter the rocks and insufficient in quantity to deposit ore minerals.

Sedimentary rocks are poorly exposed on the two sides of the range and show little evidence of mineralization except near the Blue River fault in the area between Frisco and the Boss mine. A northwest-trending fault 3 mi northwest of Dillon contains thick quartz veins that are cavernous, probably from leaching by fluorine-bearing solutions. A landslide deposit downslope from one such occurrence locally contains fluorspar. At other places nearby, granitic rocks on the west side of the Blue River fault are strongly altered (chloritized and locally sericitized or argillized). Sedimentary rocks (shale, limestone, and sandstone) on the east side of the fault are covered by glacial and landslide deposits, but considering the rock alteration and the occurrence of geochemical anomalies for silver, lead, and zinc along the fault, the sedimentary rocks possibly may contain mineral deposits.

The Eagles Nest Wilderness contains nearly 50 patented mining claims. Prospect diggings are present in many places, but aside from very small quantities of hand-picked ore obtained in a few localities, the only significant production has come from the Boss mine. The Boss mine consisted of a maze of adit workings, now all inaccessible, on nine patented and several unpatented claims. These claims were outside the boundary of the primitive area at the time of the 1969 survey but are inside the wilderness as finally established. The mine is credited with a production of about $250,000 in silver and subordinate lead and copper, mainly before 1897, though a small output was made at times until 1963. The mine produced hand-sorted sulfide ore that occurred in veinlets and pockets in quartz veins along fractures within the Blue River fault zone. Although the grade was high, the tonnage produced was small. Several mining companies have examined the property and turned it down as an exploration venture. However, only a small part of the mile-wide Blue River fault zone has been explored beneath the surface, and almost no exploration has been done beneath the tunnels.

On the basis of the aforementioned features, a strip along the Blue River fault between Frisco and the Boss mine is classed as having probable mineral-resource potential. No known deposits exist within the area except at the Boss mine, which has a record of modest production. Geologic and geochemical data provide some additional evidence of probable potential. Physical exploration would be required to prove either the existence or the nonexistence of deposits. If deposits do exist, they probably would be of silver-lead-zinc or of fluorspar types. Whether they were of a size and grade that could be worked would also hinge on exploration. However, exploration is unlikely in the foreseeable future. Ranch lands that extend almost to the wilderness boundary are being rapidly subdivided for recreational homesites, discouraging or preventing mineral investigation.

SUGGESTIONS FOR FURTHER STUDIES

Further study of the wilderness itself offers little promise for the identification of hidden mineral deposits, but studies of the regional controls and timing of mineralization in surrounding areas might well reveal areas of promise for minerals near the borders of the wilderness.

REFERENCE

Tweto, Ogden, Bryant, Bruce, and Williams, F. E., 1970, Mineral resources of the Gore Range-Eagles Nest Primitive Area and vicinity, Summit and Eagle Counties, Colorado: U.S. Geological Survey Bulletin 1319-C, 123 p.

FLAT TOPS PRIMITIVE AREA, COLORADO

By W. W. MALLORY,[1] U.S. GEOLOGICAL SURVEY, and

R. B. STOTELMEYER, U.S. BUREAU OF MINES

SUMMARY

An investigation of the Flat Tops Primitive Area in 1965 revealed little promise for the occurrence of mineral resources. This study also indicated there is little promise for the occurrence of oil and gas or coal resources.

CHARACTER AND SETTING

The Flat Tops Primitive Area is located in parts of Garfield, Eagle, and Rio Blanco Counties in northwestern Colorado. The area occupies about 230 sq mi and ranges in altitude from less than 8000 to 12,246 ft. Although roads approach the borders of the primitive area from all sides, no roads are found within the area. In addition, downed timber is so prevalent that movement in the forests is difficult at best.

The Flat Tops Primitive Area is in the northern part of the White River Plateau, a broad dome that forms the northeasternmost outpost of the Colorado Plateau's physiographic province. Rocks within the area range in age from Precambrian through Quaternary. Most of the area is covered by thick basalt lava flows of Tertiary age, but north of the 40th parallel, the bedrock is gray shale of Late Cretaceous age. Sedimentary rocks have an aggregate thickness of 14,900 ft, consisting of 7700 ft of Paleozoic rocks and 7200 ft of Mesozoic rocks. The Tertiary basalt flows vary widely in thickness, but are as much as 1500 ft thick in places.

The investigation undertaken in 1965 had several facets. Geologic maps including much of the area (Bass and Northrop, 1963; Kucera, 1962; and Sharps, 1962) were checked in the field and unmapped areas studied. Stream-sediment and soil samples were taken as a part of a geochemical survey. Data on past mineral production were compiled through search of Federal and County records and interviews with local residents, and two known prospects reported to be sites of former mining activities were examined. Results of this investigation were published in 1966 (Mallory and others, 1966).

[1]Abstracted from a report by Mallory and others (1966) by H. E. Hodgson.

MINERAL RESOURCES

No metallic minerals, coal, gypsum, or other materials have been produced within the boundaries of the Flat Tops Primitive Area, nor have any wells been drilled for oil or gas. The results of this study indicate that there is little promise for the occurrence of mineral or energy resources. The geologic environment of the primitive area is such that deposits of copper, lead, zinc, gold, and silver minerals conceivably could exist in rocks of Precambrian through Paleozoic age. Additionally, the Morrison Formation and Dakota Sandstone of Mesozoic age could contain uranium deposits. The Mancos Shale and the basalts of late Tertiary age are unlikely sources of metallic mineral deposits.

To appraise the possibility of hidden mineral deposits in the area, stream-sediment, panned concentrates from stream-sediment, and soil samples were collected for geochemical analysis. Inasmuch as most of the primitive area has a thick cap of barren basalt, most of the geochemical sampling was done near the borders, where older rocks that might be mineralized are exposed. An evaluation of samples with anomalous metal content indicated that the potential for metallic mineral resources in the area are extremely limited. The metal values are generally low in comparison with values that one might reasonably expect for a significantly mineralized area. The only known prospect is the abandoned lead-silver Dade prospect. Workings consist of a 45.5-ft adit and small stoped areas in the Paleozoic Leadville Limestone. There is no recorded production from this prospect and only a few hundred pounds of mineralized rock could be seen. Aside from this prospect, metallic minerals were seen in only one occurrence, in rocks of probable Precambrian age, and are not considred to have resource potential. No evidence was noted of alteration of the country rock such as commonly occurs near significant mineral deposits.

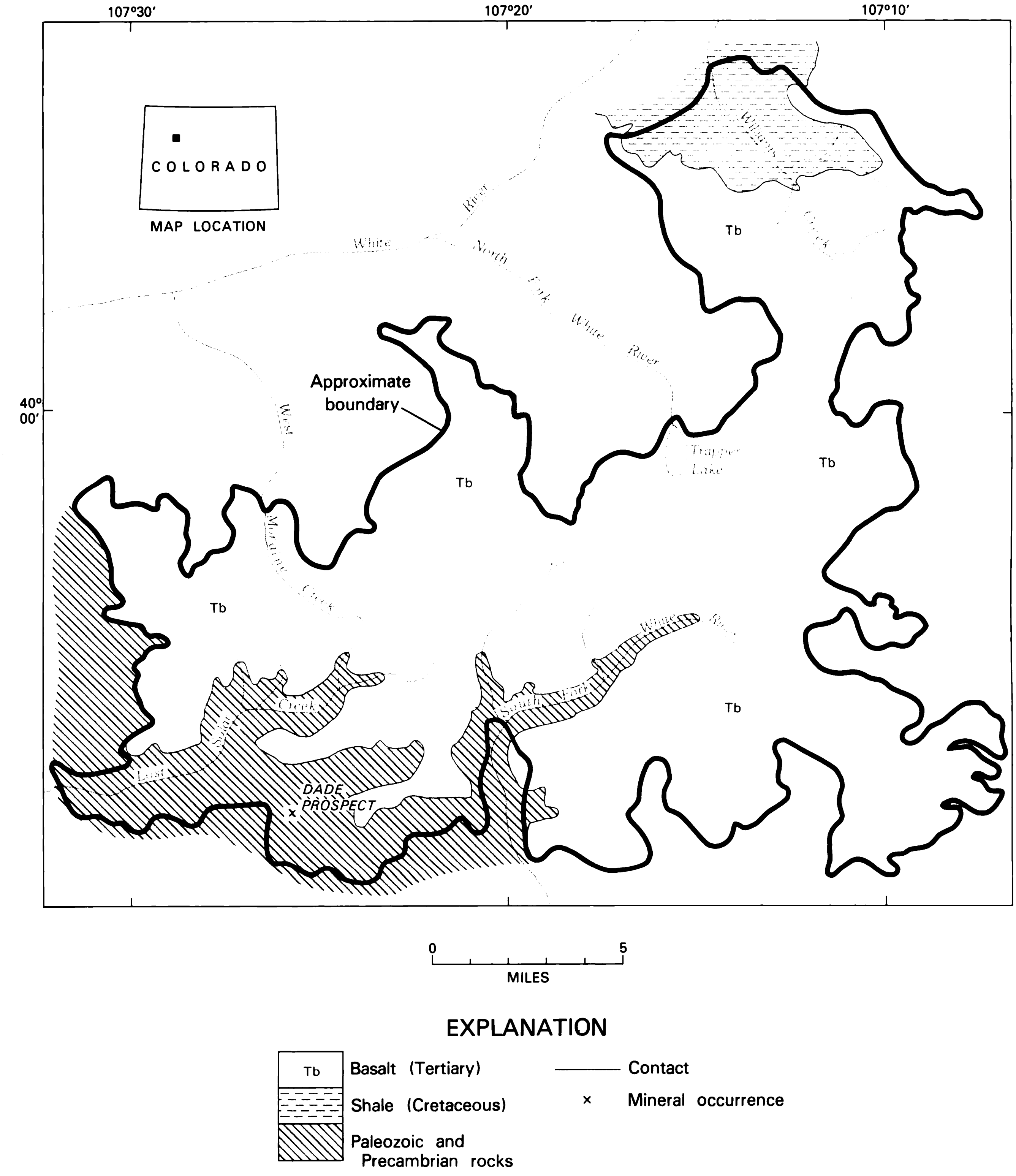

Figure 128.—Flat Tops Primitive Area, Colorado.

The northeastern part of the primitive area geologically offered the best promise for uranium resources but no evidence of uranium was discovered. Local residents stated that the area had been extensively prospected for uranium, but that no discoveries had been made.

Oil and gas resources could conceivably be present in the sedimentary rocks that underlie the Flat Tops Primitive Area, but no vestiges of oil or gas seeps were seen, nor have any been reported. The geologic structures within the primitive area are not favorable for accumulation of oil and gas. A few leases have been acquired, but the only drilling has been outside the primitive area.

Coal is produced in the Yampa field of northwestern Colorado from the Iles and Williams Fork Formations of the Mesaverde Group and from the Lance and Fort Union Formations. These formations are not present in the primitive area and no prospects for coal exist.

The Paleozoic Eagle Valley Evaporite contains gypsum and is present within the primitive area but lies beneath a thick cover of basalt. More easily accessible resources of gypsum occur only a few miles outside the primitive area, in the valleys of the Colorado and Eagle Rivers.

SUGGESTIONS FOR FURTHER STUDIES

Oil is produced from fractured zones in the Mancos Shale in several places in Colorado, but methods of systematic exploration for this type of resource have not been developed. If such methods were to be developed, reexamination of the Mancos Shale in the primitive area might be desirable. Additional studies to improve the assessment of the mineral potential for deposits beneath the volcanic cover also requires development of new techniques.

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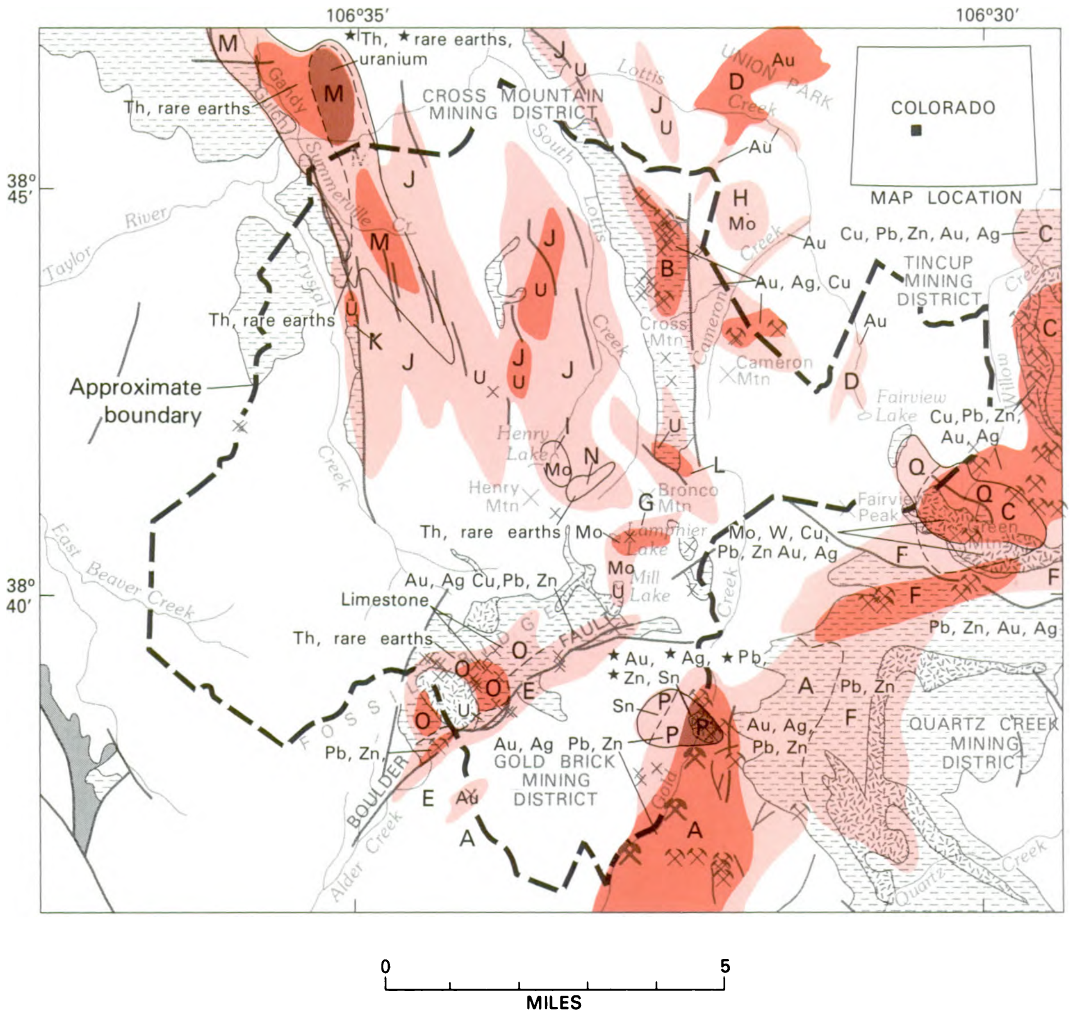
Bass, N. W., and Northrop, S. A., 1963, Geology of Glenwood Springs quadrangle and vicinity, northwestern Colorado: U.S. Geological Survey Bulletin 1142-J, 74 p.

Kucera, R. E., 1962, Geology of the Yampa district, northwest Colorado: Boulder, Colorado University, Ph.D. thesis, 844 p.

Mallory, W. W., Post, E. V., Ruane, P. J., Lehmbeck, W. L., and Stotelmeyer, R. B., 1966, Mineral resources of the Flat Tops Primitive Area, Colorado: U.S. Geological Survey Bulletin 1230-C, 30 p.

Sharps, S. L., 1962, Geology of the Pagoda quadrangle, northwestern Colorado: Boulder, Colorado University, Ph.D. thesis, 364 p.



EXPLANATION

Geologic terrane with substantiated mineral-resource potential and probable mineral-resource potential (★ Indicates resources with substantiated potential)

Geologic terrane with substantiated mineral-resource potential

Geologic terrane with probable mineral-resource potential

⚒ Mine or deposit

× Mineral occurrence

⚒ Mine

Cu	Copper	Th	Thorium
Au	Gold	Sn	Tin
Pb	Lead	W	Tungsten
Mo	Molybdenum	U	Uranium
Ag	Silver	Zn	Zinc

Tertiary igneous rocks

Mesozoic sedimentary rocks

Paleozoic sedimentary rocks

Precambrian crystalline rocks

Contact

Fault

Tertiary igneous dike

B Area discussed in text

Figure 129.—Fossil Ridge Wilderness Study Area, Colorado.

FOSSIL RIDGE WILDERNESS STUDY AREA, COLORADO

By ED DEWITT, U.S. GEOLOGICAL SURVEY, and

STEVEN E. KLUENDER, U.S. BUREAU OF MINES

SUMMARY

The Fossil Ridge Wilderness Study Area, approximately 20 mi northeast of Gunnison in central Colorado, was studied and its mineral-resource potential assessed during 1982. Portions of the study area have substantiated resource potential for gold, silver, copper, lead, zinc, molybdenum, uranium, thorium, rare-earth elements, and high-calcium limestone. Much of the area has a probable resource potential for the preceeding commodities as well as for tin. Various other elements are found in anomalous concentrations within the study area, but there is little likelihood for their occurrence in amounts sufficient to constitute resources. Exploration, especially for molybdenum, gold, and uranium, has been active in the past and is expected to continue in the future. No potential for fossil fuel resources was identified in this study.

CHARACTER AND SETTING

The Fossil Ridge Wilderness Study Area occupies about 85.5 sq mi within the Gunnison National Forest in central Colorado. Access is provided by a paved road along the Taylor River and Quartz Creek, and by all-weather roads along Willow Creek and Gold Creek. The Gold Brick and Quartz Creek mining districts border the study area on the southeast, and the Tincup district adjoins the area on the east. The Cross Mountain mining distict is contained within the north-central part of the study area. Altitudes vary from 9200 ft along the Taylor River and Gold Creek to over 13,200 ft on Fairview Peak and Henry Mountain. Steep-sided glacial valleys and cirques are typical in the central and eastern parts of the study area, but the topography, although mountainous, is more subdued in the western part. Thick conifer forests in the lower parts of the area give way to alpine tundra and meadows above 11,400 ft.

The study area is underlain chiefly by granitic and metamorphic rocks of Precambrian age that are in turn partly mantled by a thin cover of Paleozoic strata. The Precambrian and Paleozoic rocks are cut by numerous small Tertiary intrusive bodies. Glacial deposits locally obscure much of the bedrock. Faults of probable Laramide to mid-Tertiary age cut all but the youngest rock units and locally have vertical offsets of 2000 to 3000 ft.

The layered Precambrian rocks consist of an older bimodal metavolcanic assemblage and a younger pelitic metasedimentary assemblage. The metavolcanic rocks were subaqueous pillowed basalt flows and felsic tuffs. Subvolcanic sill-like bodies of diorite are associated with the mafic rocks. The metasedimentary rocks were shales, siltstones, and quartzites. The layered rocks are intruded by at least five major plutonic bodies that range in age from approximately 1700 million years to 1400 million years, and in composition from biotite granodiorite to muscovite granite.

The Paleozoic rocks consist of the Cambrian Sawatch Quartzite, Ordovician Manitou Dolomite, Ordovician Harding Sandstone, Ordovician Fremont Limestone, Devonian and Mississippian(?) Chaffee Group (dolomite, siltstone, and sandstone), Mississippian Leadville Limestone, and Pennsylvanian Belden Shale. Pennsylvanian rocks younger than the Belden Shale and Mesozoic strata are present in surrounding areas, but not within the study area. Lithologies and thicknesses of Paleozoic strata in the area are typical of central Colorado, except that the Sawatch Quartzite is locally thicker near the Taylor River than in outlying regions.

Two ages and types of Tertiary igneous rocks were identified; an older andesite porphyry that forms sill-like to laccolithic bodies within the Paleozoic strata, and a younger porphyritic rhyolite that forms high-angle dikes and small plugs in the Precambrian and Paleozoic rocks.

MINERAL RESOURCES

Portions of the Fossil Ridge Wilderness Study Area have probable or substantiated resource potential for gold, silver, copper, lead, zinc, tin, molybdenum, uranium, thorium, rare-earth elements, and high-calcium limestone. Selected areas contain anomalous amounts of manganese, antimony, bismuth, cadmium, arsenic, nickel, cobalt, chromium, tungsten, beryllium, lithium, arsenic, tantalum, barium, and vanadium, but there is little promise for their occurrence as resources. Evaluation of the resource potential is based on knowledge of the geology, stream-sediment and rock geochemistry (DeWitt and Kluender, in press) and production records and assays from mines that have operated in the past (Kluender and McColly, 1983).

The two largest areas with probable and substantiated gold and silver resource potential are along Gold Creek in the southeast part of the area (area A, on map), and along a northwest-trending zone from near Cross Mountain to southeast of Cameron Mountain in the north-central part of the area (B). The north-northeast-trending vein and shear zone system on the east side of Gold Creek has recorded gold, silver, lead, and copper production from five major and numerous minor mines. Anomalous concentrations of arsenic and zinc are associated with the precious metals. Mineralization along Gold Creek is related to a middle to late Tertiary(?) vein and fault system. The northwest-trending zone near Cross Mountain also has recorded gold, silver, and minor copper production from two small mines. Anomalous concentrations of arsenic, antimony, manganese, zinc, cadmium, and bismuth accompany the gold and silver, especially in replacement deposits in Paleozoic limestone on Cross Mountain. Vein and replacement mineralization in this area is of probable mid- to late-Tertiary age.

The Green Mountain area (C) has probable and substantiated resource potential for gold and silver as indicated by production data from two mines and by stream-sediment and rock geochemistry. This area also has a substantiated resource potential for molybdenum and tungsten. Disseminated and vein mineralization are related to a mid-Tertiary pluton and its associated hydrothermal system.

Past production of gold from gravels in Union Park and detailed sampling of those gravels in the current studies indicate areas of probable and substantiated potential for gold in Union Park and the northward-flowing tributaries to Lottis Creek (D). A small area of probable potential extends into the study area.

Three large areas and two smaller areas have a probable and substantiated resource potential for copper, lead, zinc, and molybdenum; bismuth and cadmium are present in anomalous amounts. Lead and molybdenum are much more abundant than zinc or copper. Probable and substantiated lead and zinc resource potential is indicated by production data from mines in the Gold Brick, Quartz Creek, and Tincup mining districts, and by stream-sediment geochemistry for the area along and east of Gold Creek (area A) along the Boulder fault (area E), south of Green Mountain (area F), and north of Green Mountain (area C). Vein mineralization along the Boulder fault is probably related to movement on the fault. Base-metal mineralization south of Green Mountain occurs as both veins and replacement bodies within Paleozoic limestone.

Parts of the Lamphier Lake-Mill Lake area (G) have probable or substantiated resource potential for molybdenum. The molybdenum mineralization is in quartz veins associated with a Precambrian granite. Two drainages between Cross Creek and Cameron Creek (area H) have anomalous concentrations of molybdenum, as does the Henry Lake area (I).

Much of the study area contains highly anomalous concentrations of uranium. One large area and three smaller areas have probable and substantiated resource potential for uranium. The high cirques on the west side of South Lottis Creek (area J) have areas of probable or substantiated resource potential for uranium. The west-flowing tributaries to Crystal Creek (area K) also contain sediments with anomalous amounts of uranium. In both areas, north- and northwest-trending shear zones in Precambrian granite host the mineralization. The entire Crystal Creek drainage basin is geochemically anomalous in uranium. The Mill Lake area (G) contains uranium anomalies and has a probable resource potential, but the source of mineralization is unknown. A probable resource potential for uranium is indicated along the Boulder fault (area E), and north of Bronco Mountain (area L). Mineralization north of Bronco Mountain is contained within a northwest-trending fault zone.

Areas along and northeast of Summerville Creek and Gandy Gulch (area M) have probable or substantiated resource potential for thorium and rare-earth elements. Very high thorium, cerium, lanthanum, hafnium, and ytterbium values indicate that there is a rare-earth element-rich zone within the Precambrian granite. A similar, but smaller area lacking thorium is noted east of Henry Mountain (area N).

Limestone consisting of greater than 95 percent $CaCO_3$ and less than 1 percent MgO is present within the Mississippian Leadville Limestone along the central part of Fossil Ridge (area O). This part of the study area is has a substantiated resource potential for high-calcium limestone.

Anomalous concentrations of beryllium and tin in streams between South Lottis Creek and Crystal Creek probably reflect beryl or lepidolite and accessory tin-bearing(?) minerals derived from a Precambrian granite. A probable resource potential for tin is assigned to areas west of Gold Creek (P) and northwest of Green Mountian (Q). Anomalous concentrations of boron and lithium occur throughout the Crystal Creek, upper South Lottis Creek, and Beaver Creek drainages, and reflect disseminated tourmaline mineralization in a Precambrian granite and its adjacent wallrock. Scattered lithium anomalies in the eastern part of the study area are probably related to pegmatites in Precambrian granite. Tungsten anomalies appear to correlate with tin anomalies, but anomalous tungsten also appears to be associated with dioritic Precambrian rocks west of upper Crystal Creek and northwest of lower Gold Creek. Tungsten and tin anomalies north of Green Mountain are spatially associated with mid-Tertiary molybdenum mineralization. Anomalous concentrations of nickel, cobalt, and chromium in upper East Beaver Creek, upper Alder Creek, and Willow Creek may be related to pegmatite mineralization or accessory minerals in a Precambrian syenite stock.

SUGGESTIONS FOR FURTHER STUDIES

Further geologic study of uranium, thorium, and rare-earth element mineralization between Crystal Creek and South Lottis Creek is warranted due to the extent and degree of mineralization. Similarly, the base- and precious-metal mineralization from Cross Mountain to Cameron Mountain and along Gold Creek needs additional study, especially regarding the age or ages of mineralization, in order to refine assessments of mineral potential for this area.

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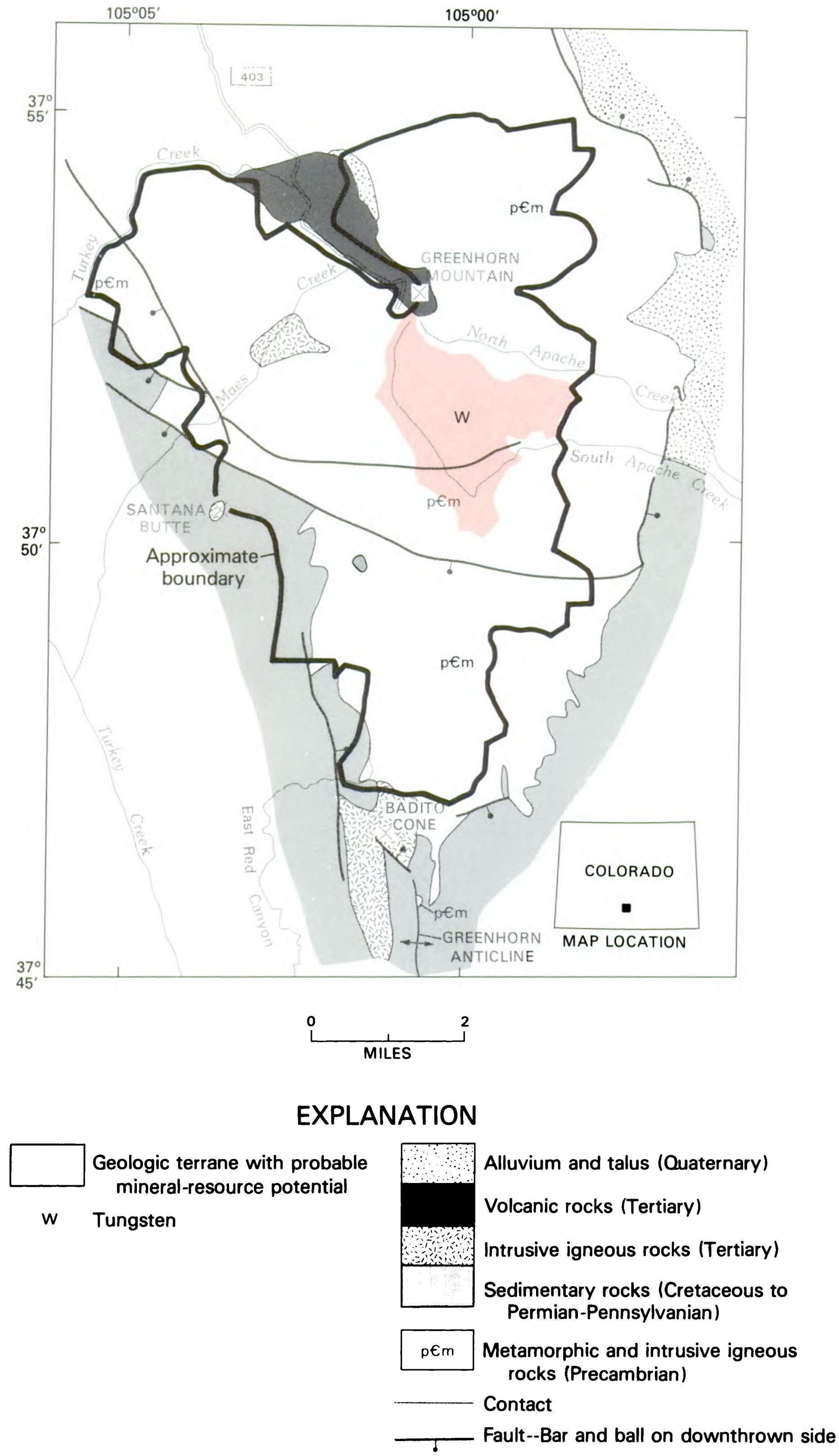

Figure 130.—Greenhorn Mountain Wilderness Study Area, Colorado.

GREENHORN MOUNTAIN WILDERNESS STUDY AREA, COLORADO

By MARGO I. TOTH,[1] U.S. GEOLOGICAL SURVEY, and

G. DAVID BASKIN, U.S. BUREAU OF MINES

SUMMARY

Mineral-resource studies of the Greenhorn Mountain Wilderness Study Area, Colorado, were done in 1981 and 1982 and one area of probable tungsten resource potential was identified. Sediment samples from streams draining into South Apache Creek have anomalously high values of tungsten. Although mineralization was not located in the underlying rock, similar rocks elsewhere in Colorado have known tungsten resources. There is little likelihood for the occurrence of oil and gas resources because of the geologic setting of the area and little promise for other mineral or energy resources.

CHARACTER AND SETTING

The Greenhorn Mountain Wilderness Study Area in south-central Colorado covers about 35 sq mi in Huerfano and Pueblo Counties. It lies 20 mi southwest of Pueblo and 130 mi almost due south of Denver. Cities within 10 mi include Rye to the northwest, San Isabel to the north, and Gardner to the southwest.

Located at the southernmost end of the Wet Mountains, the Greenhorn Mountain Wilderness Study Area is characterized by a steep eastern flank with V-shaped canyons and a gently sloping western side typified by flat-bottomed arroyos. Altitudes range from 12,347 ft at Greenhorn Mountain to 7600 ft at the southern end of the wilderness study area. Badito Cone, a round symmetrical peak (8942 ft), rises prominently just south of the study area. Access to the periphery of the study area is provided by dirt roads, one of which leads to the base of Greenhorn Mountain. Foot trails provide access into the interior of the wilderness study area and across the Wet Mountains.

The core of the Greenhorn Mountain Wilderness Study Area consists of complexely related Precambrian igneous and metamorphic rocks. Flanking these rocks are Permian-Pennsylvanian to Cretaceous sedimentary rocks as much as 4150 ft thick. Tertiary igneous plutons were emplaced at shallow depths and intrude the Precambrian rocks in Maes Creek and at Santana Butte. On the top of Greenhorn Mountain, Tertiary volcanic flow rocks and ash deposits exist as erosional remnants.

In the southern part of the study area, a southeast-plunging anticline is defined by tilted sedimentary rocks that wrap around the southern end. Bounding and less commonly traversing the study area, are high-angle normal faults. As indicated by breaks in topographic slopes, movement along some of the faults has occurred at least as late as Tertiary time.

A detailed geochemical survey of the study area involved sampling stream sediments and representative mineralized rocks for chemical analyses. All samples were analyzed for 30 elements by semiquantitative spectroscopy and some rock samples were additionally analyzed for gold and silver. The results of the geochemical survey indicate that the Greenhorn Mountain Wilderness Study Area is generally lacking in elements associated with mineralization. The streams draining into South Apache Creek have anomalous tungsten, yttrium, barium, and lanthanum, and a few isolated anomalies are present in some of the other streams, but a geologic source for the anomalies was not identified in the field.

A reconnaissance scintillometer survey was made of the study area by recording radiation measurements at randomly distributed locations and along obvious shear zones. By taking a large number of measurements it was possible to establish background levels and therefore delineate samples that were anomalous. Most of the samples fell within background levels but one sample from a fault zone in granite gneiss on the west side of the study area has radiation twice that of the background. The source of radiation is unknown, but it could be due to the presence of disseminated thorite as has been noted in similar occurrences in the northern Wet Mountains.

[1]With contributions from Daniel R. Birch, USGS.

No mining districts are present in or near the study area but there are several small prospects inside the study area. Most of the workings are small, probably dug for gold and (or) silver, and there is no evidence of production at any of the sites.

Several oil and gas leases and lease applications were on record in the wilderness study area and vicinity in September 1982; however, only about 0.15 sq mi of the wilderness study area were covered by lease applications and no test drilling has taken place on those properties.

MINERAL RESOURCES

Our studies indicate that one area within the wilderness study area has mineral-resource potential. A cluster of anomalies in barium, lanthanum, yttrium, and tungsten is present in the streams draining into South Apache Creek. Although element enrichment is indicated for this area, our mapping did not locate any mineralization or evidence of alteration in the underlying Precambrian rocks. However, similar Precambrian rocks elsewhere in Colorado have demonstrated tungsten resources. Detailed mapping would be necessary to establish the presence of mineralized rock in the area of the stream-sediment anomalies but because the tungsten anomalies are so high, it is likely that tungsten resources are present and the area is shown as having a probable tungsten resource potential.

Favorable structural and stratigraphic conditions for oil and gas reserves are present immediately south of the study area within the Greenhorn anticline (Creely and Saterdal, 1956). Most drill holes reported in this area as of 1956 had shows of oil and (or) gas but none of the holes had any production. Although part of the Greenhorn anticline extends into the wilderness study area, closed structures which act to trap oil and gas are absent. Furthermore, extensive erosion has removed the vast bulk of the sedimentary rocks considered favorable for oil and gas reserves therefore we consider the likelihood for the occurrence of oil and gas resources to be remote.

There is no known geological evidence for coal, geothermal resources, or other energy-related commodities within the wilderness study area.

SUGGESTIONS FOR FURTHER STUDIES

Detailed geologic mapping in and near the drainage basin of South Apache Creek should be done in an attempt to identify the source of the tungsten mineralization.

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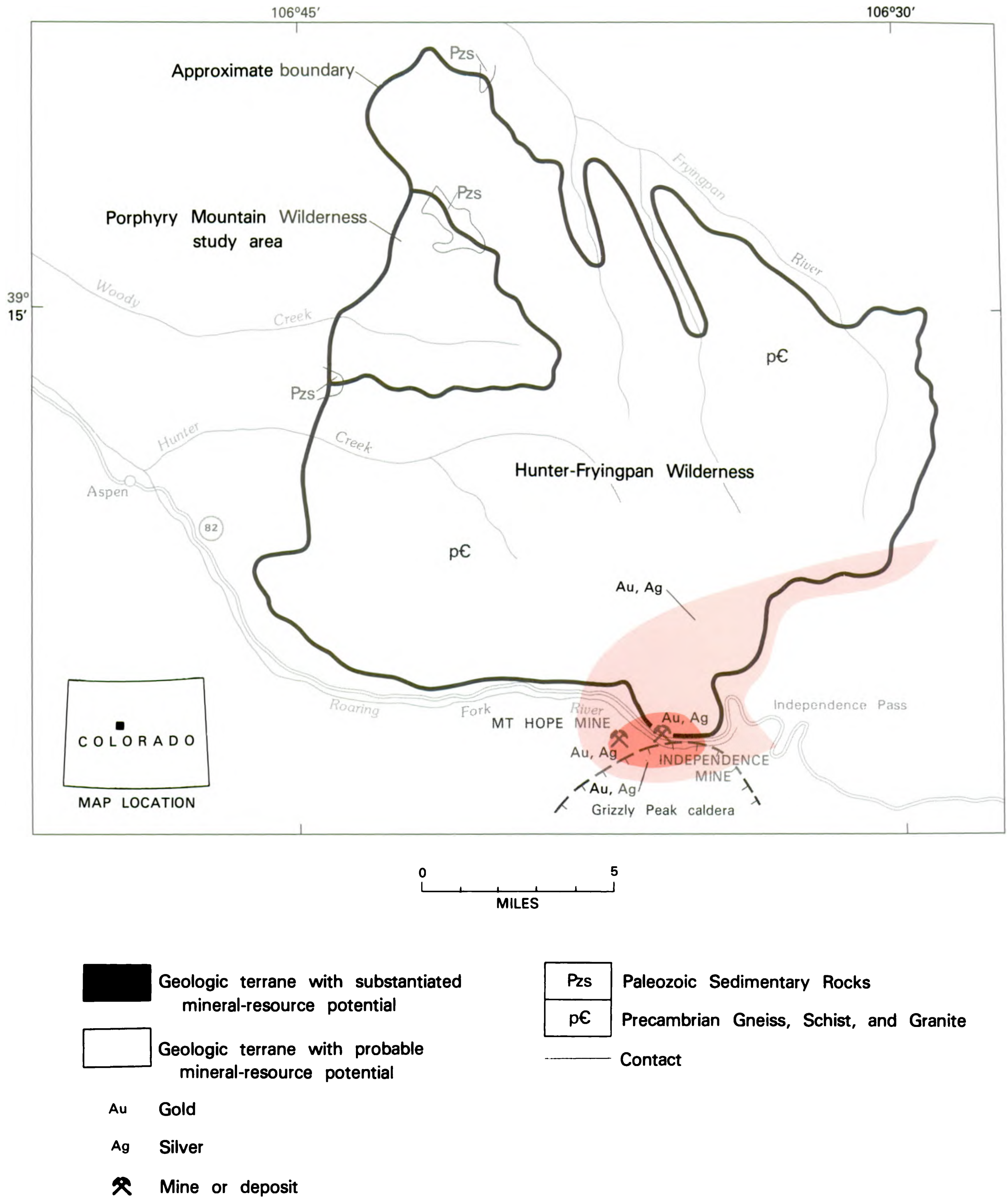

Figure 131.—Hunter-Fryingpan Wilderness and Porphyry Mountain Wilderness study area, Colorado.

HUNTER-FRYINGPAN WILDERNESS AND PORPHYRY MOUNTAIN WILDERNESS STUDY AREA, COLORADO

By STEVE LUDINGTON, U.S. GEOLOGICAL SURVEY, and

CLARENCE E. ELLIS, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Hunter-Fryingpan Wilderness and the Porphyry Mountain Wilderness study area was conducted by the USGS and the USBM in 1978 and 1979. Substantiated gold and silver resource potential was identified in one area and a surrounding area is judged to have probable mineral-resource potential for gold and silver. No other mineral or energy resources were identified in the study.

CHARACTER AND SETTING

The Hunter-Fryingpan Wilderness, located in a high, rugged region of the Sawatch Range in west-central Colorado, immediately to the east of Aspen, covers about 109 sq mi of the White River National Forest. The Porphyry Mountain Wilderness study area (known also as the Spruce Creek Wilderness study area) covers about 12 sq mi on the northwest side of the Hunter-Fryingpan Wilderness. Access is from Colorado 82 on the south, several USFS gravel roads on the west, a paved county road on the north, and by foot on the east, where the boundary is the Continental Divide.

The area is almost entirely underlain by Precambrian gneiss, schist, and granite. A thin veneer of lower Paleozoic sedimentary rock covers the northwest part. A few lower Tertiary silicic dikes cut the Precambrian rocks, and the mid-Tertiary Grizzly Peak caldera is adjacent to the southeast corner of the area.

The present mountains are the result of tectonic uplift in the late Tertiary, on faults parallel to the Rio Grande rift to the east, followed and accompanied by erosion by ice and running water.

MINERAL RESOURCES

The Aspen mining district, immediately west of the Hunter-Fryingpan Wilderness, has been a significant source of silver in the past, and probably contains a significant silver resource. Virtually all production in the Aspen district was from the Mississippian Leadville Limestone and the Pennsylvanian Belden Formation, which are from 350 to 600 ft stratigraphically above the base of the Ordovician Manitou Dolomite. There is little or no promise, because of the absence of permissive host rocks, that silver mineralization similar to that which is characteristic of the Aspen district will be found within the study area.

The area immediately adjacent to the Independence and Mt. Hope mines, in the southeast corner of the study area, has substantiated resource potential for gold and silver in quartz-sulfide vein deposits. About 45,000 oz of gold was recovered from the two mines and the remaining inferred resources are about 3600 oz of gold and about 10,800 oz of silver.

A surrounding area is judged to have probable potential for the discovery of similar gold and silver resources on the basis of numerous inactive mines and prospects which exhibit some evidence of mineralization similar to that at the Independence and Mt. Hope mines.

SUGGESTIONS FOR FURTHER STUDIES

Topical studies to clarify the relationship of the two vein deposits to the adjacent Grizzly Peak caldera would be useful in refining assessments of the potential for discovery of more deposits.

REFERENCE

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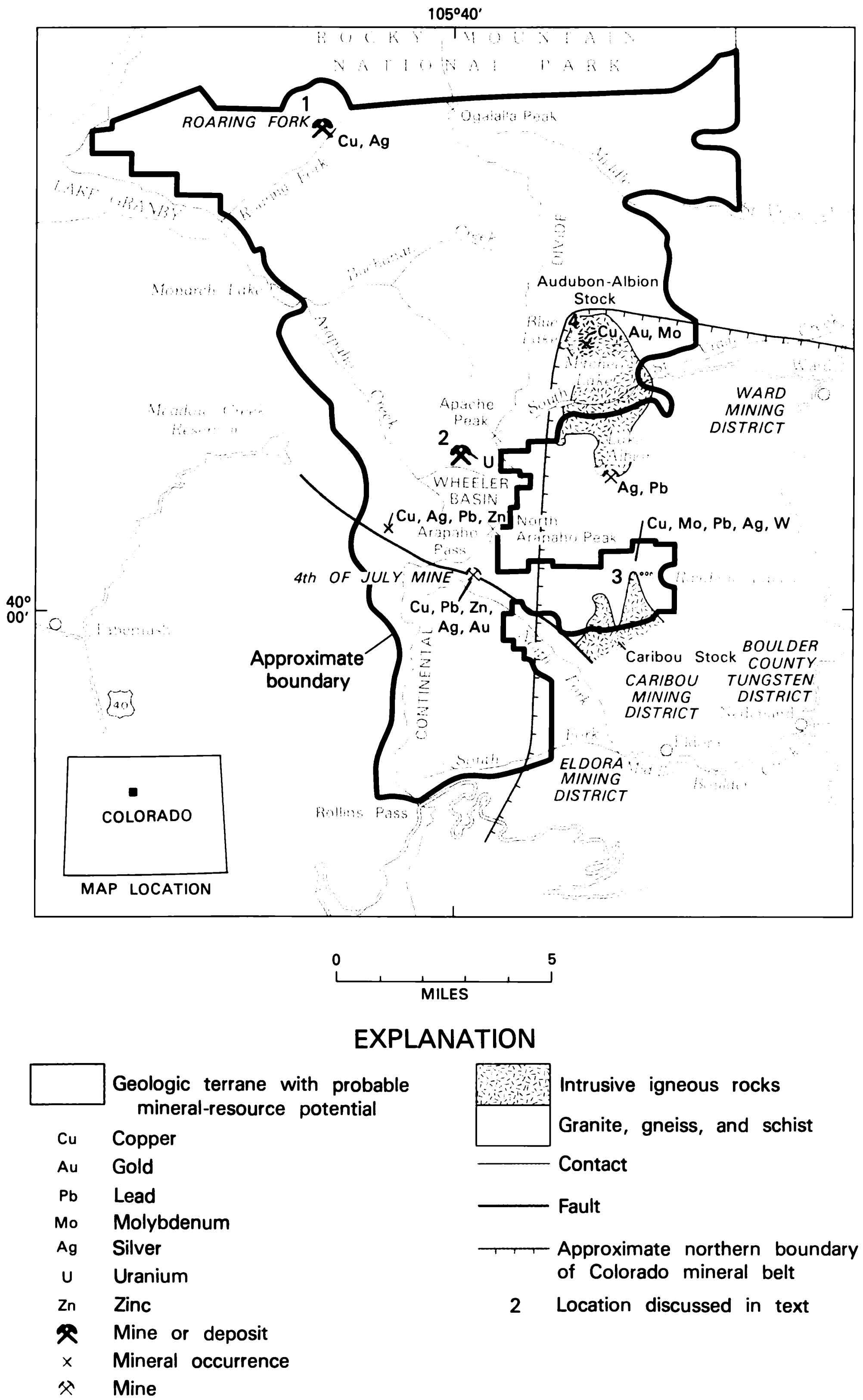

Figure 132.—Indian Peaks Wilderness, Colorado.

INDIAN PEAKS WILDERNESS, COLORADO

By ROBERT C. PEARSON,[1] U.S. GEOLOGICAL SURVEY, and

CHARLES N. SPELTZ, U.S. BUREAU OF MINES

SUMMARY

The Indian Peaks Wilderness northwest of Denver is partly within the Colorado Mineral Belt, and the southeast part of it contains all the geologic characteristics associated with the several nearby mining districts. Two deposits have demonstrated mineral resources, one of copper and the other of uranium; both are surrounded by areas with probable potential. Two other areas have probable resource potential for copper, gold, and possibly molybdenum.

CHARACTER AND SETTING

Located about 30 mi northwest of Denver, the Indian Peaks Wilderness occupies the crest and flanks of the Front Range and extends from Rocky Mountain National Park south for about 20 mi. Spectacular views of the outstanding mountain scenery are afforded daily to thousands of airline passengers approaching or leaving Denver's Stapleton International Airport. Most of the crest is high above timberline and has a rugged serrate outline as a result of intense glacial erosion. The peaks, most of which are named for American Indian tribes, rise to altitudes of 12,800 to 13,500 ft. The area is accessible by way of numerous impinging logging and mining roads that branch from highways along the east and west sides at distances of several miles. The nearest towns on the east side are Ward and Nederland that began as mining camps but now are residential communities. On the southwest side, the towns of Fraser and Tabernash, and the Winter Park ski area are within a few miles of the wilderness.

The Indian Peaks Wilderness is in a large region of crystalline rocks of Precambrian age that are exposed in the core of the Front Range. The crystalline rocks consist of schists and gneisses that were derived from old sedimentary and volcanic rocks by metamorphism and of large masses of granite that intruded the schists and gneisses after they were crumpled and folded. Precambrian granites of two ages are recognized: one group 1700 million years old, and another 1450 million years old. Much younger intrusive igneous rocks were emplaced about the same time that the Rocky Mountains were forming some 60–70 million years ago. The Front Range developed at that time as a broad low arch, and igneous activity continued intermittently and locally for another 30 million years. Most of the ore deposits in the Front Range are associated in space and time with these young intrusive rocks.

The mineral-resource study in 1972 and 1973 involved geologic mapping, a geochemical survey, and interpretation of an aeromagnetic survey. The geochemical survey involved collection and chemical analysis of samples, about 25 percent of which were stream sediments, 25 percent were unmineralized rock, and the rest showed some evidence of having been altered or affected by a mineralizing process. The aeromagnetic survey was flown in 1967 along east-west flightlines about 1 mi apart.

Most mining districts in the central Front Range of Colorado were organized in the decade following the initial discoveries in 1859. Ore was discovered in the Ward district in 1861, in the Jamestown district in 1865, and in the Caribou district in 1869. Later discoveries were the Eldora and Lost Lake districts in 1896 and the Boulder County tungsten district, in which production began in 1900. All these districts are within 10 mi of the southeast edge of the wilderness. In 1909, some ore was mined from the Lake Albion mining area, which was included in the Indian Peaks mineral survey. Small ore shipments have also been made from two mines within the wilderness. The entire wilderness has been prospected; every part of the wilderness that exhibits evidence of mineralization also exhibits evidence of prospecting.

[1]With contributions from J. C. Ratté and Gordon Johnson, USGS.

MINERAL RESOURCES

The Indian Peaks Wilderness lies along the northwest side of the Colorado Mineral Belt, an area with indefinite boundaries that contains most of the mining districts of central Colorado. The mineral belt is a narrow zone that extends southwestward diagonally across the mountain ranges from near the east edge of the Front Range. The belt is characterized by intrusive igneous rocks about 25–70 million years old, and by ore deposits of various types associated with them. On the basis of the presence of these favorable igneous rocks and the numerous small mines and prospects associated with them, the southeastern part of the Indian Peaks Wilderness is considered to be within the Colorado Mineral Belt, and hence to be more favorable for occurrence of mineral deposits than the rest of the wilderness.

A system of northwest-trending faults similar to those that controlled emplacement of ore deposits in nearby districts crosses the area. These faults are weakly mineralized, generally containing veins either in the main shears or in subsidiary fractures. The Arapaho Pass fault is the most prominent and continuous of these faults, and it is mineralized at the Fourth of July mine and numerous other places; it extends into the Caribou district east of the wilderness. Mineralizing fluids evidently used the faults as passageways and may have travelled long distances from their source.

Within the Indian Peaks Wilderness, a copper deposit and a uranium deposit are sufficiently well exposed and sampled to be classified as containing demonstrated resources, and are in areas 1 and 2 that are geochemically anomalous, weakly mineralized, and of sufficient size to be classified as having probable mineral-resource potential. A vein exposed in prospect workings and outcrop in the northwestern part of the wilderness in the headwaters of Roaring Fork contains disseminated copper-sulfide minerals (area 1). The vein averages about 10 ft wide over a length of about 1000 ft. Numerous samples contain 0.2–0.5 percent copper, 0.1–0.4 oz silver/ton, and a trace of gold. The deposit is small and in an inaccessible location, but nevertheless represents a demonstrated mineral resource. The Wheeler Basin uranium occurrence consists of disseminated uraninite crystals in complexly mixed rocks at the border of a large granite body (area 2). Several thousand tons of rock that contains 0.1–0.2 percent uranium is present within a few tens of feet of the surface. It constitutes a demonstrated mineral resource, although its remote location discourages development.

Near Rainbow Lakes (area 3), geochemical samples indicate a source of copper at the head of the valley above the lakes. Narrow quartz veins in that area are rich in several metals (copper, molybdenum, lead, silver, and tungsten) but are not abundant enough to account for the high metal values in the stream-sediment samples. Close-spaced joints in the granite are coated with limonite that probably weathered from sulfide minerals. These abundant mineralized joint surfaces and the small veins may represent leakage from a much deeper mineralized system, and thus the area is considered to have probable mineral-resource potential.

Disseminated sulfide minerals in the region between Blue and Mitchell Lakes (area 4) contain minor quantities of copper and gold. Disseminated sulfides in rocks found at the surface indicate that a large mineralizing system existed in the area, and some evidence suggests that only the uppermost part is exposed. Thus the area has a probable mineral-resource potential for large low-grade deposits of copper and gold, and possibly also for molybdenum, which is present in analyzed samples.

SUGGESTIONS FOR FURTHER STUDY

Detailed gravity and magnetic studies in the southeast part of the Indian Peaks Wilderness might detect in the subsurface igneous bodies that may be mineralized. Physical exploration such as drilling would be necessary to determine more precisely the copper resources at the Roaring Fork locality and uranium resources at Wheeler Basin.

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LA GARITA WILDERNESS, COLORADO

By THOMAS A. STEVEN, U.S. GEOLOGICAL SURVEY, and

C. L. BIENIEWSKI, U.S. BUREAU OF MINES

SUMMARY

Geologic and mineral-resource appraisal studies by the USGS and USBM in 1967-68 and 1971 in and near the La Garita Wilderness in the central San Juan Mountains of Colorado have shown that all significant known mineral resources are outside the wilderness. A few small and low-grade veins containing local concentrations of lead, zinc, and silver occur in and adjacent to the western part of the wilderness and the area is considered to have a probable mineral-resource potential.

CHARACTER AND SETTING

The La Garita Wilderness covers about 76 sq mi of rugged terrain in the central San Juan Mountains of southwestern Colorado. Altitudes range from less than 10,000 ft to 14,014 ft at the top of San Luis Peak. The geology of the wilderness was mapped by the USGS at various times during the 1960's, as part of other geologic studies in the central San Juans. Specific studies of mineralized areas and stream-sediment sampling of the whole wilderness were conducted by USGS personnel in 1967-68 and 1971. Investigations by the USBM were done largely in 1971, when claim records and locations were investigated, and all mine workings that could be found were examined and sampled. The results of these studies were published by Steven and Bieniewski (1977).

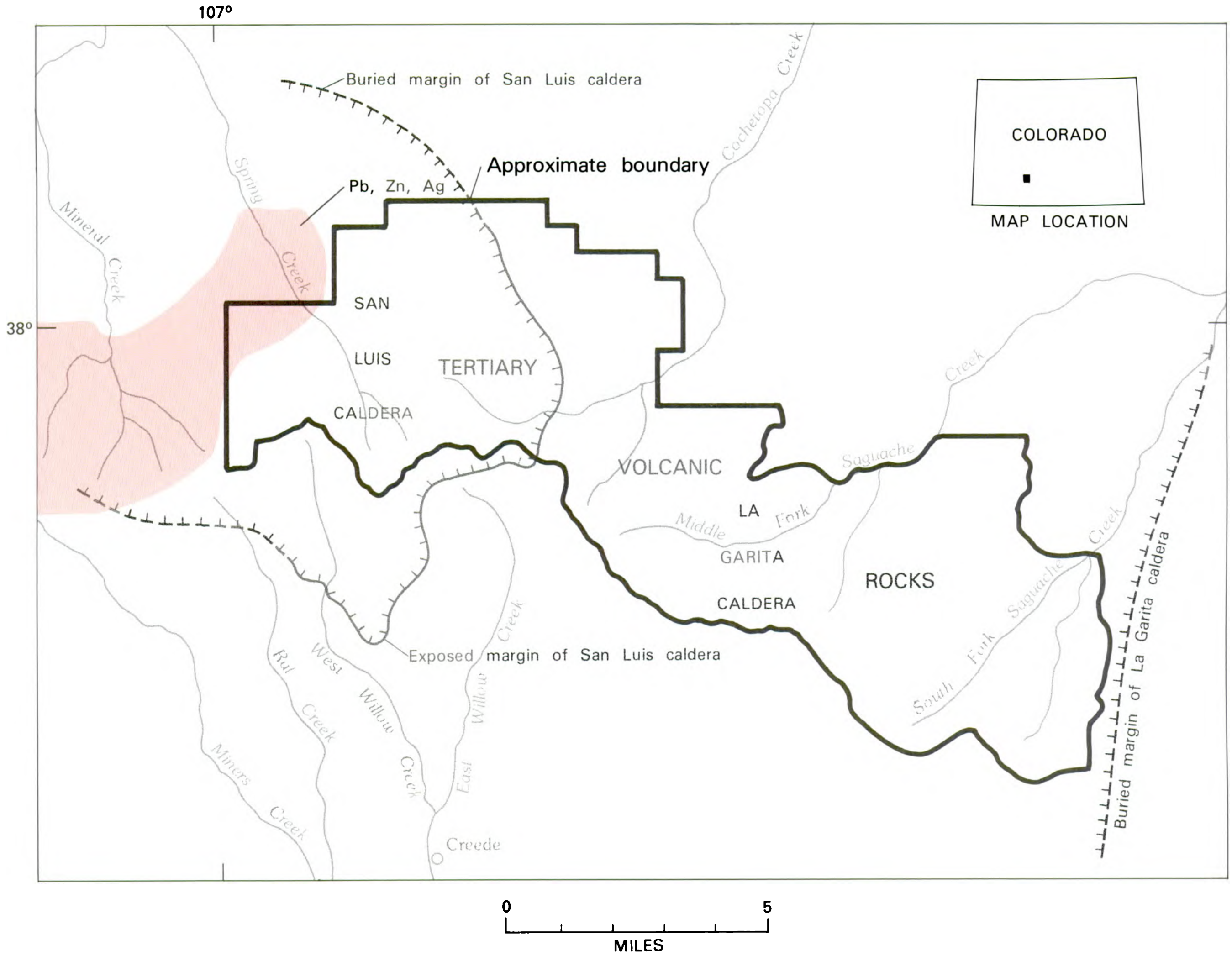
The La Garita Wilderness is underlain entirely by volcanic rocks or related intrusives that formed during a brief interval of geologic time, less than 2 m.y. (million years), between 28 and 26 m.y. ago. These rocks record only a small part of the volcanic activity that took place during that 2-million year span; further, the geology of the wilderness can be understood only in the context of the geologic history of the whole central San Juan area.

The central San Juan Mountains were a major source area for voluminous ash flows, which spread as avalanches of incandescent hot ash that congealed into widespread sheets of densely welded tuff after deposition. Major volcanic subsidence structures (calderas) formed at the sources of most of these ash flows; five calderas have been recognized near the La Garita Wilderness. In addition, two more calderas may have formed but, if so, they were obliterated by younger calderas or were covered by younger rocks. Subsidence generally took place concurrently with eruption of the ash flows, and the calderas commonly are filled with masses of densely welded tuff as much as 4000 ft thick. The entire La Garita Wilderness lies within two nonconsecutive calderas that are part of the central San Juan caldera complex. The eastern two-thirds of the wilderness is within the large La Garita caldera, the oldest subsidence structure in the vicinity of the wilderness, and the western third is within the San Luis caldera, the third youngest of the subsidence structures.

MINERAL RESOURCES

Hydrothermal activity affected rocks in or near the La Garita Wilderness at least four times during volcanic activity. The intrusive core of an old andesite central volcano is exposed on the east wall of the La Garita caldera east of the wilderness; this core and the adjacent rocks are irregularly altered and are cut locally by quartz-pyrite veins. Valuable minerals are sparse in the exposed parts of this center, and the mineralized area is entirely outside the La Garita Wilderness; thus, virtually no potential for mineral resources related to this center can be postulated for adjacent parts of the wilderness.

The thick mass of densely welded Nelson Mountain Tuff in the core of the San Luis caldera was affected



EXPLANATION

Geologic terrane with probable mineral-resource potential

Pb Lead

Ag Silver

Zn Zinc

Figure 133.—La Garita Wilderness, Colorado.

by pervasive propylitic alteration during post-emplacement intrusive and extrusive activity and resurgent doming. Many minor quartz-pyrite and quartz-calcite-pyrite veins were formed along minor fractures during this period of hydrothermal activity, and some of these veins near the northwest margin of the wilderness contain local concentrations of lead, zinc, and silver of economic interest. Most of the deposits containing valuable minerals are 0.5 to 1 mi outside the wilderness, but some deposits are adjacent to the boundary and some extend within the wilderness. All these veins are small, however, and the concentrations of valuable minerals are so erratically distributed that no mineral resource can be postulated. Larger veins, with more persistent valuable metal concentrations, would have to be found in order to support even a small mining industry in the area.

A series of intrusive plugs marking the roots of former volcanoes extends from the western edge of the La Garita Wilderness westward for about 9 mi. Many of the centers were intensely altered by hydrothermal activity during waning stages of volcanic activity, and local areas containing somewhat anomalous metal concentrations have been identified. A low-level zinc anomaly was detected in stream-sediment samples along upper Mineral Creek in and adjacent to the wilderness. Although no deposits containing concentrations even remotely approaching ore grade were seen, there are widespread indications of mineralization and the area is considered to have a probable mineral-resource potential for lead, zinc, and silver.

The most important mineralized area in the central San Juan Mountains is in the Creede mining district 3–8 mi south and southwest of the La Garita Wilderness. The ores here were deposited after development of the Creede caldera, and are localized along a series of faults that extend radially north to northwest out from the caldera. None of the faults that host the ores extend into the La Garita Wilderness, and it is unlikely that any mineral resources related to the Creede center of mineralization exist within the wilderness. No evidence was seen for geothermal energy or fossil-fuel resources within the La Garita Wilderness.

REFERENCE

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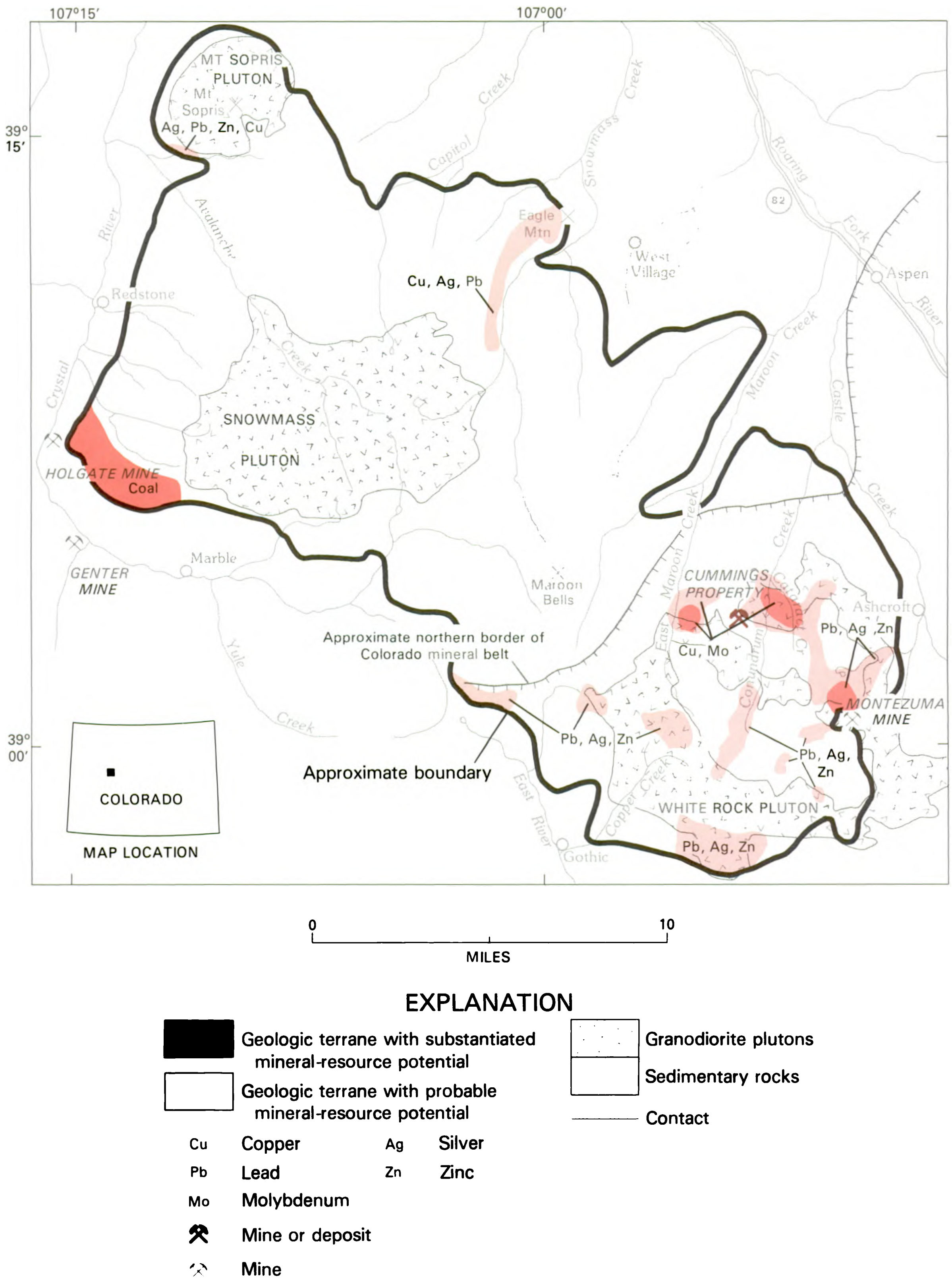

Figure 134.—Maroon Bells-Snowmass Wilderness and additions, Colorado.

MAROON BELLS-SNOWMASS WILDERNESS AND ADDITIONS, COLORADO

By VAL L. FREEMAN,[1] U.S. GEOLOGICAL SURVEY, and

ROBERT C. WEISNER, U.S. BUREAU OF MINES

SUMMARY

The Maroon Bells-Snowmass Wilderness and Additions, located in western Colorado, was examined for mineral potential during 1974–76. Evidence of mineralization is widespread and numerous areas have either probable or substantiated mineral-resource potential for one or more of the following metals: gold, silver, lead, zinc, copper, and molybdenum. In addition, part of the wilderness has substantiated coal resource potential. There is little promise for the occurrence of oil and gas or geothermal resources.

CHARACTER AND SETTING

The Maroon Bells-Snowmass Wilderness and Additions, an area of about 270 sq mi, is located in the Elk Mountains of western Colorado a few miles southwest of Aspen, Colorado. Access to the area is from Glenwood Springs to the north or from Gunnison to the south. Altitudes range from about 7500 ft to 14,265 ft. This great relief, combined with the carving by glaciation, has produced an area of spectacular mountain scenery. The area surveyed included the existing wilderness and adjacent study areas. In 1980 new boundaries were established that enclosed most of the area surveyed and some additional area that has not yet been carefully examined.

The rocks exposed in the wilderness are sedimentary—of Pennsylvanian and younger ages—that have been intruded and locally metamorphosed by igneous rocks in the forms of concordant and irregular plutons, sills, and dikes. Prior to the main intrusive period the sedimentary rocks were folded into a large anticline extending northwestward from the Sawatch uplift. Normal and thrust faulting occurred with the folding. Large areas of the bedrock are concealed by deposits of rock debris laid down during glaciation or later.

The southern third of the wilderness is considered to lie within the Colorado mineral belt, a northeast-trending zone that embraces almost all the mineral mining districts of central Colorado. Within the Colorado mineral belt large replacement metallic ore deposits are mostly confined to a few stratigraphic rock units of favorable chemical composition. These favorable host rocks are not exposed in the wilderness but are certainly present beneath the surface sedimentary rocks except where locally removed by faulting or displaced by intrusive rocks. The coal-bearing sedimentary units of the region remain only in the southwest corner of the wilderness. Likewise, the sedimentary units from which natural gas is produced in nearby parts of western Colorado are preserved only in the southwest corner.

The work done in 1974–76 to evaluate the resource potential of the wilderness and additions included geologic mapping of previously unmapped parts of the wilderness; geochemical sampling of rocks, altered rocks, and stream sediments for analyses; geophysical surveying of the area for magnetic and gravity appraisal; and a records search of claim locations, examination and mapping of mine and prospect workings, and sampling of veins, mine dumps, and altered rock.

The search of old records augmented the very visible signs of past prospecting in the wilderness. About 6000 mining claims located in or very near the wilderness were found in the files of the County seats. About 3200 of these filed claims were well enough described that they could be plotted on maps. Considering the amount of prospecting, very little production of mineral wealth occurred within the present wilderness. Many prospectors, attracted by the mineral riches of the nearby Aspen mining district, thoroughly examined the wilderness and additions and found much mineralized rock but little ore. The most favorable host rocks of the Colorado Mineral Belt, such as those that contained the rich ores found at Aspen, pass under the wilderness below levels of erosion that would make them accessible

[1]With contributions from David L. Campbell and Harley D. King, USGS, and C. L. Bieniewski, USBM.

to the scrutiny of those prospectors. Claim staking and exploration continues, and includes consideration of the area for low-grade, large stockwork molybdenum deposits.

MINERAL RESOURCES

Evidence relating to the assessment of the resource potential of metallic mineral deposits in the Maroon Bells-Snowmass Wilderness and Additions includes the following: (1) its location along the Colorado Mineral Belt, (2) the presence of intrusive rocks that might provide a source of metallic elements and heat to mobilize them, (3) faulting and fracturing that provided avenues for solutions containing metallic elements, (4) abundant occurrences of low-grade altered and mineralized rock that show that solutions containing metallic elements did indeed move through the rocks, and (5) the presence at the surface of large areas of sedimentary rock types that chemically are not themselves favorable for replacement-type ore bodies, but that overlie favorable host rocks.

No metallic mineral resources were found in the wilderness in this study, but several areas were identified as having probable or substantiated mineral-resource potential for metallic mineral resources at considerable depth; these areas are within three zones.

The Snowmass Creek fault zone extends southwestward into the wilderness from near Eagle Mountain. Occurrences of metallic elements found in the wilderness are all of small size and low grade; however, a prospect near Eagle Mountain, outside the wilderness produced and shipped some ore (Bryant, 1979, p. 115–120). Metallic elements that were found in anomalous amounts along this zone include copper, silver, lead, zinc, molybdenum, cobalt, and gold. The zone, especially the northeastern part, has a probable mineral-resource potential for copper, lead, and silver resources at depth in favorable host rocks or along fractures near the contact of the pluton.

Along the south side of the Mt. Sopris pluton, mineralized rock was found close to the igneous-sedimentary contact in veins and fractures. Metallic elements found in anomalous amounts include lead, silver, zinc, copper, molybdenum, cobalt, and gold. The area has been thoroughly prospected and ore was produced from small pods. Although there is little likelihood for deposits at the surface, there is a probable mineral-resource potential for copper, lead, zinc, and silver resources at depth along the edge of the pluton in small fractures and at the level of favorable host rocks.

The southern third of the wilderness, west of Ashcroft, belongs within the Colorado Mineral Belt and this area contains widespread occurrences of mineralized rock. Geologic factors are consistent with the possibility, if not the probability, of ore deposits being present where favorable host rocks occur at depth or where other rock types are faulted or fractured. The parts of the wilderness shown as having probable mineral-resource potential are those parts where surface indications of mineralization are concentrated. The study found examples of mineralization with two differing suites of metallic elements. One suite, with molybdenum and copper and locally tungsten, tin, lead, zinc, silver, gold, mercury, arsenic, bismuth, and antimony, is found in a few fracture-related sites and also in zoned stockwork-ore deposits with associated pyritization and alteration (Bryant, 1971, p. D13-D25). The other suite with lead, silver, and zinc and locally antimony, cadmium, bismuth, molybdenum, copper, cobalt, gold, arsenic, mercury, and fluorine, is found mostly in veins and fractures.

Two occurrences of stockwork molybdenum mineralization are considered to identify areas of substantiated potential and these areas are surrounded by areas of probable mineral-resource potential. These two occurrences, the East Maroon Creek and Conundrum-Cataract Creeks areas, were examined on the surface, and have been studied by mining companies, but ore deposits have not yet been found. The areas are thought to have resource potential because geophysical and geochemical studies suggest large masses of altered rocks below the surface. A geologic interpretation suggests intrusion of small plutons within and later than the main mass of the White Rock pluton and that some of mineral zoning may be related to the later plutons. A third area of stockwork molybdenum mineralization may be present northeast of Gothic in the Copper Creek drainage within the boundary of the 1980 addition to the wilderness but outside the area studied in 1974–76. Because of the recent boundary changes this area was not included in this study and is not shown on the map. Its resource potential cannot be assessed on the basis of available data.

The other areas delineated as having probable mineral-resource potential, with the lead-silver-zinc suite of elements, have been thoroughly prospected and it is unlikely that undiscovered ore deposits are present at the surface. Some ore-grade rock has been shipped but no sustained mining took place. Of special note is the area of the Cummings property where small quantities of ore-grade rock may remain; the possibility of a deep deposit is good and a demonstrated lead-silver-zinc resource exists at this mine. A once-productive mine, the Montezuma, lies just outside the wilderness, and it is possible that ore bodies continuous with this deposit might extend into the wilderness. A small area of substantiated lead-silver-zinc resource potential extends into the wilderness from this mine.

In the southwest corner of the Maroon Bells-Snowmass Wilderness and Additions a 900-ft-thick sequence of coal-bearing rocks underlies an area of about 6 sq mi. The beds dip southwestward as much as 40° or as little as 8° and, as the land surface slopes in the same direction, they are mostly less than 1000 ft below the surface. Gaskill and Godwin (1966) concluded that seven or more beds of coal underlie that part of the wilderness, ranging from 0.1 to 4 ft thick. Their data consist of measurements on coal outcrops that could not be traced more than 0.1 mi. The abandoned Holgate coal mine, 0.2 mi west of the wilderness, produced coking coal from a bed reported to be 4 ft thick. The Galloway coal prospect is within the wilderness; Hanks (1962) reported the coal there to be a bed of semianthracite 0.9 ft thick. The Genter mine, 0.75 mi south of the wilderness, produced semianthracite and anthracite from a bed 3.1-4.9 ft thick (Boreck and Murray, 1979). The work of Donnell (written commun., 1982), who measured and correlated coal beds in the area, indicates that the coal beds are so lenticular that it is impractical to assume continuity of a coal bed for more than 0.75 mi. Demonstrated resources calculated from points at the Holgate mine and Gaskill and Godwin's measured outcrop total 8.3 million short tons of bituminous or anthracite coal. If it is assumed that all the area of coal-bearing rocks in the wilderness is underlain by one or more coal beds, that aggregate 4 ft in thickness, the inferred resource is an additional 25 million short tons. A substantiated resource potential is assigned to this coal area.

The geologic evaluation of oil and gas potential for the wilderness took into consideration possible source beds, reservoir beds, structures, and geothermal history of the area. There are no nearby producing oil fields. Traces of petroleum residue were found in sandstones in the wilderness but these were in strata not now structurally able to serve as reservoir rocks. The only possible combination of favorable source and reservoir strata in a conceivably favorable structural setting are the Pennsylvanian Belden Formation and the Mississippian Leadville Limestone. Interpretation of geothermal information indicates that temperatures were too high for preservation of oil in these formations. It is possible that natural gas might have survived in these strata in the western part of the area. The younger strata that act as reservoir rocks in the gas fields west of the wilderness are preserved only in the southwest corner of the area, and the structural setting is unfavorable. Natural gas, dominantly methane, is certainly present in the coal beds but the coal thicknesses and burial depths are not favorable for production. The occurrence of oil or gas resources is unlikely in the Maroon Bells-Snowmass Wilderness and Additions.

Other possible mineral commodities are present in the wilderness; these include sodium, rock products, and geothermal waters. On the basis of available data, none are judged to show promise for the occurrence of resources.

SUGGESTIONS FOR FURTHER STUDIES

The area added to the wilderness in 1980 was not adequately studied to evaluate the mineral-resource potential for metals in the area northeast of Gothic. It is a mineralized area, and like the other mineralized areas within the area studied, resources are likely to be present at depth.

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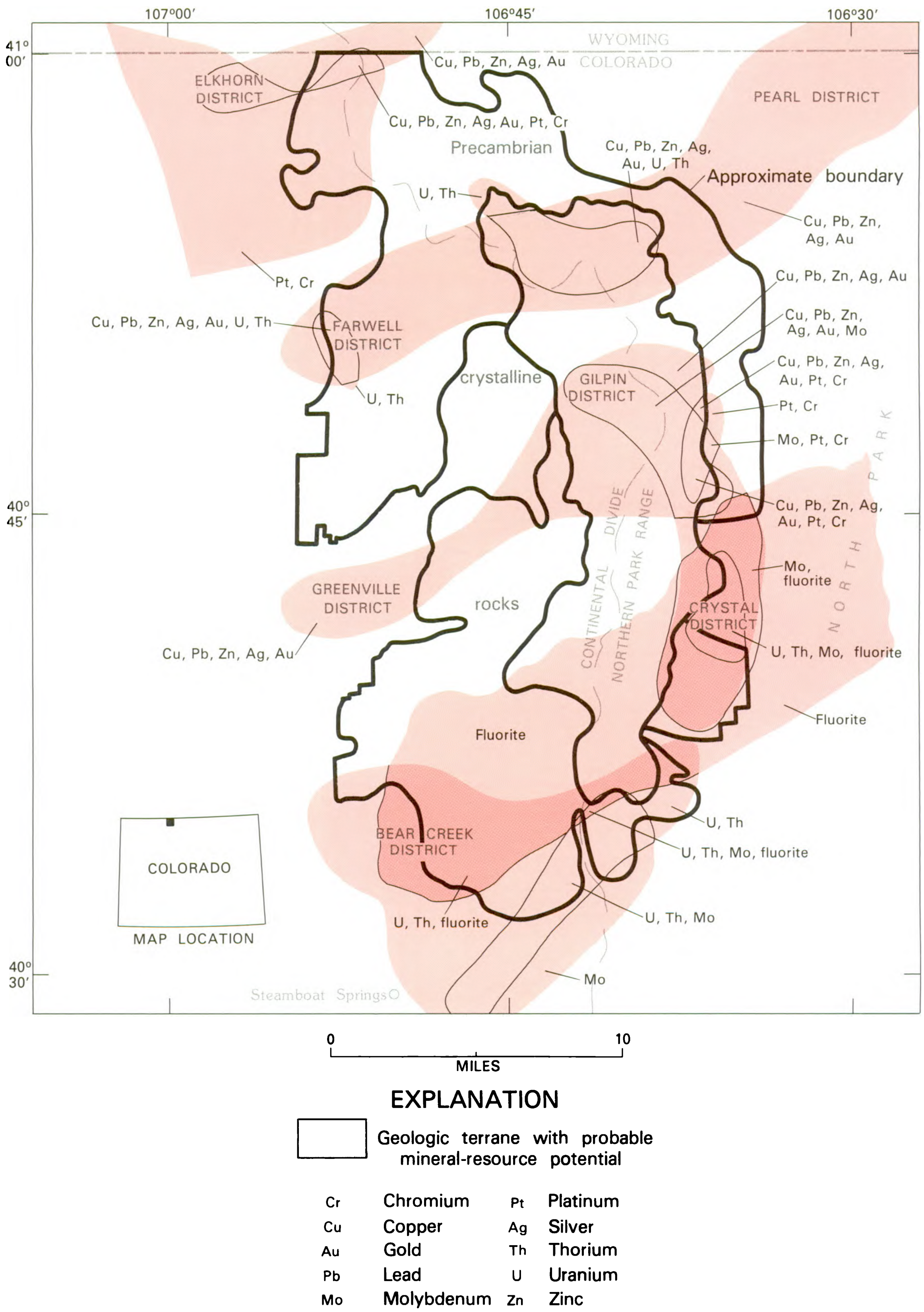

Figure 135.—Mount Zirkel Wilderness and vicinity, Colorado.

MOUNT ZIRKEL WILDERNESS AND VICINITY, COLORADO

By GEORGE L. SNYDER,[1] U.S. GEOLOGICAL SURVEY, and

LOWELL L. PATTEN, U.S. BUREAU OF MINES

SUMMARY

Several areas of metallic and nonmetallic mineralization have been identified from surface occurrences within the Mount Zirkel Wilderness and vicinity, Colorado. Three areas of probable copper-lead-zinc-silver-gold resource potential, two areas of probable chrome-platinum resource potential, four areas of probable uranium-thorium resource potential, two areas of probable molybdenum resource potential, and one area of probable fluorspar potential were identified by studies in 1965–73 by the USGS and USBM. No potential for fossil fuel or geothermal resources was identified.

CHARACTER AND SETTING

A survey of the mineral-resource potential of 945 sq mi that includes the Mount Zirkel Wilderness and northern Park Range vicinity, Colorado, was made by the USGS and USBM during the summers of 1965–73. This survey was supported by geologic and petrological studies, by detailed examination of mining claims, and by geochemical and geophysical surveys. Assembled data are contained in Snyder, Patten, and Daniels (in press) and Snyder and others (1981).

Scenery in the glaciated Mount Zirkel Wilderness is spectacular, especially in the vicinity of Mount Zirkel in the north and Mount Ethel in the south. Total relief is nearly 5000 ft with timberline lying at an average altitude of 10,500 ft. Nearly all of the wilderness is underlain by Proterozoic crystalline rocks, mainly amphibolitic to felsic high-grade metavolcanic rocks with minor interlayered metashale and marble that have been extensively intruded by bodies of syntectonic gabbro, quartz monzonite, quartz diorite, and peridotite, and by post-tectonic quartz monzonite and granite. Later during Mesozoic time the Precambrian crystalline rocks were covered by as much as 10,000 ft of marine sediments, three tiny areas of which are still contained within the boundaries of the wilderness. Post-Cretaceous compressional faults and post-Miocene tensional faults offset the younger sediments; some of these follow old Precambrian zones of weakness and some are at a large angle to them. Quaternary glacial drift and alluvial and colluvial deposits, as well as modern soil, lakes, and forest litter, mask most of the older rocks and structures at the present land surface.

Rocks of the northern Park Range have been mineralized by introduced ore elements probably four times in the geologic past, twice in the Precambrian, once(?) at the close of the Mesozoic and beginning of the Tertiary (Laramide orogeny), and at least once later in the Tertiary. The Precambrian events coincide with the two major episodes of igneous intrusion, 1.7 to 1.8 b.y. (billion years) ago (the syntectonic event) and 1.3 to 1.4 b.y. ago (the post-tectonic event). Here and elsewhere in the vicinity there is evidence that elements in minerals originally deposited in the Precambrian have been remobilized in the Laramide orogeny or in Tertiary time. Several large areas of low-grade mineralization are present at the ground surface, some discovered as a result of this survey.

MINERAL RESOURCES

Fluorite is the main mineral that possibly occurs as a resource in the wilderness and is found largely in the Crystal district which extends into the wilderness. Other possible mineral resources are less certain but could be much more valuable.

Areas of mineral-resource potential, shown on the map, are based on observations of outcrops and prospect pits, on geochemical anomalies in surface rocks and stream sediments, and on a detailed knowledge of local

[1]With contributions from Jeffery J. Daniels, USGS.

geology and distant but geologically similar producing mineral provinces. Most outcrops are small and scattered, mainly near the fringes of the wilderness or adjacent areas, but some, for example the Gilpin district, are in the center of the wilderness. The areas of potential shown on the map are untested but could be significant.

Most base- and precious-metal sulfide anomalies are in five prospected districts: Elkhorn, Farwell, Gilpin (entirely within the wilderness), Greenville, and Pearl. Other unprospected anomalous areas occur within the adjacent area. Three belts of probable copper-lead-zinc-silver-gold potential are determined by the bedrock geochemical anomalies and prospects and the northeasterly grain of both the mapped geologic units and some geophysical lineaments (some stream-sediment geochemistry suggests that the southern two belts may merge). Copper-lead-zinc-silver-gold occurrences in the northern two of these three belts are all within 2 mi of the contact of a 1.8 b.y. old granite body, which might have served as the concentrating engine for these elements; in the southern belt calc-silicate or marble beds have been favorable horizons for replacement deposits of lead-copper-zinc-silver-gold. A probable potential for base- and precious-metal stratabound sulfide deposits is assigned these geochemically favorable rocks. Many such massive sulfide deposits occur throughout the world in marine metasediments and metavolcanics of this age (1.8 b.y.).

Chromium, platinum, palladium, cobalt, and nickel are clearly associated with ultramafic rocks in the wilderness, but not in amounts exceptionally large for ultramafic rocks as a class. In rocks, the maximum chromium from analyses was 3000 parts per million in the Troutman Draw malachitic hornblendite that also had the maximum platinum plus palladium (0.09 parts per million). Two areas of probable potential for minor platinum-chromium resources are indicated on the map. One area includes a large peridotite intrusive on the ridge north of Lone Pine Creek and extends north to include high cobalt and chromium stream sediment anomalies measured on streams issuing from beneath rock glaciers. The other area is in the northwest part of the adjacent area and includes the gabbro of Elkhorn Mountain. Funnel-shaped bodies of layered gabbro the size of the gabbro of Elkhorn Mountain are known throughout the world to have a potential for magmatically segregated platinum-chromium ores.

Three areas of probable potential for uranium-thorium are indicated near the boundaries of the wilderness and adjacent areas, and another is included within the molybdenum-potential area near the Crystal district. All of these are based on the presence of a geochemical suite of uranium, thorium, beryllium, niobium, and lanthanum. Although the potential is only probable, a large low-grade uranium deposit in pegmatities and pegmatite veins of the Rössing type may exist beneath the indicated areas. The geochemical suite mentioned above for uranium is present in and also can characterize molybdenum-bearing apophyses near the tops of Tertiary porphyry vertical cylindrical intrusives in the western United States. Although no Tertiary intrusives occur at the surface in this part of the Park Range, such rocks are present both southeast and northwest of this geochemical belt.

A discontinuous linear belt of probable molybdenum potential is shown as two areas extending from the Gilpin district through the Crystal district on the east side of the wilderness and southward on the southeast side of the wilderness. The northern part of this belt includes two aeromagnetic anomalies, which have no ready explanation in the surface geology and could be revealing the tops of deeply buried Tertiary intrusive pipes.

Fluorspar veins are present just east of the Mount Zirkel Wilderness and some of these veins are known to extend into the wilderness. There is a probable potential for low-grade fluorite deposits everywhere within the steep-sided 1.4 b.y. old Mount Ethel pluton where interstitial fluorite could have been easily concentrated along joint sets, fault planes or fault breccia zones that penetrated these rocks.

Other nonmetallic commodities occur in the wilderness and include mica, feldspar, cement rock, aggregate, riprap, and ornamental stone. These commodities are small, inaccessible, and far from potential markets and no resource potential was identified.

Hydrocarbon resources have never been searched for within the Mount Zirkel Wilderness and vicinity and they are certainly not present anywhere near the present land surface. There are oil fields in suitable trapping structures on both sides of the North Park Range so the geologic environment may be suitable. A thrust fault on the west side of the range could serve as a capping seal for any hydrocarbons trapped in underlying Mesozoic rocks. Oil and gas have not been found in anticlines nearest to this thrust nor hydrocarbons in seeps anywhere within or adjacent to the wilderness, and there has been no attempt to drill through such a hypothetical crystalline caprock. It is not impossible that some oil and gas could be trapped locally at great(?) depth below the western boundary of the adjacent area but data are insufficient to assess the oil and gas potential of the area. No potential for coal was identified.

There is no evidence of a geothermal resource potential anywhere within the bounds of the Mount Zirkel Wilderness or vicinity even though there is a well-known geothermal resource just outside of this area in the vicinity of Steamboat Springs, Colorado.

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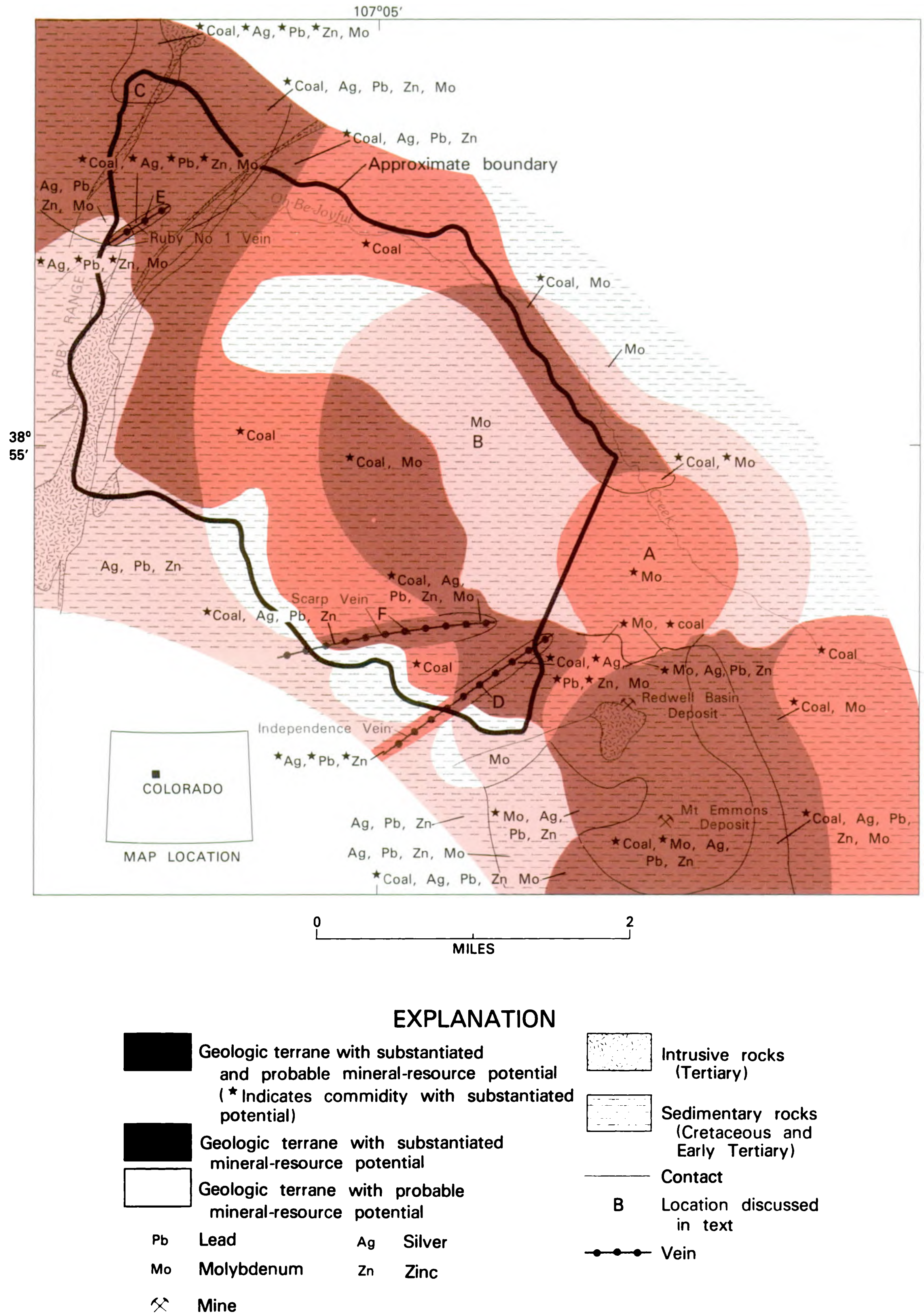

Figure 136.—Oh-Be-Joyful Wilderness Study Area, Colorado.

OH-BE-JOYFUL WILDERNESS STUDY AREA, COLORADO

By STEVE LUDINGTON, U.S. GEOLOGICAL SURVEY, and

CLARENCE E. ELLIS, U.S. BUREAU OF MINES

SUMMARY

The Oh-Be-Joyful Wilderness Study Area, near Crested Butte, Colorado, was studied by the USGS and the USBM in 1976, 1980, and 1982. Resources of molybdenum are present in two deposits immediately adjacent to the area and are inferred at one location that is partly within the study area. These three overlapping areas have substantiated mineral-resource potential for molybdenum, and are surrounded by an area of probable mineral-resource potential for molybdenum. Another area of probable mineral-resource potential for molybdenum occurs in the northwestern part of the study area. Three areas that are entirely or partly within the study area, two of which contain resources of silver, lead, and zinc, have substantiated mineral-resource potential for those commodities. In addition, the western part, and a small area in the southern part of the study area have probable mineral-resource potential for silver, lead, and zinc. More than half the study area contains inferred coal resources and has substantiated mineral-resource potential for coal.

CHARACTER AND SETTING

The Oh-Be-Joyful Wilderness Study Area (approximately 8.6 sq mi) occupies the watershed of Oh-Be-Joyful Creek on the east flank of the Ruby Range, a subsidiary of the Elk Range in west-central Colorado. Access is primarily via a jeep road up Oh-Be-Joyful Creek that traverses most of the study area and connects with an improved county road a few miles north of Crested Butte.

Most of the study area is covered with marine and continental shales, sandstones, and conglomerates that range in age from Cretaceous to early Tertiary. These rocks are intruded and metamorphosed by two distinct suites of intrusive rocks. The oldest suite is Oligocene in age and consists of a group of stocks and dikes of diorite, granodiorite, and quartz monzonite that form the core of the Ruby Range. A younger series of rocks, Miocene in age, is expressed at the surface only as a small plug of rhyolite porphyry in Redwell Basin, immediately east of the study area. At depth, these rocks are granites and granite porphyries that are the source of the Redwell Basin and Mt. Emmons stockwork molybdenum deposits.

The area is broken by numerous normal faults, generally of small displacement. Some of these contain epithermal silver-lead-zinc vein deposits and some contain dikes.

MINERAL RESOURCES

Mt. Emmons and Redwell Basin, two stockwork molybdenum deposits having demonstrated resources, occur immediately adjacent to the Oh-Be-Joyful Wilderness Study Area on the southeast.

A third deposit (A) is likely to be present in the subsurface beneath the valley of Oh-Be-Joyful Creek near the eastern boundary of the study area. Mineral zoning in associated base-metal veins and the distribution of hornfels, mineral veining, and hydrothermal alteration are similar to the nearby Mt. Emmons and Redwell Basin deposits. High-silica granites and molybdenite mineralization are known at depth, and this area has substantiated mineral-resource potential for molybdenum.

Just upstream, a fourth deposit (B) could exist in the subsurface. Some hornfels and minor veining is present and a distinct structural dome in the overlying sedimentary rocks suggests the presence of a silicic intrusive at depth. Because there has been no physical exploration of this area by drilling, it exhibits probable mineral-resource potential for molybdenum.

Near the northwest corner of the area, a radial pattern of faults and base-metal veins indicates another area (C) of probable mineral-resource potential for molybdenum. Widespread occurrence of alteration and mineralization related to the Oligocene intermediate-composition intrusive rocks makes it difficult to clearly discern younger events, possibly related to molybdenite mineralization.

Demonstrated and inferred resources of silver, lead, and zinc are present in two veins in the study area, the Independence (D) in the southeastern part of the area, and the Ruby No. 1 (E) in the northwestern part. Area C also has substantiated mineral-resource potential for silver, lead, and zinc because several veins that have high silver contents appear to intersect there.

On the basis of numerous old mines and other workings that yield vein material with moderate to high silver, lead, and zinc contents, a large region in the western part of the area, along with the extension of the Scarp vein (F) in the southern part, has probable mineral-resource potential for silver, lead, and zinc.

Throughout the upper part of the Upper Cretaceous Mesaverde Formation, numerous thin (0.5 to 3 ft) beds of coal occur. The coal ranks between high volatile B bituminous and anthracite, depending on the degree of metamorphism. The area where these coal beds are at, or within a few hundred feet of, the surface has substantiated mineral-resource potential for coal.

SUGGESTIONS FOR FURTHER STUDIES

If mineral zoning patterns and ages of the base-metal veins were better known, they would be a useful exploration guide to molybdenum deposits. A detailed mineralogic and geochronologic study of the vein deposits would be a large contribution to the understanding of mineral genesis, in this area and others.

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PIEDRA WILDERNESS STUDY AREA, COLORADO

By STEVEN M. CONDON,[1] U.S. GEOLOGICAL SURVEY, and

S. DON BROWN, U.S. BUREAU OF MINES

SUMMARY

The Piedra Wilderness Study Area, located approximately 30 mi northeast of Durango, Colorado, was evaluated in 1982 for its mineral-resource potential. Geochemical and geophysical studies by the USGS and USBM indicate little promise for the occurrence of mineral or energy resources in this area.

CHARACTER AND SETTING

The Piedra Wilderness Study Area covers about 65 sq mi of heavily wooded foothills along the northern edge of the San Juan Basin. It is located midway between Durango and Pagosa Springs, Colorado, and is 10 mi east of Vallecito Reservoir.

Access to the study area by vehicle is limited. The southern part of the area can be reached by turning north along the Piedra River where it is crossed by U.S. Highway 160. This gravel road is closed at Horse Creek, about 5 mi north of the highway, but future repairs may open it as far as the confluence of the Piedra and First Fork. The northern part of the area can be reached only by driving northwest from Pagosa Springs and coming in from the east across the Weminuche valley. The road then parallels the northern and northwestern boundary of the study area.

Access within the study area is limited to foot, horseback, or motorcycle. A system of USFS trails follows many of the streams and ridges, Mosca Creek and Sheep Creek being exceptions. Once off the trails, travel is extremely difficult owing to the dense vegetation.

The study area is a part of the Colorado Plateau physiographic province, and reflects the canyon and mesa topography typical of the province. Here, most of the mesas have been reduced by erosion to narrow ridges. The area is transitional between low, dry sagebrush country to the south and rugged, alpine mountains to the north; altitudes range from about 7000 to 10,500 ft.

A relatively high amount of rainfall (50 in. annually) and snowmelt from the higher mountains combine to produce a system of perennial streams throughout the study area. The Piedra River is the main stream; it flows through and adjacent to the study area from northeast to south. The tributary streams have substantially less flow than the Piedra and generally flow from the north and west.

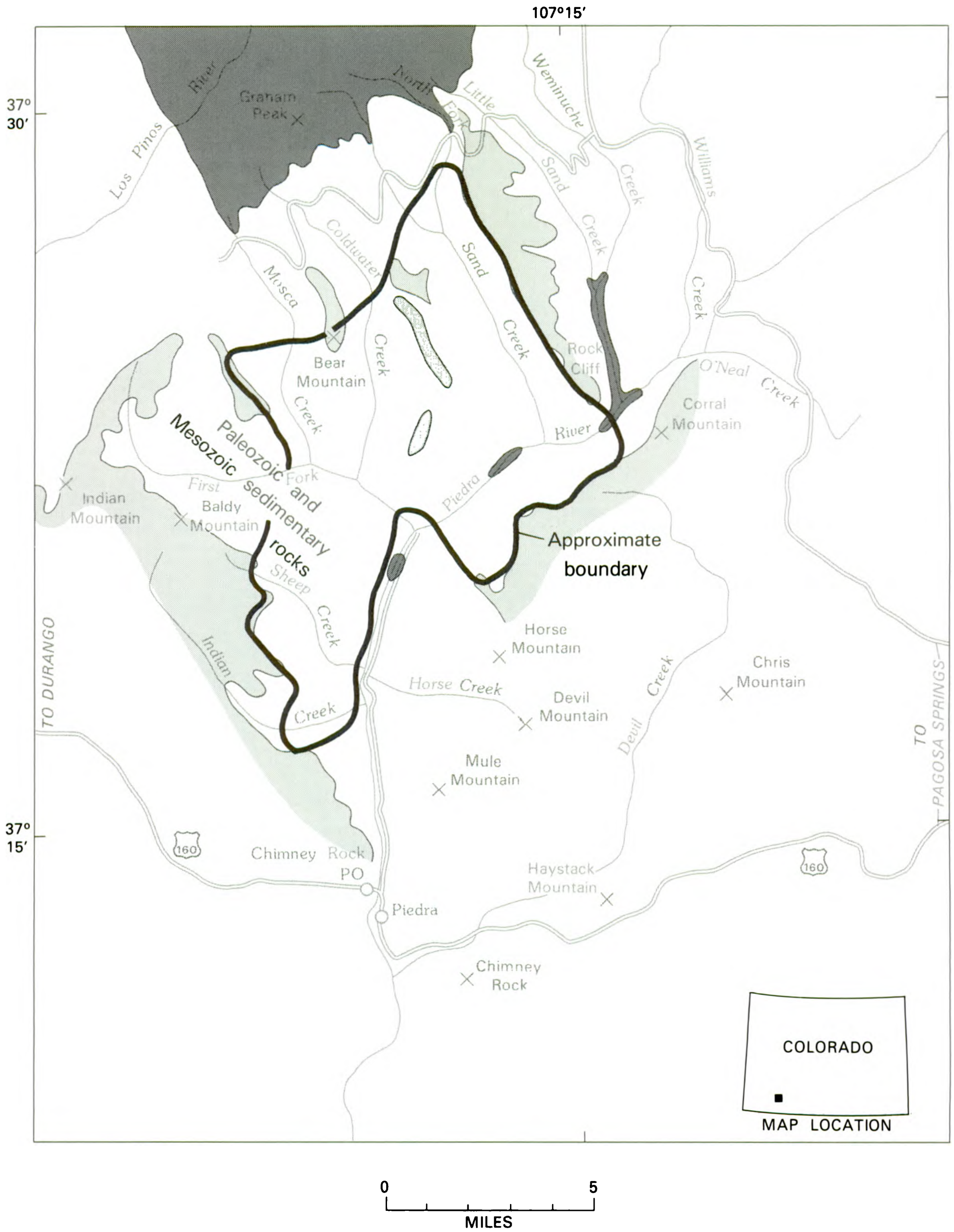
The rocks of the Piedra Wilderness Study Area range in age from Precambrian to Tertiary, from about 1460 million years to about 50 million years old, and include both crystalline and sedimentary types.

There are two kinds of Precambrian crystalline rocks: the Eolus Granite and the Uncompahgre Formation. The Uncompahgre is the older of the two and includes quartzite, phyllite, and slate. The Eolus Granite, dated at 1460 million years, was intruded into the Uncompahgre.

A series of younger sedimentary rocks, about 4000 feet thick, rests on the Precambrian basement. The Cambrian Ignacio Quartzite, Devonian Elbert and Ouray Formations, and Mississippian Leadville Limestone were deposited in and along the margins of ancient oceans. The Pennsylvanian Molas and Hermosa, Pennsylvanian and Permian Rico, and Permian Cutler Formations, were deposited in shallow seas and along the flanks of mountains. The only formation of Triassic age is the Dolores Formation, deposited on land in a system of streams and lakes. Jurassic rocks are the Entrada, Wanakah, and Morrison Formations, which also were deposited on land as sand dunes and by lakes and rivers. The Burro Canyon Formation and Dakota Sandstone, the only Cretaceous rocks within the study area, were deposited on land and on the margin of an ocean.

The Piedra Wilderness Study Area has undergone several cycles of uplift and erosion that have affected the distribution of rock units. The Rico, Cutler, and Dolores Formations, present in the southern part of the study area, have been eroded and are not present in the

[1]With contributions from Rod Vaughn, USGS.



EXPLANATION

Outcrops of Cretaceous Dakota Sandstone

Outcrops of Precambrian rocks

Contact

Figure 137.—Piedra Wilderness Study Area, Colorado.

northern part. The present structure consists of a series of anticlines that trend northwest, with the oldest (Precambrian) rocks exposed in the cores of these folds where streams have cut across them.

MINERAL RESOURCES

Several of the rock units found in the Piedra Wilderness Study Area contain known mineral deposits elsewhere. These are the Hermosa Formation, an oil producer in southeastern Utah; the Cutler Formation, which produces uranium in eastern Utah; the Entrada Sandstone, a former uranium-vanadium producer in southwestern Colorado; and the Morrison Formation, which currently produces uranium in southwestern Colorado. Because of this known potential, we gave special attention to these formations in our evaluation of the study area. Geochemical studies consisted of analyses of stream-sediment samples, water samples, and rock samples for mineral concentrations. Geophysical studies consisted of traverses with a scintillometer to detect possible concentrations of radioactive elements. Additionally, this and surrounding areas were previously studied under the recent National Uranium Resource Evaluation (NURE) program.

Mining activity in the vicinity of the study area has been minimal. The East and West Medicine mines are located just outside the western boundary and consist of several small prospect pits cut into the Wanakah Formation. A small amount of gypsum was mined for use in patent medicine. Two other surface cuts are present southeast of the study area, but no mineralization was noted. No prospect pits or any other sign of mining activity were found within the study area.

This lack of mining activity is not surprising; our sampling did not reveal any significant anomalous mineral concentrations. The Hermosa Formation has a favorable composition and structural setting for accumulation of oil, but no exploration has been done in the area. Any oil present may have been destroyed by the near-surface exposure of the Hermosa. The Cutler, Entrada, and Morrison Formations did not show any anaomalous concentrations of uranium, vanadium, or other elements. Gypsum beds occur in the Wanakah Formation; however, because of the small size and the inaccessibility of the deposits, no resource potential was identified.

The Dakota Sandstone was also checked for possible deposits of coal, although the limited area of outcrop and inaccessibility would limit the usefulness of such deposits. Here too, results were negative.

SUGGESTIONS FOR FURTHER STUDIES

Field observations, geochemical studies, and geophysical studies indicate there is little promise for the occurrence of energy or mineral resources in the Piedra Wilderness Study Area. This conclusion is supported by the findings of the earlier NURE study and is suggested by the absence of significant mining activity in the area. Further evaluation of the area is not recommended.

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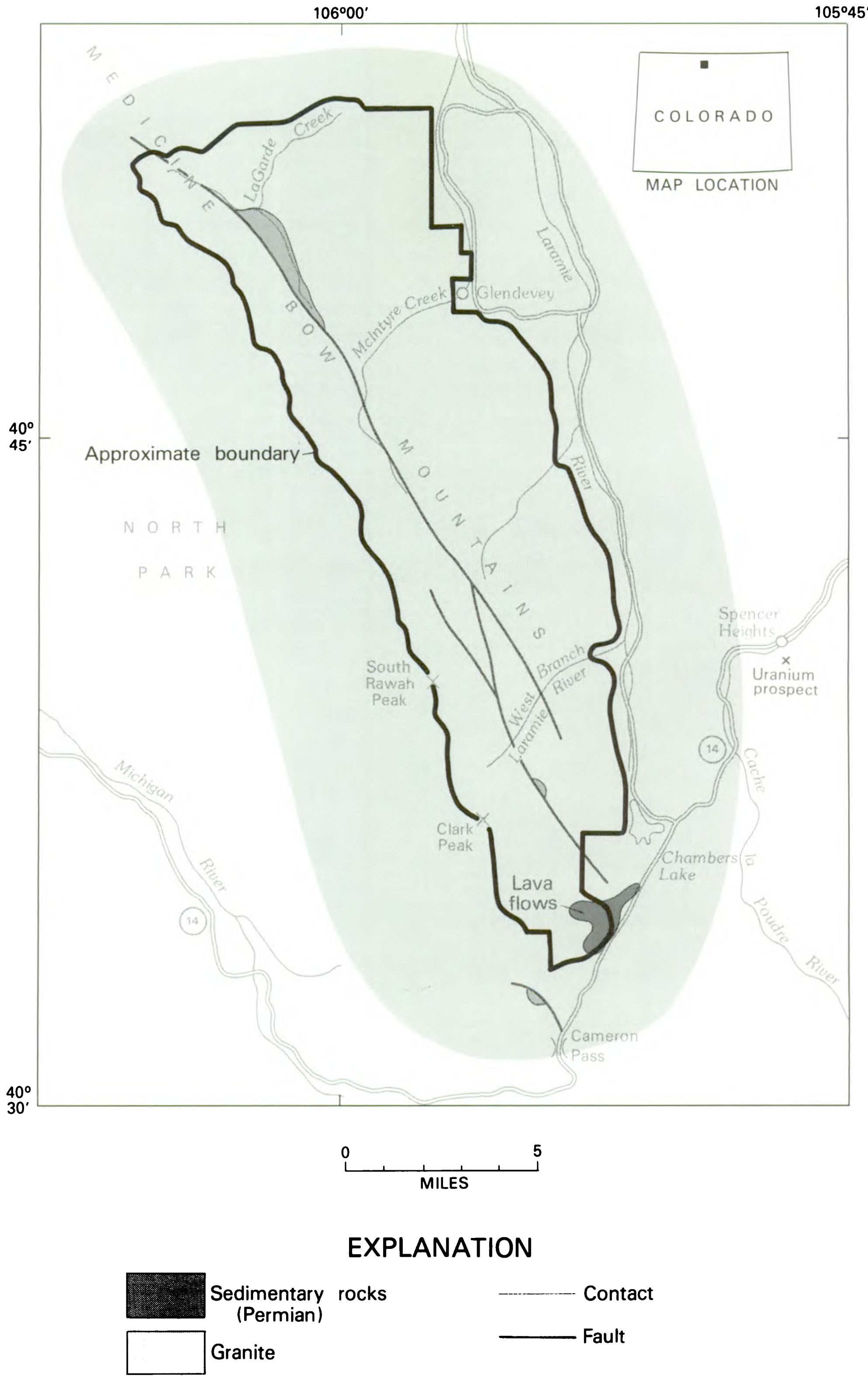

Figure 138.—Rawah Wilderness, Colorado.

RAWAH WILDERNESS, COLORADO

By R. C. PEARSON,[1] U.S. GEOLOGICAL SURVEY, and

L. L. PATTEN, U.S. BUREAU OF MINES

SUMMARY

The Rawah Wilderness, as enlarged in 1981, and some adjacent lands were studied by the USGS and USBM and their mineral-resource potential was assessed using geologic, geochemical, and geophysical data. Traces of copper, silver, uranium, tungsten, and molybdenum were found in geochemical samples, but there is little promise for the occurrence of mineral resources in this relatively unmineralized area.

CHARACTER AND SETTING

The Rawah Wilderness occupies about 119 sq mi on the east flank of the southern Medicine Bow Mountains in north-central Colorado. The crest of the range, which is approximately the west boundary of the wilderness, is sharp, between 11,800 and 12,800 ft high, and scalloped by a series of glacial cirques. The east boundary is along the Laramie River valley. Highway 14 connects Fort Collins, Colorado (60 mi to the east), with Walden, Colorado (40 mi to the west), and crosses the mountains south of the wilderness at Cameron Pass. A gravel road follows the Laramie River valley. Several trails provide access to the area from these roads.

The 43-sq-mi Rawah Wilderness was expanded to 119 sq mi when the contiguous East Rawah and East Rawah A Roadless Areas were added by passage of the Colorado Wilderness Bill in 1981.

Most of the area is occupied by inhomogeneous granitic rocks about 1700 million years old. Schists and gneisses of various kinds that represent the pre-granite country rocks are included within the granite. The inclusions are mostly less than 0.25 mi wide and 1 mi long. Much younger sedimentary rocks that formerly covered the old granitic rocks have been eroded from the wilderness except for two slabs preserved from erosion because they were dropped down against the granite along faults. Faults of many ages have broken the rocks. Those that trend northwesterly, parallel to the mountain range, are the most continuous. The entire southern part of the range is interpreted to have pivotted toward the east along a shallowly west dipping thrust fault.

The mineral-resource appraisal was made by examining the rocks during geologic mapping for signs of mineralization, by geochemical sampling, and by interpretation of aeromagnetic data. No mines and very few prospect diggings are in the wilderness. The nearest mining district of significance is the Northgate fluorspar district 10 mi northwest of the area.

MINERAL RESOURCES

The Rawah Wilderness is situated in a part of Colorado in which little mining has been done with the exception of coal and petroleum which have been produced in the nearby sedimentary basins. In addition, fluorspar mining occurs to the northwest, there are a few small precious-metal districts to the east and south, and an uranium prospect occurs a few miles to the east. The precious-metal districts are associated with bodies of intrusive igneous rock not present in the wilderness.

Several prospect pits and a shaft in the northeast part of the wilderness were dug in granite to test a weakly mineralized fault zone. Traces of copper minerals are exposed in the shaft but they are spotty and no resources of copper are evident. A few mining claims have been staked east and south of the wilderness, but little exploration was done on these claims and apparently no discoveries were made.

The geochemical survey disclosed a few weak anomalies of copper, silver, tungsten, uranium, thorium, and molybdenum. The copper and silver are in the prospect diggings mentioned above. Tungsten was detected in a

[1]With contributions from M. E. McCallum, M. L., Griswold, and V. J. Flanigan, USGS.

few stream-sediment and panned-concentrate samples in areas that suggest the possibility of weak tungsten mineralization along some of the major faults. Uranium was found in anomalous amounts in a few samples; the highest, greater than 120 parts per million in a vein a few inches wide. The anomalous thorium content of stream-sediment samples results from trace minerals in the granite. Molybdenum is present in low amounts in numerous stream-sediment samples and a few fractured and altered rocks along faults. The geochemical survey suggests the occurrence of tungsten and uranium along faults although no specific areas or targets are indicated. The copper, silver, thorium, and molybdenum anomalies probably do not indicate the existence of resources of these commodities.

A body of quartz-rich gneiss, an inclusion in the granite, in the northeast part of the wilderness contains rutile and ilmenite, ore minerals of titanium. Their content, however, is too low for the area of the quartz gneiss to be considered as having a resource potential for titanium.

In summary, no mineral resources are known in the Rawah Wilderness and the results of this study indicate that there is little promise for the occurrence of undiscovered mineral resources.

SUGGESTIONS FOR FURTHER STUDY

If our interpretation is valid that the southern Medicine Bow Mountains moved eastward along a gently west dipping thrust fault, it suggests the possibility that potential petroleum reservoir rocks are beneath the granite in at least parts of the area. This possibility could be investigated by seismic surveys or drilling.

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SANGRE DE CRISTO WILDERNESS STUDY AREA, COLORADO

By BRUCE R. JOHNSON,[1] U.S. GEOLOGICAL SURVEY, and

CLARENCE E. ELLIS, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys were undertaken, largely in 1981 and 1982, of a wilderness study area which includes most of the Sangre de Cristo Range of south-central Colorado. Four areas of probable mineral-resource potential for gold, silver, and base metals lie along a northwest structural trend which follows the western margin of the range north of the Great Sand Dunes National Monument and crosses the range south of the monument. An area of probable mineral-resource potential for similar minerals plus tungsten has been identified east of Blanca Peak at the extreme southern end of the study area. Another area of probable mineral-resource potential includes molybdenum mineralization associated with the Rito Alto stock. A small area of probable geothermal resource potential exists on the west side of the area around the Valley View Hot Springs. There is little promise for the occurrence of oil and gas resources.

CHARACTER AND SETTING

The Sangre de Cristo Wilderness Study Area includes most of the main Sangre de Cristo Range in south-central Colorado from about 7 mi south of Salida to Blanca Peak. The study area is approximately 70 mi long and averages 5 to 8 mi wide, and totals approximately 350 sq mi. The boundary generally follows the foot of the mountains except where private land or roads cause deviations. The portion of the study area west of the range crest lies in the Rio Grande National Forest; the portion east of the crest lies in the San Isabel National Forest. The town of Westcliffe is about 7 mi east of the center of the study area; Alamosa is about 15 mi southwest of the southern end of the study area.

Access is generally excellent for foot travel, with most drainages containing good trails into the heart of the range. Four-wheel drive roads cross the range at Hayden Pass on the north and at Medano Pass to the south. Altitudes range from 14,363 ft at Blanca Peak to about 8000 ft along the southwestern portion of the boundary. Several 14,000-ft peaks and numerous 13,000-ft peaks form the crest of the range for most of the length of the study area.

Most of the rocks exposed in the study area are either Precambrian crystalline rocks or upper Paleozoic clastic sedimentary rocks. Several thin, fault-bounded slivers of lower Paleozoic sedimentary rocks occur within Precambrian rocks near the western boundary of the study area. Thin units of lower Paleozoic sediments also occur locally between Precambrian rocks and upper Paleozoic sedimentary rocks. Small patches of Jurassic sedimentary rocks and Tertiary volcanic and sedimentary rocks crop out along the eastern and northeastern boundaries of the study area. The study area also contains several small granitic stocks of Tertiary age and numerous dikes and sills of mostly Tertiary age.

The Precambrian crystalline rocks are composed of several gneissic units and numerous Precambrian intrusive bodies of all sizes. A banded and layered heterogeneous package of mafic and felsic gneissic rocks occurs along the western side of the study area for most of its length. At the south end of the study area, the gneissic package is intruded by a large body of leucocratic, gneissic tonalite and by several bodies of hornblende metadiorite. Similar metadiorite bodies also intrude the gneisses at the north end of the study area. All of the gneissic units are intruded by later, weakly foliated to nonfoliated granitic bodies.

Sedimentary rocks of early Paleozoic age which crop out along the west side of the range are composed dominantly of limestone, dolomite, and sandstone. The calcareous composition of many of the lower Paleozoic

[1]With contributions from David A. Lindsey, USGS.

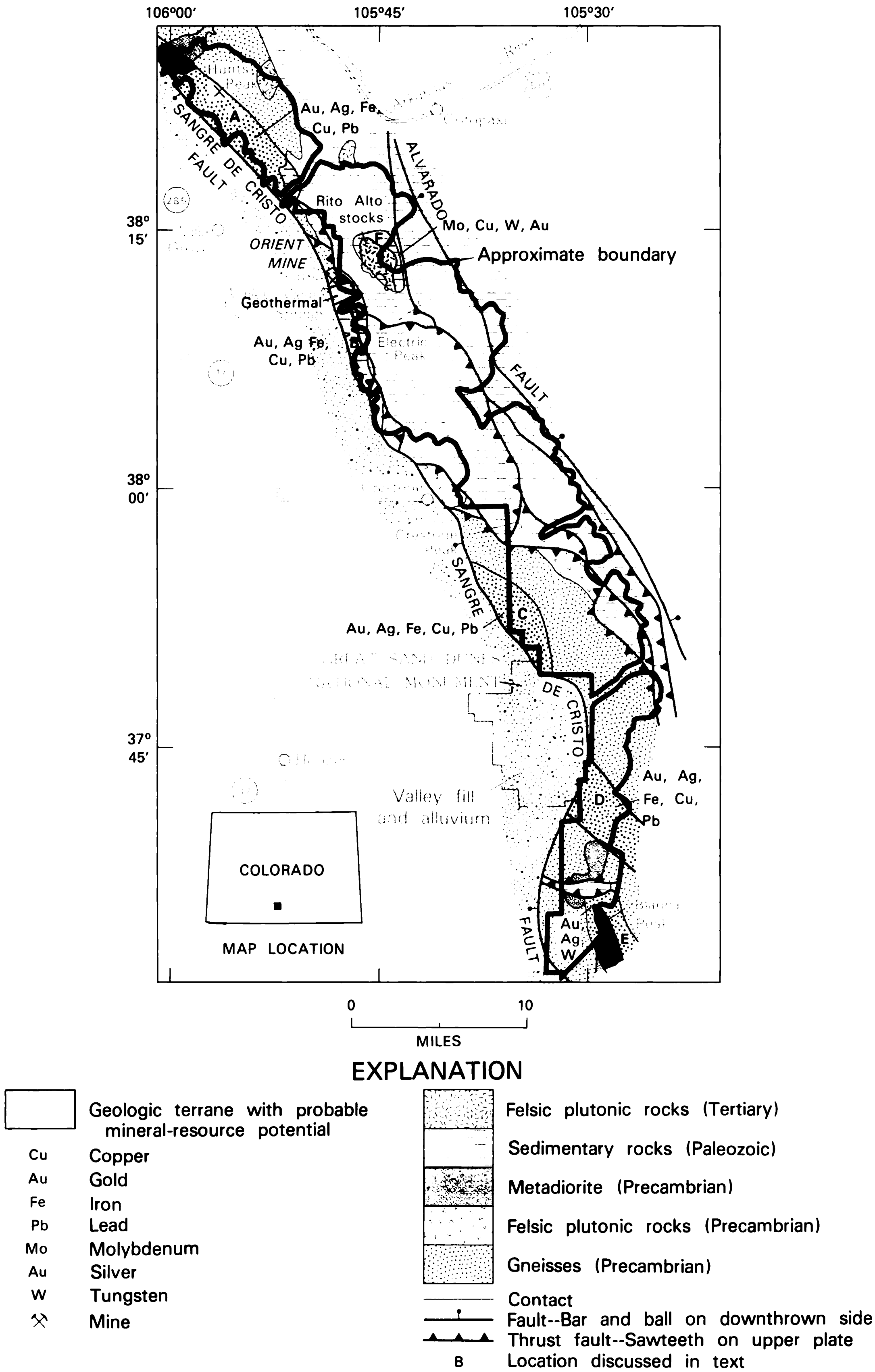

Figure 139.—Sangre de Cristo Wilderness Study Area, Colorado.

rocks makes them an ideal host for base-metal replacement deposits. Thick formations of mostly sandstone, conglomerate, and shale of late Paleozoic age crop out over much of the central and northern part of the study area. Upper Paleozoic rocks consist of as much as 6900 ft of Pennsylvanian Minturn Formation and as much as 6000 ft of Pennsylvanian and Permian Sangre de Cristo Formation. Most of the Sangre de Cristo Formation is red; the redbeds overlie an interval of calcareous beds in the lowermost part of the Sangre de Cristo Formation and the upper part of the Minturn that contains numerous small mineralized lenses having concentrations of copper and uranium.

The Precambrian and Paleozoic rocks of the study area have been folded and thrust in Laramide (Late Cretaceous to Eocene) time. The thrusts are part of a large thrust zone that extends from New Mexico northward along the east side of the Laramide San Luis-Uncompahgre uplift.

Much of the Sangre de Cristo Range in the study area is bounded by two large normal faults; the Sangre de Cristo fault extends along most of the west side of the range and the Alvarado fault extends along the northern half of the area on the east. The range-front faults formed in response to extensional rifting that uplifted the Sangre de Cristo Range and downdropped the adjacent San Luis and Wet Mountain valleys. Rifting and attendant uplift of the range probably began in late Oligocene time, proceeded rapidly at intervals beginning in early Miocene time, and continues today.

MINERAL RESOURCES

Mining activity within the study area in recent years has been limited to exploration for uranium, molybdenum, copper, and gold. Within the 20th century, gold has been produced from various properties along the west side of the study area, and uranium has been produced from a few workings scattered through the area. The study area contains no mines of significant recorded production. The Orient mine, located outside the western boundary of the study area, produced iron ore from 1880 to 1931. Production from other properties is given in Ellis and others (1983). The following descriptions of mineral resources are abstracted from Johnson and others (in press).

Areas of probable resource potential for metallic minerals which extend into the Sangre de Cristo Wilderness Study Area can be divided into three types: areas which lie along a northwest-trending fault zone that extends along most of the west boundary of the study area (A-D, on map), an area of northwest-trending veins north of Blanca Peak (E), and the Rito Alto stock and vicinity (F).

The northwest-trending mineralized zone follows most of the faulted west side of the Sangre de Cristo Range north of the Great Sand Dunes National Monument, where it may pass beneath the sand dunes, and extends southeast across the range. The concentrations of mineral occurrences and geochemical anomalies along the mineralized zone are interrupted by more barren areas, but the structural trend is interpreted to be more or less continuous. Anomalous concentrations of metals characterize several streams draining the mineralized zone. Gold occurs throughout the zone, but the relative abundance of other metals varies. Occurrences of gold, silver, iron, copper, and lead are localized within the zone by faults, shears, and calcareous strata. The calcareous rocks, which are favorable hosts for replacement deposits, crop out in the mineralized zone from Steel Canyon to Crestone, and locally further south. The iron deposits of the Orient mine, located outside the study area, replace faulted calcareous rocks. The occurrence of hot springs in the fault zone indicates potential for disseminated gold and perhaps other mineral deposits of hot-spring origin.

The Rito Alto stock is a composite granitic pluton of Oligocene age. Molybdenum, copper, tungsten, and gold mineralization are associated with the stock and nearby granitic dikes. The area of the stock has been prospected for molybdenum recently, but accurate assessment of the mineral potential of the area is limited by current lack of understanding of the level of erosion of the stock, and by inability to interpret the extent of the original mineralization system; it is an area of probable molybdenum resource potential.

At the southern end of the study area, around Blanca Peak, an area of probable mineral-resource potential has been identified on the basis of gold, silver, and tungsten mineralization associated with quartz veins. One northwest-striking quartz vein in Precambrian rock just outside the study area is exposed for about 2 mi along strike. The vein enters the study area, but is hidden under talus and its extent is unknown. The vein and its main branches have over 3000 ft of development work. Gold and silver are present in nearly every sample, and average 0.1 oz gold/ton and 2 oz silver/ton across a 4 ft width (Ellis and others, 1983). Scheelite is visible under ultraviolet light in many places. Other quartz veins within the area contain the same minerals.

Mineralized sedimentary rocks containing concentrations of copper and uranium occur in the lower part of the Sangre de Cristo Formation and the upper part of the Minturn Formation. Mineralization occurs as stratiform lenses in carbonaceous limestone, shale, and siltstone beds. Most of the mineralized lenses do not exceed 3 ft in thickness and do not extend more than a few hundred feet along strike, but one mineralized bed near the top of the Minturn Formation has been traced more or less continuously for 8 mi along strike. These occurrences have been known for many years, have been explored extensively, and no mineral resources have been identified.

Although very small massive-sulfide lenses may have escaped detection owing to the reconnaissance nature of this study, little evidence was found of Precambrian mineralization in the gneissic rocks of the study area, and there is little promise for their occurrence. No mineralized areas have been found associated with the Precambrian plutonic rocks in the study area with the exception of minor, local, disseminated sulfide minerals in the metadiorite near Blanca Peak. There is little likelihood of mineral occurrences associated with the Precambrian plutonic rocks.

A probable potential for geothermal resources exists in a small part of the study area southeast of Valley View Hot Springs, along the west side of the range. Valley View Hot Springs are outside the study area, but smaller hot springs occur nearby within the study area. There is little promise for the occurrence of oil and gas; favorable host and source rocks for oil and gas are not exposed, and are judged not to be present beneath thrusts in the study area.

SUGGESTIONS FOR FURTHER STUDIES

Mineral-resource appraisal of the Sangre de Cristo Wilderness Study Area is hampered by the reconnaissance nature of many of the geologic and mineral-deposit studies to date. Detailed study of the Rito Alto stock and vicinity might provide the data to conclude whether or not an extensive porphyry molybdenum system ever existed and if so, at what level the system is currently exposed. Similarly, detailed study of the mineralization near Blanca Peak would provide better estimates of the area's tungsten potential.

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SERVICE CREEK ROADLESS AREA, COLORADO

By PAUL W. SCHMIDT,[1] U.S. GEOLOGICAL SURVEY, and

S. A. KLUENDER, U.S. BUREAU OF MINES

SUMMARY

The Service Creek Roadless Area, near Steamboat Springs, Colorado, was studied by the USBM in 1980 and by the USGS in 1975–76 and 1982. Geologic mapping and geochemical sampling did not identify any mineral-resource potential in the area. No mining activity has been recorded for the area. An east-west topographic linear feature just south of Silver Creek, which contains clusters of single and multi-element anomalies of certain rare-earth and metallic minerals deserves further study.

CHARACTER AND SETTING

The Service Creek Roadless Area occupies an area of about 62 sq mi in the scenic mountainous regions of the Gore Range in northern Colorado. The area lies just south-southwest of Rabbit Ears Pass, about 12 mi southeast of Steamboat Springs and about 17 mi northwest of Kremmling. Total relief of the roadless area is about 4000 ft. The crest of Gore Mountain, one of the highest and only named mountainous feature in the area, has an altitude of 10,687 ft. The mountainous terrain along the western border of the roadless area, for the most part, abruptly grades into lower farm and ranch lands; whereas to the east mountainous terrain prevails. The Gore Range continues north and south of the roadless area. Secondary USFS roads give access to the east and west sides of the roadless area; U.S. Highway 40 crosses the northwestern part of the area. Two trails lead into and through the roadless area; one along Service Creek, the other along Silver Creek. Most of the terrain is covered by a moderate to dense coniferous forest. Downfall, especially within drainage basins, locally makes off-trail travel difficult. Only stretches along major drainages and a few relatively small and scattered upland areas, which are covered with lush grasses in the summer months, are free from trees.

The roadless area is dominated by a 1.7 billion-year-old batholith of quartz monzonite. Throughout this unit are randomly scattered small intrusions of younger Precambrian amphibolitic dikes and inclusions of older Precambrian metavolcanic, metasedimentary, and igneous rocks. The quartz monzonite continues both to the east and south of the roadless area, however, to the north and west it is either discontinuous or overlain by younger rocks. To the north-northwest, the quartz monzonite is intruded and overlain by Tertiary volcanic rocks that enter the roadless area at the headwaters of Harrison Creek. At the western boundary of the roadless area, sedimentary rocks of the Tertiary Browns Park Formation locally overlap onto quartz monzonite in the roadless area.

MINERAL RESOURCES

Geologic mapping and geochemical sampling of the Service Creek Roadless Area in 1975–76, north of lat 40°15′ (Snyder, 1980), and reconnaissance sampling in 1982, mainly south of lat 40°15′ (Schmidt and others, in press), show no favorable conditions for the occurrence of mineral resources. No mining activity has been recorded within the roadless area; only three prospect pits, having no identifiable mineralization, were located within the roadless area (Kluender, 1982).

The roadless area lies well north of the Colorado mineral belt, and is dominated by an essentially barren homogeneous batholith that lacks major tectonic structures, such as large-scale faults, and lacks any dominant veins or zones of alteration that would be suggestive of mineralization. Although former mining activity is recorded both north and south of the roadless area, it occurred well beyond the roadless area boundary and in a different geologic environment.

Geochemical sampling in the Service Creek Roadless

[1]With contributions by George L. Snyder and T. G. Lovering, USGS.

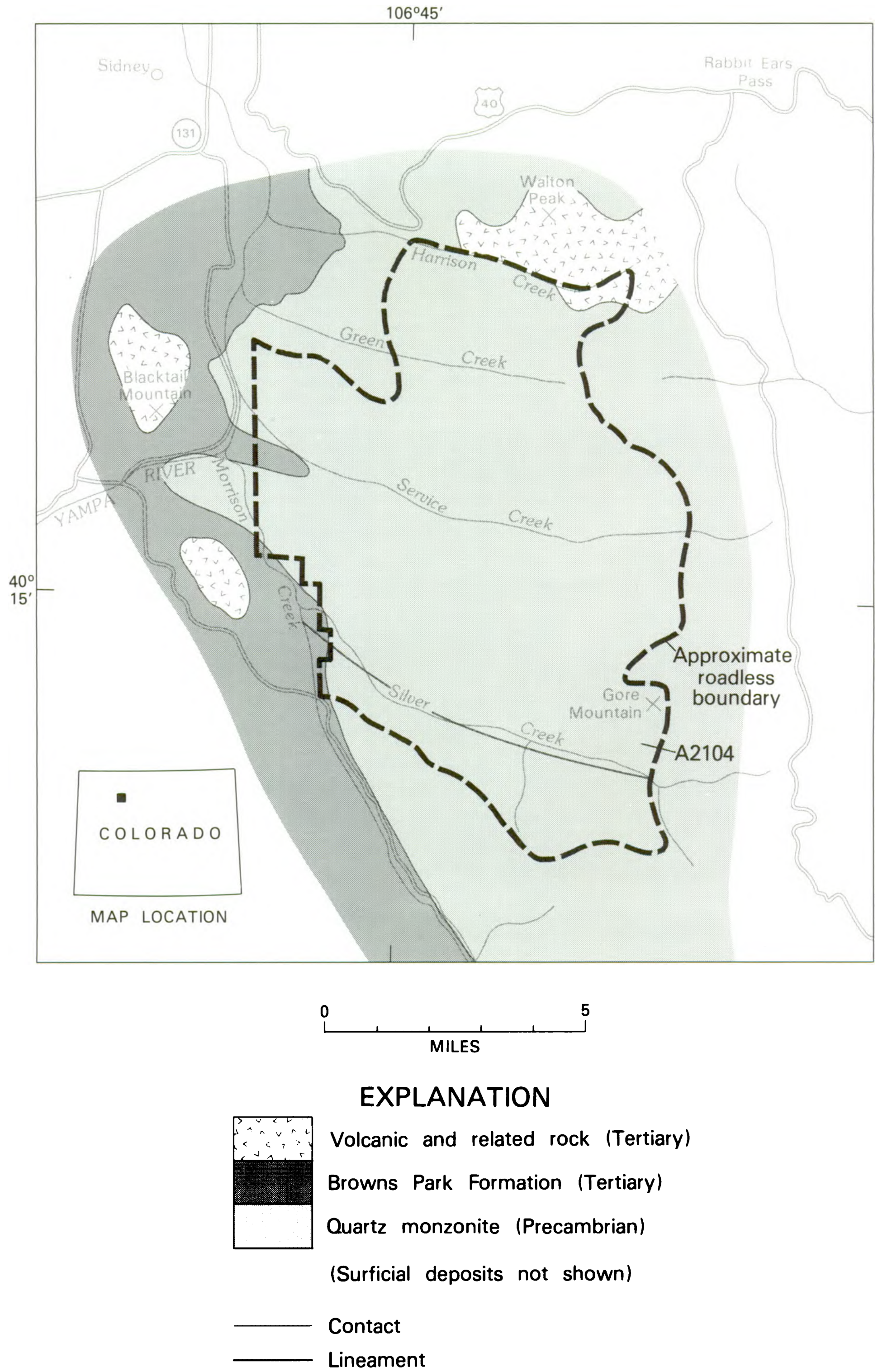

Figure 140.—Service Creek Roadless Area, Colorado.

Area has identified scattered single- and multi-element anomalies. Some stream-sediment samples contain anomalous concentrations of silver, barium, cobalt, chromium, lanthanum, manganese, nickel, lead, tin, thorium, uranium, and yttrium; some stream pan-concentrate samples contain anomalous concentrations of barium, lanthanum, molybdenum, niobium, lead, tin, thorium, vanadium, tungsten, and yttrium; and some rock samples contain anomalous concentrations of boron, barium, chromium, copper, nickel, scandium, tin, and zinc. Of these anomalies, only cobalt, chromium, lanthanum, lead, nickel, thorium, uranium, and yttrium are reported in any appreciable number of samples. The analyzed rock samples that have anomalous values were taken from small intrusive bodies or inclusions in the quartz monzonite. The small inclusions and intrusions of rock within the quartz monzonite are themselves randomly spaced and widely scattered throughout the roadless area and show neither pattern nor aerial distribution that would suggest the presence of substantial mineralization.

The principal area, possibly deserving further study within the roadless area is along and south of a linear feature just south of Silver Creek. This feature is identified from topographic and drainage features. Geochemical anomalies of both rock and stream-sediment samples identify small and isolated areas where clustering of anomalous localities exist, but no mineral-resource potential was identified.

SUGGESTIONS FOR FURTHER STUDIES

Further study of the Service Creek Roadless Area offers little, if any, promise for the identification discovery of mineral resources within the area. Although the southern part of the roadless area was mapped by reconnaissance methods, it is felt that no further examination of the area is warranted.

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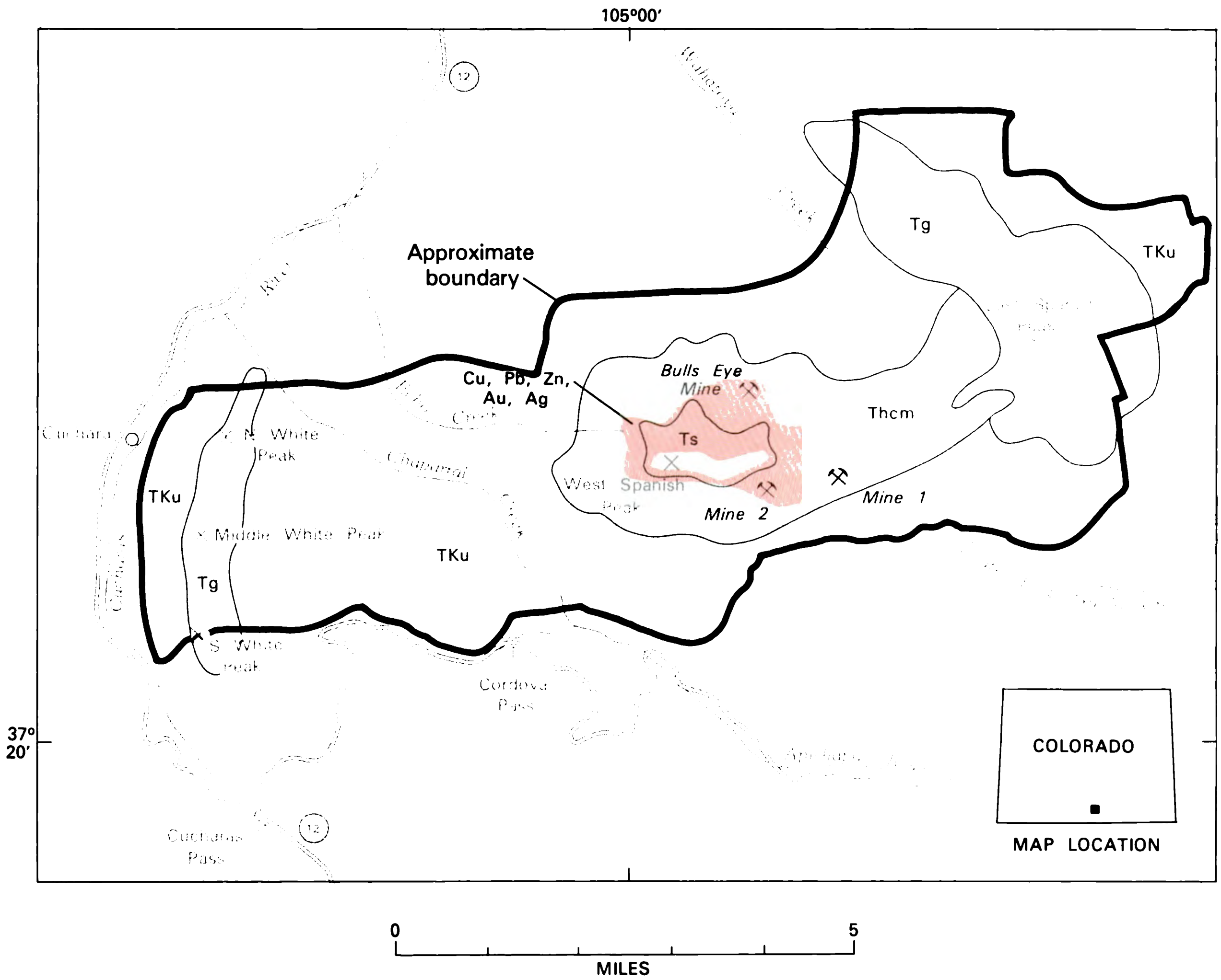

EXPLANATION

	Geologic terrane with substantiated mineral-resource potential
Cu	Copper
Au	Gold
Pb	Lead
Ag	Silver
Zn	Zinc
Ts	Syenodiorite (Tertiary)
Tg	Granite, granodiorite (Tertiary)
TKu	Undifferentiated sedimentary rocks (Tertiary and Cretaceous)
Thcm	Metasedimentary rocks (Tertiary)
———	Contact

Figure 141.—Spanish Peaks Wilderness Study Area, Colorado.

SPANISH PEAKS WILDERNESS STUDY AREA, COLORADO

By KARIN E. BUDDING, U.S. GEOLOGICAL SURVEY, and

STEVEN E. KLUENDER, U.S. BUREAU OF MINES

SUMMARY

A geologic and geochemical investigation and a survey of mines and prospects were conducted in 1982 to evaluate the mineral-resource potential of the Spanish Peaks Wilderness Study Area, Huerfano and Las Animas Counties, in south-central Colorado. Anomalous gold, silver, copper, lead, and zinc concentrations in rocks and in stream sediments from drainage basins in the vicinity of the old mines and prospects on West Spanish Peak indicate a substantiated mineral-resource potential for base and precious metals in the area surrounding this peak; however, the mineralized veins are sparse, small in size, and generally low in grade. There is a possibility that coal may underlie the study area, but it would be at great depth and it is unlikely that it would have survived the intense igenous activity in the area. There is little likelihood for the occurrence of oil and gas because of the lack of structural traps and the igneous activity.

CHARACTER AND SETTING

The Spanish Peaks Wilderness Study Area covers approximately 30 sq mi of the San Isabel National Forest in south-central Colorado. The area lies in the westernmost part of the Great Plains, bordering the eastern foothills of the Sangre de Cristo Mountains. Altitudes range from 13,626 ft on the summit of West Spanish Peak to about 8400 ft in the western portion near Cuchara. The eastern half of the study area is characterized by rugged terrain; the land and drainages slope radially away from East and West Spanish Peaks. The principal drainages are Wahatoya and Trujillo Creeks. The relief in the western half of the study area is less severe; the major drainages are the north-trending Chaparral and Echo Creeks. North, Middle, and South White Peaks (altitude 10,446 ft) are located near the western boundary of the study area.

Colorado Highway 12 and the Cucharas River parallel the study area on the west. USFS Route 415 and the Apishapa River run along the southern margin. A few secondary roads reach the boundary of the study area.

Sedimentary rocks, Paleozoic to Tertiary in age, surround the Spanish Peaks. Between 20 and 25 million years ago (Smith, 1979) the sedimentary rocks were intruded by a series of igneous rocks. The sequence of intrusion is as follows: (1) granite porphyry of East Spanish Peak, (2) compositionally similar granite of North, Middle, and South White Peaks, (3) porphyritic granodiorite intruding the core of East Spanish Peak, and (4) syenodiorite of West Spanish Peak. An impressive dike swarm, primarily trachyandesite porphyries, radiates away from West Spanish Peak; the dikes were emplaced throughout the igneous sequence. An aureole of metamorphosed sedimentary rocks surrounds the intrusive core of this peak.

To assist the assessment of the mineral-resource potential of the study area a geochemical survey was made, utilizing stream-sediment, panned concentrate, and rock samples. Each sample was analyzed semiquantitatively for 31 elements using an optical emission spectrograph. Additional analyses for gold, bismuth, antimony, arsenic, zinc, and cadmium by atomic absorption and for uranium by fluorimetry were made on the rocks and stream sediments. Results of the geochemical survey are discussed in Budding and Lawrence (1983).

West Spanish Peak is the site of past mining activity. The total production prior to 1908 from the mines on the peak was 168 oz of gold, 1176 oz of silver, 92 lb of copper, and 1067 lb of lead. Placer gold was reported by Hills (1901) from streams tributary to Wahatoya Creek and the Apishapa River. In 1932 and 1934, a few ounces of placer gold were produced from the north side of the study area. Four tons of lead-silver ore were shipped from the area in 1934 and 1935 (Colorado Mineral Resources Board, 1947).

MINERAL RESOURCES

The majority of the geochemical anomalies revealed by the survey were found in the vicinity of the old workings on West Spanish Peak. The anomalous metals include lead, zinc, silver, copper, and minor gold. All known workings in the study area are found in the zone of contact metamorphosed sedimentary rocks surrounding the intrusive of West Spanish Peak. Mineralized veinlets along a N. 65° E. shear zone have been worked in the Bulls Eye mine on the north side of West Spanish Peak. Quartz veins bear argentiferous galena, tetrahedrite, chalcopyrite, and sphalerite, associated with siderite, calcite, and barite. Two mines on the eastern side and southeastern side of West Spanish Peak (mines 1 and 2), along with workings on several ridge tops, indicate additional areas of past activity. Vein material here is similiar to that found at the Bulls Eye mine.

The known mineralized veinlets are few in number and low in grade. A substantiated mineral-resource potential for lead, zinc, copper, silver, and gold is assigned to areas proximal to the old workings and to other mineralized or anomalous areas as indicated on the map. The majority of the study area lacked significant anomalies indicating metallic deposits. There is a possibility that coal may underlie the study area, but it would be at great depth and it is unlikely that it would have survived the intense igenous activity in the area. There is little likelihood for the occurrence of oil and gas because of the lack of structural traps and the igneous activity.

SUGGESTIONS FOR FURTHER STUDIES

It is unlikely that further investigation of the study area will reveal additional resource potential. The recent drilling for petroleum and (or) for carbon dioxide just south of the study area boundary in the Apishapa River drainage should be monitored, and if successful, the potential for these commodities should be reevaluated.

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UNCOMPAHGRE PRIMITIVE AREA, COLORADO

By R. G. LUEDKE, U.S. GEOLOGICAL SURVEY, and

M. J. SHERIDAN, U.S. BUREAU OF MINES

SUMMARY

A mineral-resource study was made in 1966 and 1967 of that part of the Uncompahgre National Forest constituting the officially designated primitive area. Because the primitive area and its southern border zone contained operating mines producing gold, silver, copper, lead, zinc, and minor amounts of a few other metals, and had been a part of a highly productive mining region since the 1870's, the area was concluded to have large segments of both probable and substantiated mineral-resource potential in 1968. No energy resources were identified in the study.

CHARACTER AND SETTING

The Uncompahgre Primitive Area is in the northwestern San Juan Mountains of southwestern Colorado, and covers about 130 sq mi, mostly in the southern part of Ouray County and adjacent parts of Hinsdale, San Juan, and San Miguel Counties. It is an irregularly shaped area and is divided into two parts by a narrow corridor of excluded land that extends along the Million Dollar Highway (U.S. Route 550) through Ouray. The spectacularly rugged alpine terrain of the area, ranging in altitude from about 9000 ft to more than 14,000 ft, is dominated by sharp peaks, broad basins, and deep, steep-walled canyons; it is generally accessible by trails and a few jeep roads. Accessibility and climate, particularly the long and often severe winters, have caused problems in developing the mineral potential of the area. However, Ouray, Silverton, and Telluride, which serve as local centers to the mining and other industries of the area, are readily accessible by all-weather roads from Montrose and Durango, principal business and supply points in southwestern Colorado.

The impressive topography of the primitive area was carved by glacial and stream erosion of a thick blanket of volcanic rocks that lies on a basement of metamorphic, sedimentary, and igneous rocks ranging in age from Precambrian to Tertiary. The volcanic rocks surround a complex of subsided blocks (cauldrons) in vent areas partly within but mostly south of the primitive area. The rocks record a long, complex, and fairly complete sequence of geologic events that have affected the entire region through much of geologic time. The geologic history of the region includes several periods of deformation, erosion, and igneous activity.

The mineral deposits were formed during two distinct periods. The older deposits are related to Laramide deformation and intrusive igneous activity, and they occur mainly in the sedimentary rocks in the vicinity of Ouray and Telluride as veins, replacements, and disseminations. The younger deposits, related to the waning phases of widespread Tertiary volcanism, occur in the volcanic and underlying basement rocks in the southern half to two-thirds of the area, and are localized mainly in and along the radial and concentric fractures about the cauldrons as veins, chimneys, replacements, and disseminations. Fissure veins constitute the major source of the precious- and base-metal ores produced from the area. Erosion since ore deposition exposed the many veins and ore bodies at the surface; thus many of the larger mines within the primitive area have been developed through adits or tunnels driven from the deep canyons outside the area.

Prospecting and claim location within the area began after a treaty between the Federal Government and the Ute Indians was negotiated in 1874. During the next 30 years most of the richest deposits were discovered and mined. Through the years, reduction of the costs of ore production resulted from the building of smelters, improving methods of ore treatment, and constructing roads and railways. The mining industry of the area generally has kept pace with economic trends, and through recent consolidation of properties is carrying out deeper exploration and mining.

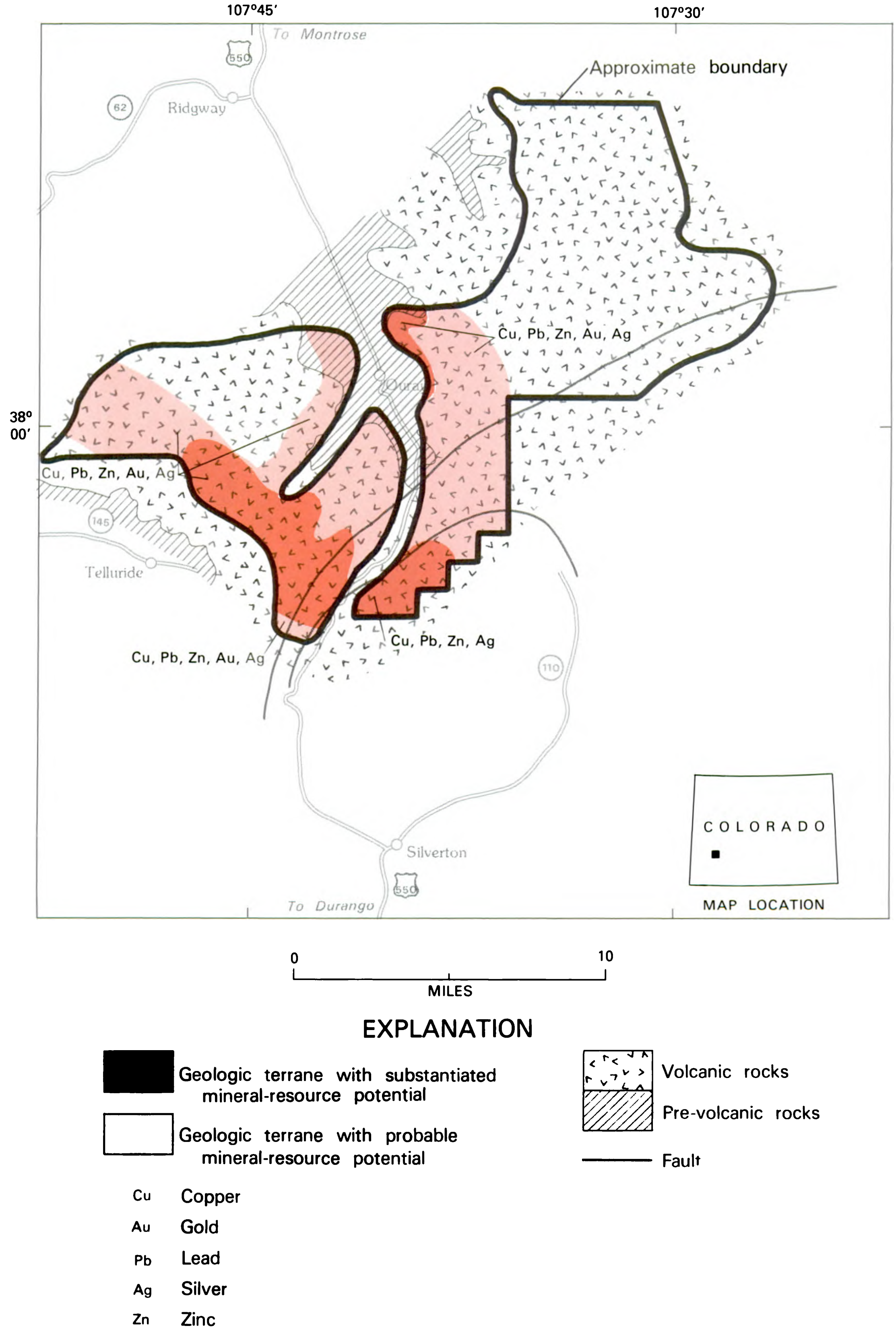

Figure 142.—Uncompahgre Primitive Area, Colorado.

Since passage of the the Wilderness Act in 1964, a mineral survey was made of the approximate 108 sq mi within the Uncompahgre Primitive Area (established in 1932) and an additional 22 sq mi added in 1966. Results of that geological and geochemical study, made in 1966 and 1967, were published in 1968 (Fischer and others, 1968). The results of geophysical studies were released in 1970 (Popenoe and Luedke, 1970). Additional geologic maps and reports on various parts of the area have been published since 1970.

MINERAL RESOURCES

Mineral production from the primitive area and a 1 1/2 mi-wide border zone has far exceeded $330 million since the early 1870's. Most of the production is in gold, silver, copper, lead, and zinc, but includes small amounts of bismuth, tungsten, uranium ores, fluorspar, bog iron ore, and some sand and gravel. Probably some antimony, arsenic, and cadmium have been recovered as byproducts at the smelters treating ores mined in the area. Occurrences of barite, gypsum, limestone, manganese, molybdenum, and various clay minerals also are known in the area.

Claim records for 1966 showed that about 4000 patented claims and more than 700 unpatented claims existed in and near the primitive area. Only a few groups of claims, however, accounted for the output of ores, which in the 1950's, 60's, and 70's came from two large mining operations and several small ones. In 1965, mines mostly in and near the primitive area, within Ouray and San Miguel Counties, yielded nearly $9.5 million worth of precious and base metals, which was 32 percent of the total Colorado production of these metals in that year. Base- and precious-metal ore reserves in 1967 were estimated to aggregate several million tons, representing about a 10-year supply of ore at the current (1967) rate of mining; additional undiscovered resources may be at least a few times greater than the known resources.

The primitive area, particularly the approximate southern two-thirds, is part of one of the most intensely mineralized regions in the United States. Ore deposits in that part of the primitive area at Ouray occur mainly in east-trending veins and in some tabular and irregularly shaped ore bodies within limestone and sandstone beds centered in part about an intensely altered granodioritic stock exposed near Ouray. Veins and clastic dikes farther north of Ouray suggest additional intrusive bodies to the northeast; if fractures and other structures favorable for localization of ore are present along that zone, significant resources might be buried northeastward beneath the volcanic rocks.

The southwestern part of the primitive area, between Ouray and Telluride and west of U.S. Highway 550, contains many veins and mines, including the area's two major operating mines in 1968. It is a part of the area in which there has been almost continuous mining since it was first opened to prospecting. Veins, some 2 to 4 mi in length, dominantly trend northwestward, radially to the cauldrons, and contain silver-bearing sulfides of lead, zinc, and copper, and gold-bearing quartz. Most of the ore came from veins in the volcanic rocks, but in recent years ore has been mined also from replacement deposits in the sedimentary rocks beneath the volcanic rocks. Much favorable ground remains to be explored.

The southernmost part east of the highway, called the Red Mountains area, was mined in the late 1800's for very high grade silver-bearing copper and lead ores, mainly in chimney and pipelike deposits located within the intensely altered and silicified rocks of the cauldron ring-fracture zones. Some mines were virtually exhausted at that time, but low-grade ore probably remained in a few mines, and, possibly, blind or undiscovered high-grade shoots may exist in others. Geologic evidence also strongly suggests the existence of undiscovered deposits; geochemical prospecting techniques (Burbank and others, 1972; Fisher and Leedy, 1973) appear promising for the discovery of such deposits.

That part of the area southeast of Ouray also contains many veins, some of which are well defined and are fairly extensive; they trend mostly northward and northeastward. A few small high-grade ore bodies of base and precious metals have been mined, but because only a relatively small part of the known veins have been explored by mine workings, the resources of the area southeast of Ouray can be determined best by extensive subsurface exploration.

The mineral potential of the remaining parts of the primitive area, principally the relatively unexplored northern one-third, is not well known and is difficult to evaluate. Geologic relationships may be favorable for the occurrence of mineral deposits at depth, but the area is concealed beneath a great thickness of barren volcanic rocks and no resource potential was identified. Little or no prospecting work by modern methods has been done.

The general distribution of individual mineral commodities—including elements that have been commercially important, and those that might be significant as geologic guides in exploration and appraisal—vary in abundance from place to place in the primitive area. Most of the production has come from the southwestern part. Gold, which occurs free in quartz, has been found mostly in veins in the southwestern part but was significant in deposits near Ouray. Most of the silver, which occurs mainly in lead sulfides, has come from veins in the southwestern part and from pipelike deposits in the Red Mountains part. Lead and zinc, as the sulfide minerals galena and sphalerite, respectively, are ubiquitous to the mineralized parts of the area. Copper, as copper sulfides, is intimately associated locally with the lead and zinc sulfides; the bulk of it was obtained from the southwestern part of the primitive area. A small tonnage of tungsten ore from mines south of Ouray was shipped, but the tungsten resource potential is mostly unknown. Fluorite, the ore mineral of fluorine, is an abundant gangue mineral in scattered vein deposits, but resources are probably small. Uranium-bearing occurrences in the easternmost part of the area have yielded small amounts of ore but others elsewhere in the area appear low in uranium content; the presence of a uranium resource is not considered likely. Antimony, arsenic, bismuth, and cadmium have been recovered from widely scattered deposits as byproducts by smelters; the occurrence of these elements in quantities sufficient to constitute a resource is not considered likely. Cobalt, nickel, molybdenum, and tin also are widely but rather erratically distributed in minor amounts in samples of vein and mineralized material. These elements may be useful as guides for geochemical exploration. Moderate-sized deposits of sand and gravel along the major drainages will continue to be exploited locally.

Much of the southern two-thirds of the Uncompahgre Primitive Area has a probable or substantiated mineral-resource potential for the occurrence of resources like those mined in the past, and unsuspected mineral occurrences may exist in nearly all of the primitive area.

SUGGESTIONS FOR FURTHER STUDY

Because of the extensive past and recent geologic literature covering the primitive and nearby areas, further study of the area offers little promise except in selected localities where detailed geologic mapping, use of geochemical and geophysical prospecting techniques, and drilling might be warranted.

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STUDY AREAS CONTIGUOUS TO THE UNCOMPAHGRE PRIMITIVE AREA, COLORADO

By THOMAS A. STEVEN, U.S. GEOLOGICAL SURVEY, and

CARL L. BIENIEWSKI, U.S. BUREAU OF MINES

SUMMARY

Important mineral deposits of several ages have been exploited at many places in the western San Juan Mountains, including the originally studied Uncompahgre Primitive Area. Although the three contiguous areas—western, central, and eastern—considered here are largely outside the more productive mining areas, a mineral study completed in 1972 indicated that there are areas of probable resource potential for base and precious metals near the margins of the areas. Results of this study indicate that there is little promise for the occurrence of fossil fuels and geothermal energy.

CHARACTER AND SETTING

A mineral survey was made by the USGS and the USBM in 1972 of three areas contiguous to the Uncompahgre Primitive Area in southwestern Colorado that were proposed for inclusion in the National Wilderness Preservation System (Steven and others, 1977). The combined area covers about 215 sq mi of rugged terrain in the western San Juan Mountains.

The western San Juan Mountains, including the three contiguous areas studied, consist of a deeply dissected volcanic plateau built in middle Tertiary time on a platform of slightly deformed Paleozoic, Mesozoic, and local lower Tertiary sedimentary rocks. Paleozoic sedimentary rocks are exposed along the lower slopes above the Uncompahgre River near Ouray, along the San Miguel River near Telluride, and in small areas northeast of Ouray. Mesozoic sedimentary rocks overlie the Paleozoic rocks in all these places and generally are more extensively exposed. Intrusive rocks emplaced during latest Cretaceous time cut both the Paleozoic and Mesozoic sedimentary rocks near Ouray and to the northeast. Conglomerate of early Eocene age unconformably overlies the sedimentary and intrusive rocks in places near Ouray, and much more widely between Ouray and Telluride. A thick pile of middle Tertiary volcanic rocks overlies the sedimentary and early intrusive rocks and, together with related intrusive rocks, constitutes the great bulk of the San Juan Mountains.

Mineralization took place during both the Late Cretaceous and middle Tertiary periods of igneous activity.

MINERAL RESOURCES

The southeastern part of the western contiguous area is cut by numerous veins. Some of them are the northwestern ends of major veins that have produced significant base- and precious-metal ore in the major mining area a few miles southeast, and mine maps indicate some underground workings within the western contiguous area. Other shorter veins extend into the western contiguous area from the Sneffels intrusive center, which lies just to the east; some of them may contain significant metallic resources at depth and the area has a probable mineral-resource potential. The several veins cutting the volcanic rocks near the Whipple Mountain center in the western part of this contiguous area indicate widespread hydrothermal activity, however low metal concentrations measured at the surface and the weak vein structures do not favor the occurrence of mineral resources.

Surface indications of hydrothermal activity are weak within the central contiguous area, but a probable mineral-resource potential exists for base- and precious-metal occurrences in the southern part. The middle Tertiary volcanic rocks at the surface unconformably overlie productive Upper Cretaceous deposits exposed along the Uncompahgre River valley near Ouray, where only the western part of a mineralized intrusive center has been uncovered by recent erosion. If the eastern side of the center is mineralized comparably to the western side, a potential exists under the volcanic cover between the Uncompahgre River and western half of the central

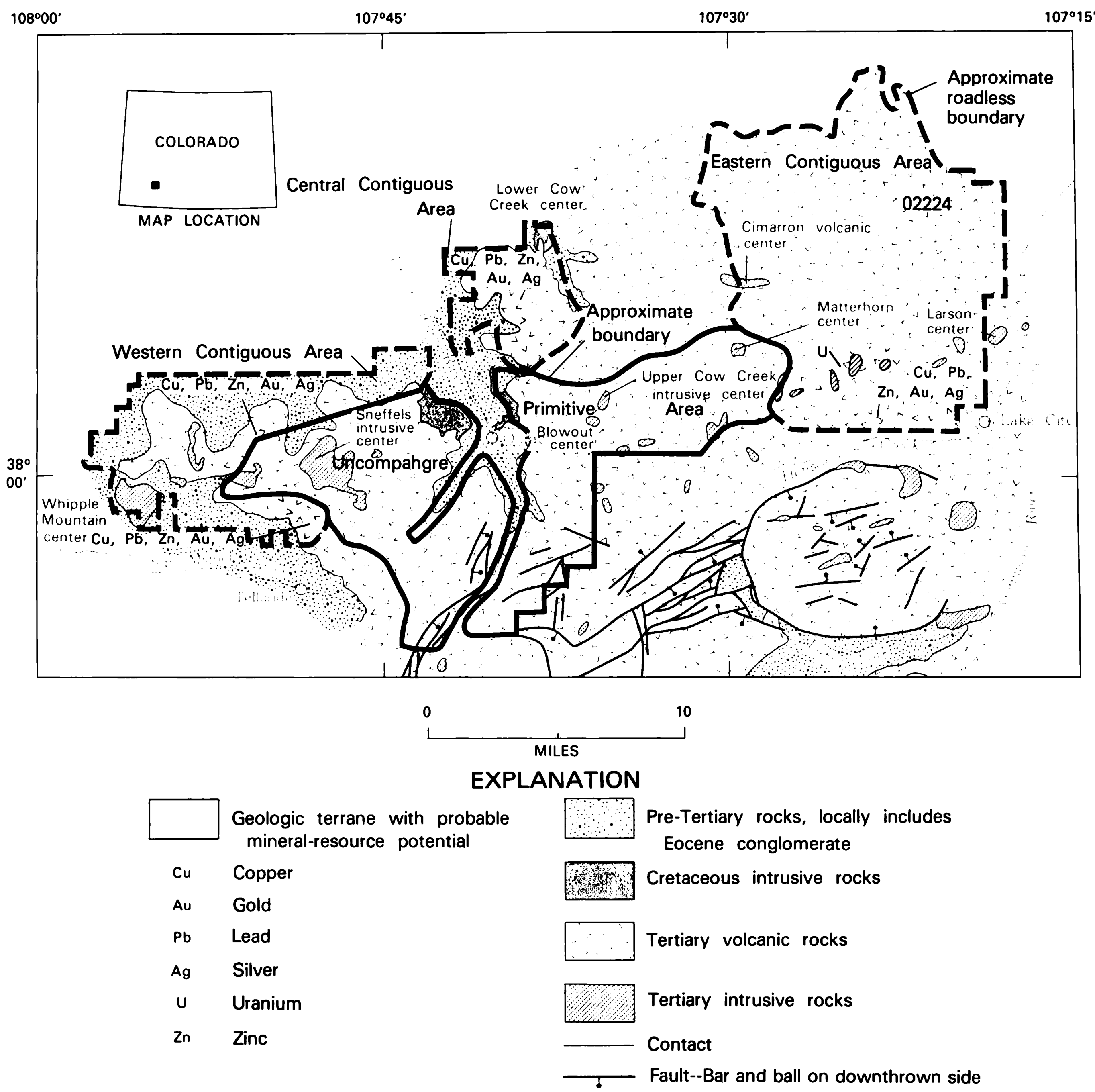

Figure 143.—Study areas contiguous to the Uncompahgre Primitive Area, Colorado.

area. Much of this area is in the original Uncompahgre Primitive Area and south of the central contiguous area, but productive veins are known along the southwest side of the central contiguous area, and similar veins almost certainly exist under the adjacent volcanic cover to the northeast. Other intrusive centers, possibly with related mineral deposits, may exist elsewhere beneath the volcanic cover in the central contiguous area. Such deposits would be difficult and expensive to find. The probability that they exist is sufficiently good, however, to postulate a probable mineral-resource potential for base and precious metal occurrences.

The Upper Cow Creek intrusive center cutting volcanic rocks on Bighorn Ridge along the northern margin of the Uncompahgre Primitive Area southeast of the central contiguous area is locally altered and some samples contain anomalous concentrations of copper. This center could contain a disseminated porphyry-type copper deposit.

Several mineralized areas occur along the southern periphery of the eastern contiguous area. These areas are in part marked by aeromagnetic lows that may be related to hydrothermally altered rock and may have resource significance. The Matterhorn volcanic center, Iron Beds altered area, and Capitol City mining area are all just outside the southwestern margin of the contiguous area; these altered and mineralized areas are associated with monzonitic intrusive bodies, and all of them may have potential for the occurrence of mineral deposits. Base- and precious-metal veins are known in lower Henson Creek along the south side of the eastern contiguous area, and at least two of these approach and may extend into the contiguous area. Several of these veins have produced significant metal in the past and probably contain significant additional resources. The best area for the occurrence of mineral deposits, however, is largely south of the eastern contiguous area.

The Cimarron volcanic center is along the western side and partly within the eastern contiguous area. The intrusive core and adjacent wallrocks are irregularly altered, but evidence for mineral deposits is sparse. The potential for disseminated copper or molybdenum deposits within the intrusive core seems better than for significant vein deposits, but available evidence does not favor the occurrence of deposits of either type.

Anomalously radioactive rhyolite intrusions, which extend eastward across the southern part of the eastern contiguous area, contain at least three areas with small concentrations of secondary uranophane in fracture zones, and a few tons of uranium ore have been mined from one of these areas. Other similar concentrations may exist, and some of them may be of sufficient size to be considered resources. Most rock appears somewhat depleted in uranium, however, and the area has only a probable uranium resource potential.

The remainder of the eastern contiguous area, embracing most of the area north of the Henson Creek drainage and east of the East Fork Cimarron River, shows only local evidence of hydrothermal activity and little likelihood for the occurrence of mineral resources.

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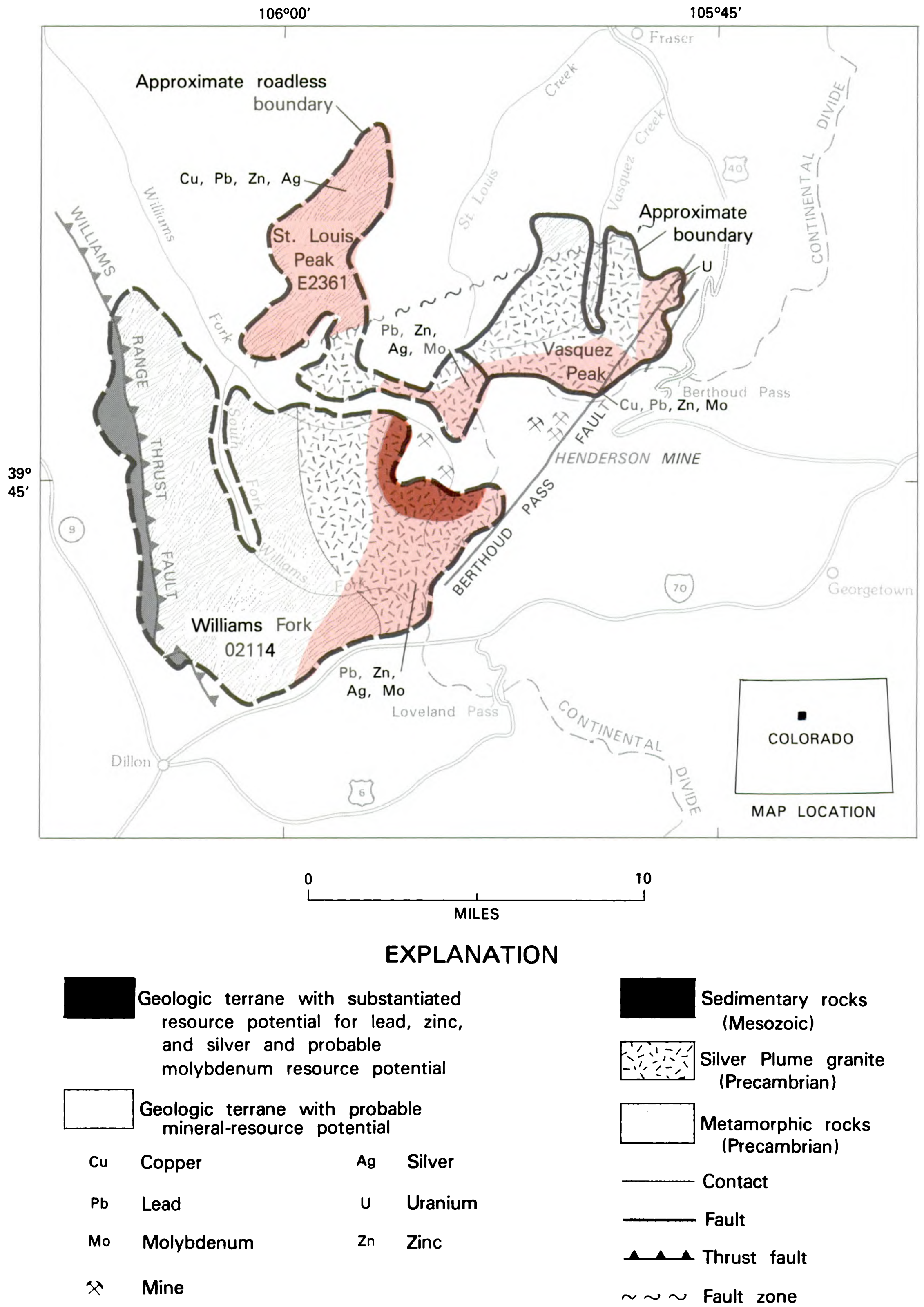

Figure 144.—Vasquez Peak Wilderness study area, and St. Louis Peak and Williams Fork Roadless Areas, Colorado.

VASQUEZ PEAK WILDERNESS STUDY AREA, AND ST. LOUIS PEAK, AND WILLIAMS FORK ROADLESS AREAS, COLORADO

By P. K. THEOBALD,[1] U.S. GEOLOGICAL SURVEY, and

A. M. BIELSKI, U.S. BUREAU OF MINES

SUMMARY

A mineral-resource survey was conducted during the years 1979–82 in the Vasquez Peak Wilderness Study Area and in the St. Louis Peak and Williams Fork Roadless Areas, central Front Range, Colorado. These three areas lie in the Colorado Mineral Belt, a long narrow region that reaches from the plains near Boulder to the southwest side of the San Juan Mountains in southwest Colorado. Probable resource potential for the occurrence of copper, lead, zinc, and silver in massive sulfide deposits has been identified in calcareous metamorphic rocks in the northern part of the St. Louis Peak Roadless Area and in the southern part of the Williams Fork Roadless Area. A probable resource potential for vein-type uranium deposits is identified along the Berthoud Pass fault zone in the eastern part of the Vasquez Peak Wilderness Study Area. A large area encompassing the eastern and southeastern part of each of the three areas has probable and substantiated potential for either high-grade lead-zinc-silver vein deposits, or larger, lower-grade clustered vein deposits. A probable resource potential for stockwork molybdenum deposits related to porphyry molybdenum type mineralizaton exists beneath the lead-zinc-silver-rich veins. The nature of the geologic terrane indicates little likelihood for the occurrence of organic fuels.

CHARACTER AND SETTING

The three areas studied, the Vasquez Peak Wilderness Study Area, the Williams Fork Roadless Area, and the St. Louis Peak Roadless Area, are on the west side of the Front Range to the north of Interstate Highway 70 and to the southwest of U.S. Highway 40 about 45 mi west of Denver. The altitudes range from less than 9000 ft in the main valley of the Williams Fork to more than 13,500 ft on the Continental Divide.

The uplift of the Front Range segment of the Ancestral Rockies began more than 200 million years ago. Subsequent erosion stripped all Paleozoic rocks from the basement in the area studied. Renewed uplift, as a broad arch, shaped the present range about 70 million years ago. During this uplift, the rocks along the west side of the range broke along the Williams Range thrust fault and the basement rocks moved upward and westward over Mesozoic sedimentary rocks that had been deposited between these periods of uplift.

Igneous activity accompanied and followed the second period of uplift and was abundant north, east, and south of the areas studied. Within the three areas, a single swarm of minor mafic dikes is the only reflection of this activity, and the abundant mineralization associated with less mafic igenous rocks to the east and south is not evident. Erosion following this second uplift stripped the overlying rocks from the basement rocks and produced the deeply weathered, topographically subdued surface of the present upland.

A third episode of uplift, about 30 million years ago, produced the present altitude of the range. Igneous activity accompanying the third uplift was much more silicic and was associated with the major episode of mineralization that produced the large molybdenum deposits of Colorado. Rhyolite dikes belonging to this igneous episode occur along the southern edge of the

[1]With contributions by R. G. Eppinger, R. R. Carlson, H. N. Barton, C. K. Moss, and R. L. Turner, USGS, and T. J. Kreidler and L. W. Hamm, USBM.

Vasquez Peak Wilderness Study Area and the eastern part of the Williams Fork Roadless Area.

The basement rocks that underlie most of the areas studied are nearly 2000 million years old. They consist of a variety of igneous and metamorphic rocks. Other than serving as the host rocks for subsequent mineralization, only two groups of these rocks directly relate to the assessment of mineral-resource potential. Massive sulfides occur in these basement rocks in a group of highly calcareous gneisses, including small amounts of marble, which crop out to the north of an ancient fault zone in the central and northern part of the St. Louis Peak Roadless Area. Pods of sulfides, now seen at the surface as iron oxides that have replaced original iron sulfides, are contained in the more calcareous rocks of this group in many places. Float blocks containing the oxidized sulfides were found in a few places on the upland surface and more abundantly in the glacial deposits of the valleys. All of the sulfides seen in place have been in pods too small to constitute a resource in themselves, but their presence indicates that the processes that have produced larger deposits in similar terrane elsewhere in the central Rocky Mountains were operative here. Geologic mapping in detail adequate to establish the distribution of this group of rocks is not available for the western and southern part of the Williams Fork Roadless Area, although the reconnaissance geology available for these areas indicates that they may be present at least in the south.

The youngest of the Precambrian basement granites, the Silver Plume Granite, crops out throughout most of the Vasquez Peak Wilderness Study Area, the southeastern part of the St. Louis Peak Roadless Area, and the eastern part of the Williams Fork Roadless Area. The granite itself is abnormally radioactive. Most of the radioactivity is from thorium but a significant part is from uranium. Concentrations of these elements in the granite are low, but along the Berthoud Pass fault zone later events appear to have redistributed and locally concentrated the uranium.

Tertiary igneous rocks, closely related to the major metal deposits throughout Colorado, are only sparsely represented in the areas studied and the mineralization associated with the early Tertiary igneous rocks is not significant within the areas. The middle Tertiary rhyolites seen occasionally in small dikes thoughout the southeastern part of the areas studied are related to mineralization. In the Henderson mine area, just south and east of the areas studied, a middle Tertiary intrusive center hosts the world's second largest accumulation of molybdenum ore. Within the areas studied, alteration, veining, and mineralization are abundant in the vicinity of the outcrops of the rhyolite dikes. The distribution of these features suggests that intrusive centers similar to the one at the Henderson mine may exist at depth in the eastern part of the Williams Fork Roadless Area and in the easternmost lobe of the St. Louis Peak Roadless Area.

The areas studied are structurally complex; the ground is favorable for the occurrence of mineral deposits. In the north, north- and east-trending faults predominate. On the west, the Williams Range thrust, and parallel faults to the east of it, trend northwesterly. On the east, the Berthoud Pass fault zone trends northeasterly, converging southwesterly with the Williams Range fault system. The triangle within these three domains is a confusion of faults, and contains the most evidence of mineralization.

Tertiary and Quaternary sedimentary rocks are unconsolidated and mantle the upland, the valley walls, and the valley floors. Slumping deforms the upland surface and landslides deform the valley walls. In all, this cover limits the amount of visible bedrock to less than a third of the area.

Geochemical evidence for mineralization has been obtained from concentrates of heavy minerals from stream sediments and soils, from rocks and soils collected over shear zones, altered areas, and from prospect pits. Although slightly anomalous values for lead were found in zones along faults in the Mesozoic sedimentary rocks and along faults in Precambrian rocks that extend southeastward into the Williams Fork Roadless Area from the main Williams Fork valley, these zones lack significant concentrations and are not regarded as containing resources. Many samples with anomalous amounts of copper, lead, zinc, and silver were found in the portions of the area studied underlain by the calcareous metamorphic rocks; these samples commonly contain pyrite and occasionally the zinc-bearing oxide mineral, gahnite.

Many samples from the southeastern side of the Williams Fork Roadless Area and the Vasquez Peak Wilderness Study Area contain anomalous amounts of lead, silver, zinc, molybdenum, and some contain anomalous quantities of copper, tin, and gold. Pyrite and fluorite are seen in many samples and some contain galena, sphalerite, molybdenite, and chalcopyrite. A near-surface source for these metals is likely.

Regional gravity surveys have defined a large regional gravity low approximately coincident with the major areas of mineralization in central Colorado. Three large molybdenum deposits as well as many smaller deposits are located along the edge of this gravity feature. The three areas studied are at the north end of this regional gravity low. More detailed gravity surveys within and adjacent to the areas define a cluster of smaller-scale gravity lows in the areas where rhyolite dikes have been seen and hydrothermal alteration is most intense. The observed coincidence of a general magnetic low found by an aeromagnetic survey with the gravity low is compatable with this interpretation.

Two organized mining districts, the La Plata to the west and the Daily (Atlantic) to the east, overlap the three areas studied along the Continental Divide in the vicinity of the Henderson mine.

Two unorganized mining districts, the Byers Peak (St. Louis Lake) and the Iron Creek, are just to the east of the main part of the St. Louis Peak Roadless Area on the west side of St. Louis Creek.

MINERAL RESOURCES

The pods of sulfides in the calcareous metamorphic rocks contain significant quantities of lead, zinc, silver, and copper. Two occurrences in well-exposed terrane east of the St. Louis Peak Roadless Area are large enough to have justified underground exploration. Similar, larger deposits of massive sulfides may exist in the poorly exposed terrane in the northern part of the St. Louis Peak Roadless Area, and in the southern part of the Williams Fork Roadless Area. These areas have probable mineral-resource potential.

Active, and reportedly favorable, exploration for uranium along the Berthoud Pass fault zone, and the observed occurrence of secondary uranium minerals in a few localities on the fault zone, indicate a probable resource potential for vein-type uranium deposits in the eastern part of the Vasquez Peak Wilderness Study Area.

Geologic, geochemical, and geophysical evidence, and the abundance of prospects and small mines, some with known production, support an evaluation of probable resource potential for portions of the southern part of the Vasquez Peak Wilderness Study Area, the southeastern part of the St. Louis Peak Roadless Area, and the eastern part of the Williams Fork Roadless Area and a substantiated resource potential for the northeast part of the Willams Fork Roadless Area. The most likely type of near-surface deposit to be found in this area would be silver-, zinc-, and lead-bearing veins similar to those already known. Because the combined available evidence supports the concept of several centers of mineralization related to middle Tertiary igneous intrusives, a probable resource potential exists in these areas for stockwork-type molybdenum mineralization at depth.

SUGGESTIONS FOR FURTHER STUDIES

Geologic mapping in the southern and western parts of the William Fork Roadless Area is presently not sufficiently detailed to identify many of the subtle geologic features that control the mineral occurrences. Detailed geologic studies in these areas would be required to improve assessment of the resource potential.

Improvement of the sensitivity of geochemical and geophysical techniques might provide better estimates of the size, nature, and location of mineral resources. Experimental work in the detection of massive sulfide deposits would be particularly desirable in the northern part of the St. Louis Peak Roadless Area where Precambrian massive sulfide deposits would not be expected to have large-scale or pervasive halos of alteration and mineralization.

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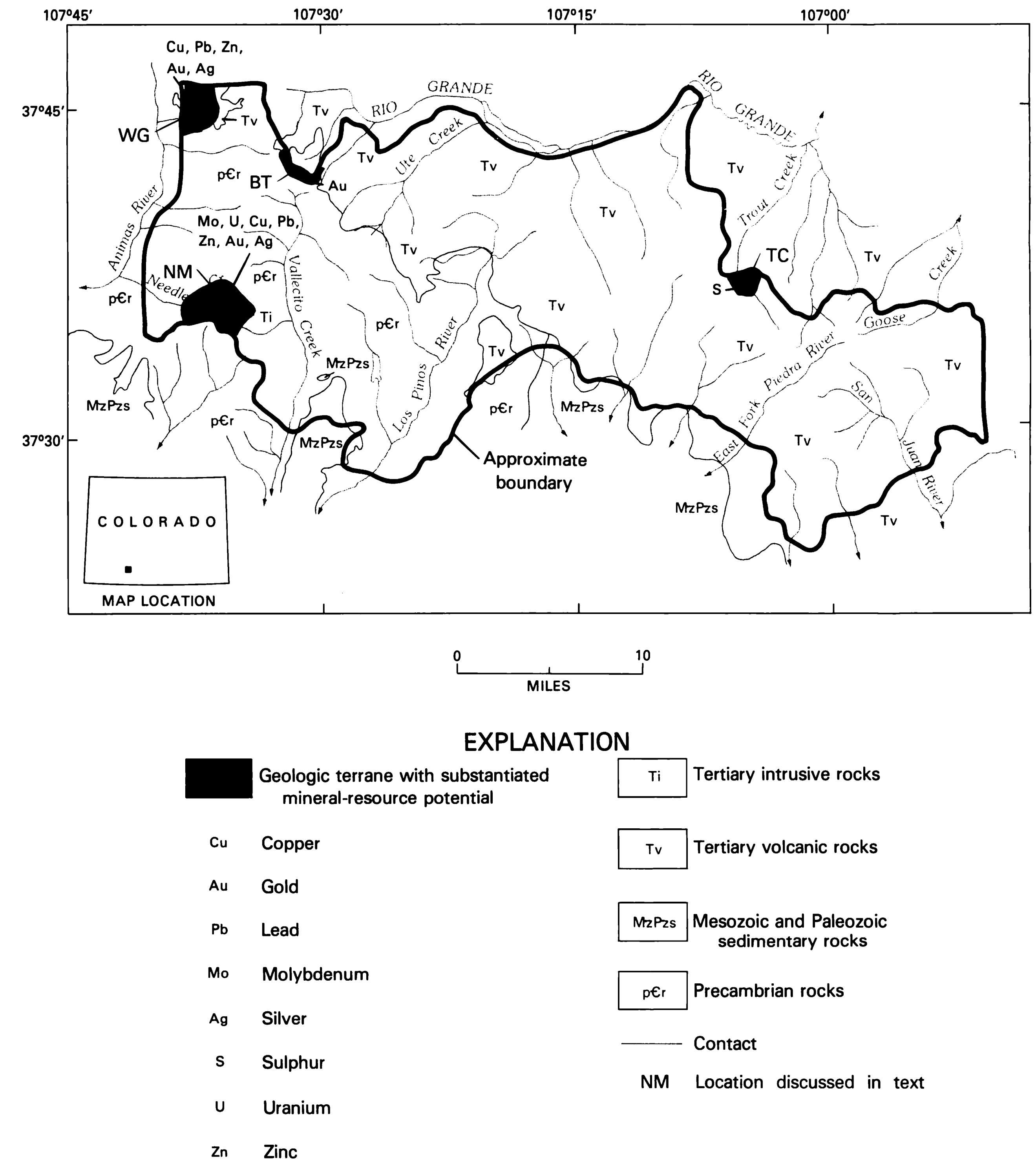

Figure 145.—Weminuche Wilderness, Colorado.

WEMINUCHE WILDERNESS, COLORADO

By THOMAS A. STEVEN, U.S. GEOLOGICAL SURVEY, and

F. E. WILLIAMS, U.S. BUREAU OF MINES

SUMMARY

A mineral survey of the Weminuche Wilderness was conducted in 1965–68. Although little mineral production has been recorded in the area, it borders several highly productive mining districts and mineral deposits probably exist within parts of the wilderness. Within and near the wilderness, evidence of substantiated mineral-resource potential was found in the following four areas: (1) the Needle Mountains mining district, in the southwestern part of the wilderness, (2) Whitehead Gulch, in the northwestern part of the wilderness, (3) the Beartown mining district, along the north margin of the wilderness, and (4) the Trout Creek-Middle Fork Piedra River area, in and adjacent to the northeastern part of the wilderness. Of the four areas, the Needle Mountains mining district has the most promise for significant mineral resources, particularly of molybdenum and uranium. A probable oil and gas resource potential exists in the eastern half of the area in traps in sedimentary rocks under volcanic cover.

CHARACTER AND SETTING

A mineral survey by the USGS and USBM of the adjoining San Juan and Upper Rio Grande Primitive areas was made during 1965–68 (Steven and others, 1969). In somewhat modified form, this combined area has since been included in the National Wilderness Preservation System as the Weminuche Wilderness, which covers about 500 sq mi of rugged terrain in the San Juan Mountains of Colorado. Subsequently, several areas contiguous to the Weminuche Wilderness have been designated for study to determine their suitability for inclusion within the wilderness system; these studies have not been completed and the present summary is limited to the primitive areas originally surveyed.

Geologically, the Weminuche Wilderness is divisible into two parts that contrast strongly in age, rock types, stuctures, and conditions of origin. The older, western part of the wilderness consists of the Precambrian terrane of the Needle Mountains; this terrane consists of two sequences of metamorphic rocks cut by a succession of plutonic intrusive rocks. Most of the remainder of the area is covered by a younger assemblage of volcanic rocks of middle Tertiary age, whose complex history of eruption and accumulation bears little relation to the Precambrian geology exposed in the Needle Mountains. Paleozoic and Mesozoic sedimentary rocks intervene between these widely differing assemblages of rocks in adjacent areas and extend under the edge of the volcanics beneath the eastern half of the wilderness.

The oldest unit in the Precambrian terrane of the Needle Mountains is the Vallecito Conglomerate, which forms a thick mass of metaconglomerate and pebbly quartzite near Vallecito Creek and Los Pinos River in the southern part of the Weminuche Wilderness. The Precambrian Irving Formation stratigraphically overlies the Vallecito Conglomerate with little or no apparent discordance. The Irving Formation consists of a varied assemblage of metavolcanic rocks with minor local siliceous beds containing enough magnetite to be called "iron-formation." Plutonic intrusive masses of Twilight Gneiss, Tenmile Granite, and Bakers Bridge Granite were emplaced into the Irving Formation during subsequent folding and metamorphism. Erosion then cut deeply into the older Precambrian rocks and conglomerates, sandstones, and black pyritic shales of the Precambrian Uncompahgre Formation were deposited. These sedimentary rocks, in turn, were folded and metamorphosed. Late in the second period of Precambrian deformation and metamorphism, five silicic plutons, including two of Eolus Granite (1.46 billion years old), invaded the earlier rocks.

Few sedimentary rocks crop out in the Weminuche Wilderness, and these are almost entirely of the older

Paleozoic formations that cover the southward-dipping flank of the Needle Mountains. The upper part of this sedimentary section projects beneath the Tertiary volcanic rocks in the eastern half of the wilderness.

Volcanic rocks in the Weminuche Wilderness comprise a complexly intertonguing assemblage of lava and pyroclastic units derived from many different centers. Some of these local centers are marked by intrusive cores, but others are obscured by their own or younger accumulations, or by volcanotectonic subsidence structures (calderas) that formed time and again in response to different eruptive episodes. The volcanic activity took place largely in mid-Tertiary time, mostly between 35 and 26 million years ago.

The volcanic rocks in the Weminuche Wilderness came from three major source areas. The Conejos Formation, the oldest volcanic unit in the southern and eastern parts of the wilderness, consists largely of conglomeratic debris that formed an outwash apron, marginal to a series of composite volcanoes of andesitic to rhyodacitic composition in the eastern San Juan Mountains. The great sequence of ash-flow deposits and related quartz latitic to rhyolitic lava flows overlying the Conejos Formation was derived largely from a great caldera complex that extends from the eastern part of the wilderness northward across the central part of the San Juan Mountains. The volcanic rocks in the western part of the wilderness, on the other hand, were derived largely from another caldera complex in the western part of the San Juan Mountains. The earliest rocks from this source make up rhyodacitic volcanoes that extended northeastward across the western San Juan Mountains. Renewed eruptions deposited a sequence of ash flows that spread widely and resulted in concurrent collapse of calderas in the source areas.

Local centers, generally of andesitic to rhyodacitic composition, occur here and there throughout the volcanic terrane, and the related lava flows and volcanic breccias form local accumulations at many different stratigraphic positions.

MINERAL RESOURCES

The section of sedimentary rocks underlying volcanic rocks in the eastern half of the Weminuche Wilderness may contain oil- and gas-bearing reservoir rocks, and an oil seep exists in volcanic rocks just east of the wilderness. Although it is difficult to identify specific targets for exploration, a probable potential for petroleum resources under the eastern part of the wilderness clearly exists.

Four areas with substantiated mineral-resource potential—the Needle Mountains mining district, the Beartown mining district, the Whitehead Gulch area, and the Trout Creek-Middle Fork Piedra River area—are around the periphery of the Weminuche Wilderness, just inside or extending just outside the boundary. The Needle Mountains mining district and surrounding area (NM on map), has disseminated molybdenite in some of the intrusive rock that forms its center, and the surrounding Precambrian granitic rocks are cut by numerous related veins, some of which contain uranium, copper, lead, zinc, silver, and gold in significant concentrations (Schmitt and Raymond, 1977). The Beartown mining district (BT on map) has many small veins containing local shoots of rich gold-telluride ore. Although the small size of the veins and the sporadic distributions of the shoots mitigate against a large resource, the district has substantiated gold resource potential. Whitehead Gulch area (WG on map) lies along the south margin of a highly mineralized area along the southern flank of the Silverton caldera that has produced more than $70 million worth of base and precious metals. Veins in the Whitehead Gulch area are numerous but generally short and narrow, and the metal values are irregularly distributed in them. Although there seems to be little chance for the discovery of a large mineral resource in this area, there is a substantiated base- and precious-metal resource potential for several small deposits. Native sulfur has been mined from the Trout Creek area (TC on map) adjacent to the northeast margin of the wilderness, and scattered occurrences farther south indicate an area at least 3 mi across in which similar deposits might occur. Dense timber, soil cover, glacial drift, and younger volcanic rocks obscure relationships in much of the area of interest. A substantiated sulfur resource potential exists in the area, but physical exploration is needed for it to be fully assessed.

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WEST ELK WILDERNESS, COLORADO

By D. L. GASKILL, U.S. GEOLOGICAL SURVEY, and

H. C. MEEVES, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys of the West Elk Wilderness and adjacent areas were conducted in 1971–74 and included geologic mapping, geochemical sampling, geophysical studies, and an investigation of mines and prospects. Areas with substantiated mineral-resource potential for bituminous coal with 75 million tons of demonstrated reserves and areas with probable mineral-resource potential for base and precious metals associated with igneous intrusions of Tertiary age were identified in this study. There is little promise for the discovery of oil and gas resources in the area.

CHARACTER AND SETTING

The West Elk Wilderness occupies about 275 sq mi in the southern part of the West Elk Mountains of west-central Colorado between the towns of Gunnison and Paonia.

The southern part of the wilderness is a rugged, deeply dissected terrain of coarsely stratified volcanic deposits, breccias, lava flows, and tuffs, representing many volcanic eruptions from local and distant sources. The volcanic deposits locally form spectacular erosional features, such as hoodoos, pinnacles, castelated ridges, fluted spurs, and colorful escarpments. In contrast, the northern part of the wilderness is eroded into older sedimentary rocks, mostly shales and sandstones, intruded by a melange of porphyritic igneous (granodiorite) sills and laccoliths. Glacially sculpted laccolithic mountains flanked by precipitous cliffs, forested mesas, and spacious well-watered valleys dominate the northern part of the wilderness. Streams radiating outward from the area have cut many scenic canyons, some more than 2000 ft deep, across both the volcanic and sedimentary rock terrain. Most of the area is forested and includes a rich flora and fauna. Altitudes range from about 7000 ft to over 13,000 ft. Many peaks and ridges in both the southern and northern part of the area are above timberline.

The wilderness lies over an uplifted fault block (the Gunnison uplift) composed of crystalline Precambrian basement rocks and overlying sedimentary rock strata of Mesozoic age. The block was tilted north and beveled by erosion prior to extrusion of the volcanic rocks in the area. Thus the volcanic rocks overlie a major erosional surface developed on the older northward-dipping sedimentary rocks. The sedimentary rocks range from less than 1000 ft thick along the southern boundary of the wilderness area to more than 8000 ft thick in the northernmost part of the wilderness.

Most of the volcanic material in the area was derived from a now largely denuded volcano (the West Elk volcanic center, locality 1 on map). The West Elk volcanic center forms a broad dome of intrusive and basal extrusive rocks cut by a swarm of dikes radiating from a common center. The central basal core rocks of the volcano are surrounded by layered breccias and lava flows that dip away from the volcanic center on all sides. Other satellitic vent areas, dike conduits, and a number of granodioritic and rhyolitic intrusive bodies are located within the volcanic pile west and southwest of the West Elk volcanic center. The wilderness is transected by the southwest-trending Ruby Range intrusive zone and the westerly trending Curecanti fault zone (locality 2). These fracture zones intersect at the West Elk volcanic center.

MINERAL RESOURCES

The wilderness is on the trend of the Colorado Mineral Belt which contains many of the major mining districts in Colorado. These districts are localized around prophyry intrusive centers of Late Cretaceous and Tertiary age. Although no metal production has been reported from the West Elk Wilderness, the area contains at

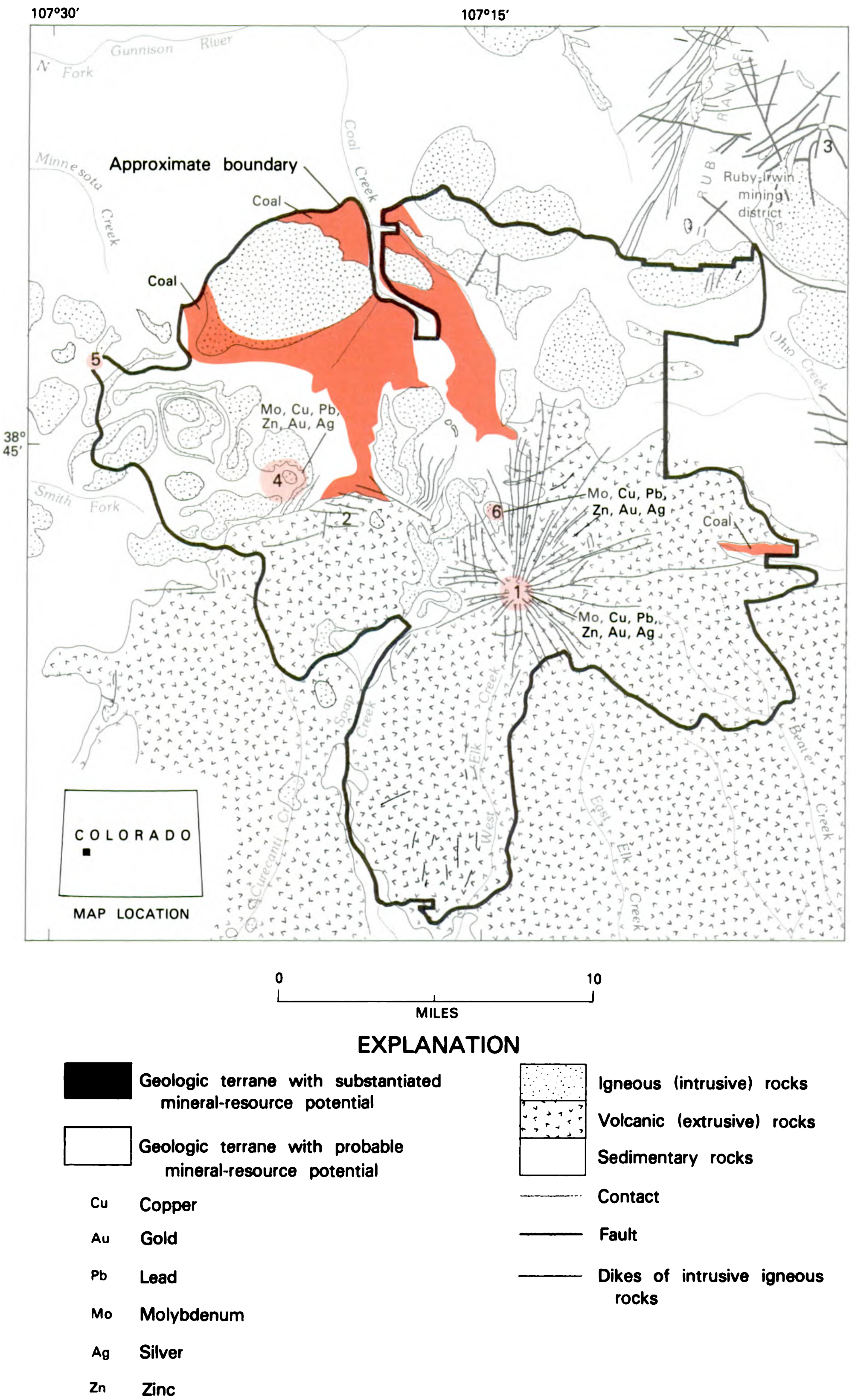

Figure 146.—West Elk Wilderness, Colorado.

least one major volcanic center, and several weakly mineralized igneous bodies of interest. The northeast boundary of the wilderness is about 2 mi southwest of the Ruby-Irwin mining district. Mines in this district have produced considerable silver, lead and zinc, and some gold and copper. Recent discovery in this district of what is referred to as the third largest known deposit of molybdenum in the world is currently being developed at Mount Emmons (locality 3), about 4-1/2 mi northeast of the wilderness boundary.

A mineral survey of the West Elk Wilderness (Gaskill and others, 1977) included geologic mapping, geochemical and geophysical surveys, and investigation of mining claims and prospects. There are no patented mining claims in the wilderness. Most of the unpatented claims are in the vicinity of Sheep Mountain (locality 4), and in the northeast corner of the wilderness. Stream-sediment, panned concentrate, fresh, altered and mineralized bedrock, and soil samples were collected and analyzed or assayed for 30 or more elements.

Thick beds of bituminous, low-sulfur coal are present in the northern and eastern parts of the wilderness. The areas shown as having substantiated coal potential are those known or inferred to contain one or more thick coal beds. The only coal production within the wilderness has come from two small workings long abandoned. Most of the coal resources are located along Coal Creek and its tributaries where as many as five coal beds, 3 to 8 ft thick, are reported. Coal resource potential within the wilderness is estimated to have demonstrated coal resources of 75,000,000 tons. More extensive areas are inferred to be underlain by thick coal beds (locally overlain by laccoliths), but, due to thickness of overburden and structural complexities associated with igneous intrusions, are not presently considered as resources.

Favorable criteria for the presence of metalliferous deposits in the wilderness include anomalously high values of base and precious metals (molybdenum, copper, lead, zinc, gold, and silver) and other elements associated with altered and locally pyritized rocks. Most of the anomalous metal values are clustered around Sheep Mountain (locality 4) and in the area of the West Elk volcanic center (locality 1). These and other metal anomalies are shown on sample location maps in Gaskill and others (1977). Most of the samples from these two localities contain anomalous amounts of several metals, and most of them seemingly relate to intrusive rocks or postulated volcanic vents. The relationship of anomalous metal values to geologic and inferred geophysical structures in the area indicate a probable mineral-resource potential at Sheep Mountain, in the area of the West Elk volcanic center.

A central intrusive body at Sheep Mountain consists of an inner core, or plug of vertically flow banded porphyry surrounded by hydrothermally altered and pyritized granodiorite that has domed surrounding igneous sills and sedimentary strata. The intrusive body is well exposed over a vertical distance of about 1800 ft. Samples from the intrusive contain anomalous amounts of base and precious metals. The geologic environment suggests the possibility of an ore deposit at depth under Sheep Mountain.

The dike swarm at the hub of the West Elk volcanic center probably overlies a stock similar to those exposed in the Ruby Range (Ruby-Irwin mining district) northeast of the wilderness area. The mineralized stocks of the Ruby Range appear to connect with the West Elk volcanic center by dikes and a broad zone of fractures.

No drilling for oil or gas has been reported in the wilderness. The sedimentary formations in the area contain reservoirs of oil and gas elsewhere in the region; but within the West Elk Wilderness, these strata are intruded at many, or most, horizons by myriad thick sills and laccolithic bodies, suggesting that the discovery of oil and gas is unlikely.

SUGGESTIONS FOR FURTHER STUDIES

Further investigations by geophysical, geochemical, and geochronological methods are needed to locate buried intrusive structures, vent areas in the volcanic pile, and to establish timing of mineralization. Physical exploration, essentially deep drilling, will probably be necessary to prove the existence of buried mineral deposits.

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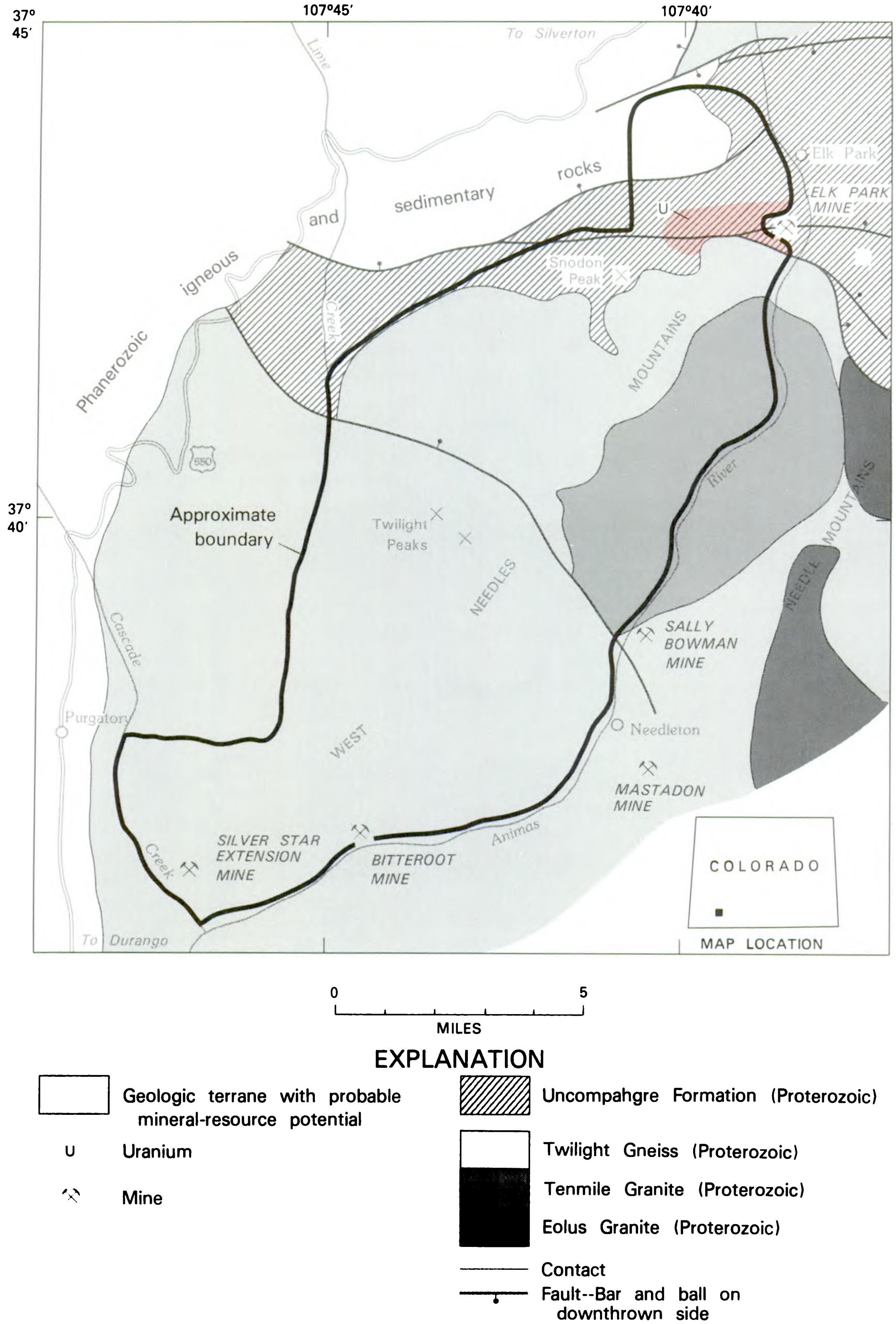

Figure 147.—West Needle Wilderness Study Area, Colorado.

WEST NEEDLE WILDERNESS STUDY AREA, COLORADO

By RICHARD E. VAN LOENEN, U.S. GEOLOGICAL SURVEY, and

DAVID C. SCOTT, U.S. BUREAU OF MINES

SUMMARY

The West Needle Wilderness Study Area, southwestern Colorado, was evaluated for mineral-resource potential in 1982. An area extending westward into the wilderness near the Elk Park mine, has a probable mineral-resource potential for uranium. Uranium resources, and associated silver, nickel, cobalt, and copper, are located at the Elk Park mine, directly adjacent to the eastern study area boundary. No potential for other mineral or energy resources was identified in this study.

CHARACTER AND SETTING

The rugged West Needle Mountains lie within the San Juan National Forest, midway between Durango and Silverton and west of the Animas River in southern Colorado. The West Needle Wilderness Study Area occupies approximately 35 sq mi, or nearly all of the West Needle Mountains. The area consists of two parts; one is 25 sq mi, in La Plata and San Juan Counties, and is managed by the USFS and the other is 10 sq mi, in San Juan County, and managed by the U.S. Bureau of Land Management (BLM). Both areas were studied simultaneously and are referred to only as the West Needle Wilderness Study Area.

The West Needle Wilderness Study Area was studied by the USGS and USBM in 1982 (Scott, 1983; Van Loenen and Scott, 1983). As the name implies, the West Needle Mountains are made up of very steep and rugged picturesque peaks resulting largely from glaciation. Altitudes range from 7800 ft along the Animas River to more than 13,000 ft on Twilight Peak. A spectacular natural boundary around most of the study area is provided by the Animas River canyon on the east and south and Lime and Cascade Creeks on the west.

The area is accessible from U.S. Highway 550, the major road between Durango and Silverton, Colorado; the Lime Creek road (USFS road 591) which follows parts of the western boundary; and the Durango-Silverton Narrow Gauge Railroad, which follows the eastern boundary along the Animas River. The railroad and railroad right-of-way which separates the West Needle from the Weminuche Wilderness, provides access to several trails leading into both areas. This railroad, completed in 1882 for shipping ore from Silverton to Durango, is now a very popular tourist attraction and operates between these two towns during the summer months only.

The West Needle Mountains are the western part of the Needle Mountain uplift, a deeply eroded domal arch exposing a large mass of metamorphic and igneous rocks of Proterozoic age. This uplift is flanked on the north and east by Tertiary volcanics and on the south and west by Paleozoic and younger sedimentary rocks. The metamorphic rocks are of two distinctive types; an older sequence derived from volcanic, intrusive, and sedimentary rocks called the Twilight Gneiss, and a younger succession of quartzites and slates called the Uncompahgre Formation. Both units were intruded by granites and highly deformed during metamorphism.

The West Needle Wilderness Study Area includes parts of two mining districts and is near a third. Significant mineral production has come from these districts, the primary one being the Animas district which contains the Silverton cauldron complex, located approximately 8 mi north of the study area boundary.

Prospecting in the West Needle Wilderness Study Area was intermittent from about 1881 to 1934. In 1956, uranium was discovered at the Elk Park mine, on the eastern boundary of the West Needle Wilderness Study Area, but no mining activity was observed at the mine in June, 1982.

No patented claims were on record in the study area as of September, 1982. However, 310 unpatented claims were on record in the West Needle Wilderness Study Area. Most of the claims in the study area were staked by Exxon Minerals Company during their exploration for uranium in 1980–1981, at the Elk Park mine, but dropped after 1981.

During the time of the study, assessment work and prospecting were being done only at the Hidden Hole prospect, located inside the western boundary.

MINERAL RESOURCES

Although the study area is contiguous to several mining districts, only a small part of the area was found to have a potential for mineral resources. This area west of the Elk Park mine, in the northeastern part of the study area has probable resource potential for uranium. Structures that localized uranium in the mine extend westward into the study area.

Several small mines and prospects in and near the West Needle Wilderness Study Area are in the northwest part of the Needle Mountain mining district and were developed along quartz fissure veins. The Silver Star Extension mine and the Bitteroot mine are located on unpatented claims within the southern part of the West Needle Wilderness Study Area. These veins occupy minor fault zones in the Twilight Gneiss. No records of production were found and analytical data from samples collected from these old workings do not indicate mineral-resource potential. Similar fractures in the younger overlying limestones to the north and west of the study area also contain traces of mineralization. Small isolated patches of limestone crop out within the study area, however no indication of mineralization was found.

Based on analyzed samples, the limited nature of the controlling structures, and past records of production, no resource potential for fissure veins was identified in areas underlain by either the ancient Twilight Gneiss or the overlying younger limestones in the West Needle Wilderness Study Area.

The Uncompahgre Formation underlies the northern part of the West Needle Study Area and consists of nearly 8000 ft of east-west trending interlayered quartzite, phyllite, and slate and a thin discontinuous section of basal conglomerate. The phyllite and slate were intercalated pyritic black shale prior to metamorphism and are by far the most favorable host rocks for uranium occurrences in the study area. They are commonly radioactive and have scintillation counts several times background. Anomalously high uranium values in samples reported by Burns and others (1980) ranged from 100 to 300 parts per million. Composite samples representing several hundred feet of rock averaged from 5 to 25 parts per million uranium. Although the uranium concentrations are not unusual for this rock type (slate and phyllite from black shale), the anomalous values may represent concentrations of uranium as the result of lateral secretion, that may have occurred during metamorphism. The basal conglomerate has been the subject of intensive studies by the USGS (Barker, 1968) for its gold potential and more recently by Burns and others (1980) in a uranium evaluation for the U.S. Department of Energy. On the basis of numerous sample analyses, studies of environments of depositions, the age of the formation, and other factors, the conglomerate was determined to be unfavorable for the occurrence of deposits of uranium or gold of the Precambrian fossil placer type.

Uranium was discovered near the west bank of the Animas River in Elk Park in 1956. Sporadic production since 1957 has yielded small amounts of uranium ore which averaged approximately 0.2 percent U_3O_8. The deposit is a fissure-vein occurring along faults cutting the Uncompahgre Formation. The quartzites and slates of this formation are isoclinally folded, along east-west trends, and in this area many of the folds have ruptured, allowing passage of the mineralizing fluids. The mineralized vein fillings range in size from tiny fractures to fault breccias several feet across. Uranium occurs in either simple veins associated with pyrite and hematite or in complex vein systems containing sulfides and arsenides (Scott, 1983). Small amounts of copper, cobalt, silver, zinc, and molybdenum were detected in uranium-bearing samples. Exxon Minerals Company conducted a drilling program during 1980 and 1981, which resulted in the delineation of a large low-grade resource. There was no activity at the Elk Park mine during the summer of 1982. The only access to the mine is that provided by the Durango-Silverton Narrow Gauge Railroad which now only operates during the summer months.

Although the Elk Park deposit is located outside the West Needle Wilderness Study Area boundary, the east-west structures that localized the mineralization can be traced well inside the study area. No surface indications of mineralization were found inside the study area; however, it is reasonable to assume that mineralization may occur at depth along these known structures. This area has a probable resource potential for uranium.

If the original black shales did indeed provide the uranium and other metals for the Elk Park deposit, then it is conceivable other deposits might exist, given the same favorable conditions, elsewhere in the Uncompahgre Formation in the study area.

SUGGESTIONS FOR FURTHER STUDIES

Further information on the origin of the uranium in the deposit at Elk Park would be useful in assessing the mineral potential of the Uncompahgre Formation. If the uranium was introduced from one of the younger Tertiary intrusive centers rather than it being derived from the original black shales, it would reduce the chances of other occurrences in similar host rocks to those at Elk Park.

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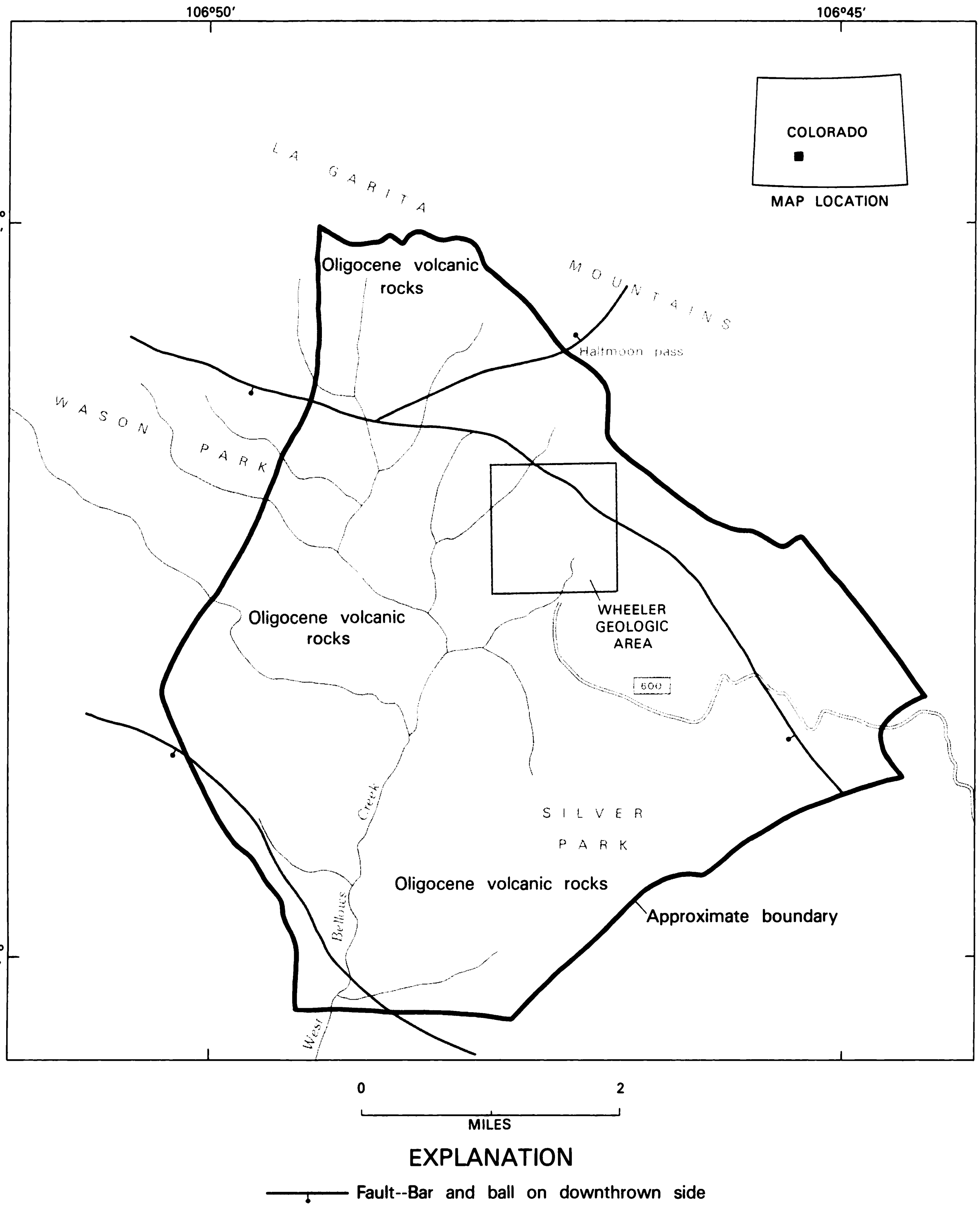

Figure 148.—Wheeler Wilderness Study Area, Colorado.

WHEELER WILDERNESS STUDY AREA, COLORADO

By WILLIAM H. RAYMOND,[1] U.S. GEOLOGICAL SURVEY, and

CARL L. BIENIEWSKI, U.S. BUREAU OF MINES

SUMMARY

No mineral-resource potential was identified in the Wheeler Wilderness Study Area as a result of field and laboratory investigations conducted by the USGS in 1982 and by the USGS and USBM in 1971 in the adjacent La Garita Wilderness. Analytical data and indications of previous mining or prospecting are negative with respect to indications of mineral deposits. If mineral deposits exist, they would likely be associated with one of two anomalies which may be related to an intrusive at a depth of 1000 ft or more, as indicated by aeromagnetic and gravity surveys.

CHARACTER AND SETTING

The Wheeler Wilderness Study Area occupies about 21 sq mi in the La Garita Mountains in Mineral County, southwestern Colorado, about 6 mi east of Creede. The original focus of interest in the area was the Wheeler National Monument, a 1/2 sq mi area containing outcrops of deeply dissected Rat Creek Tuff of Oligocene age, which was established as a national monument by Theodore Roosevelt in 1908. In 1950, Congress abolished the Wheeler National Monument and returned management responsibility to the USFS which, in 1962, delineated a 1–sq-mi tract including the original Wheeler National Monument, which was withdrawn from mineral prospecting, location, entry, or purchase; the 1–sq-mi tract was thereafter referred to as the Wheeler Geologic Area. Subsequently, surrounding terrane was added resulting in the 21 sq mi Wheeler Wilderness Study Area covered in this report.

The spectacular badlands in Rat Creek Tuff are perched on and amidst tuffs, flows, and breccias of the La Garita caldera. The entire study area lies within this sequence of Oligocene volcanic rocks; no older rocks are exposed in or near the study area.

MINERAL RESOURCES

Despite its proximity to the Creede mining district and the similarity of geologic framework, the Wheeler Wilderness Study Area appears to have little promise for mineral resources. Sulfide minerals were not identified within the study area, and there is no evidence of mining or prospecting activities.

Anomalous zinc in stream-sediment samples and panned concentrates, occurs over a wide area in the drainage of West Bellows Creek, but analyses of magnetic concentrates from the same samples show that the zinc is in magnetite derived from the tuffs of the area. It is therefore concluded that resources of zinc are not likely to occur in rocks exposed in the study area.

Anomalous uranium which occurs in widely scattered samples in the study area is attributed to a high background of uranium in volcanic glass, and it is unlikely that significant accumulations of uranium are present.

One stream-sediment sample at the southern boundary of the area contains gold at the lower limit of detection, but there is no other evidence of occurrences of gold in the study area.

Two aeromagnetic anomalies were identified in this study. One of them is thought to be related to topography, the other may be related to topography but has been interpreted to be related to a buried pluton. Although the possibility of mineralization exists, no surface expression is known, and drilling would be required to verify this interpretation.

The remote setting and very limited access, together with unfavorable geochemical data, would seem to preclude the occurrence of mineral resources in the study area. No energy resources were identified in this study.

[1]With contributions from James G. Crock, USGS.

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WILSON MOUNTAINS WILDERNESS, COLORADO

By CALVIN S. BROMFIELD, U.S. GEOLOGICAL SURVEY, and

FRANK E. WILLIAMS, U.S. BUREAU OF MINES

SUMMARY

Based on a mineral survey completed in 1969, two areas in the Wilson Mountains Wilderness have a probable mineral-resource potential. One area is on the east margin of the area in the Trout Lake mining district, and the other is near the center of the area, the Mount Wilson mining district. Both areas have had a modest base and (or) precious metal production from narrow veins and have a probable potential for the occurrence of similar deposits. Of more significance is a probable mineral-resource potential for disseminated copper mineralization in the Mount Wilson mining district.

CHARACTER AND SETTING

The Wilson Mountains Wilderness consists of about 68 sq mi in the San Miguel Mountains in southwestern Colorado. The San Miguel Mountains form a distinct west-trending group of rugged peaks on the west edge of the San Juan Mountain region. The area contains serrated ridges and towering peaks, three of which rise to over 14,000 ft (Mt. Wilson, 14,246 ft, El Diente, 14,159 ft; and Wilson Peak, 14,017 ft). Magnificent panoramas of these imposing peaks can be had on State Highway 145 which runs near the eastern and southeastern boundary of the area.

The high country in the San Miguel Mountains was already an established primitive area when the Wilderness Act was passed in 1964. As provided in that act a mineral survey was carried out by personnel of the USGS and USBM in the summer of 1966 and 1969, and the results were published (Bromfield and Williams, 1972).

Igneous intrusions of relatively young geologic age (middle Tertiary) have invaded nearly flat lying volcanic rocks of similar age and older sedimentary rocks along an east-west belt. The intrusive rocks, harder and more resistant to erosion, form the backbone of the San Miguel Mountains, and the sedimentary rocks, softer and more easily eroded, form the lower slopes, where they are widely concealed by glacial deposits and spruce forests. Though only about 5000 ft of sedimentary and volcanic rocks are exposed, total thickness of concealed rocks above the ancient (Precambrian) basement is on the order of 7000 to 8000 ft.

MINERAL RESOURCES

The Wilson Mountains Wilderness lies on the western fringe of the Telluride-Silverton-Ouray region, one of the great base- and precious-metal mining regions in Colorado. Most of the more than $500 million in total production has come from mines 8–10 mi northeast of the wilderness, chiefly from northwest-trending veins cutting volcanic rocks and radial to a large complex volcanic collapse or caldera. West of the caldera is a similar system of westward-trending veins, closely associated with a belt of intrusive rock. This system, much weaker, and containing fewer veins than the northwest-trending system extends westward into the wilderness as far as the stock near Mt. Wilson. Within the wilderness veins of this system are found in an east-west zone, or belt 1–2 mi wide and about 7 mi long extending from the east boundary westward into Silver Pick and Navajo Basin. The veins are generally narrow and ore shoots small, and are concentrated in two areas, the Trout Lake mining district on the east, and the Mount Wilson mining district in the center of the area.

Metal mining activity in the western San Juan Mountains began in the early 1870's and by 1877 claims had been located on the east margin of the area on the San Bernardo vein. The Silver Pick vein in Silver Pick Basin was discovered in 1883, and probably by 1900 all the known and now patented claims (about 50), had been located. Approximately $1.78 million in gold, silver, copper, lead, and zinc have been mined from the Wilson Mountains Wilderness, mostly in the years preceding 1930. The bulk of the production has come from two

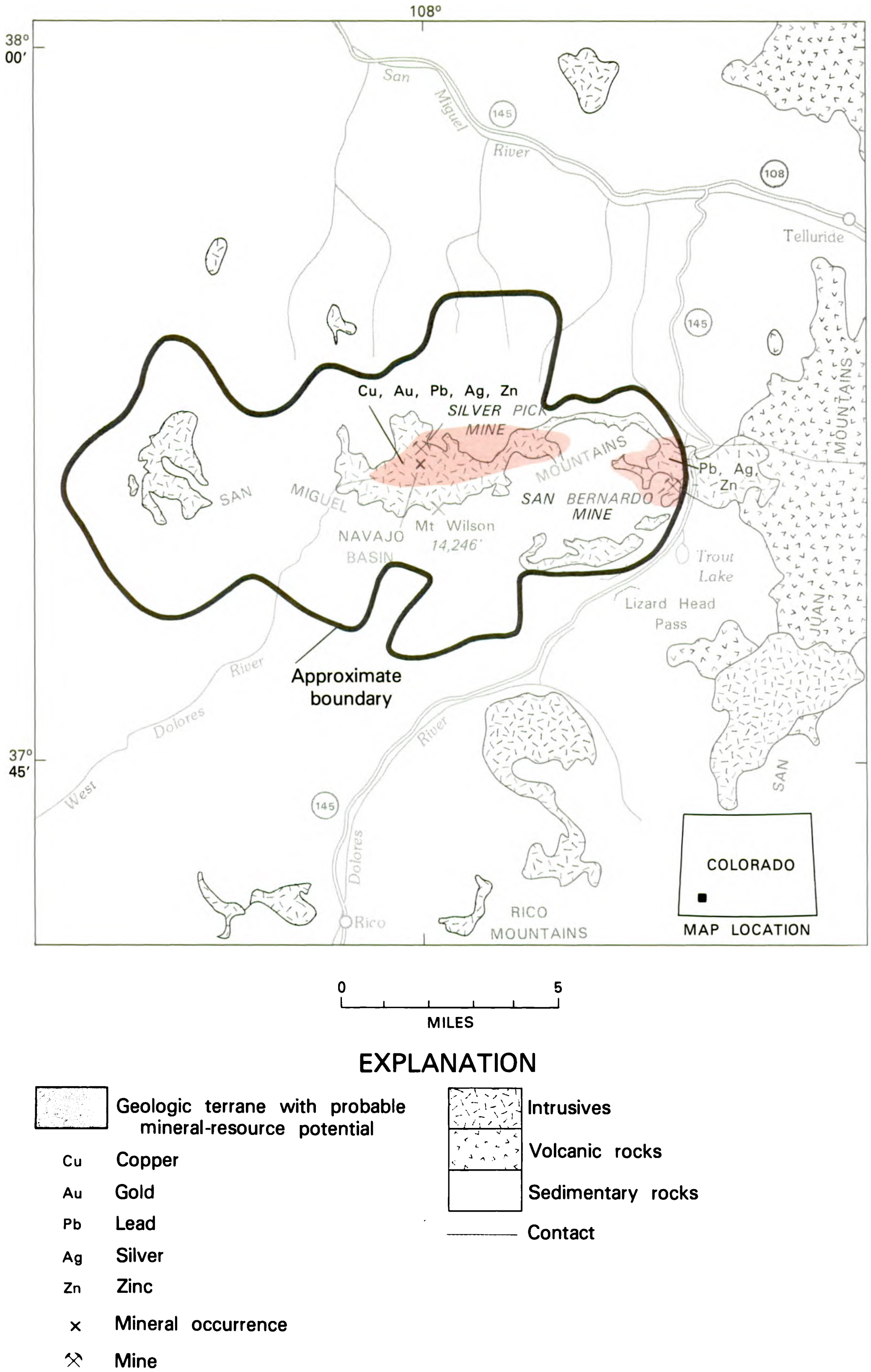

Figure 149.—Wilson Mountains Wilderness, Colorado.

veins, the Silver Pick, mined chiefly for gold, and the San Bernardo, mined for silver, but with accompanying lead, zinc, and copper.

Further evidence of mineralization is shown by widespread alteration in the area of the Wilson Mountain Wilderness. Disseminated fine-grained pyrite, which accompanies much of the alteration, has been oxidized and yields colorful and conspicuous areas of iron staining in the rocks. Alteration of this type commonly accompanies the mineralizing process in many metal mining districts and is considered presumptive evidence for the circulation of hot mineralizing fluids. Of more direct significance is an area of quartz monzonite in Navajo Basin that was found by our investigation to contain disseminated copper sulfide. This copper mineralization represents a possible copper resource, and the occurrence is similar to the porphyry copper deposits that have formed large low-grade deposits in the southwestern U.S. and elsewhere.

A geochemical survey of stream sediments showed anomalous values of copper, lead, and zinc which generally reflected known areas of mineralization. Stream sediments from Navajo Basin consistently contained high copper values, and reflect the area that contains disseminated copper sulfides.

Thin beds of low-rank bituminous coal occur in outcrop in the Cretaceous Dakota Sandstone just south and north of the area, and thus thin coal probably occurs in subsurface, but as this formation occurs at depths of more than 1000 ft, the area it underlies is not classified as having mineral-resource potential for coal.

It is concluded from the historical, geologic, and geochemical evidence outlined above that two areas have probable mineral potential. One, the Trout Lake mining district on the east side of the wilderness; and, two, the Mount Wilson mining district in the center of the wilderness. The Trout Lake mining district can be expected to contain vein deposits of silver-lead-zinc-copper type. The Mount Wilson mining district could be expected to contain vein deposits similar to the Trout Lake area, as well as gold-bearing quartz veins. Based on past experience veins in both areas would generally be narrow. Of considerably more significance is the potential for porphyry copper-type deposits in the Mount Wilson mining district.

SUGGESTIONS FOR FURTHER STUDIES

Exploration including extensive sampling and drilling would be needed to define the limits, grade, and volume of copper mineralization in Navajo Basin. However, a study utilizing the extensive growth of knowledge about alteration and mineralization zoning in porphyry copper systems would be valuable in assessing the mineral potential, and as a basis for planning a drilling project.

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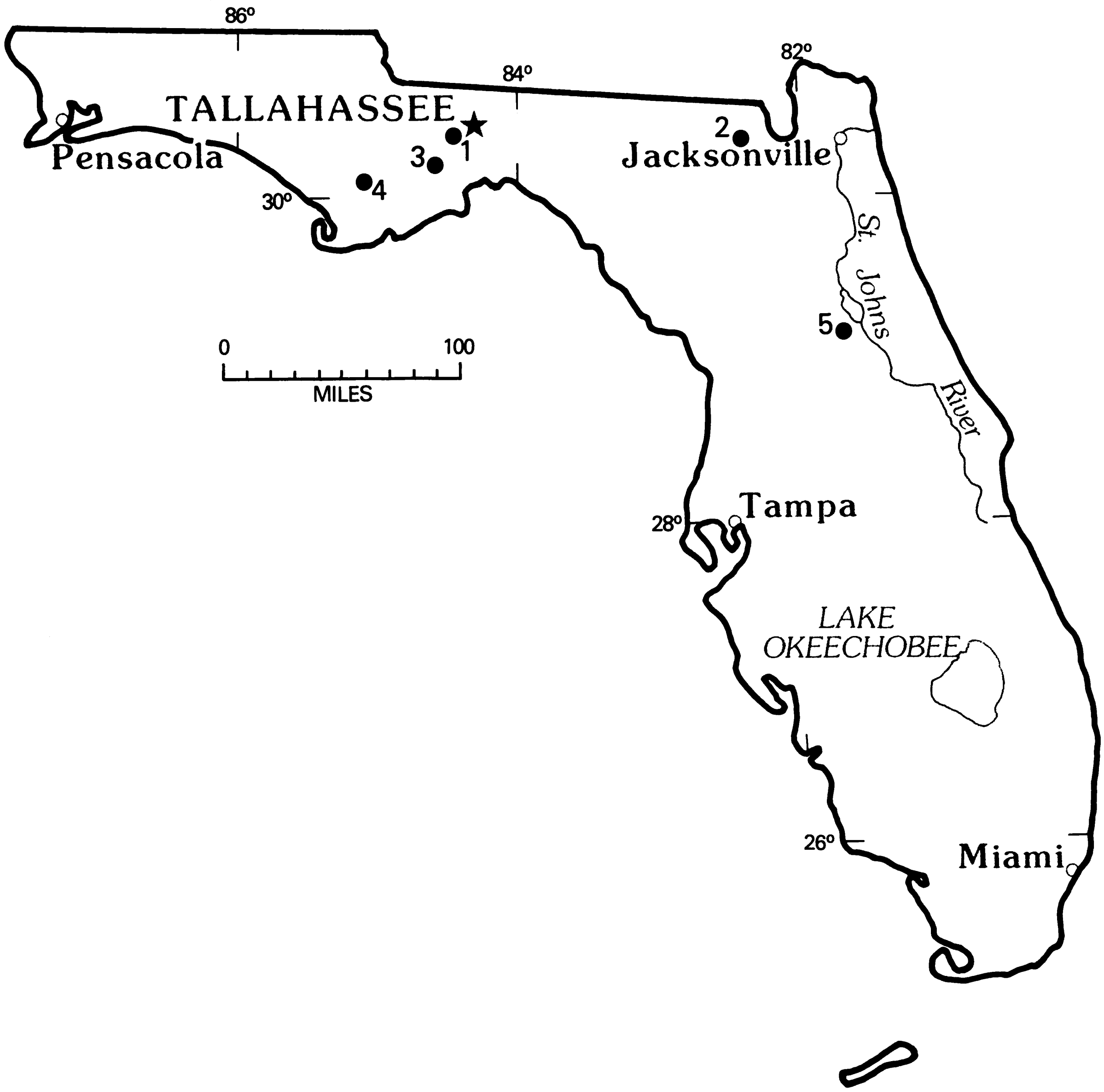

Location of areas studied.

FLORIDA

Map No.	Name of Area
3	Bradwell Bay Wilderness and Sopchoppy River Wilderness study area
1	Clear Lake Roadless Area
5	Farles Prairie and Buck Lake Roadless Areas
2	Natural Area Roadless Area
4	Savannah Roadless Area

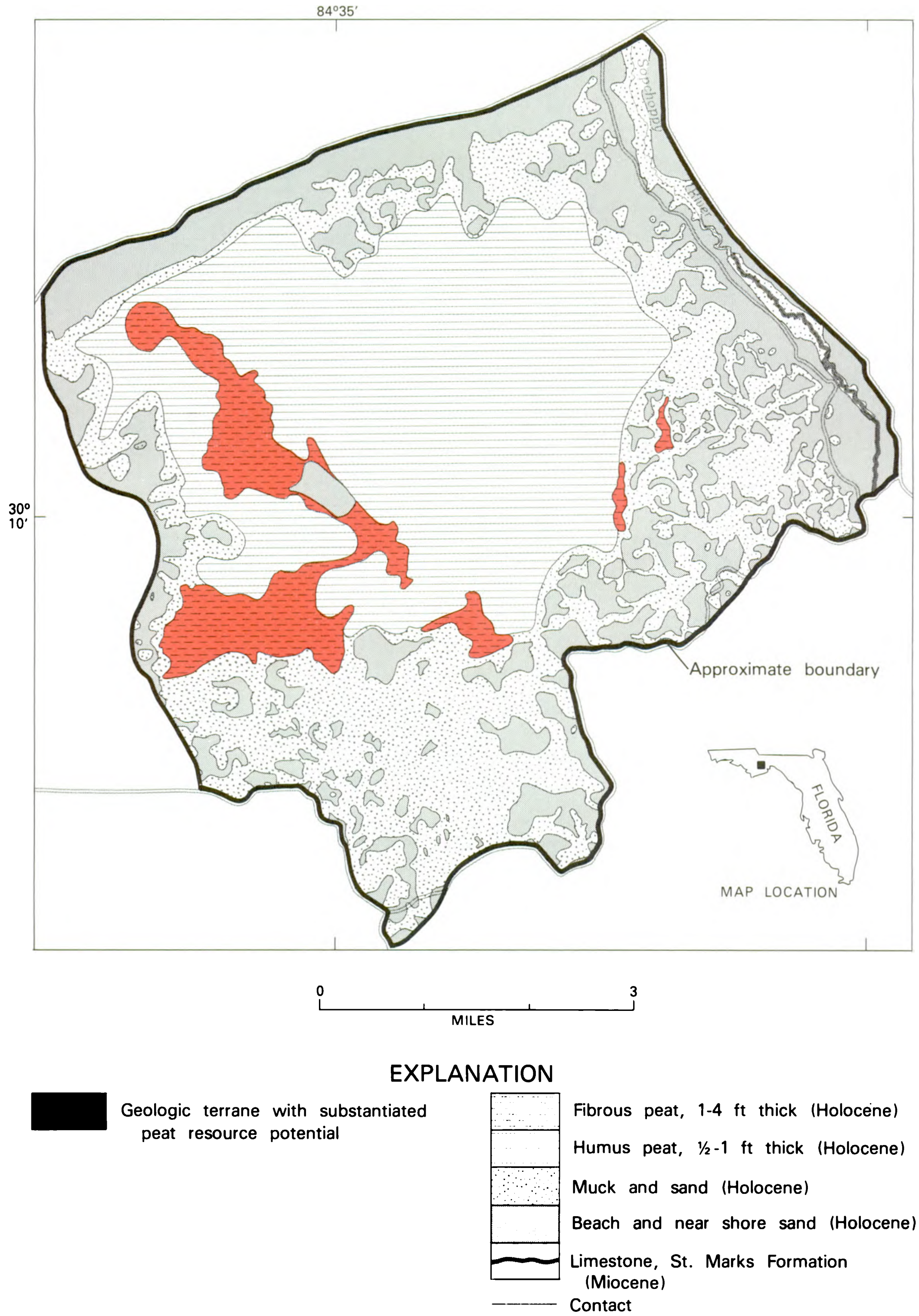

Figure 150.—Bradwell Bay Wilderness and the Sopchoppy River Wilderness study area, Florida.

BRADWELL BAY WILDERNESS AND THE SOPCHOPPY RIVER WILDERNESS STUDY AREA, FLORIDA

By CORNELIA C. CAMERON,[1] U.S. GEOLOGICAL SURVEY, and

PETER C. MORY, U.S. BUREAU OF MINES

SUMMARY

A survey to determine the mineral-resource potential, especially for oil, phosphate, fuller's earth, sand, and peat, was conducted in 1974 in the Bradwell Bay Wilderness and the Sopchoppy River Wilderness Study Area. On the basis of this survey, the entire area was concluded to offer little promise for the occurrence of mineral resources except the commodity peat. Approximately 136,000 tons of demonstrated peat resources, on a dry weight basis, are available in areas of substantiated peat resource potential from bay swamps in the area, but the deposits are shallow and widespread. Large quantities of quartz sand are available in ancient beach ridges and in deposits that were originally laid down in a shallow nearshore marine environment. Sieve tests show that the sand is generally too fine for mortar and masonry use; it is not suitable as moulding or glass sand because it lacks the required size grades and purity.

CHARACTER AND SETTING

The Bradwell Bay Wilderness and the Sopchoppy River Wilderness Study Area are within the Apalachicola National Forest, Wakulla County, Florida, approximately 20 mi southwest of Tallahassee. The Bradwell Bay Wilderness comprises 34 sq mi of swamp and pine woods bordered on the northeast by the Sopchoppy River Wilderness Study Area, a narrow strip of 2 sq mi along the river. The wilderness is one of many swamps in the Florida panhandle called "bays" because of the bay trees growing in them.

The wilderness and wilderness study area are in the East Gulf Coastal Plain which in this region is divided into two subprovinces, the Tallahassee Hills on the north and the Apalachicola Coastal Lowlands on the south. The Cody scarp is the east-west dividing line between the subprovinces. The surface from the toe of this scarp drops southward across the Bradwell Bay Wilderness to the modern shore line. Slight differences in altitudes in the swamps on this surface mark ancient beach ridges and spits, and a few low scarps.

The surface is covered by as much as 30 ft of sand and peat beneath a tangle of vegetation extending monotonously in all directions. The Sopchoppy River flows southward from a flat-floored valley in the north through a narrow V-shaped valley cut in a sand-covered, deeply weathered limestone terrane along the eastern edge of the Bradwell Bay Wilderness. Bedrock exposures are limited to the banks and bed of the river. Here, weathering of limestone of the St. Marks Formation of early Miocene age forms karst topography, featuring honeycomb weathering and sinks. Older Oligocene and younger Miocene rocks are exposed in adjacent counties to the north and east and pre-Oligocene rocks are known only from drill holes in the surrounding areas.

MINERAL RESOURCES

The Hawthorn Formation, of middle Miocene age, from which phosphate and fuller's earth are chiefly produced in Florida, is not found in the Bradwell Bay Wilderness and the Sopchoppy River Wilderness Study Area; therefore, there is little promise for the occurrence of these resources. Some phosphate pellets, however, were found in auger holes in younger sands deposited in an estuary during Pliocene and early Pleistocene time. The sands were derived from older rocks presumably the Hawthorn Formation and do not constitute a resource for phosphate.

[1]With contributions from James B. Cathcart and Philip J. Gerachi, USGS.

The Bradwell Bay Wilderness is about 175 mi east-southeast of the Jay oilfield in the western panhandle of Florida. Part of the production is from the Smackover Formation of Jurassic age, which is also the target formation for drilling in the vicinity of the wilderness. Four oil test holes have been drilled in the vicinity of the Bradwell Bay Wilderness but all proved to be unsuccessful. These four test holes, now abandoned, are alined along a northeast trend immediately northwest of the Bradwell Bay Wilderness. There is little promise for the occurrence of oil and gas in the Bradwell Bay Wilderness and Sopchoppy River Wilderness Study Area because although hydrocarbons may have been generated in the area, no evidence of an oil trap was found in the abandoned test wells to the northwest.

According to ASTM Committee, the term "peat" may be used only with respect to organic matter of geological origin, and not for lignite or other coal. According to the ASTM, peat forms mainly from dead plant remains through the agency of water in the absence of air; it is found in a bog, swampland, or marsh and has an ash content not exceeding 25 percent on a dry-weight basis. The peat deposits of the United States are currently being studied for use in agriculture as a soil conditioner and in horticulture as a packing material and growing medium. They are also being studied for potential gaseous and solid fuel potential.

The most favorable environment for peat accumulation in the Bradwell Bay Wilderness and Sopchoppy River Wilderness Study Area is the bay swamp which is characterized by the presence of sweetbay trees, which are protected from fire encroachment by surrounding swamps of cyrillaceous shrubs that act as buffers. Elsewhere, bay swamps are adjacent to fire-prone pine-palmetto flatwoods and are subject to burning before much peat can accumulate. Within this most favorable type of area are an estimated 136,000 tons of peat on a dry weight basis having an ash content of not more than 25 percent. However, the peat layer is discontinuous, only 1 to 4 ft thick, and drainage, clearing, and access problems are severe. Thicker peat in more accessible areas is available elsewhere in Florida.

Quartz sand from abandoned beaches can be found on terraces southeast of the wilderness and within Wakulla County. Quartz sand from a similar environment is also abundant in the wilderness, but fails to comply with acceptable ASTM standards for use in mortar and masonry. Nor is the sand recommended as a source of moulding and glass sands as defined by the American Foundrymen's Society. Beds of tidal-marsh deposits near the surface are contaminants.

The Florida-Georgia fuller's earth district, the major area for producing fuller's earth in the United States, is 24 mi north of the wilderness. The Hawthorn Formation, the principal host for fuller's earth deposits, has not been found in the Bradwell Bay Wilderness and Sopchoppy River Wilderness Study Area and there is little promise for the occurrence of fuller's earth resources.

SUGGESTIONS FOR FURTHER STUDY

Further study of the wilderness offers little promise for identifying mineral or energy deposits with resource potential.

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CLEAR LAKE ROADLESS AREA, FLORIDA

By SAM H. PATTERSON[1], U.S. GEOLOGICAL SURVEY, and

THOMAS M. CRANDALL, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey in 1980 and 1981 the Clear Lake Roadless Area was concluded to offer little or no promise for the occurrence of mineral resources. The only commodity that has been mined in the area is clayey sand used in stabilizing USFS roads and in highway construction. Although there are large clayey sand resources in the Clear Lake Roadless Area, there are virtually unlimited resources of this material in the surrounding region. No peat more than a few inches thick occurs in the area. Limestone underlies all of the Clear Lake area but is under thick overburden. The region has been explored for heavy minerals and phosphate, but no resources have been found. There appears to be little promise for discovery of oil and gas in the Clear Lake area. However, the area and nearby lands have not been thoroughly tested for oil and gas, and the possibilities for discovery cannot be ruled out.

CHARACTER AND SETTING

The Clear Lake Roadless Area occupies about 10 sq mi in the Apalachicola National Forest, Leon County, Florida, which is in the Big Bend region about 10 mi southwest of Tallahassee. The area is bounded on the southwest by Florida Highway 267 and on the other sides by unimproved USFS roads.

The entire Clear Lake area is blanketed by unconsolidated sediments overlying a thick sequence of sedimentary rocks that were deposited in the eastern part of the Apalachicola embayment. The unconsolidated sediments consist of Pleistocene and Holocene clayey sand and soil, having a total thickness of about 35 ft. The formations that underlie the unconsolidated sediments and are in contact with them are the St. Marks and Hawthorn Formations of Miocene age and the Jackson Bluff Formation of Pliocene age. The St. Marks is composed of carbonate, the Hawthorn of sandstone, sandy limestone, and clayey sand, and the Jackson Bluff of a very fossiliferous dark clayey sand. The rocks that underlie the St. Marks Formation include about 2800 ft of Oligocene (includes Suwanee Limestone) and Paleocene beds and nearly 4000 ft of Cretaceous strata. Little is known about the older rocks below the Clear Lake area, but sedimentary formations of Jurassic and Triassic and probably early Paleozoic age as well as crystalline rocks are present in the central part of the Apalachicola embayment and probably underlie the Clear Lake area.

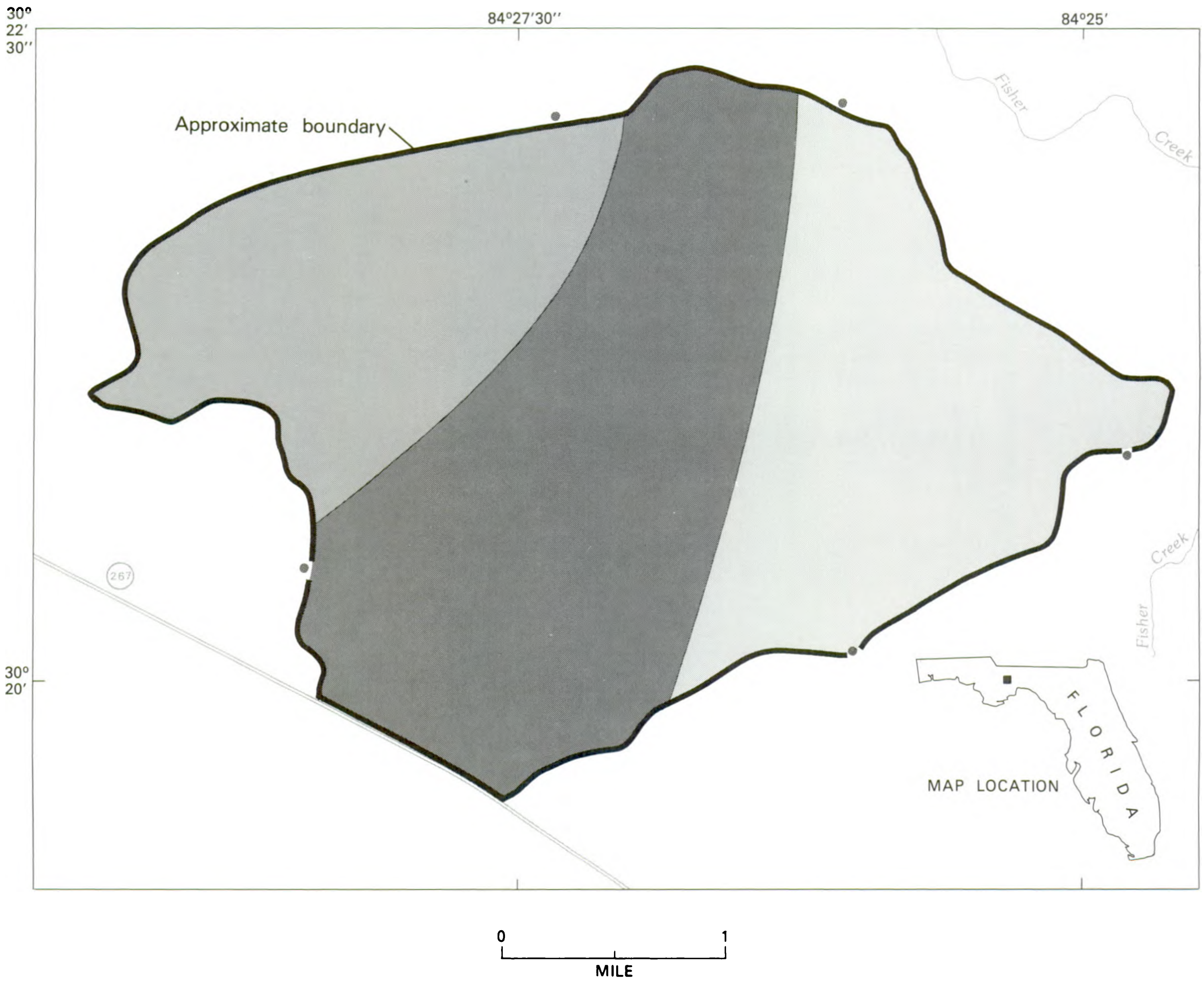
The sedimentary formations underlying the Clear Lake area dip gently to the southwest toward the Apalachicola embayment which was formed by downwarping of crustal rocks. The central part of the embayment is filled with sediments of Triassic to Quaternary age having a thickness of more than 14,000 ft. No faults have been recognized in the Clear Lake area. However, strata have been disturbed in many places by slumping into solution cavities.

MINERAL RESOURCES

The geology of the area had been investigated by the Florida Bureau of Geology (Hendry and Sproul, 1966) and the mineral potential of the area was investigated by the USGS and the USBM in 1980 and 1981. Reports by Hendry and others (1982) and Crandall (1982) summarized herein provide the information on mineral-resource potential.

The only mineral material that has been produced in the Clear Lake area is clayey sand used in the construction of Florida Highway 267 and in stabilizing USFS roads. Although large quantities of clayey sand resources in the unconsolidated surficial material are present in the Clear Lake area, they are not shown on the

[1]With contributions from C. W. Hendry, Jr., Florida Bureau of Geology and J. W. Sweeney, USBM.



EXPLANATION

Jackson Bluff Formation (Tertiary)

Hawthorn Formation (Tertiary)

St. Marks Formation (Tertiary)

Contact

• Drill hole or well--Formations penetrated are identified by Hendry and Sproul (1966, table 2)

Entire area is blanketed by Holocene and Pleistocene sand and clayey sand

Figure 151.—Clear Lake Roadless Area, Florida.

map because virtually unlimited quantities of similar materials occur in the surrounding areas outside the roadless area.

Limestone in the St. Marks Formation occurs under about 35 ft of overburden in the eastern one-third of the Clear Lake area and under thicker overburden in the central and western parts of the area. This limestone resource is not shown on the map because similar rock under thinner overburden occurs in extensive areas east of the Clear Lake area. The limestone east of the area is also closer to potential markets in the Tallahassee area.

Other mineral resources either do not occur in the Clear Lake area or are too deeply buried and include common clay, fuller's earth, heavy minerals, phosphate, and sand and gravel. Very thin deposits of peaty material are present in the area, but they are too small and impure to be assessed as having mineral-resource potential.

The entire Clear Lake area has been leased for oil and gas in the past, but there were no active oil or gas leases or applications for leases in the area as of October, 1981. According to the reports and records of the Florida Bureau of Geology, many exploratory wells have been drilled in search for oil and gas in the region. To date, only a few shows of oil have been found, and all of the holes have been dry. At least 30 were deeper than 5000 ft and 15 were deeper than 10,000 ft. The deepest hole bottomed at 14,570 ft. Surprisingly, two of the shallow holes were reported (Hendry and Sproul, 1966, p. 105) to have good shows of oil. These two wells are located less than 20 mi from the Clear Lake Roadless Area.

Although there are no reasons for optimism about the discovery of oil and gas in and near the Clear Lake area, the possibilities cannot be completely ruled out. The principal reasons for the unfavorable outlook are the large number of dry holes in the region and the probable absence of the Jurassic Smackover Formation. Geologists believe that the Smackover Formation has the greatest promise for oil and gas in the region because it contains the oil and gas produced in the Jay field in the westernmost Florida panhandle and nearby fields in Alabama (Babcock, 1972). The Smackover has been found to be present in several wells southwest of Clear Lake and is thought to underlie about 2000 sq mi in the region. However, the updip limit of this formation is shown by Applegate and others (1978, fig. 1) to be more than 15 mi west of the Clear Lake area in Liberty County. Reasons why some possibility remains for oil and gas discoveries in the study area include the following: (1) the shows of oil in dry holes east of the area, noted in the foregoing paragraph; and (2) uncertainty as to whether or not formations older than the Smackover may contain oil and gas.

The Clear Lake area has not been thoroughly explored for oil and gas and the possibility for either being present still exists.

SUGGESTIONS FOR FURTHER STUDIES

The blanket of unconsolidated surficial materials covering the Clear Lake area rules out the acquisition of significant additional geologic information by field studies, and the Florida Bureau of Geology has published a report on the geology of Leon County (Hendry and Sproul, 1966) in which the area is located. Accordingly, further evaluations of the mineral potential of the Clear Lake area are not warranted.

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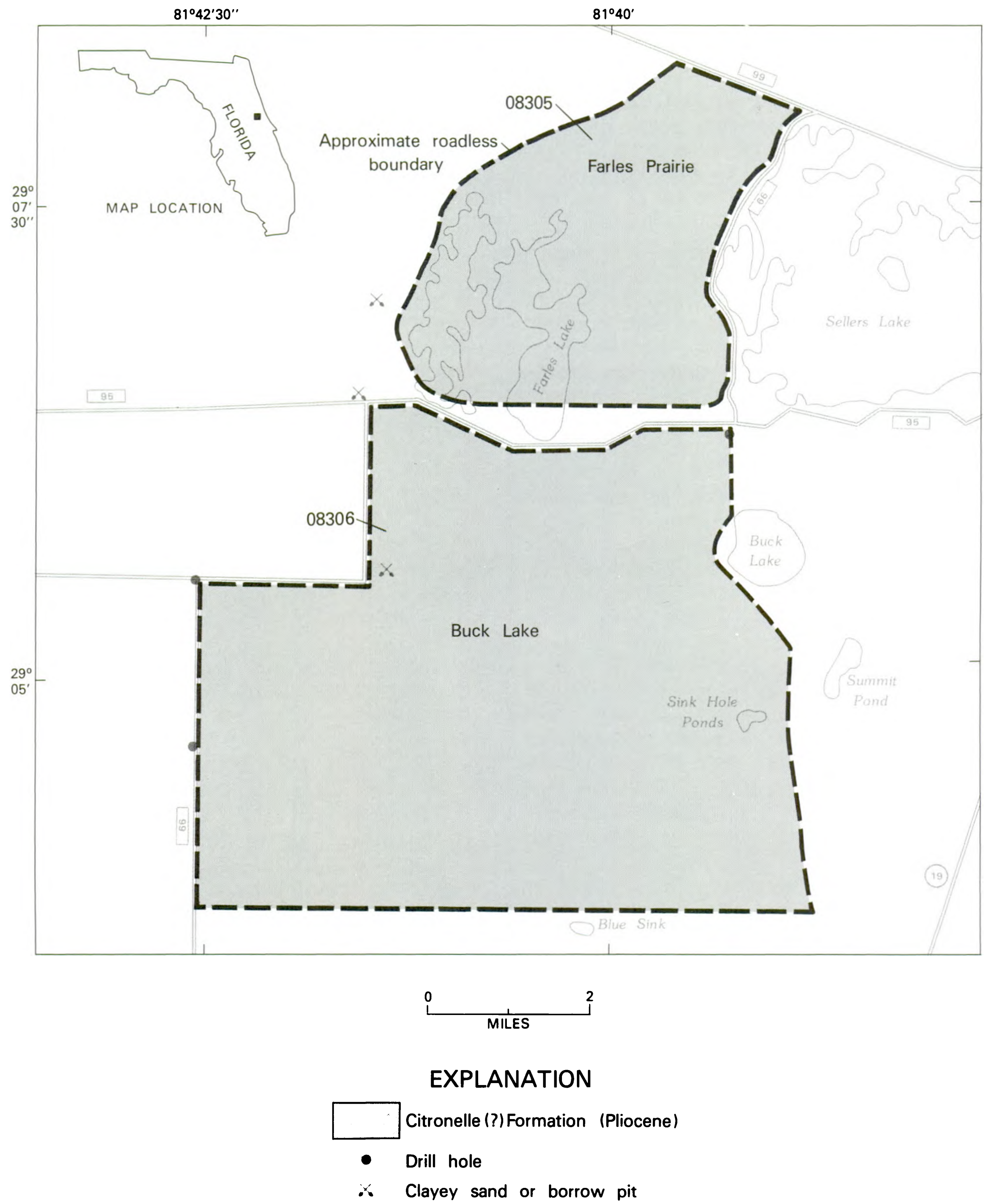

Figure 152.—Farles Prairie and Buck Lake Roadless Areas, Florida.

FARLES PRAIRIE AND BUCK LAKE ROADLESS AREAS, FLORIDA

By SAM H. PATTERSON, U.S. GEOLOGICAL SURVEY, and

THOMAS M. CRANDALL, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys in 1980 and 1981 conducted by the USGS and USBM of the Farles Prairie and Buck Lake Roadless Areas showed little promise for the occurrence of metallic mineral or energy resources; the possibility for the occurrence of hydrocarbons, however, cannot be ruled out. The only mineral material that has been produced in the roadless areas is clayey sand used in stabilizing USFS roads. The large quantities of clayey sand occurring in the areas are not identified as resources because virtually unlimited resources are present in the surrounding region. Limestone underlies all of the two areas, but is too far from markets and under too much overburden for quarrying. Heavy minerals and phosphate are present in the two areas but are not sufficiently concentrated to be identified as resources.

CHARACTER AND SETTING

The Farles Prairie Roadless Area occupies about 3.4 sq mi and the Buck Lake Roadless Area about 8.9 sq mi in the Ocala National Forest, Marion County, Florida. The areas can be reached from Ocala by taking Florida Highway 40 east about 32 mi to Florida Highway 19 then south on this road to USFS Road 62 which leads through the U.S. Navy Tracking Station to the Farles Prairie Roadless Area.

The two roadless areas are in the Central Highlands physiographic province of Florida, and the topography is a modified karst with a thin veneer of windblown sand at the surface. Farles Prairie Roadless Area is an area of low sand hills in the eastern part and shallow lakes and flat prairies in the west. Buck Lake Roadless Area is almost entirely an area of low sand hills, and has only a few scattered ponds. Altitudes in the two areas range from 50 to 140 ft above sea level.

The mineral potential of the Farles Prairie and Buck Lake Roadless Areas was investigated by the USGS and the USBM in 1980 and 1981. Reports by Crandall (1982), Cathcart and Patterson (1983) and Cathcart and others (1983) provide information on the geology and mineral potential of the areas.

The surface of the Farles Prairie and Buck Lake Roadless Areas is blanketed by unconsolidated soil and sand. This surficial blanket is no more than 5 ft thick in most places, but is as much as 100 ft thick in sink hole fillings. These surficial materials are underlain by a second unconsolidated blanket consisting of white, red, and orange sand that is 40 to 60 ft thick. The age of this unconsolidated layer is uncertain, but it is probably of Pliocene age and has been called the Citronelle(?) Formation. The Citronelle(?) rests unconformably on Miocene strata that consist of an unnamed upper Miocene formation and the middle Micoene Hawthorn Formation which is chiefly sand; both contain phosphate. The lower part of the Hawthorn contains considerable dolomite. The two Miocene units have been removed by erosion from parts of the Ocala National Forest, but they have a total thickness of as much as 200 ft in the Farles Prairie and Buck Lake Roadless Areas. About 4000 ft of sedimentary rocks ranging in age from Cretaceous to Eocene underlie the Hawthorn Formation and rest unconformably on an older basement of crystalline and Paleozoic sedimentary rocks.

MINERAL RESOURCES

No minerals have been mined in the Farles Prairie Roadless Area, and the only production in the Buck Lake Roadless Area has been clayey sand used in stabilizing USFS roads. Although large resources of clayey sand in the Citronelle(?) Formation are present in the two roadless areas, they occur as virtually unlimited resources in surrounding areas.

Phosphate deposits occur in the Hawthorn Formation and the unnamed upper Miocene formation in both areas. The deposits have been explored by widely spaced drill holes, including three holes drilled during this study. No significant deposits of phosphate have been found in the Ocala National Forest. The P_2O_5 content of samples of pebble fraction was only 13.1 percent and the results of analyses of samples collected during this investigation failed to indicate the presence of high-grade phosphate and no phosphate resource potential was identified.

Other minerals that are produced in the region of the Ocala National Forest either do not occur in the Farles Prairie and Buck Lake Roadless Areas or were not identified as resources in this study; these include limestone, fuller's earth, kaolin, heavy minerals, and peat. The Eocene Ocala Limestone underlies both areas but is too deeply buried to be quarried and large resources of this limestone are located in places much closer to markets. No fuller's earth or kaolin clays of sufficient purity to form valuable deposits occur in the two areas. One sample of common clay tested by the USBM had excellent ceramic properties, but it came from an interval 86–94 ft below the surface. Small amounts of heavy minerals occur in the unconsolidated surficial material, Citronelle(?) Formation, unnamed upper Miocene formation, and Hawthorn Formation. However, no concentrations sufficiently rich to be identified as resources were found. Organic rich muck and small accumulations of peaty material occur in some of the swamps in the two areas, but no low-ash peat deposits are present.

Oil and natural gas are produced from Lower Cretaceous Sunniland Limestone in southern Florida and from the Jurassic Smackover Formation in western Panhandle Florida. Jurassic beds are not present in the Ocala National Forest, and beds of Early Cretaceous age, present both to the east and west, are missing in the area, where beds of Late Cretaceous age rest on Paleozoic rocks.

Several exploratory holes for oil and gas have been drilled in and around the Ocala National Forest, but all holes were dry and abandoned. There is little reason for optimism regarding possible oil and gas accumulations in the subsurface in Farles Prairie and Buck Lake Roadless Areas, because of the number of dry holes in the surrounding areas, and because rocks that contain oil and gas elsewhere in Florida are not present here.

SUGGESTIONS FOR FURTHER STUDY

Because of the blanket of surficial material covering the Farles Prairie and Buck Lake Roadless Areas little could be accomplished by further field observations, and drilling would be required to obtain much more information about geology. The principal potential valuable mineral in the area is phosphate, but information now available indicates there is little possibility for the occurrence of large high-grade deposits.

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NATURAL AREA ROADLESS AREA, FLORIDA

By SAM H. PATTERSON,[1] U.S. GEOLOGICAL SURVEY, and

THOMAS M. CRANDALL, U.S. BUREAU OF MINES

SUMMARY

Mineral surveys in 1980 and 1981 of the Natural Area Roadless Area, Florida, identified a substantiated resource potential for scattered low-grade phosphate deposits. The area has little promise for the occurrence of other mineral resources or oil and gas, although the possibilities for the occurrence of these two hydrocarbons cannot be ruled out. The only mineral material that has been produced in the area is clayey sand used in stabilizing USFS roads, but virtually unlimited quantities of similar material are present in the surrounding region. Peaty material is present in swamps in the roadless area, but none of it is thick or pure and no resource potential was identified. Limestone underlies all of the Natural Area Roadless Area but is under too much overburden for quarrying. Heavy minerals are present in the area but are not sufficiently concentrated to consider the area as having resource potential.

CHARACTER AND SETTING

The Natural Area Roadless Area occupies about 6.8 sq mi in the Osceola National Forest, Baker County, Florida. The area is 18 mi northeast of Lake City which is in northern peninsular Florida. The Natural Area Roadless Area is bounded by USFS Road 277 on the south and road 235 on the west. The surface of the roadless area is a flat swampy plain. The highest altitude is 133 ft above sea level and the lowest point is only about 10 ft lower.

The mineral potential of the area was investigated by the USGS and the USBM in 1980–81 (Crandall, 1981; Cathcart and others, 1983; and Patterson and others 1983.

The entire Natural Area Roadless Area is blanketed by unconsolidated sediments of Pleistocene and Holocene age, that overlie a sequence of Tertiary sedimentary rocks. The surficial sediments in swamps consist of peaty material and organic-rich muck. The shallow soils in the drier areas are rarely more than a 1 ft thick A horizon and consist chiefly of clayey sands. The swamp deposits and shallow soils are underlain by 25–35 ft of unconsolidated sand and clayey sand. Miocene rocks underlying the unconsolidated beds consist of an unnamed formation and the Hawthorn Formation, having a total thickness of 240–280 ft. Both of these formations contain phosphate. About 3300 ft of sedimentary rocks ranging in age from Cretaceous to Eocene underlie the Hawthorn Formation and rest unconformably on an older basement of crystalline and Paleozoic sedimentary rocks.

MINERAL RESOURCES

The only mineral material that has been produced in the Natural Area Roadless Area is clayey sand used in stabilizing USFS roads. Although large resources of clayey sand in unconsolidated surficial material are present in the roadless area, virtually unlimited quantities of similar material occur in surrounding areas.

Scattered phosphate deposits occur in the Miocene Hawthorn Formation and an unnamed upper Miocene formation in the Natural Area Roadless Area. The deposits have been explored by widely spaced drill holes. Preference right lease applications for phosphate have been filed on large acreages in parts of the Osceola National Forest located west and southwest of the Natural Area Roadless Area, but no lease applications have been filed for tracts within the area. Although the phosphate in the roadless area is low grade, the entire area has a substantiated phosphate resource potential.

Limestone in the Ocala Limestone underlies the entire

[1]With contributions from James B. Carthcart and Cornelia C. Cameron, USGS.

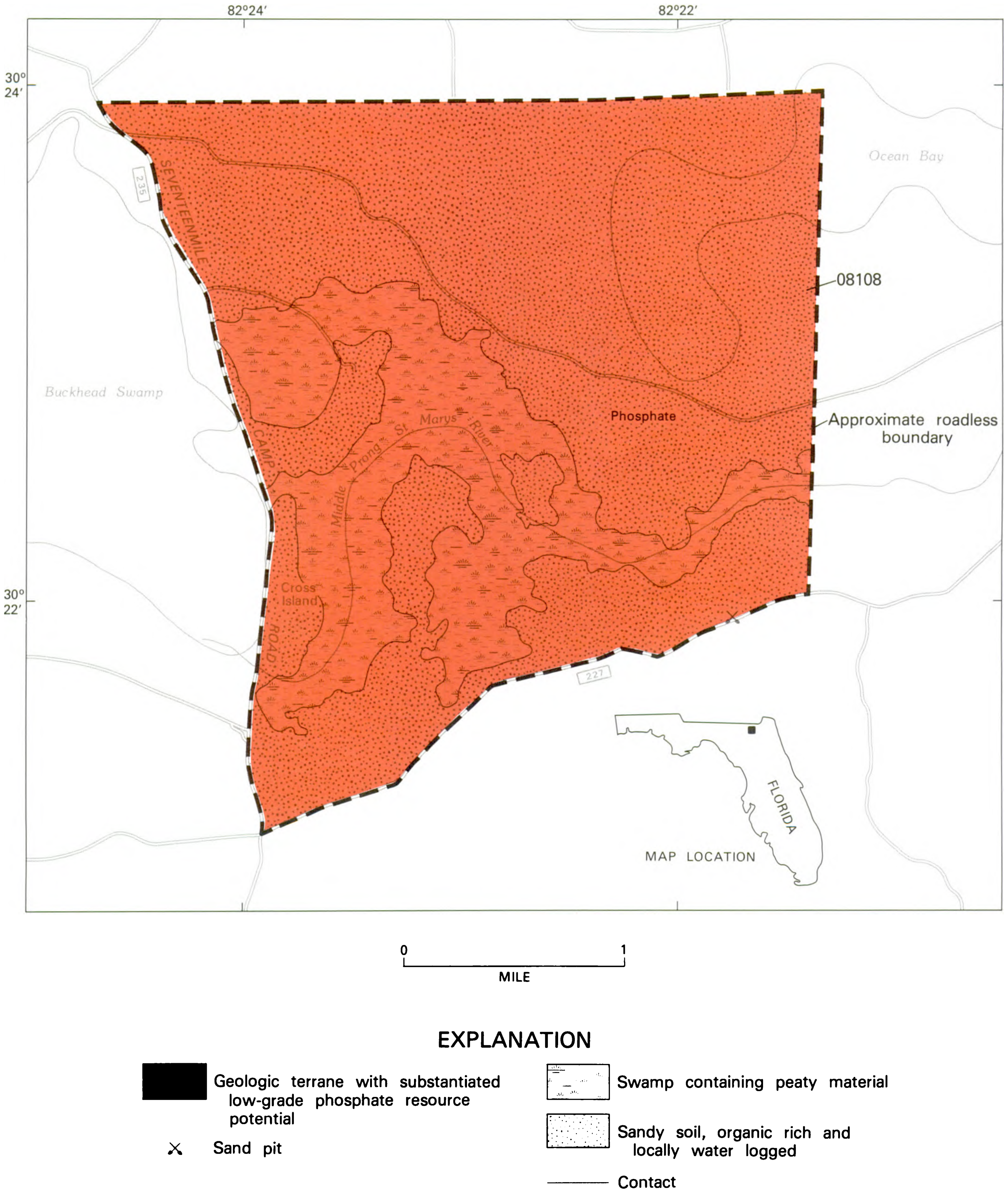

Figure 153.—Natural Area Roadless Area, Florida.

area, but is too deeply buried to be amenable to quarry.

Peat material occurs in swamps in the area, but the deposits generally contain more than 25 percent ash, the current maximum cut off in commerical quality peat.

Small quantities of heavy minerals occur in unconsolidated surficial sand in the Natural Area Roadless Area. However, these heavy-mineral accumulations are much lower in grade than deposits currently being mined in the Trail Ridge district of Florida, and no resource potential was identified.

According to the reports and records of the Florida Bureau of Geology, many exploratory holes have been drilled in the region surrounding the Osceola National Forest in search for oil and gas. To date, only a few shows of oil and gas have been found, and all of the holes have been dry. Only three of the 29 holes in the region were drilled deeper than 5000 ft; the deepest was 5862 ft, one hole was 4444 ft deep, and all other holes were less than 3500 ft deep. Thirteen of the dry holes penetrated Paleozoic strata. A driller's log of the St. Mary's River Oil Corporation well, located 35 mi northeast of the Natural Area Roadless Area, noted several shows of oil at depths between 1812 and 4795 ft and evidence of gas at two intervals.

Although no potential for oil and gas was identified in the Natural Area Roadless Area, the possibilities cannot be completely ruled out. The principal reasons for an unfavorable outlook are the large number of dry holes in the region and the absence of the formations that contain oil and gas in the fields in southern and westernmost Florida. The oil in the southern Florida fields is in Lower Cretaceous formations, and in the Jay field in the western Florida Panhandle it occurs in the Jurassic Smackover Formation. In the vicinity of the Osceola National Forest, the lowermost Upper Cretaceous formation rests unconformably on Paleozoic rocks.

Some possibility remains, however, for the occurrence of oil and gas in deep rocks in the Natural Area Roadless Area. The Paleozoic rocks have not been adequately explored in the region of the Osceola National Forest, and according to one authority, rocks of Paleozoic age in northern Florida and on the adjacent continental shelf should contain 100 million barrels of oil and 0.5 trillion cu ft of gas. The shows of oil and gas, like that in the St. Mary's River Oil Corporation dry hole located 35 mi northeast of the roadless area, suggest that valuable quantities of oil and gas may also be present in northern Florida. The westward thinning of Cenozoic and Upper Cretaceous formations and the wedging out of Lower Cretaceous beds are excellent conditions for the occurrence of updip pinch-out sedimentary traps. Whether or not traps of this type are present in the subsurface of the Osceola Forest is unknown, but if they exist, they might contain hydrocarbons.

SUGGESTIONS FOR FURTHER STUDIES

Because of the blanket of surficial material covering the Natural Area Roadless Area, little could be accomplished by further field investigations and drilling would be required to obtain information about the geology and to assess the oil and gas potential. Many drill holes would be needed to adequately evaluate the phosphate potential of the area. No reasons for investigating the possibilities for minerals other than phosphate are apparent.

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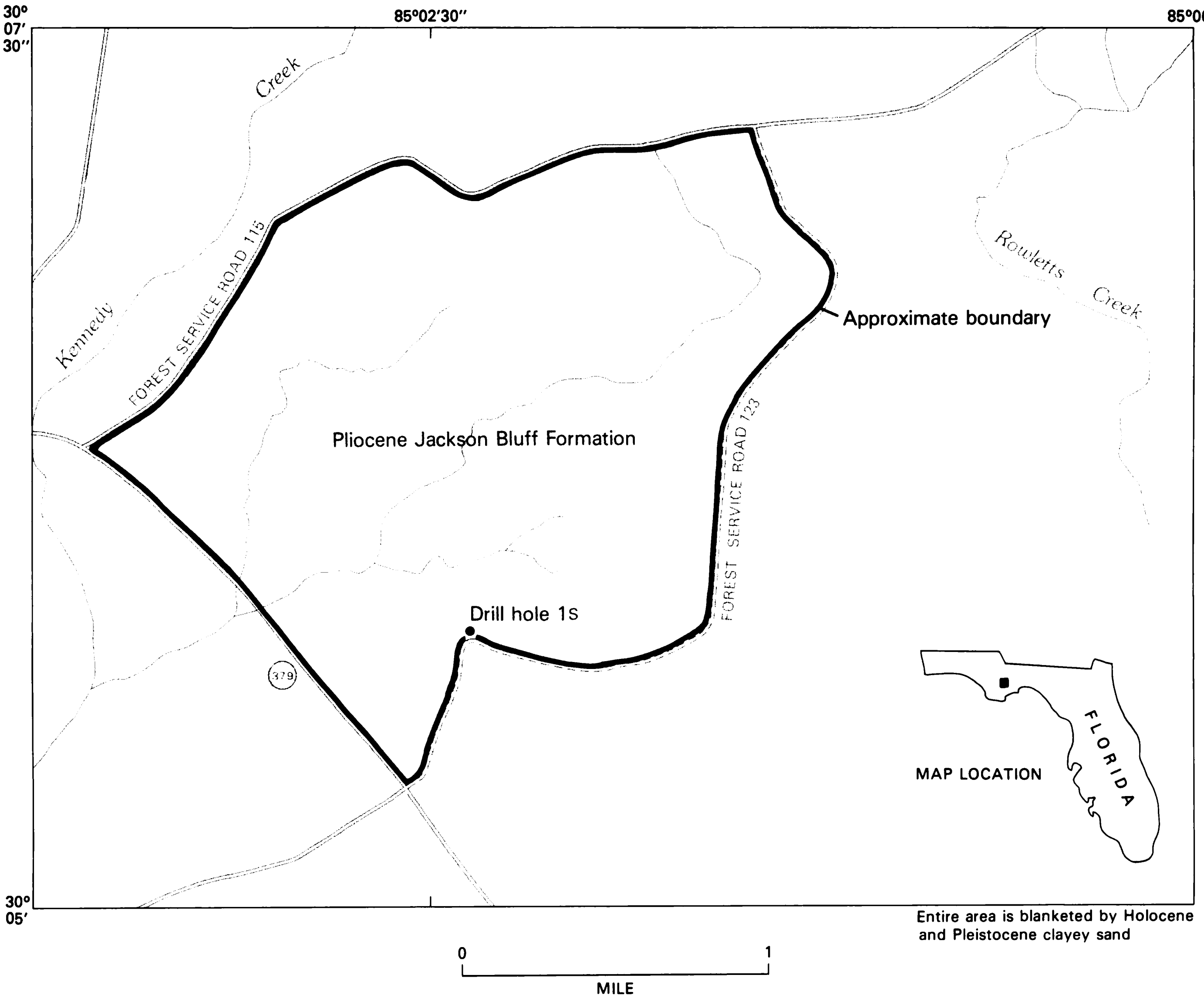

Figure 154.—Savannah Roadless Area, Florida.

SAVANNAH ROADLESS AREA, FLORIDA

By SAM H. PATTERSON,[1] U.S. GEOLOGICAL SURVEY, and

THOMAS M. CRANDALL, U.S. BUREAU OF MINES

SUMMARY

On the basis of a mineral survey in 1980 and 1981 the Savannah Roadless Area was appraised to offer little promise for the occurrence of mineral resources. The commodities identified in the area are deposits of sand and gravel; however, they are deeply buried, far from potential markets, and more readily accessible material exists outside the roadless area. The possibility that oil and gas might occur in the Jurassic Smackover Formation or in other formations at depth cannot be ruled out.

CHARACTER AND SETTING

The Savannah Roadless Area occupies about 3 sq mi in the Apalachicola National Forest, Liberty County, Florida, which is in the Big Bend region about 50 mi southwest of Tallahassee. The area is in lowlands of the Gulf Coastal Plain at altitudes of 25–43 ft. It is bounded on two sides by USFS roads and on the third by County Highway 379. The area can be reached on County Highway 379 by traveling 6 mi northwest from Sumatra, a small village in southern Liberty County located on Florida Highway 65. No mineral materials other than clayey sand used in surfacing USFS roads and in highway construction have been produced within 25 mi of the Savannah area in recent years. In 1981 about 51 percent of the Savannah area was under simultaneous oil and gas lease, and an application for an oil and gas lease on an additional 6 percent of the area was on file.

The mineral potential of the Savannah Roadless Area was investigated by the USGS and the USBM in 1980 and 1981. Reports by Patterson and others (1982) and Crandall (1982), summarized herein, include the results of those studies.

The entire Savannah area is blanketed by unconsolidated sediments overlying a thick sequence of sedimentary rocks that were deposited in the Apalachicola embayment. The surficial blanketing material consists of a thin soil horizon overlying a thickness of about 60 ft of Pleistocene-Holocene sand, gravel, and clay strata. The surficial materials overlie the Pliocene Jackson Bluff Formation, which consists of coarse sand-to gravel-size shell fragments, quartz sand, and clay, containing trace amounts of phosphate pellets, heavy minerals, and glauconite. The Jackson Bluff Formation forms the bedrock throughout the area and is underlain by a thick sequence of older sedimentary rocks.

The Savannah area is located in the central part of the Apalachicola embayment that was formed by the structural depression of crustal rocks to form a deep basin. The embayment was filled by Triassic to Quaternary sediments having a total thickness of more than 14,000 ft. Deeply buried strata along the axis of the embayment plunge about 65 ft/mi to the west-southwest. Shallow rocks, that were deposited after the embayment was mostly filled, dip only a few feet per mile toward the Gulf of Mexico. No faults have been recognized in the Savannah area.

MINERAL RESOURCES

The only mineral commodity in the Savannah area is a subsurface bed of sand and gravel in the unconsolidated surficial materials (Patterson and others, 1982). Cuttings from one drill hole (1S on map) showed this bed to be 13 ft thick, lying at a depth of 37 to 50 ft, and to consist mostly of remarkably pure angular quartz; only 17 percent of the sample was finer than coarse sand, and 28 percent was gravel. Although the sand and gravel is more suitable for construction and other uses than that produced elsewhere in Florida, it is far from possible markets, under excessive thicknesses of overburden and more readily available material exists outside the roadless area.

[1]With contributions from Walter Schmidt, Florida Bureau of Geology.

Extensive deposits of clayey sand of the type used in road construction and stabilizing occur in the Savannah area, and the sand is dug intermittently in two pits located 2 mi south of the area. The clayey sand in the Savannah area was not identified as having resource potential as unlimited resources of such material are present in the surrounding region.

Other industrial minerals—limestone, common clay, peat, and fuller's earth—are presently or have in the past been mined or investigated in the Big Bend region, but they either do not occur in the Savannah Area or are deeply buried.

According to the reports and records of the Florida Bureau of Geology many exploratory wells have been drilled in search of oil and gas in the Big Bend region of Florida. To date, only a few shows of oil have been found, and all of the holes have been dry. Thirty of the holes bottomed at depths of more than 5,000 ft. Of these, 15 were deeper than 10,000 ft and the deepest bottomed at 14,570 ft. Surprisingly, two shallow dry holes, located about 50 mi east of the Savannah Area, were reported to have good shows of oil. Oil stains were found in the Smackover Formation and in a conglomeratic calcareous sandstone of the Norphlet Formation also of Jurassic age in a dry hole located 20 mi west-northwest of the Savannah area.

Although there are no reasons for optimism about the discovery of oil and gas in and near the Savannah area, the possibilities cannot be completely ruled out. Oil and gas are produced from the Smackover Formation in the Jay field in the westernmost Florida panhandle and nearby fields in Alabama. Therefore, this formation may have some potential for oil and gas in the Big Bend region. The Smackover Formation, however, has been intersected by several dry holes in parts of the Big Bend region lying to the east, south, and west of the Savannah area. Other reasons for not ruling out the potential for oil and gas discovery in the Savannah Area include (1) the shows of oil in dry holes in the region noted in the foregoing paragraph, (2) uncertainties as to whether or not formations older than the Smackover may contain oil and gas, and (3) the geologic favorability of the region for the occurrence of both structural and sedimentary traps. The Savannah area and surrounding region has not been thoroughly explored, and insufficient data were obtained in this study to evaluate the oil and gas resource potential.

SUGGESTIONS FOR FURTHER STUDIES

Because of the blanket of surficial materials covering the Savannah Roadless Area the acquisition of further meaningful geologic information would require costly core drilling, and there seems to be little likelihood of discovery of valuable mineral deposits. The type of work that would be fruitful is the regional core drilling program now underway by the Florida Bureau of Geology, which includes several widely spaced drill holes. The products of this program will include significant improvement in knowledge of stratigraphy, structure, geologic history, and water- and mineral-resource potential of the region.

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GEORGIA

Location of areas studied.

GEORGIA

Map No.	*Name of Area*
1	Big Frog Wilderness Study Area and additions, Tennessee and Georgia—See Tennessee
8	Blood Mountain Roadless Area
6	Chattahoochee Roadless Area
4	Cohutta Wilderness, Georgia and Tennessee, and Hemp Top Roadless Area, Georgia
3	Ellicott Rock Wilderness and additions, South Carolina, North Carolina, and Georgia—See South Carolina
2	Overflow Roadless Area, Georgia and North Carolina
7	Rich Mountain Roadless Area
5	Tray Mountain Roadless Area

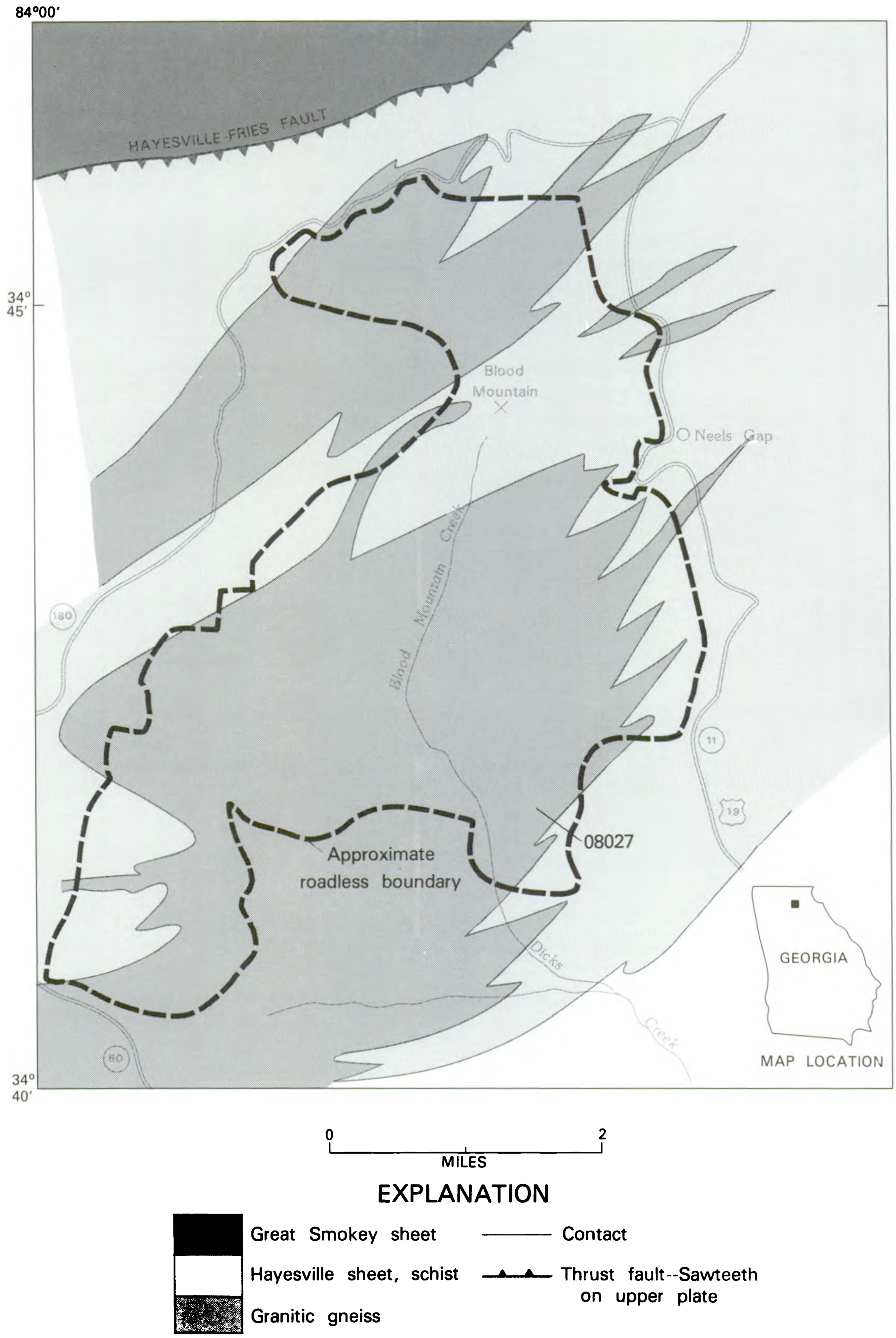

Figure 155.—Blood Mountain Roadless Area, Georgia.

BLOOD MOUNTAIN ROADLESS AREA, GEORGIA

By ROBERT P. KOEPPEN,[1] U.S. GEOLOGICAL SURVEY, and

MICHELLE K. ARMSTRONG, U.S. BUREAU OF MINES

SUMMARY

A mineral-resource survey made in 1981 of the Blood Mountain Roadless Area, Georgia, indicates that there is little promise for the occurrence of mineral and energy resources. Natural gas may be present at great depth, perhaps 5 mi down and below the overthrust sheets of the Blue Ridge Mountains, but presently available information is not adequate to evaluate the resource potential of this commodity.

CHARACTER AND SETTING

The Blood Mountain Roadless Area occupies approximately 16 sq mi of Chattahoochee National Forest in the Blue Ridge Mountains of northern Georgia. The area is centered about 12 mi south of Blairsville and covers parts of Lumpkin and Union Counties. U.S. Highway 19 closely parallels the area's eastern boundary, and Georgia Highways 60 and 180 are near its western and northwestern boundaries. A few secondary roads, as well as some logging and USFS roads, provide limited access to the fringe of the roadless area. In addition, a number of foot paths, including the Appalachian Trail, provide access to some of the remote parts of the roadless area. The terrane is heavily forested and characterized by rugged mountainous topography with narrow valleys, sharp ridges, and steep hill slopes. The highest altitude is 4458 ft on Blood Mountain and the lowest altitude is about 1800 ft on Dicks Creek at the southern edge of the area. Tributaries of the north flowing Nottely River, the northwest flowing Toccoa River, and the south flowing Chestatee River drain the area.

The Blood Mountain Roadless Area is underlain by polydeformed and metamorphosed rocks of the Tallulah Falls Formation of Proterozoic age. The Tallulah Falls Formation is part of the Hayesville sheet, one of several large crustal blocks emplaced by westward-directed movement over low-angle thrust faults in the southern Blue Ridge Mountains (Nelson, 1982). One of these faults, the Hayesville-Fries fault, separates rocks of the Hayesville sheet from rocks of the Great Smoky sheet, about 0.5 mi north of the Blood Mountain Roadless Area. However, rocks of the Great Smoky sheet are not exposed in the roadless area.

Rocks of the Tallulah Falls Formation within the roadless area consist of biotite gneiss, mica schist, metasandstone, quartzite, amphibolite, and minor calc-silicate layers. Granite and granodiorite gneiss are also present. In addition, pegmatite veins and pods of various sizes are widely dispersed throughout the area. Migmatite of biotite gneiss and granitic gneiss are abundant. Metamorphic index minerals indicate that the assemblage is of sillimanite grade. Rocks within the roadless area are complexly deformed and large-scale fold interference patterns are commonly seen. All the rocks are jointed throughout the roadless area, and most joints are steeply inclined. Thin pegmatite and quartz veins occupy some of the early joints (Nelson, 1983).

A mineral-resource survey of the Blood Mountain Roadless Area was made by USGS and USBM personnel during the fall and winter of 1981. The survey included reconnaissance geologic mapping (Nelson, 1983), geochemical studies (Koeppen and Nelson, 1983), mine prospect examination (Armstrong and Sabin, 1983), and mineral-resource potential (Koeppen and others, 1983).

The Federal Government owns 99 percent of the surface rights and about 87 percent of the mineral rights in the roadless area. The remainder are privately owned. Oil and gas lease applications were filed for approximately the southern two-thirds of the area, and 10-year leases were issued for about 1.3 sq mi in May 1982. At last report, no drilling for oil or gas has taken place on the leased tracts. There are no known prospects or mines within the roadless area.

[1]Contribution from A. E. Nelson, USGS, and A. E. Sabin, USBM.

MINERAL RESOURCES

The Blood Mountain Roadless Area lies within the northern Georgia pegmatite district (Lesure and Shirley, 1968). Mica occurrences in the roadless area are minor, poor quality, and low grade; no potential for mica resources was identified.

Gneiss and schist suitable for crushed rock and aggregate underlie much of the roadless area. Good sources for these materials abound throughout the region, closer to potential markets.

The geologic studies, reconnaissance geochemical survey, and search for prospects (Koeppen and others, 1983) indicate little promise for the occurrence of other mineral resources in the area.

Recent seismic studies (Cook and others, 1979) indicate that Paleozoic sedimentary rocks like those in the Tennessee Valley may underlie the overthrust rocks of the Blue Ridge Mountains of Georgia. The Paleozoic rocks are buried by about 5 mi of metamorphic rocks, and temperatures and pressures probable at those depths suggests that any hydrocarbons present would be in the form of natural gas and not oil. The possibility of concentrations of gas in these rocks is uncertain; no reasonable assessment of the gas potential can be made on the basis of available information.

SUGGESTIONS FOR FURTHER STUDIES

Further seismic studies and exploratory drilling are needed to evaluate the gas potential of this part of the Eastern Overthrust Belt.

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CHATTAHOOCHEE ROADLESS AREA, GEORGIA

By ARTHUR E. NELSON,[1] U.S. GEOLOGICAL SURVEY, and
ROBERT A. WELSH, JR., U.S. BUREAU OF MINES

SUMMARY

A mineral survey made in 1981 indicates that the Chattahoochee Roadless Area, Georgia, offers little promise for the occurrence of mineral resources even though gold, mica, sillimanite, soapstone, dunite, chromite, and nickel have been mined nearby, and source rocks for these commodities are present in the roadless area. Granite gneiss, gneiss, schist, and metasandstone in the roadless area are suitable for stone, crushed rock, or aggregate; however, other sources for these materials are available outside the roadless area, closer to present markets. The potential for the occurrence of hydrocarbons (probably gas) beneath the thick regional thrust sheets in this area cannot be adequately evaluated from available data.

CHARACTER AND SETTING

The Chattahoochee Roadless Area occupies approximately 36 sq mi in the Chattahooche National Forest, centered about 12 mi southeast of Blairsville, Georgia. The terrane is heavily forested, has a rugged topography with narrow valleys, sharp ridges, and steep slopes. In places, the slopes exceed 45°, whereas commonly they range from 20 to 30°; rarely are they less than 10°. The roadless area occupies parts of Towns, White, and Union Counties. The highest altitude is 4045 ft on Horsetrough Mountain and the lowest is about 1664 ft in Horton Creek west of Helen in the southern part of the area. Tributaries of the north-flowing Hiwassee River, the south-flowing Chattahoochee River, and the northwest-flowing Nottely River drain the Chattahoochee Roadless Area.

Georgia State Routes 17, 66, 180, and the Richard Russell Highway (348) lead to a few secondary, logging, and USFS roads that provide limited access to the roadless area. In addition, the Appalachian Trail traverses part of the area's high ground.

The Chattahoochee Roadless Area is underlain by Precambrian metamorphic rocks that form two thrust sheets. The northwest border of the roadless area is underlain by part of a narrow thrust sheet of mafic-ultramafic rocks that includes serpentinite, dunite, pyroxenite, and gabbro. The rest of the roadless area is underlain by rocks of the Hayesville thrust sheet that includes mafic and felsic gneisses, schist, metasandstone, and granitic gneiss. About 300 ft southeast of the roadless area the Shope Fork fault juxtaposes the Hayesville sheet against the lower-grade metamorphic rocks of the Helen belt (Nelson, 1983), which includes metasandstone, schist, and mafic gneiss.

Rocks underlying the roadless area have been complexly folded and faulted. Some exposures show that the rocks have been deformed by as many as five generations of folding. The second generation folds form the regional folds with northeast-trending fold axes. Numerous thrust faults characterized the terrane surrounding the roadless area, but except for the faults bounding the Hayesville sheet in and near the roadless area, other faults with large displacements were not observed. However, numerous small faults with displacements ranging from several inches to 4 ft or more are common. Locally some ductile shear and mylonite zones are also present.

Rocks of the Hayesville sheet within the roadless area are in the sillimanite zone of regional metamorphism, as all compositionally favorable rocks contain sillimanite. The rocks are highly migmatitic and contain many irregular granitic masses. In addition, anatectic melt material and feldspathic segregations are widespread. Sillimanite which is widely distributed is commonly present in rocks with a low muscovite content. These rocks were probably metamorphosed about 450 to 480 million years ago, during the Taconic orogeny. The granitic rocks and pegmatites were probably intruded near the peak of metamorphism.

[1]With contributions from Robert P. Koeppen, USGS, and Ronald W. Mikolajczyk, USBM.

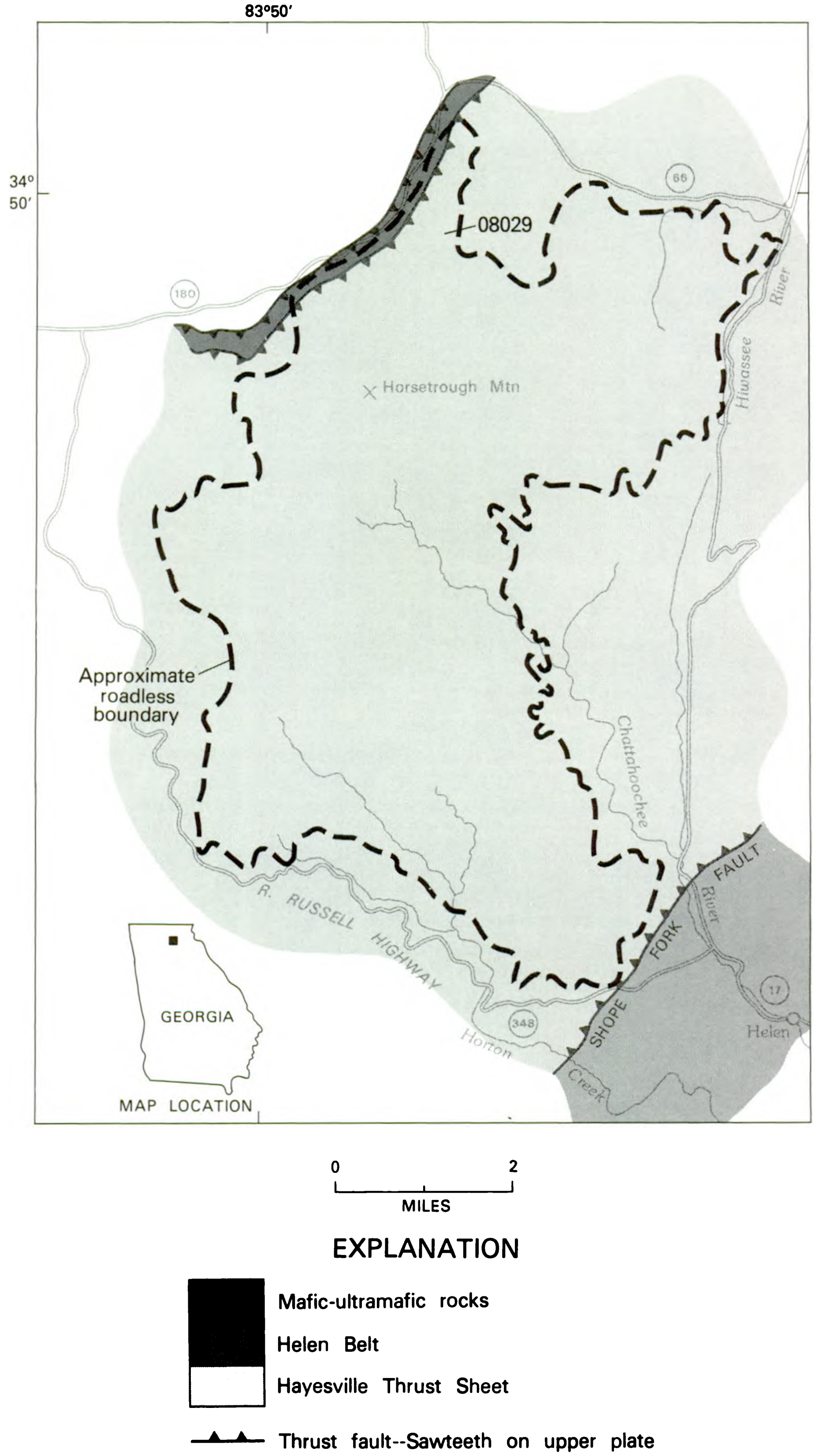

Figure 156.—Chattahoochee Roadless Area, Georgia.

The Hayesville thrust sheet, the mafic-ultramafic rocks as well as the adjoining Helen belt together form a series of thrust slices that overlie younger Paleozoic rocks along a master decollement. This thrust fault decollement, based on projections of seismic data, is believed to be nearly 5 mi below the surface of the roadless area.

The Federal Government owns surface rights to more than 99 percent of the roadless area. Mineral rights are 71 percent Federally owned and 29 percent privately owned. There is no mining activity of record in the roadless area. Oil and gas exploration permits are held on 0.2 sq mi and applications are pending on about 8.2 sq mi in the roadless area.

MINERAL RESOURCES

The roadless area is underlain by rock types that contain mineral deposits outside the area. Within 1 mi of the area's boundary, gold, mica, and construction stone have been mined (Welsh and Mikolajczyk, 1982; Nelson and others, 1983). The most recent mining near the roadless area was a small-scale gold placer operation located about 3 mi to the southeast in the Helen belt. Gold mining in the Helen belt has occurred intermittently for the past 150 years. Placer deposits in tributary valleys of the Chattahoochee River as well as veins, and saprolite were mined for gold. Within the roadless area only one particle of gold was found in the stream-sediment samples, and gold resources are considered unlikely. Muscovite mica was mined from pegmatites in Union County, where some mica sheets were 12 to 15 in. across. Pegmatites in the roadless area are small unzoned pods or veins and the observed muscovite rarely exceeds 3 in. in diameter. The mica and sillimanite from occurrences in the roadless area are of poor quality and low grade. A small stone quarry is present along the eastern boundary of the roadless area but has not been recently worked. Much of the rock underlying the roadless area is suitable for use as crushed stone or aggregate. Good sources for these materials also are known closer to present markets outside the roadless area.

Farther to the east and northeast of the roadless area in the Hayesville thrust sheet, some bodies of mafic-ultramafic rock have been mined for asbestos, olivine, and chromite. Numerous mafic-ultramafic bodies are widely dispersed throughout the Hayesville thrust sheet; they vary in size, ranging from a few feet in width and several tens of feet in length to some that cover several square miles. The mafic-ultramafic rocks present along the northwest boundary of the roadless area includes thin bands of impure dunite and soapstone; sparsely disseminated chromite and nickel are present as accessory minerals. Samples from the ultramafic rocks show the soapstone and dunite to be of poor quality and the chromite and nickel contents are low; no resource potential was identified.

A reconnaissance geochemical survey was undertaken to determine if any unidentified mineral deposits exist within the roadless area (Koeppen and Nelson, 1983). Samples of bedrock, stream sediment, and panned concentrates were analyzed by 31 element emission spectrographic method. Most of the samples contain normal chemical abundances and distribution. Nonmagnetic splits from several panned concentrates of streams along the southern edge of the area have moderately enriched abundance of tin (200 to 300 parts per million), but no other evidence was found for concentration of metals in rocks of this area. It is unlikely that any metallic mineral resource occurs within the roadless area.

Sedimentary rocks that contain hydrocarbons in the Tennessee Valley may form a part of the Paleozoic rocks that underlie rocks of the Hayesville thrust sheet, the mafic-ultramafic bodies, and the Helen belt in the vicinity of the roadless area. The Paleozoic rocks lie below a nearly 5 mi thickness of metamorphic rocks in thrust sheets of the Blue Ridge. As little is known about these rocks, their hydrocarbon resource potential cannot be evaluated.

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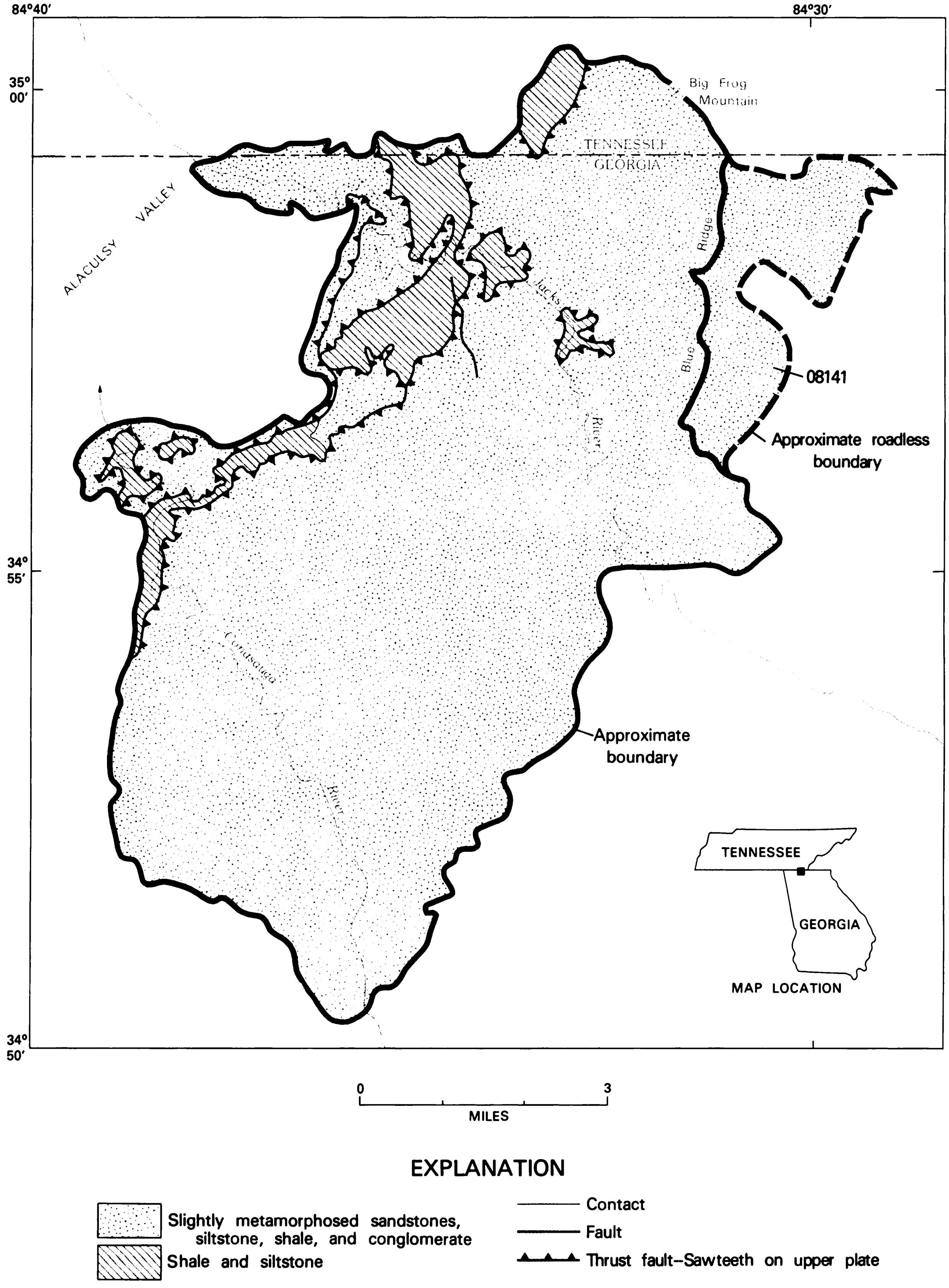

Figure 157.—Cohutta Wilderness, Georgia and Tennessee, and Hemp Top Roadless Area, Georgia.

COHUTTA WILDERNESS, GEORGIA AND TENNESSEE AND HEMP TOP ROADLESS AREA, GEORGIA

By JACOB E. GAIR,[1] U.S. GEOLOGICAL SURVEY, and

GERTRUDE C. GAZDIK, U.S. BUREAU OF MINES

SUMMARY

A survey done between 1977 and 1979 has found little or no promise for the occurrence of metallic mineral-resources in the Cohutta Wilderness and the adjacent Hemp Top Roadless Area. The Cohutta Wilderness is located mainly in northern Georgia and extends a small distance into southeastern Tennessee; the Hemp Top Roadless Area borders part of the Cohutta Wilderness on the east and extends southward from the Georgia-Tennessee line. The study area is underlain by slightly metamorphosed folded and faulted sedimentary rocks of late Precambrian age. The Ducktown mining district, Tennessee, lies only ten miles to the northeast, but apparently the Ducktown mineral-rich zone does not reach into the study area. No energy-resource potential was identified by this survey.

CHARACTER AND SETTING

The Cohutta Wilderness is an area of about 55 sq mi wholly within rugged mountainous and wooded country in northern Georgia and southeastern Tennessee about 6 mi south of the Ocoee River gorge. The adjacent Hemp Top Roadless Area is about 4-1/2 sq mi in size. The north edge of the study area is 22 mi southeast of Cleveland, Tennessee, and 10 mi southwest of Ducktown. The most conspicuous landmark in the area, Big Frog Mountain, is on the north boundary of the Wilderness. South of the Big Frog Mountain, Hemp Top is a prominent high point along the steep-sided, south-trending Blue Ridge on the boundary between the wilderness and the roadless area. Several other steep north-south ridges cross the area. The principal streams are Jacks River and Conasuaga River which flow generally northwestward across the area. Unpaved roads reach points on the wilderness boundary and extend along parts of the boundary, from paved highways that surround the area. Most travel within the wilderness must be done on foot.

The study area is underlain by folded and faulted slightly metamorphosed sedimentary rocks of late Precambrian age that belong to the Ocoee Supergroup. In a large part of the area these rocks consist of an interlayered sequence of impure sandstones (mixtures of quartz and feldspar sand grains, clay, and mica flakes), siltstone, shale, and pebbly conglomerate. Many rock layers contain scattered iron sulfide grains of pyrite and pyrrhotite (from traces to a few percent), but the rocks display no other evidence of metallic mineral content, and the iron sulfide content, unaccompanied by significant amounts of base metals, is too low to be classified as having a resource potential. These sandstones and other sedimentary rocks are complexly faulted by thrusting from the east and all the rocks of this interlayered sequence have been moved westward on thrust faults. Below the principal thrusts, there are green and dark-gray to black pyrite-bearing shales and siltstones. These shales and siltstones are found principally in and near valley bottoms in the western part of the area.

MINERAL RESOURCES

A mineral-resource survey of the Cohutta Wilderness and Hemp Top Roadless Area was made between 1977 and 1979 by the USGS and the USBM. Reports on this survey have been published (Gair and others, 1982; Gair and Slack, 1982; Gair, 1982).

Rocks of the Ocoee Supergroup contain the massive sulfide deposits at Ducktown and smaller deposits such

[1]Assisted by J. F. Slack, Richard Ketelle, Andrew Grosz, Timothy Muzik, Thomas Hanley, Donald Henry, Ann Stevenson, and Gregory Morley, USGS, and Maynard L. Dunn, Jr., USBM.

as those about 80 mi to the northeast of the study area near the Fontana Reservoir. The specific rock formations which contain the copper-zinc and massive iron-sulfide mineralization at Ducktown appear to be confined to a belt east of the study area. The Ocoee rocks are also the source for placer gold deposits at Coker Creek a few miles north of Ducktown. The gold particles in those placers came either from certain layers of the Ocoee or from quartz veins that penetrate the Ocoee rocks. Ocoee rocks should not be categorized as having mineral-resource potential merely because deposits exist in some places in these rocks. Supporting evidence such as visible mineralization or geochemical or geophysical anomalies is necessary if the specific areas being evaluated are to be classed as having resource potential.

No visible mineralization was seen in the area other than the minor disseminated iron sulfides typical of the Ocoee rocks, and a few minor concentrations of iron oxides near faults. The latter occurrences are similar to those in the Alaculsy Valley a few miles west of the wilderness, although smaller, and probably result from the concentration of limonite along faults formed by weathering of iron silicate minerals and the disseminated iron sulfides from the Ocoee rocks. The iron content in these faults is highly variable, volume is small, impurities are high, and no iron resource potential was identified for these occurrences.

During the wilderness survey, samples of stream sediment, soil, and rock were collected in the Cohutta Wilderness and Hemp Top Roadless Area, and were spectrographically analyzed to determine the relative amounts of 30 elements in each sample. On the average, a few samples of each type were taken from each square mile of the study area, and sediment was sampled from virtually every stream course longer than 2000 ft. In addition, three concentrate samples of heavy minerals were obtained by panning stream sediments in the western part of the Cohutta Wilderness. It is likely that any mineral deposit of significant size close enough to the surface to be affected by weathering would be respresented by characteristic minerals or trace elements in one or another of the materials sampled. Relatively large amounts of some trace elements were found in a few isolated samples, but most of these occurrences are interpreted as not indicating the existence of undiscovered mineral deposits and no mineral-resource potential was identified.

High background amounts of cobalt and nickel occur in several samples within an area in the northeast part of the Cohutta Wilderness. The presence in this area of high background amounts of these two different trace elements that are often associated in nature constitutes a weak geochemical anomaly, but no resource potential was identified.

About 36 of the approximately 900 samples collected contain barely detectable or small measurable amounts of gold. These sample sites are widely separated from one another and there is no indication that gold occurrences are localized in any particular part of the study area. Such a localization would suggest a source of significant size which might have resource potential. The scattered distribution of gold-bearing samples actually observed and the very small amounts of gold in the samples indicate that the gold in the samples represents insignificant occurrences—probably isolated small quartz veins containing some disseminated flakes of gold and (or) local zones in Ocoee sedimentary rock that contain small amounts of disseminated gold. There is little promise for the occurrence of gold resources in this area.

In the western part of the Cohutta Wilderness anomalous amounts of tin were found in several samples of soil, rock, and stream sediment, and in the magnetic fraction of panned concentrates from three stream-sediment samples. The largest values for tin occur in the magnetic material most likely in the mineral magnetite. The tin resource potential tends to be negated because the tin in magnetite is not recoverable. The tin-bearing samples are widely separated, with numerous tin-barren samples in between, so it is likely that the sources of tin are local and small. This consideration and the presence of the tin in the magnetic parts of the panned concentrate samples suggest that there is little promise for the occurrence of tin resources in the western part of the wilderness.

SUGGESTIONS FOR FURTHER STUDIES

Detailed sampling in the vicinity of the known gold-bearing and tin-bearing samples might outline small areas of low-grade mineralization, but it is unlikely that such mineralization would constitute a significant mineral resource.

Recent seismic studies (Cook and others, 1979) indicate that the slightly metamorphosed rocks of the Cohutta-Hemp Top area have been moved a 100 mi or more westward on major thrust faults over younger nonmetamorphosed sedimentary rocks. The sedimentary rocks which are buried many thousands of feet beneath the surface of the Cohutta area have an unknown potential for oil and gas—probably gas at the inferred depth of burial and temperatures implicit at such depth. This potential could only be verified by a program of deep drilling.

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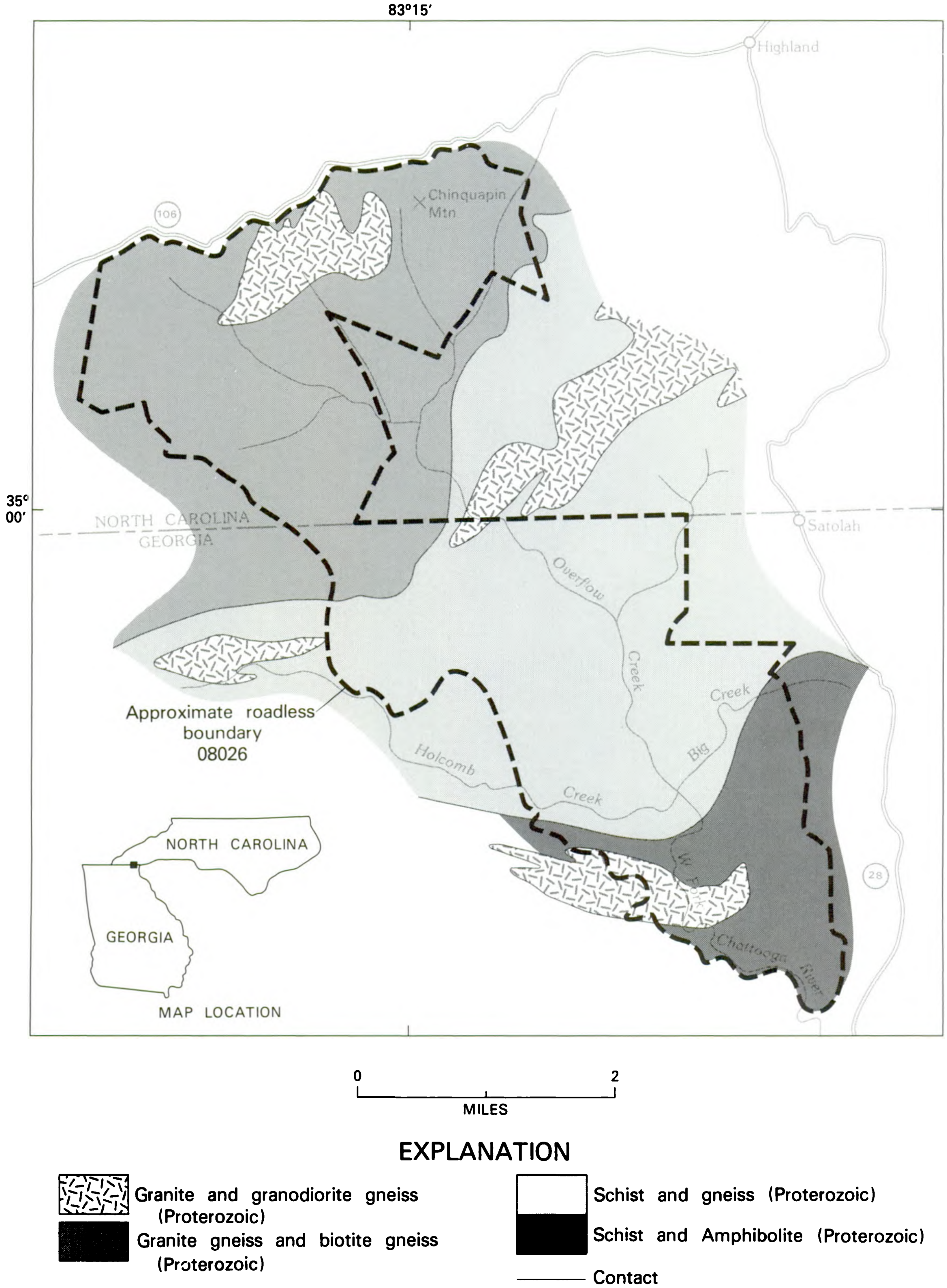

Figure 158.—Overflow Roadless Area, Georgia and North Carolina.

OVERFLOW ROADLESS AREA, GEORGIA AND NORTH CAROLINA

By ROBERT P. KOEPPEN,[1] U.S. GEOLOGICAL SURVEY, and

MICHAEL P. DAVIS, U.S. BUREAU OF MINES

SUMMARY

The Overflow Roadless Area in the Blue Ridge Mountains of Georgia and North Carolina is underlain by complexly folded schist and gneiss of Proterozoic age. A mineral-resource survey done between 1980 and 1982 found little likelihood for the occurrence of mineral or energy resources in the area. Minor isolated localities of mica pegmatite and amethyst gemstone occur in the area. Gneiss and schist suitable for rock aggregate are present in large quantities, but similar rocks abound outside the area. Natural gas may possibly be present at great depth beneath the overthrust of the Blue Ridge, but presently available information is not adequate to evaluate this potential.

CHARACTER AND SETTING

The Overflow Roadless Area consists of 7.5 sq mi in the Chattahoochee National Forest of Rabun County, Georgia, and 5 sq mi of adjacent Nantahala National Forest, Macon County, North Carolina. The area is centered about 4 mi southwest of Highlands, North Carolina, and about 12 mi northeast of Clayton, Georgia, in the eastern Blue Ridge Mountains. North Carolina Route 106 forms the northern boundary of the area, while Georgia and North Carolina Route 28 lies somewhat to the east. Three USFS roads, 86B, 86D, and 79, provide limited access to the central part of the roadless area.

The highest altitude is about 4170 ft on Chinquapin Mountain on the northern edge of the area, and the lowest altitude is about 1610 ft in the West Fork of the Chattooga River at the southern end of the area. The terrane is heavily forested and characterized by rugged topography with sharp to rounded crests capping steep valley slopes. In the southern part of the area the topography is dominated by the cliff-bound walls of the deeply incised West Fork of Chattooga River and its tributary, Overflow Creek, which drains the center of the roadless area and from which the area takes its name.

Mineral-resource surveys of the Overflow Roadless Area were made by the USGS during 1981 and 1982, and by the USBM during 1980. This survey included reconnaissance geologic mapping (Nelson and Koeppen, 1983), geochemical studies, mine and prospect examination, and evaluation of mineral-resource potential.

The Federal Government owns all surface and mineral rights within the Overflow Roadless Area. There are currently no outstanding prospecting or mining permits nor have there been any recent applications.

The bedrock in the roadless area is the severely deformed and metamorphosed Tallulah Falls Formation of Galpin (1915), originally sedimentary and minor volcanic rocks of Proterozoic age. The principal rock types are schist, gneiss, amphibolite, metasandstone, metagraywacke, and minor quartzite. Sparce metamorphic index minerals indicate the assemblage is kyanite or sillimanite grade. Variable sized bodies of granite, granodiorite gneiss, and migmatite, and veins and pods of pegmatite and quartz are numerous and widely scattered through the roadless area. Several small bodies of mafic and ultramafic rock are present nearby and may also be present in small undetected pods within the area.

Complex fold interference patterns indicate the rocks have been deformed by several generations of folding. Jointing in the rocks is ubiquitous throughout the roadless area. Thrust faults are common in the Southern Appalachian Mountains, but faults displacing map units in the Overflow Roadless Area have not been observed. Some minor shear zones and faults with relatively small displacements occur in individual exposures.

[1]With contributions from A. E. Nelson, USGS.

MINERAL RESOURCES

The Overflow Roadless Area lies within the westernmost monazite belt of Mertie (1979, p. 66), and immediately west of the Hall County Gold Belt, a 2-mi-wide band of isolated auriferous veins and associated stream placers (Yeates and others, 1896). A geochemical survey of rock, panned concentrate, and stream-sediment samples indicates little promise for the occurrence of monazite, gold, or other metallic mineral resources in the roadless area.

The roadless area includes a part of the Rabun pegmatite district, a region of poorly exposed and weathered pegmatites (Lesure and Shirley, 1968). Greenish-brown bent and ruled sheet mica was encountered in scattered localities within the roadless area, but all occurrences are small and low grade. Amethyst is present at a small number of localities marked by spoil piles along the northern edge of the roadless area. The amethyst occurs in minor quartz veins associated with a small, highly deformed body of granitic gneiss present there. The area remains of interest to amateur gemstone collectors, but based on reconnaissance examination there seems little likelihood for the occurrence of gemstone resources.

Gneiss and schist in the roadless area are suitable for use as crushed rock or aggregate. However, similar stone is abundant throughout the region.

Recent seismic studies (Cook and others, 1979) indicate that Paleozoic, possibly hydrocarbon-bearing, sedimentary rocks may underlie the overthrust rocks of the Blue Ridge Mountains of Georgia. The Paleozoic rocks are buried by 5 mi or more of metamorphic rock and the implied temperatures and pressures at these depths suggest any hydrocarbons present would be in the form of natural gas and not oil. The possibility of finding concentrations of gas in these rocks cannot be evaluated from available information.

SUGGESTIONS FOR FURTHER STUDIES

Further seismic studies and exploratory drilling are needed to evaluate the natural gas potential of this part of the Eastern Overthrust Belt.

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RICH MOUNTAIN ROADLESS AREA, GEORGIA

By MICHAEL P. FOOSE, U.S. GEOLOGICAL SURVEY, and

ROBERT M. THOMPSON, U.S. BUREAU OF MINES

SUMMARY

A mineral-resource survey of the Rich Mountain Roadless Area, Georgia, carried out in 1981, shows it to have little promise for the occurrence of mineral or energy resources. Stone for aggregate resources occur in the area, but abundant alternative sources of crushed stone exist in nearby areas. Rocks underlying the area are partly correlative with those that are known to host stratabound base-metal deposits, but no evidence for this type of mineralization was found, and no resource potential for this type of deposit was identified in this study. Recent seismic surveys indicate that natural gas may exist in this region at depths of between 5000 and 45,000 ft; deep drilling would be needed to evaluate the potential for this resource.

CHARACTER AND SETTING

The approximately 26.4 sq mi which make up the Rich Mountain Roadless Area are located in the Chattahoochee National Forest, Gilmer and Fannin Counties, Georgia. The area is situated between the towns of Blue Ridge and Ellijay, Georgia, and has an irregular boundary that is east of U.S. Highway 76, south of County Highway 153, and north and west of County Roads 216 and S1010. Numerous small roads extending in from this perimeter provide good access to the edges of the roadless area. However, only one very rough road provides access to the central part of the area.

Topography is moderately rugged with altitudes ranging from 1600 ft to 4080 ft. Slopes steeper than 20° are common. Although maximum relief is in excess of 2400 ft, local relief is on the order of 800 to 1800 ft. Second growth of hardwood forests cover most ridges, while drainages often have heavy growths of laurel and rhododendron. Trails and abandoned logging roads allow good foot access within most of the roadless area.

The mineral-resource survey of the roadless area was made in the fall of 1981 and consisted of geologic mapping, geochemical studies, and examination of mines and prospects in and near the area. Results of these studies have been published (Foose, 1983; Foose and Sears, 1983; Foose and Thompson, 1983; Thompson and Girol, 1982).

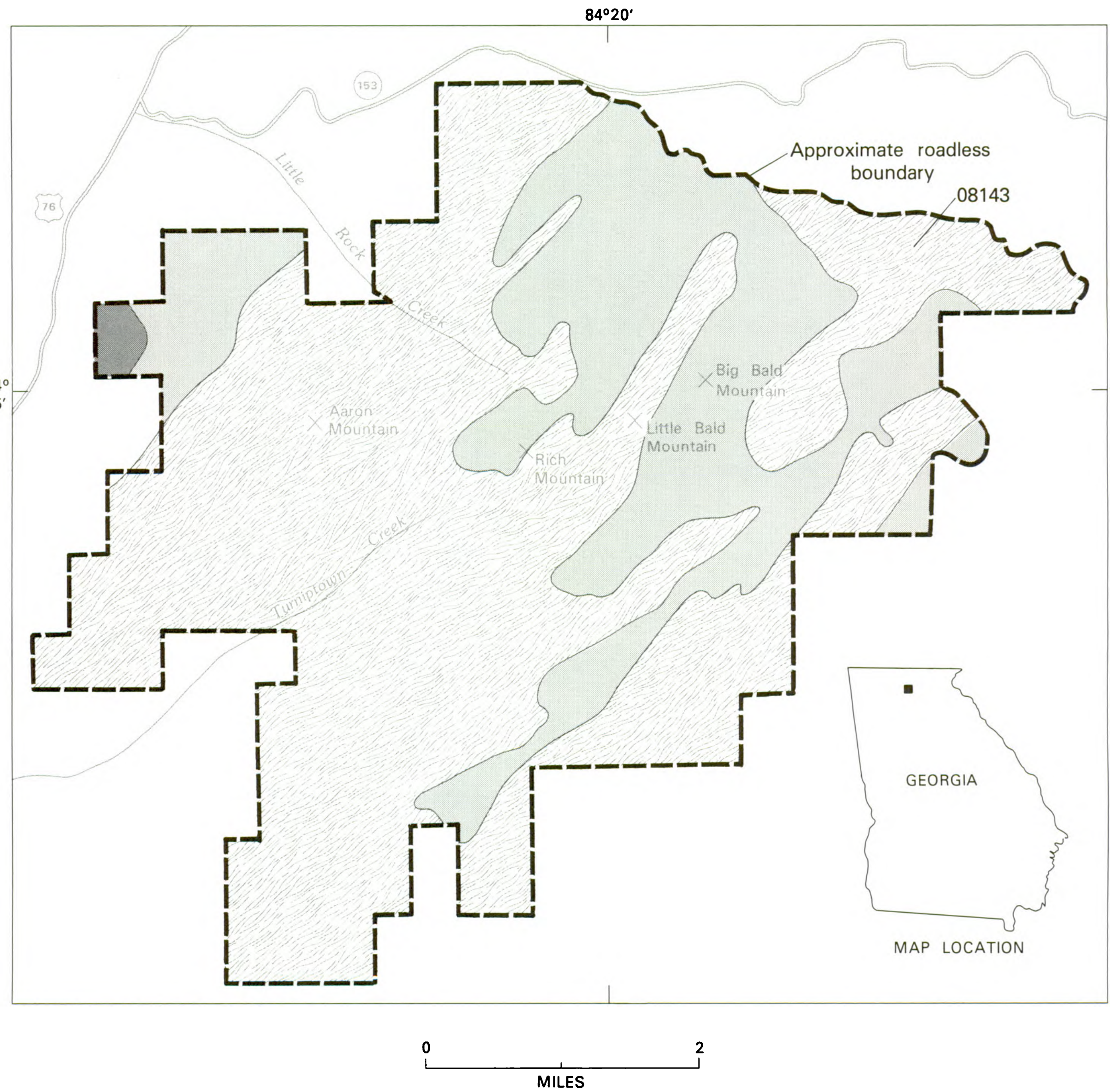
The Federal Government owns about 99 percent of the surface rights and 96 percent of the mineral rights in the roadless area. The outstanding 1 percent of the surface rights, with accompanying mineral rights, are privately owned. Oil and gas lease applications, filed in 1979 and 1980, include about 96 percent of the Federal mineral rights.

Three rock units are recognized within the roadless area. The lower two (Hothouse and Dean Formations) are predominantly sequences of metasandstones, metasiltstones, and schists of Precambrian age that are part of the Great Smoky Group. They are overlain by the Cambrian(?) Nantahala Slate which is mostly carbonaceous slates.

Subsequent to deposition of the original sediments, the rocks experienced multiple deformation. The first and most intense folding generated northeast-trending, step-shaped folds that have anticlines with relatively long gently dipping southeast limbs and relatively short, steeply dipping northwest limbs. These folds form a large anticline that passes through the center of the roadless area and is gently cross folded by a later period of northwest-trending folds. Fault offsets have not been recognized.

Mineral assemblages are characteristic of the amphibolite facies of metamorphism. Isotopic ages from other parts of the Blue Ridge province indicate that peak metamorphism occurred about 450 million years ago, during the Taconic orogeny.

The reconnaissance geochemical sampling of this area did not reveal evidence of mineralization or even the presence of unusual concentrations of metallic elements.



EXPLANATION

Nantahala Slate (Cambrian?)

Dean Formation, mostly schist (Precambrian)

Hothouse Formation, mostly metasiltstones (Precambrian)

Contact

Figure 159.—Rich Mountain Roadless Area, Georgia.

Local concentrations of high background values can mostly be explained as resulting from chemical variations associated with bedrock.

Considerable mineral-related activity has occurred adjacent to the roadless area and includes mining of gold, iron, manganese, talc, and marble, and prospecting for copper and silver. Stone for road aggregate is extracted from a quarry on White Path Creek, close to the roadless area's western margin. The sites of all these activities are confined to stratigraphic units that are not present in the roadless area, and therefore these activities are not considered to reflect potential for similar resources within the roadless area.

MINERAL RESOURCES

The geologic and geochemical surveys indicate little promise for the occurrence of mineral resources within the Rich Mountain Roadless Area. Sandstones occur within parts of the Great Smoky Group and may provide a source of crushed stone. However, little chance exists that these would be used as they are relatively inaccessible, and occur as discontinuous lenses. More easily worked sources of stone are readily available outside the roadless area.

Rocks of the Great Smoky Group host major base-metal sulfide deposits. However, the formation in which this stratabound mineralization occurs is stratigraphically below rocks in the roadless area. Further, Great Smoky Group rocks around Rich Mountain contain only trace amounts of sporadically distributed iron sulfides, have no significant metal anomalies, and show no unusual concentration of minerals that are commonly associated with base-metal sulfide deposits. Although a possibility exists for resources at depth, no evidence for this type of mineralization was identified in this study.

Gold is reported as occurring in placers along streams issuing from the roadless area and in veins located south and east of the area. Placers on White Path Creek, near the roadless area's west margin, produced 5000 troy oz of gold, and four of the five largest gold nuggets found in Georgia, one of which weighed 4.5 lbs. Searches for a vein source of this gold have been unsuccessful. It has been postulated that the source was gold-bearing veins that have subsequently been eroded away.

Gold or its companion element, silver, were not detected in any samples. All samples of vein quartz were barren of sulfides and had only trace amounts of metals. Careful processing of the heavy fraction of stream sediments, both by panning and by laboratory heavy-liquid separation, failed to identify concentrations of gold. No gold resource potential was identified in this study.

Recent seismic profiles across the southern Appalachians have generated much interest in oil and gas exploration. These studies (Cook and others, 1979) show the metamorphic rocks in this region to be thrust over well-layered sedimentary rocks that occur between 5000 and 45,000 ft below the surface. The possibility of hydrocarbons occurring in these layered sediments is under investigation; however, the depth and temperatures at which they occur make existence of liquid hydrocarbons unlikely. Natural gas, however, could be present. At this time, no reasonable estimate of this resource can be made.

SUGGESTIONS FOR FURTHER STUDIES

Deep drilling would be necessary to evaluate the natural-gas potential of sedimentary rocks at depths of 5000 to 45,000 ft below the surface.

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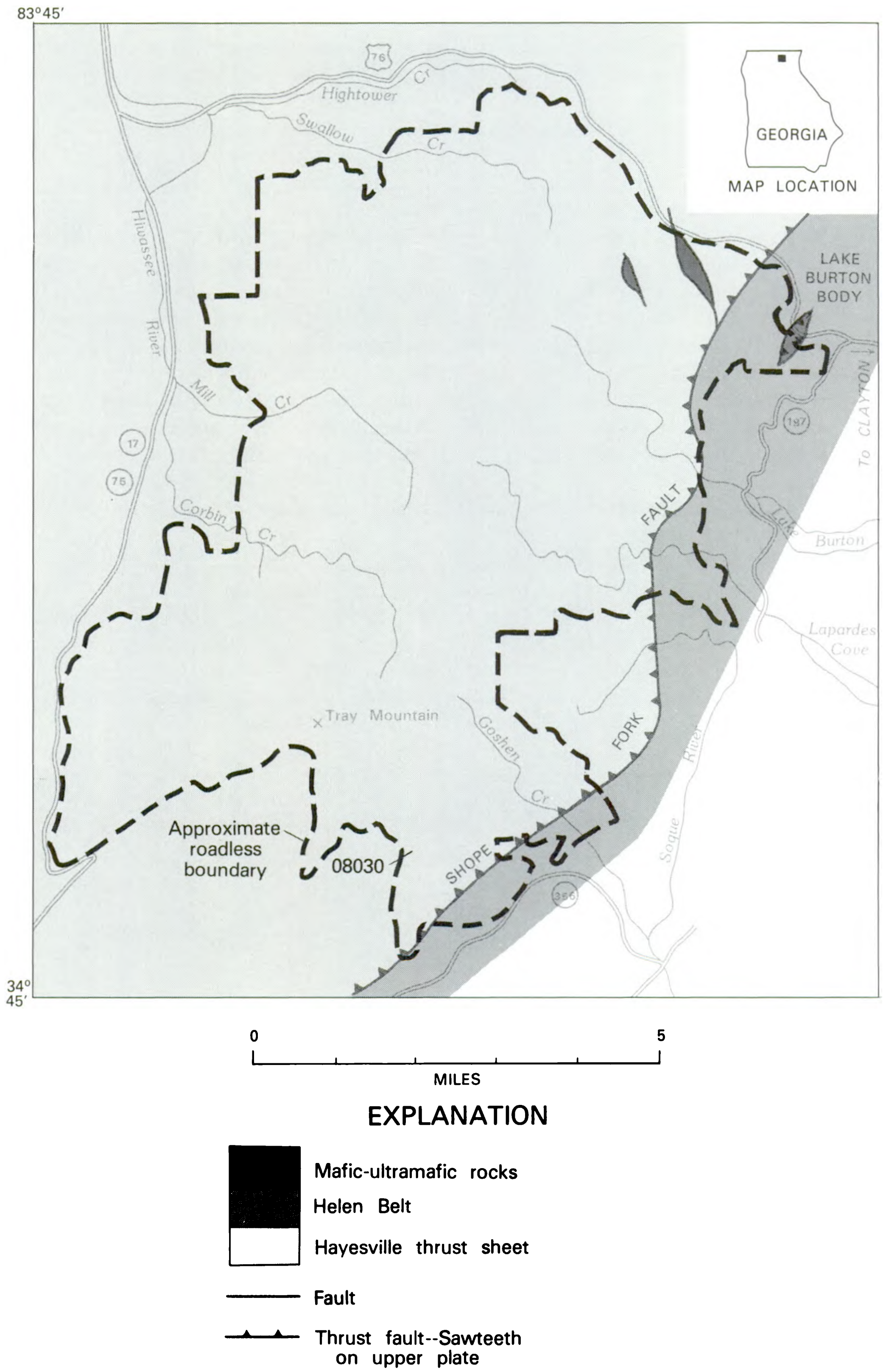

Figure 160.—Tray Mountain Roadless Area, Georgia.

TRAY MOUNTAIN ROADLESS AREA, GEORGIA

By ARTHUR E. NELSON,[1] U.S. GEOLOGICAL SURVEY, and

MARK L. CHATMAN, U.S. BUREAU OF MINES

SUMMARY

A mineral survey made in 1981 indicates that the Tray Mountain Roadless Area has little promise for the occurrence of metallic mineral resources. Rocks underlying the Tray Mountain Roadless Area are suitable for crushed rock or aggregate; however, other sources for these materials are available closer to present markets. There is a possibility for the occurrence of hydrocarbon resources underlying the area at great depth, but no hydrocarbon potential was identified.

CHARACTER AND SETTING

The Tray Mountain Roadless Area occupies slightly more than 57 sq mi in the Chattahooche National Forest, about 14 mi west of Clayton, Georgia. The roadless area lies in parts of Rabun, Habersham, White, and Towns Counties. The terrane is heavily forested and has a rugged topography with narrow valleys, sharp ridges, and steep slopes. Commonly the hill slopes range from 20° to 30° but in places the slopes exceed 45°. The highest altitude is 4433 ft on Tray Mountain and the lowest is 1910 ft in McClure Creek in the southern part of the roadless area. Tributaries of the north flowing Hiwassee, the southeast flowing Tallulah, and the southwest flowing Chattahoochee Rivers drain the roadless area. Georgia State Routes 17, 197, 356, and U.S. Highway 76 lead to a few secondary roads as well as some logging and USFS roads and trails that provide limited access to the roadless area. The Appalachian Trail also traverses part of the area's high ground.

The roadless area is underlain by metamorphic rocks that form parts of two major lithotectonic units, the Hayesville thrust sheet and the Helen belt (Nelson, 1982). A major fault, the Shope Fork fault, separates the Hayesville sheet on the northwest from the Helen belt on the southeast. Most of the roadless area is underlain by rocks of the Hayesville sheet which includes mafic and felsic gneisses, schist, metasandstone, and granitic gneiss, all of Proterozoic Z(?) age. The Helen belt, which occupies a small area in the southeast part of the roadless area is underlain by metasandstone, schist, and mafic gneiss of probable Proterozoic Z age. Many of the rocks in the Helen belt have been altered to a deep saprolite. Several mafic-ultramafic bodies have been emplaced along faults into the rocks of the Hayesville sheet and the Helen belt; they include serpentinite, dunite, pyroxenite, and gabbro. The youngest rock in the roadless area is a diabase dike of probable Triassic or Jurassic age that intrudes rocks from both the Hayesville sheet and the Helen belt.

Rocks underlying the roadless area have been complexly folded and faulted. Although the rocks have been deformed by several generations of folding, the second generation folds form the regional folds whose axes trend northeast. Besides the Shope Fork fault and the faults bounding the mafic-ultramafic bodies, numerous faults with small displacements and local shear and narrow mylonite zones are also present.

Both the Hayesville thrust sheet and the Helen belt form part of a series of major thrust sheets overlying younger Paleozoic rocks along a master decollement. This decollement thrust fault, based on projections of seismic data, is believed to be nearly 5 mi below the surface in the area.

MINERAL RESOURCES

The Tray Mountain Roadless Area is underlain by rocks that in neighboring areas contain mineral deposits. Mica has been mined from numerous widely scattered pegmatites that commonly occur throughout the Hayesville thrust sheet. Although some small mica-bearing pegmatites are present within the roadless area,

[1]With contributions from Robert P. Koeppen, USGS.

large pegmatites containing mica have not been observed. Gold from placer and lode deposits, and massive sulfide deposits containing primarily pyrite have been mined from rocks in the Helen belt southeast of the roadless area. However, alluvial concentrates of heavy minerals from the roadless area contain only trace amounts of gold and there is no evidence that massive sulfide deposits occur within the roadless area. A heavy forest cover conceals much of the rock in the roadless area, but where rocks are exposed they show little evidence of mineralization, or extensive alteration.

Farther to the east and northeast of the roadless area in the Hayesville thrust sheet, some mafic-ultramafic bodies have been mined for asbestos, olivine for foundry sand, and chromite. Mafic-ultramafic bodies commonly are present in the Hayesville thrust sheet; they vary widely in size, ranging from a few feet in width and several tens of feet long to some that cover several square miles. Three mafic-ultramafic bodies are present in the roadless area; two are in the Hayesville thrust sheet, and one is in the Helen belt, which is here called the Lake Burton body. The Lake Burton body also extends northward beyond the roadless area boundary. Olivine has not been identified in either of the two bodies present in the Hayesville thrust sheet, but olivine together with associated serpentine, nickel, chromite, and cobalt are present in the Lake Burton body. This body contains an estimated 5.0 million short tons of olivine in the roadless area (Nelson and others, 1983). Although the mafic-ultramafic bodies contain metals, no metallic or olivine resource potential was identified in this study.

Analysis of bedrock, stream-sediment, and panned concentrate samples, with the exception of ultramafic samples from the Lake Burton body, did not reveal unusual abundances or distributions of metals or elements which might be associated with mineral deposits (Koeppen and Nelson, 1983). However, splits from panned concentrate samples from six drainages in the southwest quadrant of the roadless area have anomalously high lead abundances, two to three orders of magnitude above the 20 to 100 parts per million mean value for panned concentrates in this area. Although the source of the lead is unknown, absence of other corroborating geologic evidence makes the likelihood of occurrence of a lead-bearing resource in the area unlikely.

Sedimentary rocks that contain hydrocarbons in the Tennessee Valley may underlie the Hayesville thrust sheet and the Helen belt in the roadless area at great depth. There is a small possibility of obtaining hydrocarbon products from such rocks, but they are untested. Much of the rock underlying the roadless area is suitable for use as crushed rock or aggregate, and several small quarries for local supplies of these materials are present in and near to the roadless area. However, because good sources for aggregate and crushed stone are close to present markets, there is no immediate use for rock in the roadless area as a source for stone.

All surface rights in the roadless area are owned by the Federal Government. Mineral rights for 21 sq mi in the roadless area are privately owned, but the remaining mineral rights are Federally owned. A 0.6 sq mi mining lease for olivine is currently in effect, and oil and gas exploration permits have been applied for on 3.7 sq mi (Chatman, 1982, 1983) No mining is currently under way within the roadless area. The mining of asbestos, limited prospecting for gold, olivine, and some crushed rock quarrying are the only mineral activities on record.

SUGGESTIONS FOR FURTHER STUDIES

Detailed studies are needed to establish the presence or absence and mineral-resource potential of olivine, nickel, cobalt, and chrome in the two mafic-ultramafic bodies in the Hayesville thrust sheet.

The cause of the lead anomaly in pan concentrate samples taken from the southwest part of the roadless area has not been established; the mineral residence and source of the anomaly remain to be determined.

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