NAME OF WELL.	Date when Drilled.	Depth in Feet.	Product in Barrels per day in July, 1887.
Pico, No. 1	1875	700	5
Pico, No. 2	1875	900	5
Pico, No. 3	----------	----------	----------
Pico, No. 4	1876	1,000	30
Pico, No. 5	1880	1,100	25
Pico, No. 6	1880	1,500	25
Pico, No. 7—*flowing*	1882	1,200	40
Pico, No. 8	1882	500 1,000 1,500	0
Pico, No. 9	1882	1,550	35
Pico, No. 10	1882	900	0
Pico, No. 11	1882	1,500	0
Pico, No. 12	1882–1883	1,300	18
Pico, No. 13	1882–1883	1,600	40
Pico, No. 14	1883	1,500	0
Simi, No. 1	1883–1884	1,300	0
H. and S. Star, No. 1	1883	1,650	30
San Fernando, No. 1	1882	1,200	20
San Fernando, No. 2	1882	1,450	40
San Fernando, No. 3	1882	1,375	25
San Fernando, No. 4	1882	1,555	18
San Fernando, No. 5	1882	1,600	15
San Fernando, No. 6	1882	2,330	10
San Fernando, No. 7	1882	1,900	0
San Fernando, No. 8	1886–1887	1,325	60
San Francisco, No. 1	----------	----------	----------
San Francisco, No. 2	1881	1,500	5
San Francisco, No. 3	1883	1,300	0
San Francisco, No. 4	1883	1,550	40
H. and S. Hill, No. 1	1883	1,800	0
H. and S. Hill, No. 2	1883	1,200	0
H. and S. Hill, No. 3	1883	1,600	5

Annual report of the state mineralogist for the year ...

California State Mining Bureau

CA

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Calif. Dept. of Natural Resources. Div. of Mines, Calif. journal of mines and geology....

CALIFORNIA STATE MINING BUREAU.

WILLIAM IRELAN, JR., STATE MINERALOGIST.

Mr. Irelan Office

SEVENTH ANNUAL REPORT

OF THE

STATE MINERALOGIST.

FOR THE YEAR ENDING OCTOBER 1, 1887.

SACRAMENTO:
STATE OFFICE : : : : J. D. YOUNG, SUPT. STATE PRINTING.
1888.

Documents Dept.

TABLE OF CONTENTS.

Compliments of

Wm. Irelan Jr.

State Mineralogist

To Honorable R. W. Waterman, *Governor:*

Sir: The Trustees of the State Mining Bureau herewith submit their report, in pursuance of the Act of the Legislature entitled "An Act supplementary to an Act entitled 'An Act to provide for the establishment and maintenance of a Mining Bureau, approved April 16, 1880,' approved March 21, 1885."

Respectfully,

J. Z. DAVIS,
G. W. GRAYSON,
W. S. KEYES,
S. HEYDENFELDT, Jr.

October 1, 1887.

Note.—Hon. George Hearst, Trustee, was absent when the report was made.

REPORT OF TRUSTEES OF STATE MINING BUREAU.

Since the publication of the sixth annual report of the State Mineralogist and of the Trustees, the work of the Bureau has made most gratifying progress, and has, we think, met the approval of all classes of the community. The scope of its investigation has been enlarged, and a good beginning has been made in carrying out the plans and purposes of the Act of April 16, 1880, providing for the establishment and maintenance of a State Mining Bureau. A chemical laboratory (heretofore so greatly needed) has been constructed and sufficiently equipped to enable the chemists of the Bureau to do a great deal of necessary work.

GEOLOGICAL FIELD WORK.

In pursuance of the Act of the State Legislature, approved March 9, 1887, requiring that one half the amount appropriated for the support of the Bureau for the thirty-ninth and fortieth fiscal years be used for geological work in the field, the Trustees have secured the services of experts, eminent in their several specialties, who have most generously devoted their time and talent to the public service, for what the Trustees are constrained to admit is an inadequate renumeration; nevertheless their zeal has not flagged and their work speaks for itself.

These attachés of the Bureau, appointed after consultation with, and the approval of, the State Mineralogist, are in the order of their appointment as follows: Watson A. Goodyear, Melville Attwood, Adolph H. Weber, and Dr. W. D. Johnston.

The Trustees are pleased to acknowledge the cordial relations established and at present existing between the Bureau and all other State institutions, and particularly with the University of California. Professor Jackson has, in conjunction with the State Mineralogist, undertaken the examination and testing of the various building stones occurring in our State. The Bureau has caused to be forwarded to quarrymen, architects, and builders, a circular asking for samples for testing. The response has not, as yet, been commensurate with the importance of the subject, but it is hoped and expected that many more specimens will, in the near future, be sent in for examination, to the great practical advantage of owners, workers, and users of such material. The circular is inserted in the report of the State Mineralogist.

VISITORS.

Over thirteen thousand persons have visited and inspected the collection in the Bureau, whose names appear on the register, during the past year; in addition a large number have failed to register.

MUSEUM.

The exhibits displayed in the Museum have shown a most gratifying increase, not only in objects directly cognate to the work of the Bureau, but also in the interesting subjects of ethnology, conchology, ornithology, etc.

The Museum has been enriched by the gift of many interesting exhibits, which add greatly to the value of the display and prove the liberality and devotion to practical science of many of our fellow citizens. The only regret of the Trustees is that the space is already too limited, so that much attractive material is unavoidably stored in boxes.

List of Donors to Museum from October, 1886, to October, 1887.

Acker, E. O. C.
Aldrich, H. A.
Attwood, Melville.

Bacon, Frank M.
Baker, J. C.
Barnes, Henry.
Barney, Jas. M.
Batchelder, C. S.
Bell, Edmund.
Bell, J. W.
Bennett, L. J.
Blacklock Quarry Company.
Blake, Prof. William P.
Blanding, Louis.
Bowen, H. A.
Boynton, B. R.
Bradford, Miss M.
Brady, O. E.
Braverman, M.
Brewer, Dr. B. B.
Brittan, W. G.
Bromley, Miss Carrie.
Brown, George L.
Brown, James B.
Brown, William.
Bryant, John.
Bugbee, S. W.
Burbridge, S. L.
Burnell, W.
Bush, Mrs. A. E.

Campbell, H. H.
Chambers, R. C.
Chapman, Major John.
Clark, T. P.
Cohen, Mrs. M.
Cohen, Morris.
Cohen, Hon. Richard.
Collins, D. W.
Collins, John.
Corbett, W. S.
Cornish, Mark.
Corrington, W. R.
Crawley, C. C.
Cresswell, John.
Cronise, W. H. V.

Daggett, Hon. John.
Dana, A. W.
Davidson, T.
Davis, George.
Davis, J. A.
Davis, J. Z.
Deney, L. B.
Detert, W. F.
Dickey & Co.
Dickinson, Thos.
Dolman, G. B.
Donnelly, Dr. E.
Doutrick, Frank.
Dunn, R. G.
Dunn, R. L.
Durden, H. S.

Edwards, H. J.
El Dorado Slate Company.
Ellenwood, Wm.
Epperson, J. M.
Evans, L.

Farwell, Captain J. D.
Fehser, F. W.
Flanagan, T. L.
Fleming, E. C.
Flint, Thomas, Jr.
Fielding, Frank E.
Fitzgerald, Chas.
Foorman, S.
Fowler, W.

Gallagher, Edward A. T.
Glass, Louis.
Gibb, R. B.
Goodyear, W. A.
Graham, John.
Grayson, G. W.
Greene & Spencer.

Hanson, J. W.
Hanks, H. G.
Harlan, C. C.
Harper, John.
Harmony Borax Company.
Hatsell, John.
Hausman, F. H.
Hay, T. J.
Healey, P. J.
Hearst, Hon. George.
Heath, Wm. McK.
Hellmann, Fred.
Henderson, W. A.
Hentz, A. H.
Heslewood, J. A.
Heydenfeldt, Judge S.
Heydenfeldt, S., Jr.
Hgule, Mr.
Hill, Benj.
Hindley, Mr.
Hitchcock, C. A.
Holcombe, S. E.
Holmes, A. J.
Holt, J. H.
Humboldt County Fair Association.
Hutchins, E. P.

Idaho Mining Company G. V.
Irelan, William, Jr.

Jack, R. E.
Jackson, J. P.
Johnston, Dr., William D.
Jordan, J. L.
Judson, A.
Jutton, D.

Kaneko, S.
Kates, J. P.
Kaufman, Charles.
Kelley, Jay G.
Kelley, J. M.
Kellogg, L. C.
Kelly, John W.
Keil, Frederick C.
Kennedy, John F.
Keyes, W. S.
King, Richard H.
Knox, W. C.

Larkin, Frank.
Leadbetter, C. H., Jr.
Leviston, William.
Liddell, W. H.
Litten, W. P.
Livingston, C. H.
Lord, A. R.
Lorquin, E. F.
Lovelock, Mrs. George.
Lyle, W. S.

McCuen, John.
Madden, William J.
Markson, Phil. A.
Martin Brothers.
Martin, G. W.
Maxwell, John W. C.
Maxwell, Dr. R. T.
Maynard, Miss M.
Melville, H. F.
Meyer, A.
Millard, W. L.
Minckler, W. D.
Mitchell, H. K.
Monteverde, F. E.
Moore, Lewis A.
Morgan, D. W. C.
Mount Shasta Chrome Mining Company.

Nevada County Fair Association.

Patten, Daniel.
Patton, W. H.
Paul, A. B.
Pierce, Owen
Pierce, Webb N.
Pittard, H. L.
Porter, Dr. Thomas.
Porterie, Alex.
Powell, Dr.
Powell, J. W.
Prefumo, P. B.
Presho, James.
Provincial Secretary's Department, British Columbia.

Quimet, L. H.

Rangely, Robert.
Reeg & Landecker.
Reeves, C. P.

Reynegom, F. W., Van.
Richards, John.
Riddle, Hon. John A.
Robinson, William.
Rogers, E. J.
Rogers, Mrs. L. S.
Rourke, T. J.
Ryan, J. E.

Sanborn, J. R.
Sargent, Hon. B. V.
Sato, N.
Schneider, C. G.
Schubert & Kruft.
Scupham, J. R.
Shasta County Fair Association.
Sinton, R. H.
Skinner, James T.
Smith, E. Martin.
Smith, H.
Smith, W. H.
Sonnenfeld, Samuel.
Southern Ledge Stone Company.
Spates, K.
Spring, Menzo.
Spurrier, G.
Staddon, Samuel.
Stansfield H.
Stockton, William.
Stone, Mrs. A. J.
Stough, Mrs. J. P.
Stow, H. R.
Sublette, William.
Sutro, A.
Switzer, John.

Taylor, B. R.
Tehachapi Stone and Marble Company.
Terry, L. A.
Thomas, F. F.
Thompson, M.
Thurber, J. L.
Titus, J. S., Jr.
Towle Brothers.
Treadwell, J. B.
Tyson, Mrs. J.

Valencia, J. C.
Verger, J. A.
Victor Marble Company.
Vulcan Powder Company.

Ward, William.
Warren, Mrs. S. A.
Watson, G.
Watts, W. L.
Weber, A. H.
Weinberg, E. A.
Weiss, J. S.
Wheeler, M. A.
White, Miss Bertha A.
White, Charles W.
White, D. Morgan.
Winants, N.
Williams, H.
Williams, J. G.
Williams, Mr.
Wilson, John.
Wilton, W. H.
Wolleb, E.
Wood, R. E.
Woodhull, S. D.
Woodward, W. A.
Wores, Charles R.
Wren, Hon. Thomas.

Yreka Journal, Proprietors of.
Young, N. G.

FACILITIES FOR RECEIVING SPECIMENS.

Wells, Fargo & Co. continue to favor the State Mining Bureau by delivering free, packages weighing less than twenty pounds, from all parts of the Pacific Coast.

We are also pleased to acknowledge the kindness of Goodall, Perkins & Co. for gratuitously transporting packages to the State Mining Bureau, on their line of Pacific Coast steamers.

LIBRARY.

The Library, in view of the short time taken for its collection, is particularly well supplied with all the more recent standard books and treatises on mining, mineralogy, metallurgy, geology, etc. We are indebted to Senators Leland Stanford, J. P. Jones, Geo. Hearst, and Wm. M. Stewart for many valuable books of reference, and also to our Representatives in Congress, who have taken great interest in the welfare of the Bureau.

The Library possesses, amongst other rare and valuable publications, a complete set of the United States Geological Survey Reports, a complete set of the proceedings of the "American Institute of Mining Engineers" (due to the courtesy of the Institute, through its Secretary, Dr. R. W. Raymond); many of the Geological Survey publications of the various States of the Union, and a very complete set of monographs and industrial pamphlets, which are conveniently arranged and indexed for public consultation. Since the issue of the last report there has been an increase of over seven hundred books, besides many valuable pamphlets.

NEWSPAPERS.

The following newspapers continue to be sent to the State Mining Bureau free:

Arizona Gazette, Phœnix, Arizona.
Humboldt Standard, Eureka, Humboldt County, California.
The Mountain Messenger, Downieville, Sierra County, California.

The Free Press, San Buenaventura, Ventura County, California.
Grass Valley Daily Union, Grass Valley, California.
California Demokrat, San Francisco, California.
Inyo Independent, Independence, Inyo County, California.
Mining and Industrial Advocate, San Francisco, California.
Mining Review, Chicago, Illinois.
Financial Mining Record, New York.
Wood and Iron, Minneapolis, Minnesota.
The Weekly Star, San Francisco, California.
West American Scientist, San Diego, California.

ACCOUNTS FROM OCTOBER 1, 1886, TO OCTOBER 1, 1887.

Receipts.

Balance, October 1, 1886	$9,207 13
Paid into Mining Bureau Fund	6,893 90
Appropriation, July 1, 1887	30,000 00
Total	$46,101 03

Disbursements.

Rent	$2,775 00
Salary of State Mineralogist	3,000 00
Salaries	3,950 50
Salaries (geological field work)	1,780 00
Museum	763 20
Library	2,076 41
Minerals	961 80
Postage	659 25
Traveling expenses	552 75
Traveling expenses (geological field work)	989 60
Laboratory	2,327 85
Clerical assistance	262 60
Freight and express charges	218 85
Sundries	612 99
Sundries (geological field work)	52 65
Wells, Fargo & Co.	1,984 37
Total	$22,967 82
Balance of appropriation and in Mining Bureau Fund	23,133 21
	$46,101 03

To his Excellency, R. W. WATERMAN, *Governor of the State of California:*

SIR: In accordance with the Act of the Legislature entitled "An Act to provide for the establishment and maintenance of a Mining Bureau," approved April 16, 1880, I herewith transmit my report.

Very respectfully,

WM. IRELAN, JR.,
State Mineralogist.

SAN FRANCISCO, October 1, 1887.

REPORT OF THE STATE MINERALOGIST.

The greater part of the material embodied in this report was obtained by those connected with the State Mining Bureau through personal observations which necessitated actual inspection of the fields of operation.

All attachés of the Bureau have been received with uniform kindness and courtesies in all parts where their respective investigations required their presence.

The Trustees have been unremitting in their attention to the affairs of the institution, and it is largely due to their personal efforts that the Bureau, having specially in view the development of the economic minerals of the State, ranks with any similar establishment in the world. Great obligations are due to those who have so kindly assisted us in our endeavors to give to the public the capabilities of our State.

To Mr. J. Z. Davis, Chairman of the Board of Trustees of the State Mining Bureau, we are especially indebted for his generous donations, which have so largely added to the usefulness of the institution and to the attractions of the Museum.

The report is confined to the subjects of Petroleum, Asphalts, Natural Gas, Coals, and Building Stones, for the reason that very little information has been published as to their existence and extent in the State, notwithstanding the fact that their great importance is universally recognized. Furthermore, the fund appropriated for geological field work by the last Legislature only became available in July, and in consequence the time to make investigations of the other various economic minerals occurring so abundantly throughout the State was limited.

To the lateness in entering the field is likewise due the want of time necessary to make as comprehensive or complete analyses of the material gathered as wished for.

ORIGIN OF PETROLEUM.

It is a theory generally accepted that organic remains were the original matter from which petroleum originated, but just how or through what agency the oil was freed or produced is a problem whose solution seems to be very remote. The once popular theory that petroleum was the natural product of coal is altogether of the past, as the many deep wells have proven that the oil-bearing strata lie far below the coal beds.

It is manifest that limestone was the primitive depository of the original substance, and that the gas which was set free at the time of the chemical decomposition of the organic matter, or the water contained in the fissures of the rock, or both, were the agents that furnished the power to drive the oil into the less compact sandstones and shales. It might here be mentioned that Mr. Carll, the eminent geologist, says, an oil sand is capable of absorbing one tenth of its bulk in oil, and under pressure even as much as one eighth.

The natural petroleum springs of California in many cases show by the ebb and flow of the liquid, and the many bubbles coming to and bursting on the surface, that in most instances gas is the special power; therefore it seems safe to predict that where natural illuminating gas is found in well-boring petroleum is close by.

Hon. J. P. Lesley, the State Geologist of Pennsylvania, says: "The origin of petroleum is still an unsolved problem. That it is in some way connected with the vastly abundant accumulation of paleozoic sea-weed, the marks of which are so infinitely numerous in the rocks, and with the infinitude of coralloid sea animals, the skeletons of which make up a large part of the limestone formations which lie several thousand feet beneath the Venango oil sand group, scarcely admits of dispute; but the exact process of its manufacture, of its transfer, and its storage in the gravel beds, is utterly unknown. That it ascended into them rather than descended seems indicated by the fact that the lowest sands hold oil when those above do not, and that the upper sands hold oil when they extend beyond or overhang the lower."

PETROLEUM FIELDS OF CALIFORNIA.

The petroleum fields of California where oil is found in merchantable quantities are almost exclusively within the boundaries of the southern counties, yet the oil has been found in other parts of the State, but not in sufficient quantity to warrant much expenditure. It is to be regretted that the shortness of time at our disposal is not sufficient to do justice to the importance of the subject. W. A. Goodyear and A. H. Weber, field assistants of the State Mineralogist, were delegated to work up the petroleums, coals, and natural gas branches of the State's industry, and the reports of their investigations and deductions are embodied herewith. Enough facts have been gathered to give a fair idea of what is being done and a pretty correct statement of the output of the wells. Pennsylvania is really the cradle of the petroleum industry, and our oil men must needs draw largely from her experience and study carefully the opinions of her very able geologists who have devoted the better part of a lifetime in endeavoring to solve its many problems. With a better knowledge of the geology of the petroleum fields of our State, we may in the future be able to prospect for oil with an equal success of reward as the miner for gold upon the auriferous belt; not that the miner is always successful or does not make many failures, but his knowledge, obtained by experience and observation, has taught him that gold is more likely to be found in certain formations. The "practical miner," as well as the "practical oil man," is disposed to condemn any one who may draw inferences not in harmony with their opinions. The ability to be able to locate with a possible chance of success is not of itself practical, but is a knowledge acquired by theory and study applied to practical uses, and the following will more fully explain the advantages of such acquirements.

Extracts of the letter of transmission of the Hon. J. P. Lesley, Geologist of the State of Pennsylvania, to his Excellency Governor Henry M. Hoyt, Chairman of the Board of Commissioners of the Second Geological Survey of Pennsylvania, dated at Philadelphia, October 25, 1880. In writing of Mr. John F. Carll, the geologist in charge of the oil regions of that State, Mr. Lesley says:

"The main feature of the report is the settlement of the true character of the Venango oil sand group as a distinct and separate deposit, with characteristic marks distinguishing it from the paleozoic formations of a preceding and a succeeding age; the differentiation of the group into three principal and other subordinate layers of gravelly sand, holding more or less oil and gas; the local variability of these sands, their singular persistency beneath long and narrow belts of country, their change into barren shales elsewhere, and their independence of other oil-bearing sands and shales of an earlier and of a later date.

"Seeking for oil in unexplored ground, is like seeking for tobacco in a smuggler's trunk. The traveler and his luggage look suspicious; that is the full extent of the customs officer's knowledge. The tobacco must be found, if at all, with the probe. The officer's instinct may be deceived; the trunk may have no false bottom; or the false bottom may hold no tobacco.

"Just so, the geologist who knows the district knows more than the oil man, but he does not know whether sand exists at a given spot beneath the surface; nor whether, if there be a sand, it holds oil or not; nor whether, if the oil be there, it will flow towards a drill hole. But this ignorance of facts, all of them out of sight and out of reach before experiment, he shares with everybody else. No one, absolutely, no one, can know such facts before a well is bored.

"But what the geologist does know is the depth beneath the surface at a given spot at which a given oil-sand in the series ought to lie, and consequently the depth of a required trial hole. This fact men who are not geologists may also be acquainted with in the immediate neighborhood of productive wells, or in a local district where they are familiar. But let them go to other localities, more or less distant, and their knowledge becomes ignorance, because it is restricted by special experience. Whereas the geologist carries his knowledge of one locality with him to another, because *his* knowledge is theoretical, that is, reduced to system, and subject to well established laws of earth structure. He knows that no two well records are alike in detail. He is therefore obliged to discover their general or classical resemblance.

"Until practical oil men learn to value the theoretical principles established and illustrated by Mr. Carll, in this report, it cannot be expected to reach its highest pitch of usefulness. That these principles are not visionary will be clear to every thoughtful reader of it. That they are supported by a great multitude of harmonized facts is plainly shown by its maps and sections. That they have virtually governed geologists, even when less well comprehended than Mr. Carll has now made them to be, is a historical fact put on record by printed reports of experts. That they ought to govern explorers of new territory follows as a matter of course; and so far as oil seekers consent to respect the reasonable results of long, close, and experienced investigation, so far will their pecuniary risks be diminished, and the actual cost of discovery be reduced to a minimum.

"A flagrant example of this truth is given by Mr. Carll on page 137, where he describes the disastrous consequences to a great many people of a purely geological, purely theoretical mistake made by the oil men of the "Fourth Sand Belt of Butler County," calling themselves practical men, but working on a theory all the same. Practical men, so called, are just as theoretical, and much more theoretical, than men of science; the distinction being, that the latter base their theories on a wide range of well connected facts, while the former establish theoretical prejudices upon the basis of a comparatively narrow circle of the facts with which they happen to be very familiar.

"The Venango well sinkers had grown accustomed to the three oil sands of Oil Creek, and they constructed and carried with them into the new field a theory of three sands which was merely a local prejudice. The first sand they struck was to them, theoretically, the Venango First Sand, and when they reached a second they theorized upon it as the Venango Second Sand. All they had to do now, according to their former practice and present theory, was to go one stage lower to the Venango Third Sand, and they would be sure (theoretically) to get great wells. But when they reached their theoretical third sand, it proved to be poor in oil. Their theory, however, arrested them here in spite of their being practical; in fact precisely because they were practical men. They could not be induced to go deeper; they knew what they were about; no geologist could teach them anything; they had worked on Oil Creek; they knew by long experience and at great cost that there existed no oil beneath the third sand; why then should they go deeper?

"Now, the fact is, that as long as they remained practical men on Oil Creek, they were all right; their local theory was a good one. But being merely practical men they were unconscious of the great law that a local theory is not good off its own ground, and must subject itself everywhere else to some larger theory, constructed slowly and painfully, not by practical, but by theoretical men, by men of science, by men who know the *relative value of the theories of practical men.*

"Had the land owners and oil producers of the Fourth Sand Belt respected geological theories enough to take them into consideration, they would have made progress towards profitable truth, by steps taken in the following order: 1. Although their first sand resembled the first sand on Oil Creek, they would have suspected that the same kind of sand might be deposited at different times in different parts of the old water area, and therefore that resemblance did not prove identity. 2. They would have considered the evidence which Mr. Carll published in his first report, proving that the three sands of Oil Creek (sometimes locally subdivided into four or five) form a single group, with hundreds of feet of soft drilling ground over it, and a great depth of soft drilling ground under it; and they would have kept an extra careful record of their drillings, to see if this proved true in their new field. 3. They would have found thus that their three sands in Butler County did *not* form a single group, as on Oil Creek, but that the upper soft drilling ground lay between their Butler first and second sands. 4. This would have led them, *theoretically*, to deepen their wells, in order to make their oil group complete, and they would have found a fourth sand to correspond with the bottom (or third) sand of Oil Creek.

"The consequences of their scorn of theoretical geologists are depicted on page 137 of this volume. Concluding that they were working in a poor field of the third sand (whereas they were really exploiting the second sand), they sold out and moved off. The new comers, influenced insensibly by the light thrown on the region by the geological survey, tried the experiment of sinking deeper, struck the true third sand, and restored the prosperity and reputation of the Butler belt.

"But clinging still to the old error of supposing the uppermost sand to be the Venango First (whereas it was the Third Mountain Sand, or Berea Grit of Ohio; the Pithole Grit of this report), they called the rich, new, lowest sand thus obtained the fourth sand, and insisted on placing it underneath the Venango Third, whereas it is identical with it.

Not only do "practical oil men" theorize in spite of themselves (as their drillings along certain compass lines show in a remarkable manner), but they are as capable of theorizing well, and reaching just conclusions, as thoroughbred geologists are, if they would take the pains: first, to observe the facts; second, to exhibit them properly on paper; and third, to compare together a sufficient number of them, so as to discover their real connection and relationship. No shrewder or more intellectual people exist. No better observers live. If they only believed in scientific methods of research, they would need no enlightenment from geologists. But they despise a slow, painstaking, accurate, wide extended, systematic investigation. They bring a handful of sand to a geologist and expect him to declare from an examination of it alone, apart from all other circumstances, what rock it comes from, how much oil that rock probably holds, and how fast the oil from it will probably flow, or be pumped. To furnish such an opinion would be mere quackery; and yet on such specimens, and such opinions—opinions called "practical," but which are purely and simply "theoretical," mere prejudices adopted from some former and distant experience—costly and futile attempts are made to open new oil fields in barren measures.

"Oil men ought to make themselves their own geologists. The elements and principles of geology ought to be part of their stock in trade. They have more ample opportunities for acquiring this kind of useful knowledge than any other class of men living. They know and feel the necessity for examining with minute attention the oil sands, and they do this work admirably well when they reach them; but they pay no heed to the geology of the other parts of their bore-hole.

"If they did, the knowledge they would thus get would be of far more importance to them, for it would enable them to compare one well with another and thus cover the true relationships of the oil sands. They form a theory and then examine the facts. A geologist collects and puts together the facts before he allows himself to construct a theory. They theorize that the oil sand they want lies so many hundred feet beneath the surface, and they pay little or no attention to the hundreds of feet of various measures through which they pass in descending to that depth.

"No wonder that they are as liable to blunder in sinking a second hole as in sinking the first. In fact, by this utter disregard of his well records, except just where low sands lie, a man may sink a hundred wells and have no more true, safe, reliable knowledge of the subject than he had at first.

"Nor does time seem to cure the evil, but only to confirm it.

"What was a reproach to the oil-well sinker of ten or fifteen years ago is a reproach to the generality of oil-well sinkers in 1880. Where are the records of the scores of thousands of holes bored? And how absurdly, suicidally indefinite, inexact, fragmentary, and unreliable are the few records which have been made and preserved! What an immense, what an irretrievable loss, not to science merely, but to the intellectual stock in trade of oil men, has happened! It is impossible for a geologist not to feel and speak warmly on such a subject, and it would be shirking a sacred duty if the Geological Survey of Pennsylvania did not do its best to place this flagrant omission of common business precaution, this wholesale waste of valuable business information, this fruitful source of business embarrassment, distraction, and disaster, in its true form and colors, before the eyes of the whole oil-producing community.

"To return to the subject of the importance of geological generalization, as seen in a practical light, I may be permitted to describe in the first person a singular case in point.

"In 1841 I was ordered by the Chief of the First Geological Survey to report on the counties lying along the New York line, and down the eastern bank of the Allegheny River, as far as the Kiskiminetas. Other assistants on that survey had already discovered and reported the geological structure of the Allegheny River and Beaver River water basins, and the rate of descent of the rocks southward and southwestward, in relation to tide level, had been calculated. My business was to follow and locate upon the map the anticlinal and synclinal rolls which locally change and modify this general dip, and to identify the principal coal beds over a large area.

"After the discovery of petroleum (which, of course, did not in the least set aside or essentially change the structure of western Pennsylvania as established by the first survey), I happened to be employed by the Brady's Bend Company to examine their property, and to give them, among other items, an opinion upon the probable existence and depth of oil beneath it. To do this I merely did what any geologist who had thoroughly studied that country would have done, I calculated the vertical distance from the oil sand on Oil Creek up to coal A; then I calculated the dip of the measures between Oil Creek and Brady's Bend; and then I identified coal A at Brady's Bend. I reported that the Venango oil sand, *if it extended under ground as far as Brady's Bend*, ought to lie at one thousand one hundred feet beneath water level. Any geologist who knew the country could have done this. It required no genius, no uncommon knowledge, nothing but a plain, simple, systematic, or scientific, in other words, true theoretical method of applying known facts for discovering the unknown. Any oil man could have done the same, if he had noticed the rock-layers as he went up and down the river, and put this and that carefully together.

"Yet, when, after a few months, oil was actually struck at Brady's Bend, within a few feet of the depth which I had assigned to it, the astonishment of all classes of oil men was ludicrously extravagant; a score or two of copies were made from the manuscript report, and these copies passed from hand to hand as precious things, and their author was looked upon as a prodigy of mental penetration, and was offered large sums of money to locate wells in different districts; none of which offers, of course, were accepted, because he was as ignorant of the actual existence of an oil-bearing sand in any given locality as everybody else.

"The story has its moral. Let 'practical men' believe in and respect the slowly, carefully reached, conclusions of 'theoretical men' enough to take them into consideration, so far as to comprehend them, and to govern themselves by them in their own collection and collation of facts relating to their own pecuniary interests.

"When a geologist like Mr. Carll has spent years in sifting and comparing the data of a great geological problem, and publishes his mature conclusions in a modest, earnest, plain, unvarnished report like that which is contained in this volume, it is probable, to say the very least, that its value to practical men like oil producers, struggling with immense obstacles to fortune, will be real in proportion to the pains they take to understand it."

Mr. Lesley further states:

"The chemical theory, so called, which looks upon petroleum as condensed from gas, the gas having been previously distilled from the great black slate formations (Marcellus and Genesee) must face the objection that such a process, if chemically possible, which is doubtful, ought to have distributed the oil everywhere, and permanently blackened and turned into bituminous shales the entire thickness of this part of the earth crust for several thousand feet. It fails to explain the petroleum obtainable from the cannel coals and from the roof shales of bituminous coal beds.

"And it fails also to explain the entire absence of petroleum from immense areas of not only shales, but sand and gravel rocks equally underlaid by the Marcellus and Genesee formations.

"The supposed connection of petroleum with anticlinal and synclinal axes, faults, crevices, cleavage planes, etc., is now a deservedly forgotten superstition. Geologists well acquainted with the oil regions never had the slightest faith in it, and it maintained its standing in the popular fancy only by being fostered by self-assuming experts who were not experienced geologists."

PETROLEUM DEPOSITS IN VENEZUELA.

These deposits have been known from the earliest history of the country, and as early as 1824 samples were sent to the United States and Europe. Although its existence in these parts was known, the knowledge of the extent of the deposit was very meager until, in 1880, E. H. Plumacher, American Consul, embodied a description thereof in the consular report to the United States. The emanation of the oil is accompanied by large quantities of natural gas, which, from time to time, becomes fired, causing irregular flashes of light, which the superstitious, awe-stricken natives attribute to the wrath of Satan.

Mr. Plumacher gives the following description of his observations:

"At a little more than seven kilometers distance from the confluence of the rivers Tara and Sardinarte, there rises a sand bank of about eight or ten meters in height, and it extends for about twenty-five or thirty meters. On its surface is visible a collection of cylindrical holes, apparently artificially made, and of different diameter, through which gush out with violence streams of petroleum mixed with boiling water, causing a noise which might be produced by two or three steamers blowing off steam. This noise may be heard at a considerable distance, and the column of vapor which ascends therefrom would also be perceptible a great way off if the thickness of the forest did not obstruct the view.

"All that land, over a great distance, abounds in petroleum, and it is wonderful what a coolness and luxuriance the forest which shades it preserves. The few who have visited the place in search of balsam copaiva have given it the name of 'El Inferno.' * * * The government has never interested itself with its exploration, neither have any other particular individuals done so, although many have possessed the means and the knowledge adequate to such an undertaking."

PETROLEUM DEPOSITS IN THE ARGENTINE REPUBLIC.

There also comes to us a report of immense oil deposits in the Argentine Republic. One of these deposits is located in the province of Jujuy. It consists of a lake of about eighty-eight acres in extent, and unknown depth, and is covered with a cap of asphalt. The liquid itself is somewhat thick, is of a black color, and has no disagreeable odor.*

Since then I have had assurance from those who have visited that province, that throughout its whole extent there exist these lakes covered with an inflammable liquid like pitch; also bituminous rocks which burn like stove coal, and valleys full of a substance resembling liquid pitch or having the appearance of asphalt; and springs from which flows oil instead of water. Some of these stories seemed so exaggerated as to be almost incredible. I have to inform the Department, however, that Dr. Luis Brackenbusch, Professor of Geology in the University of Cordoba, a scientist of high standing here and in Germany, has just completed a careful survey of the regions referred to, and made a map of the same. The result of his investigations and explorations is somewhat marvelous. After a thorough geological and geographical examination of that province, he makes the announcement that there exist subterranean rivers of liquid

*Consular report, Buenos Ayres, March 4, 1882, E. L. Baker, Consul.

kerosene, whose depth it is not possible yet to determine with precision, and which it will be necessary to learn by means of perforation.*

PETROLEUM, WHERE FOUND.

Petroleum is an article that has a very extensive distribution; in fact, reports of its discovery are received from nearly every country, even England and Scotland being producers to a limited extent; but from no quarter do we have any authentic reports of a largeness of production to equal that of Russia or the United States of America. Reports of the production of the different countries are to be found in the United States consular reports.

PETROLEUM IN RUSSIA.

The accounts of the production of petroleum by the wells at Baku, on the Caspian Sea, though seemingly fabulous, are nevertheless true, as the standing of those who have reported upon the output is beyond a question of doubt.

A very graphic description of the oil fountains of Russia's petroleum belt is given by Mr. Charles Marvin, who visited the fields and spent much time in their investigation, in his published work entitled, "The Region of the Eternal Fire," of which the following is an extract:

"In America there are over twenty-five thousand drilled petroleum wells. Baku possesses four hundred, but a single one of those four hundred wells has thrown up as much oil in a day as nearly the whole of the twenty-five thousand in America put together. This is very wonderful. But a more striking fact is, that the copiousness of the well should have ruined its owners, and broken the heart of the engineer who bored it, after having yielded enough oil in four months to have realized in America at least one million sterling.

"'In Pennsylvania that fountain would have made its owner's fortune; there's £5,000 worth of oil flowing out of the well every day. Here it has made the owner a bankrupt.' These words were addressed to me by an American petroleum engineer, as I stood alongside a well that had burst the previous morning, and out of which the oil was flying twice the height of the Great Geyser in Iceland, with a roar that could be heard several miles around. The fountain was a splendid spectacle—it was the largest ever known at Baku. When the first outburst took place, the oil had knocked off the roof and part of the sides of the derrick, but there was a beam left at the top, against which the oil broke with a roar in its upward course, and which served in a measure to check its velocity. The derrick itself was seventy feet high, and the oil and the sand, after bursting through the roof and the sides, flowed fully three times higher, forming a grayish-black fountain, the column clearly defined on the southern side, but merging into a cloud of spray thirty yards broad on the other. A strong southerly wind enabled us to approach within a few yards of the crater on the former side, and to look down into the sandy basin formed round about the bottom of the derrick, where the oil was bubbling and seething around the stalk of the oil-shoot like a geyser. The diameter of the tube up which the oil was rushing was ten inches. On issuing from this, the fountain formed a clearly defined stem about eighteen inches thick, and shot up to the top of the derrick, where in striking against the beam, which was already worn half through by the friction, it got broadened out a little.

* Consular report, Buenos Ayres, March 20, 1883, E. L. Baker, Consul.

Thence continuing its course more than two hundred feet high, it curled over and fell in a dense cloud to the ground on the north side, forming a sand-bank, over which the olive-colored oil ran in innumerable channels towards the lakes of petroleum that had been formed on the surrounding estates.

"Now and again the sand flowing up with the oil would obstruct the pipe, or a stone would clog the course; then the column would sink for a few seconds lower than two hundred feet, to rise directly afterwards with a burst and a roar to three hundred feet. Throughout the previous day a north wind had been blowing, causing the oil and sand to fall in a contrary direction from that pursued while we were there. Some idea of the mass of matter thrown up from the well could be formed by a glance at the damage done on the south side in twenty-four hours—a vast shoal of sand having been formed, which had buried to the roof some magazines and shops, and blocked to the height of six or seven feet all the neighboring derricks within a distance of fifty yards. Some of the sand and oil had been carried by the wind nearly one hundred yards from the fountain, the sand-drenched roofs of the adjacent buildings showing how far the cloud of matter had extended. From this outer boundary, where the oil lay an inch or so deep on the ground, the sand-shoal rose gradually, until at the rim of the crater it was about twenty feet deep, the surface being hard and soddened, and intersected with small channels, along which the oil was draining off to the lakes. On the opposite side a new shoal was forming, and we could see the sand as it fell, drifting around the neighboring derricks and burying all the outhouses in the way.

"Here and there gangs of men were at work with wooden spades, digging and clearing channels round about the mouth of the well, to enable the oil to flow away. Their task was no easy or agreeable one. Upon their heads and shoulders oil and sand never ceased to fall, and they had to be careful to avoid being drawn into and engulfed in the vortex round the base of the crater. Luckily no stones of any size were being thrown up with the oil. Sometimes blocks weighing several pounds are hurled up from the depths below, and then it becomes a dangerous matter to approach a petroleum fountain. Standing on the top of the sand-shoal we could see where the oil, after flowing through a score of channels from the ooze, formed in the distance on lower ground a whole series of oil lakes, some broad enough and deep enough to row a boat in. Beyond this, the oil could be seen flowing away in a broad channel towards the sea.

"It may be asked how a magnificent oil fountain of this description should be able to make its owner a millionaire in one hemisphere and a bankrupt in another. The answer is simple enough. The fountain belonged to a small Armenian company, the "Droojba," having ground enough to establish a well upon, but nothing to spare for reservoirs. Consequently, all the oil was flowing away upon other people's property, and the amount subsequently caught and saved upon the waste lands afar off was being sold at such a low price as to be altogether inadequate to meet the claims for compensation from those whose houses and shops had been engulfed and their derricks hindered from working, by the sand thrown up from the well. Had the "Droojba" possessed plenty of land round about their well, to store the oil, they would not have been so badly off, but their well happened to be in the midst of several hundred estates covering the Balakhani Plateau, and hence the damage done ruined them.

"A feature in the American oil supply is, that while there are many wells yielding thousands of gallons of petroleum daily, the larger proportion give only hundreds. The richest well on record, I believe, has not exceeded two hundred thousand gallons a day. At Baku the wells are nearly all of them what Americans would consider extremely copious ones. A well yielding only a few hundred gallons of oil a day a Baku firm would not consider worth working. This is not remarkable, seeing that the richest of the Baku wells has yielded two million gallons, or ten times the largest yield in America, in twenty-four hours.

"Flowing wells yielding from forty thousand to one hundred and sixty thousand gallons of oil every day, of rare occurrence in America, are quite common at Baku. The ordinary yield of the pumping wells is from ten thousand to twenty-five thousand gallons. It is common for these pumping wells to be worked for years, without the supply diminishing. Gospodin Kokereff has one which has already produced sixty million gallons of oil, and still continues to yield the same rate as at the outset. In Group VIII, is a flowing well belonging to the Baku Petroleum Company, which for two years has given a regular supply of forty thousand gallons daily from a depth of two hundred and fifty-two feet, without showing signs of exhaustion.

"In 1875 there was a third fountain in Group XIII, which spouted six hundred thousand gallons of oil every twenty-four hours. This belonged to the Company of Petroleum Participators, which has had a number of fountains in the course of its career. In 1874 the well, which was one hundred and ninety-six feet deep, and had been giving eight thousand gallons a day for some time, began to diminish. Boormeister, the German engineer, thereupon began to bore deeper to obtain a fresh supply. At two hundred and eighty feet he lost oil altogether, although plenty of gas came to the surface. At three hundred and fifteen feet he reached a bed of rock. This was so hard that he had to put on eight men to drill through it. Suddenly, on the twenty-sixth of October, the boring tool broke through the roof of the subterranean reservoir, and only one man was then needed instead of eight. To ascertain the cause of this sudden facility of working, the tool was withdrawn, when a small fountain of oil began to spout. This ceased after a few minutes, and then the gas began to roar, accompanied by a sort of explosion below, producing perceptible trembling of the earth round about the well. Afterwards oil and gas spouted at intervals. To keep both down a cap of half-inch boiler plate was placed over the tube; but in the night the oil suddenly broke it off, and began to spout forty feet high. The next day oil flowed at the rate of six hundred thousand gallons in twenty-four hours. Four huge lakes of oil were formed in the course of a month, the fountain not being closed over until the twenty-third of November.

"In 1877 Orbelovi Brothers had a great fountain from a well two hundred and ten feet deep, with a bore of ten and one half inches. The oil spouted slightly for a few days, and was then capped, but in making some improvements afterwards to the cap the pressure below burst it off the tube, and the petroleum issued with a fury nothing could check. In half an hour a reservoir holding forty thousand gallons was filled, and then the oil ran all over the place, forming a series of lakes. This fountain never spouted less than forty thousand gallons of oil a day, and sometimes attained one million two hundred thousand gallons. The total quantity of oil lost before the fountain was subdued was forty million gallons.

"A less striking but more valuable fountain, in 1877, was Meerzoeff's No. 5, in Group IX. The oil was first touched in 1876. The following spring, in deepening the well to three hundred and forty feet, the oil began to spout at the rate of eighty thousand gallons daily; the gravity being 0.865. After awhile it was successfully capped, and has since then given a permanent supply, amounting, up to the end of 1883, to sixteen million gallons.

"In 1878 the Caspian Company had a fountain from a depth of four hundred and sixty-two feet, giving one hundred and sixty thousand gallons daily. Altogether, the well spouted nearly ten million gallons of oil, of which six millions were sold for liquid fuel, and the remainder lost. Several remarkable fountains occurred the following year. One of these was in Group V, and belonged to Gospodin Mnatsakanoff. The well was two hundred and ninety-four feet deep, with a tube of number twelve iron, ten inches in diameter. The first month water and gas issued, then the sand started to spout, and played for four hours, followed by petroleum, bursting off the cap that had been successfully fixed. For one hundred and twenty days the oil spouted without cessation day and night, the average flow being one hundred and twenty thousand gallons daily—a record which the most copious well in America has never been able to maintain beyond two or three weeks. The total quantity of oil thrown up was fifteen million gallons, of 0.868 specific gravity. Of this, two million gallons were sold at half a copeck the pood, or between 7d. and 8d. the ton. Six hundred thousand gallons were sold to the Caspian Company for 800 roubles (£80) for the entire quantity—being used for fuel—and the remainder was burnt or allowed to sink into the soil. The tube, costing £500, was completely worn to pieces.

"In 1881 Gospodin Mnatsakanoff began deepening a twelve-inch well, which had exhausted the oil at two hundred and ninety-four feet. Having reached four hundred and thirty-four feet, oil was touched again. Great pains were taken to pack round about the tube, and fix a good cap to resist the pressure, but after a few days the oil broke through all impediments, and spouted. From September thirteenth to November first a total of three million three hundred and twenty thousand gallons issued, which was sold for 18,000 roubles (£1,800). The fountain was then placed under control. The following year, from February nineteenth to the end of the navigation season, the well was allowed to spout, and ejected eighteen million gallons, which was sold for 86,000 roubles (£8,600).

"In 1882 Krasilnikoff had two fountains. One was at Shaitan Bazaar, where a well was completed his engineers had been working upon at intervals since 1877. At a depth of three hundred and seventy-eight feet sand began to shoot up the tube, and after a time oil flowed at the rate of one hundred and sixty thousand gallons a day; the gravity being 0.850–51. Eleven days elapsed before a cap could be fitted; the loss during the interval being eight hundred thousand gallons. After the well was capped, it gave an abundant supply under firm control from the same depth for fifteen months. In the case of the second fountain the depth of the bore was five hundred and four feet, and the well spouted eighty thousand gallons a day. The total outflow was four million eight hundred thousand gallons, of which one million six hundred thousand were sold as fuel and the rest allowed to run to waste in lake Saboontchi. On the third of September the fountain caught fire and flared with terrific fury for ten days, when it was extinguished.

"At Shaitan Bazaar, Orbelovi Brothers had an enormous fountain at their No. 2 well. The engineers began boring it by hand in 1877, and completed it in 1881. The tube was twelve inches in diameter, diminishing to ten and one half. At a depth of four hundred and ninety feet oil was struck, and spouted four million gallons in a week. The stem of the fountain was over two hundred feet high, and a strong wind blowing at the time carried the oil spray five hundred yards to the office of the Baku

Petroleum Company, the manager of which lodged a complaint against Orbelovi Brothers, affirming that there was a serious danger of the establishment being set on fire. The oil flowed into a saline depression, and was there burnt to get rid of it. When the fountain ceased playing, the tube was found to be choked and ruined. Since then the well has remained unworked.

"In 1882 the Company of Petroleum Participators had a fountain at their No. 9 well, from a depth of four hundred and seventy-six feet. The tube was ten inches in diameter, and was composed of three-sixteenths inch iron. Its installation was effected under the supervision of Lentz, whose system of concreting round about the upper part of the well had proved so successful on a previous occasion. The fountain lasted twenty days, during which it carried to the surface eight million gallons. The average was four hundred thousand gallons a day. Of this one million six hundred thousand gallons were sold, one million two hundred thousand gallons conducted to a depression and stored, and five million two hundred thousand gallons lost. A cap was fixed on the sixth day. The well has since proved one of the most productive at Balakhani.

"The same year the Baku Mining Company had a fountain from a well four hundred and fifty feet deep. The tube was fourteen inches in diameter. In September it spouted four hundred thousand gallons in twelve days; in December one million two hundred thousand gallons in six days; and early in January, 1883, four hundred thousand gallons in two and one half days. Of the total of two million gallons, only six hundred and forty thousand gallons were sold, at $\frac{3}{4}$ copeck the pood (about 11d. the ton). The specific gravity of the oil was 0.867.

"A very remarkable fountain was Nobels' No. 9 well, which spouted from a depth of six hundred and forty-two feet one hundred and twelve thousand tons, or nearly thirty million gallons of oil, in four weeks. The height of the fountain was two hundred feet, and it threw the oil and sand for a distance of two hundred feet round about the derrick. Thanks to the extensive means of the company, only one million gallons were lost out of the thirty millions spouted; and of the latter, twenty million gallons were at once converted into kerosene and other products, and the remainder stored in reservoirs. After the pressure in the well had fallen, so that the orifice could be conveniently plugged by mechanical means sufficiently tight to resist the force below, the delivery of oil was still at the rate of six hundred barrels per hour. Another fountain, at their No. 25 well, threw up nearly two million gallons of oil daily, from a depth of five hundred and eighty-two feet. The pressure in the tube, ascertained by scientific instruments, was about two hundred pounds to the square inch. The well now yields a million gallons of crude oil per diem.

"But the great fountain of the year, and one whose renown penetrated to every part of Europe, was the Droojba. The maximum pressure of gas in previous fountains had not exceeded four atmospheres, but in the case of Nobels' No. 9 fountain and the Droojba, it exceeded thirteen. I have already described, in the opening part of this chapter, what a magnificent spectacle it was. Had the well been situated at the bottom of the monument, it would have spouted higher than the golden ball at the top. This "oil volcano" threw up—according to the estimate of the local experts, Mr. B., an American petroleum engineer, who chanced to be at Baku, the semi-official newspaper "Baku Isvestie," and a number of other authorities—four hundred thousand or five hundred thousand poods, or from one million six hundred thousand to two million gallons of oil every day for some time after the first outburst, which occurred on the first of September. In the middle of November it was still spouting two hundred and forty thousand gallons a day, and a three-inch iron boiler plate was ground to pieces in an attempt to divert the stalk of the fountain.

"With regard to the Droojba, in consequence of the prodigious outflow of oil, the crude article lost its value for the moment. Fedoroff filled his reservoirs with two million eight hundred thousand gallons of oil for 300 roubles, or £30. No one would give more than ¼ copeck the pood for what had previously fetched 2 or 3 copecks. Thousands of tons were burnt outside the district to get rid of it; thousands were led towards the Caspian; huge lakes of oil were formed near the well, and on one occasion the liquid suddenly flowed into a distant engine-house, and but for the promptness of the engineer in extinguishing his petroleum furnace the whole locality would have been ablaze. Houses were completely buried by the sand cast up with the oil. All efforts to stop the fountain on the part of Baku experts were fruitless. The indignation in Russia at the waste of oil was unbounded. At Baku all the well owners formed themselves into a congress to decide upon means for checking the fountain. Finally the Government of St. Petersburg was appealed to, and 2,000 roubles were assigned to equip two engineers to proceed to Baku. On the nineteenth of December the fountain suddenly stopped of its own accord—the pipe had got blocked—but after three hours it burst out afresh with increased violence. At length, on the twenty-ninth of December, Zorgé, a neighboring well-owner, succeeded in fixing a cap, and, in spite of a strong filtration round the tube, the oil remained under control the whole winter. Directly the outburst was stopped, a great disturbance took place in Nobels' No. 14 well, showing a connection of both with the same reservoir. The depth of the Droojba well was five hundred and seventy-four feet. The quantity of oil spouted was reckoned to have ranged between two hundred and twenty thousand and five hundred thousand tons, which, in America, would have yielded from £616,000 to £1,400,000 sterling.

"Such a prodigious outflow of oil was without parallel, not only in the annals of commerce, but in the records of science. The old eternal fire, and the blazing water at Baku, sink into insignificance compared with such a marvel. To the man of science the oil fountains of the Apsheron peninsula promise to become a source of permanent interest. Now the oil fields are more developed there are plenty of curious facts that need elucidation; one of the most striking of these is, that the fountains always play the fiercer after a north wind. Why this should be the case no one has yet satisfactorily explained.

"The owners of the Droojba, for want of capital to grip their good fortune, let a million sterling slip through their fingers. Gariboff, the engineer, appalled by the havoc, and vainly trying to check it, broke his heart; but had the Armenian firm been a rich European company, with the engineering resources of the west at its command, the result would have been very different. The Droojba oil well would have been more valuable than many a gold mine.

"Were there any guarantee that the oil would be as little wasted, as in the case of Nobels' wells, I should be the last to support the agitation that has been set on foot at Baku to place the fountains under government supervision. But when a single man pricks the earth, and wastes for ever fifty millions or one hundred millions gallons of good oil—enough to supply London for years—then there is an end to the common sense of the *laisser fairè* doctrine, and the State ought to step in and suppress the outburst at the owner's cost, even though that cost be confiscation."

The Russian oil of commerce has less color and odor than the American oil. The American crude oil is superior to that of Russia in the larger percentage of illuminant; but on the other hand the Russian oil excels in the greater quantity of its lubricant.

PETROLEUM AS A FUEL.

Petroleum as a fuel has not as yet taken the place of coal in the United States of America, and from the present outlook it seems that it will be a long time before the succession takes place, at least in those parts where coal is so abundant as in Pennsylvania.

It requires one hundred and ninety-two gallons of petroleum to equal two thousand pounds of coal as a heat producer. With the present price of good steam coal in California the utilization of petroleum might prove an economy, and as the yield of the latter is becoming larger every day it is to be hoped that some one of our inventors may soon come forward with an appliance that will give more perfect combustion than anything we have now in use. The combustion at present is far from being satisfactory, the heat is irregular, and every absorbing material in and about the fire-rooms becomes saturated with the unconsumed volatilized oil; but petroleum has the advantage over coal in point of storage and the almost imperceptible percentage of ash.

On the Caspian and Black Seas petroleum fuel has entirely superseded coal, for the simple reason that in these sections there is an almost fabulous production of the oil, while the use of coal necessitates an importation.

For manufacturing purposes, in many instances where petroleum is used as a fuel, the articles are far superior to those made by the use of coal. The principal objection to former experiments made with the crude oil for steam purposes by the Central Pacific Railroad Company, was the vaporization and after-condensation, on the surroundings, of the unconsumed oil, and also the large amount of smoke and soot. This goes to prove that there was an imperfect combustion, due to the absence of heat and an insufficient supply of air; that is to say, the blast did not supply air in sufficient quantities to form a chemical unity with the carbon and hydrogen of the oil. The apparatus for supplying air and oil should be so constructed that the fuel and air would be so intimately mixed that the oxygen would unite with the carbon and hydrogen, the component parts of petroleum, and generate carbonic acid and water respectively.

In Russia, after the lighter oils are driven off, the crude material is used for the purpose of generating steam in the locomotive boilers and on the steamers; and beside getting up steam in much less time than with other fuel, the combustion is perfect even to the absence of smoke and soot. The oil is fed into the tender from tanks, at the different stations, and thence through pipes into the furnaces, where it meets the steam jets. The tanks on the tenders are so elevated that the oil reaches the furnaces by gravitation through conductors so regulated that the oil is fed slowly and in small quantities.

The following extract is taken from Executive Document, No. 131, House of Representatives, forty-ninth Congress, second session, from the reports of Lieutenant Wm. H. Schuetze, United States Navy, transmitted from the Department of State on the first of February, 1887, as follows: "Refuse petroleum has nearly supplanted wood as steamer fuel in all the Volga boats, estimated to be about two thousand in number."

As far as any information could be gathered on the preparation of a new fuel, in Russia, the following would answer as a general description: To the boiling oil not less than one nor more than three per cent of common soap is added, and the ebullition continued until the soap is completely dissolved, which takes about half an hour, when the liquid suddenly turns into a waxy-like substance which hardens on cooling, and then the material can be pressed into bricks or any required form. It is difficult to kindle, but when once alight it gives off an intense heat, is slowly consumed without emitting any smoke, only leaving a percentage of ash in accordance with the amount of soda or potash contained in the soap used. It is further claimed that in comparison with anthracite coal, the latter is consumed in one third of the time, with one seventh of the heating power.

Experiments are being made by some of the manufacturers of Springfield, Ohio, with crude petroleum as a fuel in the manufacture of malleable iron, with fair possibility of success. The Champion Electric Light Company, at the same place, claims twenty per cent saving over coal by the use of petroleum.

Through the kindness of the Central Pacific Railroad Company, an examination into the methods of using petroleum as a fuel on their steamers was made, in company with Mr. Wm. McKenzie, Division Master Mechanic and Chief Engineer of Steamers, and much valuable information obtained, which is incorporated in this paper.

After the lighter oils are driven off, the residual, which is obtained from the Pacific Coast Oil Company's refinery, is used for steam purposes on the five following steamers, viz.:

Julia	400 working horse-power engine.
Oakland	998 working horse-power engine.
Piedmont	1,238 working horse-power engine.
Transit	800 working horse-power engine.
Thoroughfare	600 working horse-power engine.

The four first named use the oil regularly, but the Thoroughfare, being a freight boat, is only called into occasional use, therefore particular mention will only be made of those in constant service and the amount of material they consume per month of thirty-one days, and calculated in barrels of forty-two gallons each:

Residual or heavy oils consumed in 31 days by steamer Julia	600 barrels.
Residual or heavy oils consumed in 31 days by steamer Oakland	1,750 barrels.
Residual or heavy oils consumed in 31 days by steamer Piedmont	2,200 barrels.
Residual or heavy oils consumed in 31 days by steamer Transit	1,450 barrels.

The steamers Piedmont and Oakland, plying between San Francisco and Oakland, having the more powerful engines, and necessarily using a larger amount of fuel than the others, it would, perhaps, be better for the purposes of illustration to confine the description entirely to them.

The Piedmont makes between San Francisco and Oakland, in one day, eighteen and one half round trips, and thirteen and one half on the following day, or, in forty-eight hours, a total of thirty-two round trips. The engineer, Mr. H. Hughes, states that in a day of eighteen and one half round trips there is consumed a little over three thousand three hundred gallons of oil, and that previously when coal was used it required about forty tons of the latter for two days, or thirty-two round trips. Therefore, in agreement with the statement of the engineer, there would be consumed for each round trip something over one hundred and seventy-eight gallons of oil, or the equivalent in coal of one and one quarter tons; or, to be a little more explicit, about one hundred and forty-two gallons of oil would equal for the purpose of creating steam power, one ton of Carbon Hill coal.

On the Piedmont, as well as the Oakland, the feed tanks for supplying the furnaces are horizontal cylinders, and confined under the main deck, and each having a capacity for a two days' supply of oil. As they are not sufficiently elevated to furnish enough pressure for a proper feeding of the oil, small pumps are used for the purpose of raising the oil from the tanks to from ten to twelve feet above the level of the burners; the latter it reaches by gravitation. Each tank is supplied with pipes running from the top through the hull of the boat on either side for the purpose of carrying off any gas that may be generated by the oil.

The engines are low pressure condensing engines running with thirty to thirty-five pounds of steam. Fresh water is used for the boilers and salt water for the condensers.

The Piedmont has two large boilers, with two furnaces to each boiler and three burners to each furnace.

At the burners the oil is atomized, or in other words, blown into the furnace as a fine spray, by a jet of dry steam which is fed by a redhot iron pipe passing through the furnace to the burners.

The construction of the furnaces and burners may be more fully understood by an examination of the accompanying illustrations. Figure 1 is a vertical longitudinal section of one of the furnaces.

Figure 2 is a vertical elevation of the fronts of the two furnaces belonging to one of the boilers, showing the positions of the oil and steam pipes, together with a horizontal view of the curved pipe E, in which the steam is superheated before it passes to the burners.

Figure 3 shows the details of construction of one of the burners, and the mode of its connection with the oil and steam pipes which run horizontally across the top of the furnace door openings.

Each burner A consists of two concentric tubes with a peculiar shaped mouthpiece. The inner tube, one fourth inch in diameter, is the transmitter of the superheated steam, and is surrounded by a second tube leaving an annular space one eighth inch wide between the two, which forms the conduit for the oil.

The conduit does not open directly into the furnace, but instead, the inner tube is contracted to about one eighth of an inch near the mouthpiece by swedging, and just beyond the contraction it is pierced with numerous small holes through which the oil passes from the annular space to the inside of the inner tube, where it meets and unites with the superheated steam before reaching the mouth of the burner.

The mouthpiece screws on to the outer tube, as shown in illustration A. Horizontally it is flattened and drawn out until the final opening through which the united steam and oil enter the furnace is a straight slit one and one half inches long and one sixteenth of an inch wide—flaring outwards at each end.

The cocks or valves which regulate the supply of oil and steam to the burners are peculiar in construction. By reference to Figure 3 it will be seen that in each case the valve-stem projects a short distance beyond the valve-seat into the pipe leading to the burner; and this portion of the stem is ground to fit the pipe in which it slides so closely that even when the valve is raised a short distance from its seat, no oil nor steam could reach the burners were it not for the following device: In the cylindrical surface of this projecting portion of the valve-stem are placed several little channels parallel with its axis, and of different lengths, one of them reaching entirely up to the valve-seat, while the others are successively shorter. The result is, that when the valve is but a little raised from its seat, only a very small quantity of oil or steam can pass to the burner through the longest one of these little channels; but as the valve is opened further the

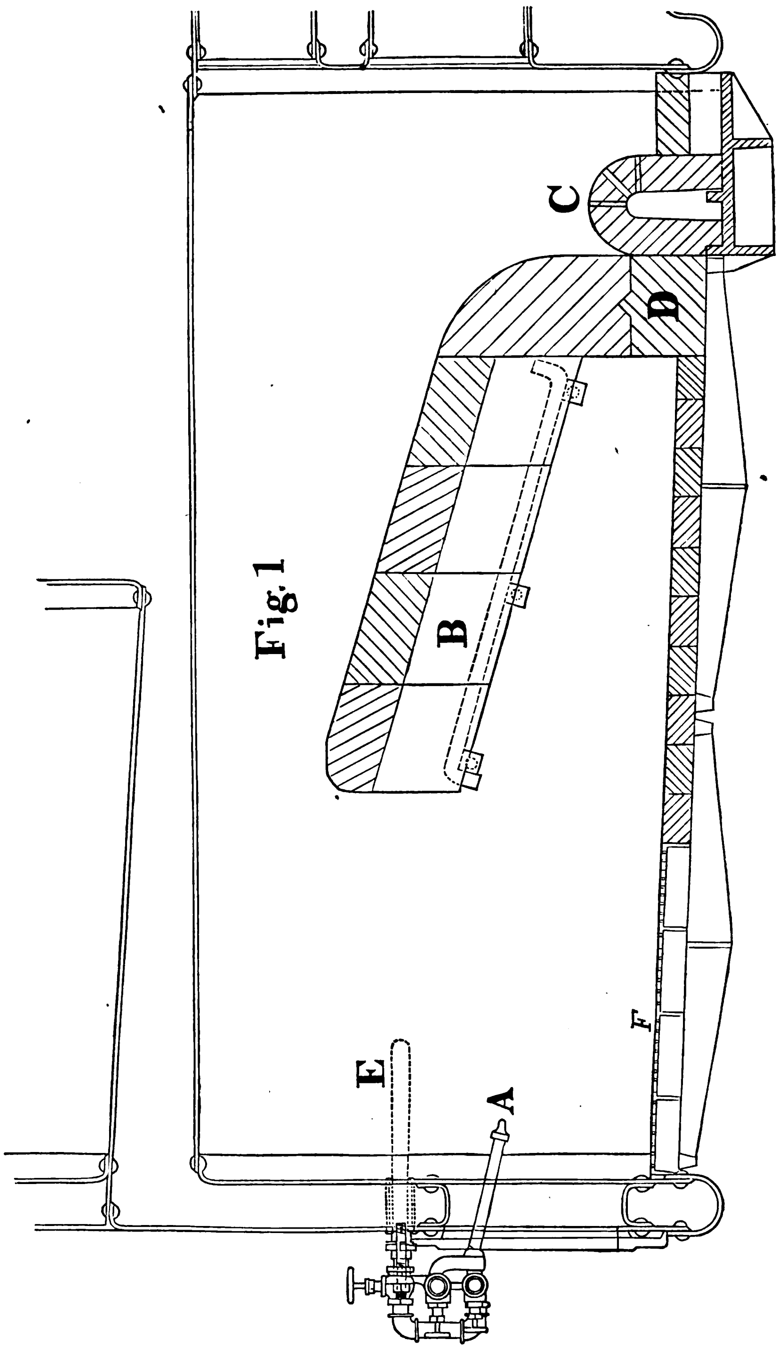


Fig. 1

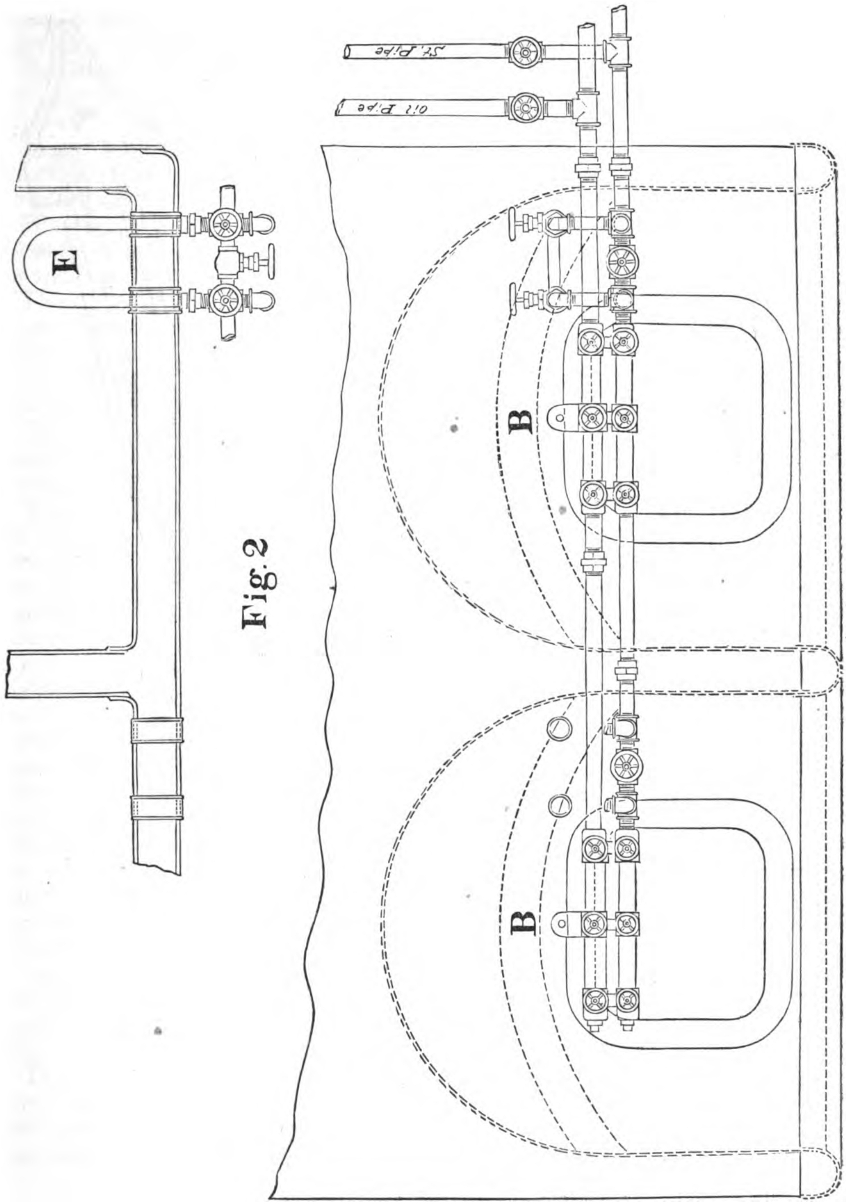


Fig. 2

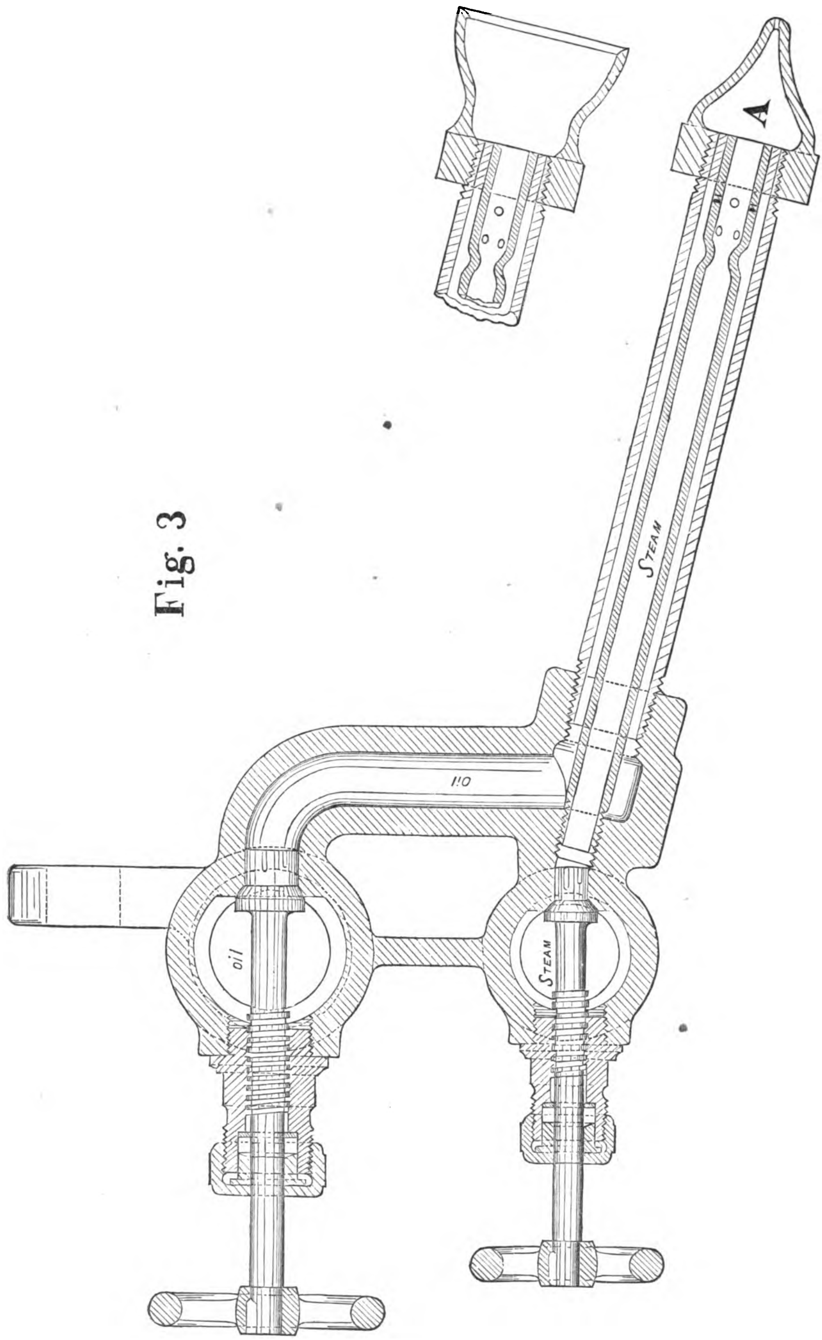


Fig. 3

quantity passing gradually increases till a second channel opens out, and later on a third one, and so on.

By this means the quantities of oil and steam passing to each burner can, at any moment, be regulated with the greatest nicety, and perfectly adjusted to each other.

There are three burners in position at the door opening, placed along the top of the furnace inclining slightly downward as they enter, and reaching from four to six inches inside.

Where the old grates, formerly used for burning coal, are replaced by those for burning oil, the latter (see F) are iron plates perforated with quarter inch circular holes.

The floors of the ash-pits are covered with a layer of sand and ashes mixed, for the purpose of absorbing any oil that may not be consumed, of which the amount is minimum.

The flame, a very long one, is at the mouth of the burner intensely hot and dazzling white, and almost smokeless.

The combustion, however, is not perfect, for the force of the blast propels small particles of the heavier oils through the flame to the walls of the furnace, where, if not consumed, they find their way to the ash-pit.

The air admitted through the grate, beneath the burners, is not sufficient for the oil's combustion, but by the following described very ingenious arrangement, the flame is met by a fresh supply of air and the consumption of the oil is made more nearly complete. A few feet in front of the burners a low, hollow arch of fire-brick runs transversely from side to side across the floor of the furnace, thus occupying a position similar to that of the fire-bridge in an ordinary furnace, but the flame does not pass immediately over the arch. On top of this arch rests the foot of another fire-brick arch, as shown in Figures 1 and 2, which spans the furnace transversely, and at the same time slopes upwards and backwards to within a short distance of the furnace door, where it stops. The inclination of the burners is such that the flame first strikes the floor of the furnace near the wall, as shown in D, Figure 1. It then turns upwards and backwards, doubling upon itself—passing up under the arch B to near the top of the furnace door, where it strikes and heats the curved tube E in which the steam employed to atomize the oil is superheated; then, curving over the top of the arch B, it passes forwards and downwards toward the flues. As the flame passes over the top of the hollow arch-bridge C, it meets another stream of air, which, coming from the interior of the arch-bridge C, and flowing out through numerous holes in the fire-brick forming the upper part of the arch, aids very materially to complete the combustion of the oils.

The first boiler flues through which the products of combustion pass are large ones, twelve to eighteen inches in diameter, but quite short. Under the central portion of the boiler comes another chamber, where further combustion can take place and more air be supplied if needed.

SOUTHERN PACIFIC COMPANY, OFFICE AUDITOR M. P. & M. DEPT.,
SAN FRANCISCO, February 16, 1886.

Col. C. F. CROCKER, *Third Vice-President Southern Pacific Company:*

DEAR SIR: Some days since you handed me a statement showing the amount of water evaporated to one pound of Carbon Hill coal under an ordinary stationary boiler; also amount evaporated to one gallon of petroleum on steamer Piedmont.

While it is hardly fair to make comparisons between a stationary boiler and boilers on a steamer, the figures given show very favorably for the Carbon Hill coal; though it would be interesting to know at what temperature the water was furnished the stationary boiler. I have no doubt but that it was furnished at, at least, 150 degrees Fahrenheit, while the water furnished the Piedmont boilers was at about 50 degrees Fahrenheit. This of course would cut a considerable figure in the calculations. We have no stationary boilers that are burning oil, therefore cannot make comparison on that basis; though scientific works on this subject give "the equivalent evaporative power of one pound of combustible under one atmosphere at 212 degrees Fahrenheit," as follows: coal, 14.62; oil, 28.50. I desire to submit the following, which may be of interest to you. From tests made on steamer Piedmont we find the following:

One ton of Carbon Hill coal evaporates ten thousand nine hundred and sixty gallons of water at a cost of $5 40, or $.00049 per gallon.

One ton of oil (two hundred and fifty gallons) evaporates twenty-two thousand six hundred and eighty gallons of water for $10, or $.00044 per gallon, which shows a saving in oil over coal of $.00005. In both cases the water was evaporated from about 50 degrees Fahrenheit.

The figures given below will show the relative cost for running steamer Piedmont with coal and oil.

In months of May, June, July, and August, 1885, when burning Carbon Hill coal, the cost was as follows:

2,476 tons of coal		$13,368 45
11 firemen		3,064 20
Total		$16,432 65
Average cost per month		4,108 16
Total miles run	17,843	
Cost per mile for fuel	$74\frac{92}{100}$ cents.	
Cost per mile for firemen	$17\frac{18}{100}$ cents.	
Total cost per mile run	$92\frac{10}{100}$ cents.	

In months of October, November, and December, 1885, and January, 1886, when burning oil, the cost was:

316,879 gallons oil		$12,845 04
6½ firemen		1,870 88
Total		$14,715 92
Average cost per month		3,678 98
Total miles run	17,275	
Cost per mile for fuel	$74\frac{35}{100}$ cents.	
Cost per mile for firemen	$10\frac{83}{100}$ cents.	
Total cost per mile run	$85\frac{18}{100}$ cents.	

By the use of oil the saving is $429 18 per month, or $5,120 16 per year, which is $10\frac{44}{100}$ per cent.

On steamer Thoroughfare the saving is greater than on steamer Piedmont, and on the steamer Solano about the same.

Yours truly,

N. H. FOSTER,
Auditor M. P. & M. Dept.

SOUTHERN PACIFIC COMPANY, OFFICE AUDITOR M. P. & M. DEPT.,
SAN FRANCISCO, October 26, 1887.

A. N. TOWNE, *Esq.*, *General Manager Southern Pacific Company:*

DEAR SIR: Inclosed please find statements showing comparison between coal and oil for steamers Transit, Oakland, Julia, and Piedmont. You will note that the saving in favor of oil for the—

Transit is	$9\frac{8}{10}$ per cent.
Oakland	$24\frac{43}{100}$ per cent.
Julia	$22\frac{38}{100}$ per cent.
Piedmont	$21\frac{24}{100}$ per cent.

Yours truly,

N. H. FOSTER,
Auditor M. P. & M. Dept.

TRANSIT.

May and June, 1887, with coal:

Miles run		5,157
Tons Carbon Hill coal, $764\frac{1}{2}$, at $5	$3,822 50	
Firemen, 12, at $70	840 00	
		$4,662 50
Cost per mile run, coal		$74\frac{12}{100}$ cents.
Cost per mile run, firemen		$16\frac{29}{100}$ cents.
Total		$90\frac{41}{100}$ cents.

August and September, 1887, with oil:

Miles run		5,181
Barrels fuel oil, $2,617\frac{8}{10}$, at $1 40	$3,664 92	
Firemen, 8, at $70	560 00	
		$4,224 92
Cost per mile run, oil		$70\frac{74}{100}$ cents.
Cost per mile run, firemen		$10\frac{81}{100}$ cents.
Total		$81\frac{55}{100}$ cents.
Percentage in favor of oil		$9\frac{8}{10}$

JULIA.

July, 1887, with coal:

Miles run		1,364
Tons Carbon Hill coal, $217\frac{3}{4}$, at $5	$1,088 75	
Firemen, 2, at $70	140 00	
		$1,228 75
Cost per mile run, coal		$79\frac{82}{100}$ cents.
Cost per mile run, firemen		$10\frac{26}{100}$ cents.
Total		$90\frac{8}{100}$ cents.

September, 1887, with oil:

Miles run		1,312
Barrels fuel oil, $555\frac{1}{4}$, at $1 40	$777 35	
Firemen, 2, at $70	140 00	
		$917 35
Cost per mile run, oil		$59\frac{25}{100}$ cents.
Cost per mile run, firemen		$10\frac{67}{100}$ cents.
Total		$69\frac{92}{100}$ cents.
Percentage in favor of oil		$22\frac{38}{100}$

PIEDMONT.

For months of December, 1886, and June, 1887, with coal:

Miles run		8,797
Tons Carbon Hill coal, 1,299¼, at $5	$6,496 25	
Firemen, 22, at $70	1,540 00	
		$8,036 25
Cost per mile run, coal		$73\frac{84}{100}$ cents.
Cost per mile run, firemen		$17\frac{51}{100}$ cents.
Total		$91\frac{35}{100}$ cents.

For months of August and September, 1887, with oil:

Miles run		8,995
Barrels fuel oil, 4,022½, at $1 40	$5,631 50	
Firemen, 12, at $70	840 00	
		$6,471 50
Cost per mile run, oil		$62\frac{61}{100}$ cents.
Cost per mile run, firemen		$9\frac{34}{100}$ cents.
Total		$71\frac{95}{100}$ cents.
Percentage in favor of oil		$21\frac{24}{100}$

OAKLAND.

July, 1887, with coal:

Miles run		4,540
Tons Carbon Hill coal, 618¾, at $5	$3,093 75	
Firemen, 11, at $70	770 00	
		$3,863 75
Cost per mile run, coal		$68\frac{14}{100}$ cents.
Cost per mile run, firemen		$16\frac{96}{100}$ cents.
Total		$85\frac{10}{100}$ cents.

September, 1887, with oil:

Miles run		4,419
Barrels fuel oil, 1,729¾, at $1 40	$2,421 65	
Firemen, 6, at $70	420 00	
		$2,841 65
Cost per mile run, oil		$54\frac{80}{100}$ cents.
Cost per mile run, firemen		$9\frac{51}{100}$ cents.
Total		$64\frac{31}{100}$ cents.
Percentage in favor of oil		$24\frac{43}{100}$

SOUTHERN PACIFIC COMPANY, OFFICE AUDITOR M. P. & M. DEPT.,
SAN FRANCISCO, October 6, 1885.

TIMOTHY HOPKINS, *Esq.*, *Treasurer Southern Pacific Company:*

DEAR SIR: Replying to your favor of some days since, relative to the use of oil as fuel, I would respectfully submit the following.

During the year 1884, steamer Solano consumed:

5,014½ tons Empire coal, at $3 80		$19,055 10
2,190¼ tons Carbon Hill coal, at $5 50		12,046 30
Total for year		$31,101 40
Average cost per month	$2,591 79	
Miles run per month	5,973	
Cost per mile for fuel	$5 20	

During June, July, and August, 1885, she consumed:

3,715 barrels oil, at $1 70 per barrel		$6,315 50
Average cost per month	$2,105 16	
Miles run	1,372	
Cost per mile for fuel	$4 60	

This shows a saving in fuel of $486 59 per month, or $18\frac{7}{10}$ per cent.

The amount of oil burned per horse-power per hour on this steamer, is as follows:

Oil burned per day	1,620 gallons.
Average time burning oil	5.8 hours.
Oil burned per hour	279.31 gallons.
Indicated horse-power	1,702.
Oil burned per horse-power per hour	.1641 gallons.

Assuming the number of hours burning coal to be the same as oil, the result would be for coal during the year 1884:

Coal burned per day	39,479 pounds.
Time burning coal (assumed)	5.8 hours.
Coal burned per hour	6,807 pounds.
Indicated horse-power	1,702.
Coal burned per horse-power per hour	4 pounds.

Steamer Thoroughfare for five months, February to June, inclusive, 1884, consumed:

3,821¼ tons Ione coal, at $3 96	$15,132 15
92 tons Carbon Hill coal, at $5 50	506 00
Total	$15,638 15
Add six firemen at $70 per month each	2,100 00
Total for five months	$17,738 15
Average cost per month	3,547 63

For five months, February to June, 1885, inclusive, she consumed:

Oil costing	$8,635 98
Add two firemen at $70 per month each	700 00
Total for five months	$9,335 98
Average cost per month	1,867 19

This shows a saving for five months of 1885, over corresponding five months of 1884, of $8,402 17, or $1,680 43 per month, or $47\frac{36}{100}$ per cent.

Total saving for steamers Solano and Thoroughfare for month as above, $2,167 02, or $26,004 24 per year.

The boilers are so located on the steamer Solano that no saving in firemen can be made.

The space occupied for the storage of oil is about 50 per cent less than for coal.

The kind of oil used is the residuum after the volatile substances have been extracted.

Oil is adapted for use on locomotives. I believe it is now being used on locomotives in Russia.

It would hardly be practical here, however, as the supply of oil at present is limited, and I doubt whether it would be much cheaper in any event, considering the price we are now paying for coal, which is less than $7 per ton.

Yours truly,

N. H. FOSTER,
Auditor M. P. & M. Dept.

REFINING.

This is a process of distillation whereby the oils of different gravity, of which the crude petroleum is mechanically composed, are separated from each other at their respective points of vaporization; the various distillates being collected in separate receivers, and the coloring matter, together with the impurities, remaining in the retort.

This method of separating liquids of unlike gravity was patented in England nearly two centuries ago, therefore it is not, as many suppose, an offspring of the petroleum industry.

In the beginning the oil was refined at or near the wells, but since the improved method of transportation by pipes, the crude oil is conveyed to the nearest seaport town, and there submitted to fractional distillation.

The first operation in the refinery, after filling the stills, is fractional distillation; the second, treating with sulphuric acid; the third, agitation with an alkali.

The crude oil having been run into the still, a gentle fire is started, and the oils of a lighter gravity soon begin to vaporize and pass over into the receiver. The gravity of the oil should be taken from time to time as it comes over, and the heat raised according to the gravity of the distillate. When the distillate indicates a gravity of 60 degrees Baumé, the stream should be directed into the kerosene receiver, and there collected until the gravity has reached 38 degrees, when it is again changed and passed into another tank until no more distillate comes over. Connected with the still is a condenser of coiled or straight iron pipe, which is cooled by being kept in a tank through which flows a constant stream of water.

The first result, containing gasoline, naphtha, and benzine, is redistilled, and each fraction, as indicated by its specific gravity, gasoline 95 degrees to 80 degrees, naphtha 80 degrees to 65 degrees, and benzine 65 degrees to 60 degrees, collected in a separate receiver.

The second distillate, which is the illuminating oil, is conveyed to a lead-lined tank and thoroughly mixed by means of stirrers, or any effective method, with about two per cent by volume of sulphuric acid. If now allowed to remain at rest for a short time a thick dark tar-like liquid will settle beneath the oil. The dark sedimentary stuff is drawn off and the oil is well washed by agitating with water, then with a solution of soda or ammonia to destroy the acid, and lastly, again with water to remove every vestige of the chemicals.

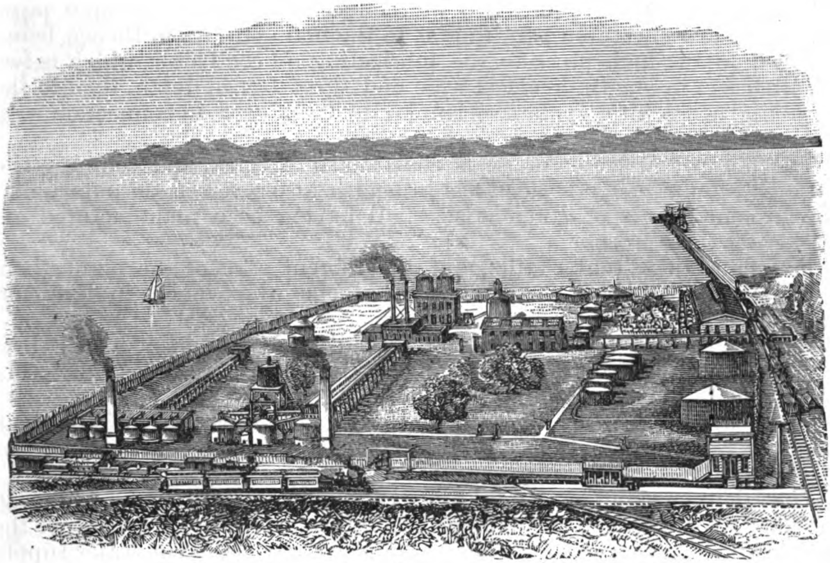
The third and last distillate, containing the lubricating oil and paraffine, is first treated with sulphuric acid, then with soda lye, and lastly distilled. The resulting distillate is set aside in a suitable vessel until the paraffine, by crystallization, separates from the lubricating oil.

REFINING AT THE PACIFIC OIL COMPANY'S WORKS AT ALAMEDA POINT, CAL.

Through the kindness of the managers of this company we are enabled to give the following description of their refinery, and the manner in which they conduct the process of refining.

The refinery of the Pacific Coast Oil Company, at Alameda Point, covers an area of fifteen acres, and is situated at the junction of the Southern Pacific Company, broad gauge system, and the South Pacific Coast railway system, narrow gauge, and also has communication to deep water by the Southern Pacific Company's wharf at Alameda Point.

The construction of this refinery was commenced in 1879, and additions have been made from time to time, as the increase of the business de-



PACIFIC COAST OIL COMPANY'S REFINERY AT ALAMEDA POINT.

manded. Refining was begun at these works in the fall of 1880, and has since been continuously prosecuted.

The storage capacity of the works consists entirely of tanks constructed in the most thorough manner of boiler iron, and are some forty in number, varying in capacity from twenty thousand barrels down to seventy-five barrels, making a total storage capacity of seventy-five thousand barrels. (It should be understood that a barrel of oil is forty-two gallons.)

These storage tanks comprise the storage for the crude oil and all its products, consisting of 86 degrees Baumé gasoline, 74 degrees naphtha, 63 degrees benzine, refined oil, lubricating oils, gas oil, and oil for fuel purposes.

In addition to the storage capacity above mentioned, there is one main still of a capacity of one thousand barrels; one continuous still of two hundred and fifty barrels daily capacity; two steam stills, four hundred barrels capacity each; one gasoline still, two hundred barrels; six tar stills for the manufacture of lubricating oils of a capacity of forty barrels each; and one lubricating oil still, one hundred barrels.

The stills are what are known as the "cheese-box" pattern, with corrugated bottoms which allow for contraction and expansion.

The main still is built with a globe top, with a dome above, six feet in height. This main still has twenty-five three-inch outlet vapor pipes, running into a sheet-iron pan, thence into the main condenser, two hundred and twenty-five feet in length, three feet in depth, and nine feet in width; and from the condenser into the "manifolds," and from the "manifolds" into the "observation boxes" in the receiving house, from whence the different products are conveyed by pipes to their different storage tanks.

The receiving house is built of brick; the "observation boxes" are of cast-iron with plate-glass faces, and the discharge pipes are connected with the observation boxes by gate-valves.

The tar or lubricating oil stills are connected by four-inch vapor pipes running into a sheet-iron pan, similar to the main still, from thence, being reduced to two-inch pipes to the lubricating oil condenser, which is two hundred feet in length, five feet wide and three feet in depth, then to the receiving house with appliances similar to those used in connection with the main still.

The pump and boiler house is constructed of brick, and contains two six-inch tubular boilers sixteen feet in length, also seven steam pumps and two air compressors of different sizes, all having been manufactured expressly for these works.

For connections, tanks, stills, and the different parts of the plant, there are many miles of pipes, varying from two inches to six inches in diameter, most of which are run under ground.

The "agitators" are three in number, built of iron and lined with sheet lead, the largest having a capacity of one thousand barrels, and the other two of one hundred and thirty barrels each.

There are two "bleaching" tanks of iron, with a capacity of one thousand barrels each, standing in a building of octagon shape, with glass sides and roofs.

The laboratory and water tanks are contained in a two-story building, the lower part of which is used for the laboratory, and the upper for the tanks, which have a capacity of five hundred barrels. The water supply needed for the works is obtained from four surface wells upon the premises, which furnish an ample supply; and at a moment's notice a stream of water can be directed to any part of the premises, from the steam pumps.

The lubricating house contains presses for pressing the paraffine oils, and settling tanks containing steam pipes, for the finishing of the oils. Said tanks are eight in number, with a total capacity of five hundred barrels. This building is two stories in height, the lower part being occupied by the presses, ice house, and barreling works for the lubricating department.

The warehouse is a building forty-eight by two hundred and ten feet, two stories in height, and contains cooper shop, can machinery, tin shop, and soldering house, and fillers for the illuminating oils, besides a storage capacity for five thousand cases. All the cans and cases used in the packing of refined oils are made upon the premises, the wooden shooks for the cases being brought from Truckee in carloads. The can machinery is the best of its kind in use, and has a filling capacity of two thousand cans a day, each can containing five gallons.

The office is situated on the northeast corner of the property, at the junction of the two railroads, and is a freight station for the Southern Pacific Company, and is also a station of the Western Union Telegraph Company, and the Bay and Coast Telegraph.

The main supply of oil refined at these works is brought in the cars from the wells in Los Angeles and Santa Clara Counties, the company having in its service sixty-five broad gauge cars and two narrow gauge cars. A four-inch pipe line also runs from the works to the Southern Pacific Company's wharf, and such oil as is brought from Ventura County, by steamer, is transferred to the company's tank-lighter, which has a capacity of five hundred and thirty barrels, and is pumped to the works through this line. The lighter is also used for the transferring of the products of the refinery to different points on the Bay of San Francisco.

METHOD OF REFINING.

The main still is charged with eight hundred and fifty barrels of crude oil, the only oil thus far used for this purpose being from the Pico Cañon and being of a gravity of thirty-nine degrees Baumé. Under this main still are eight burners, and the fuel used is the residuum of the oil. From this distillation there are five products, viz: "Gasoline stock," "benzine stock," "water white distillate stock," "standard white distillate stock," and a residuum which is used for fuel oil or lubricating stock. If used for fuel the lighter products are taken off until the residuum is of a gravity of twenty-four degrees Baumé and a fire test of two hundred and fifty degrees; this being the oil which the Pacific Coast Oil Company is furnishing the Southern Pacific Company as fuel for its ferry steamers. If run down to lubricating stock, the residuum is left of a gravity of twenty-one degrees Baumé.

The four lighter products above mentioned are then run through the steam stills, the products resulting therefrom being the following distillates, viz.: eighty-six degrees gasoline, seventy-four degrees naphtha, sixty-three degrees benzine, and a gas oil of from forty-six degrees to fifty degrees, a forty-six degrees water white illuminating and a forty-four degrees standard white illuminating. These distillates are then treated in the various ways necessary to produce the refined products of the same gravities, the illuminating distillates being agitated with an air blast and treated with acids which are drawn off and the oil washed with a solution of sal soda and water, after which the oil is sprayed into the bleacher, when it is ready for sale.

This product is a pure water white oil of about one hundred and fifteen degrees flash test, which, in burning qualities, is equal to any eastern oil, with the single exception of a slight tendency to smoke; this tendency to smoke, however, is not pronounced, except where poor burners are used.

The lighter products, gasoline, naphthas, and benzines, are in every way superior to any of eastern manufacture, being entirely odorless and having far superior drying qualities when used in paints.

According to the statement of the managers of the company, Pico Cañon, thus far, has been the only locality on this coast which has produced, in paying quantities, an oil of a sufficiently light gravity to pay for refining, there being little or no gasolines, naphthas, and benzines in the oils from other localities. In Moody Gulch, Santa Clara County, a limited production has been developed of an oil very similar to the product of the Pico Cañon wells. All of this oil is being refined at the Alameda Point Refinery. The production thus far has been small but promises well for future development. Prospecting in this vicinity is being steadily carried on.

CHEMISTRY OF PETROLEUM.

Petroleum is a complex hydrocarbon compound of the paraffine series—consisting of a mixture of several compounds, though not chemically united.

The crude mineral oils have a strong odor of bitumen, and, when unadulterated, a specific gravity ranging from .780 to 1.100; and in color, passing through the various shades, from an almost pure white to a decided black.

Petroleum is but little soluble in alcohol, and quite insoluble in water, but unites readily with chloroform, ether, and the hydrocarbons. It is a solvent for the fixed oils with the exception of castor oil. Petroleum frequently contains nitrogen, oxygen, and sulphur, and in the thickened mass in San Luis Obispo County, gold has been found; of course the latter element is purely accidental. California petroleum contains a much larger percentage of sulphur, so far as known, than that found elsewhere. The average composition of petroleum is about 85 per cent of carbon and 15 of hydrogen, and it is highly combustible.

ASSAY OF CRUDE PETROLEUM.

Fractional distillation is the only proper method of arriving at the actual assay. The apparatus employed in the operation consists of a retort, copper preferred, connected with a condenser, and a graduated cylinder for receiving the distillate.

For distillation 500 c. c. of the crude material should be operated upon, and the fluid going over at the different temperatures collected in separate cylinders. Through the water jacket of the condenser a constant stream of cold water is kept flowing to condense the vapors arising from the retort. The graduated cylinder is placed at the lower end of the condensing tube, in a vessel of cold water, in such a position that the distillate will flow into it. A thermometer is fitted into the tubulure of the retort, by the means of a tightly fitting cork, for the purpose of marking the degrees of distillation of the various liquids. After the specific gravity, odor, and color are carefully noted, the process of distillation is commenced.

The flame is now applied to the retort, gently at first, and increased according to the requirements of each distillate, and until no more volatile matter is driven off.

The gravities of the different distillates are taken, by the hydrometer for liquids lighter than water, carefully noted, and the percentage calculated.

The following are the results of the investigation of some of the petroleum oils of California, obtained by Dr. W. D. Johnston, chemist of the State Mining Bureau:

SAN MATEO COUNTY.

LANE'S WELL—PURISSIMA CAÑON.

Crude oil	Specific gravity .855, about 34° B.
Distillate below 150° centigrade, 18 per cent	Specific gravity .759, about 54° B.
Distillate from 150°-300° centigrade, 44 per cent	Specific gravity .817, about 41° B.

TUNITAS WELL.

Crude oil	Specific gravity .799, about 45° B.
Distillate below 100° centigrade, 9.90 per cent	Specific gravity .707, about 68° B.
Distillate from 100°-125° centigrade, 17.30 per cent	Specific gravity .739, about 59° B.
Distillate from 125°-150° centigrade, 19.50 per cent	Specific gravity .761, about 54° B.
Distillate from 150°-200° centigrade, 17.20 per cent	Specific gravity .795, about 46° B.
Distillate from 200°-250° centigrade, 11.80 per cent	Specific gravity .837, about 37° B.
Distillate from 250°-300° centigrade, 6.00 per cent	Specific gravity .858, about 33° B.

SANTA CLARA COUNTY.

WELL NO. 4—MOODY'S GULCH.

Crude oil	Specific gravity .812, about 44° B.
Distillate below 100° centigrade, 9.40 per cent	Specific gravity .716, about 65° B.
Distillate from 100°-150° centigrade, 24.40 per cent	Specific gravity .756, about 57° B.
Distillate from 150°-200° centigrade, 17.10 per cent	Specific gravity .798, about 47° B.
Distillate from 200°-250° centigrade, 14.80 per cent	Specific gravity .836, about 39° B.
Distillate from 250°-300° centigrade, 3.60 per cent	Specific gravity .860, about 34° B.

VENTURA COUNTY.

Tar Creek—Pumping Well.

Crude oil	Specific gravity .833, about 28° B.
Distillate below 100° centigrade, 10.00 per cent	Specific gravity .720, about 64° B.
Distillate from 100°-125° centigrade, 6.80 per cent	Specific gravity .755, about 55° B.
Distillate from 125°-150° centigrade, 5.50 per cent	Specific gravity .777, about 50° B.
Distillate from 150°-200° centigrade, 9.70 per cent	Specific gravity .809, about 43° B.
Distillate from 200°-250° centigrade, 11.00 per cent	Specific gravity .856, about 33° B.
Distillate from 250°-300° centigrade, 7.10 per cent	Specific gravity .889, about 27° B.

Sespe, No. 2.

Crude oil	Specific gravity .859, about 33° B.
Distillate below 100° centigrade, 9.10 per cent	Specific gravity .700, about 70° B.
Distillate from 100°-125° centigrade, 9.20 per cent	Specific gravity .734, about 61° B.
Distillate from 125°-150° centigrade, 8.80 per cent	Specific gravity .762, about 54° B.
Distillate from 150°-200° centigrade, 11.80 per cent	Specific gravity .798, about 45° B.
Distillate from 200°-250° centigrade, 9.00 per cent	Specific gravity .822, about 40° B.
Distillate from 250°-300° centigrade, 8.00 per cent	Specific gravity .876, about 30° B.

Green Oil Well—Adams Cañon.

Crude oil	Specific gravity .853, about 34° B.
Distillate from 100°-125° centigrade, 7.80 per cent	Specific gravity .740, about 59° B.
Distillate from 125°-150° centigrade, 9.00 per cent	Specific gravity .762, about 54° B.
Distillate from 150°-200° centigrade, 18.00 per cent	Specific gravity .795, about 46° B.
Distillate from 200°-250° centigrade, 14.40 per cent	Specific gravity .832, about 38° B.
Distillate from 250°-300° centigrade, 10.00 per cent	Specific gravity .861, about 33° B.

Wild Bill Well—Adams Cañon.

Crude oil	Specific gravity .915, about 23° B.
Distillate below 150° centigrade, 9.20 per cent	Specific gravity .732, about 61° B.
Distillate from 150°-200° centigrade, 10.80 per cent	Specific gravity .813, about 42° B.
Distillate from 200°-250° centigrade, 8.00 per cent	Specific gravity .846, about 35° B.
Distillate from 250°-300° centigrade, 7.70 per cent	Specific gravity .880, about 29° B.

LOS ANGELES COUNTY.

Pico Well, No. 2.

Crude oil	Specific gravity .865, about 32° B.
Distillate below 150° centigrade, 10.60 per cent	Specific gravity .781, about 49° B.
Distillate from 150°-200° centigrade, 20.60 per cent	Specific gravity .800, about 45° B.
Distillate from 200°-250° centigrade, 16.20 per cent	Specific gravity .833, about 38° B.
Distillate from 250°-300° centigrade, 11.30 per cent	Specific gravity .858, about 33° B.

H. & S. Well, No. 3—Pico Cañon.

Crude oil	Specific gravity .846, about 35° B.
Distillate below 100° centigrade, 11.20 per cent	Specific gravity .723, about 62° B.
Distillate from 100°-125° centigrade, 9.30 per cent	Specific gravity .752, about 56° B.
Distillate from 125°-150° centigrade, 9.50 per cent	Specific gravity .775, about 51° B.
Distillate from 150°-200° centigrade, 13.60 per cent	Specific gravity .802, ybout 44° B.
Distillate from 200°-250° centigrade, 13.40 per cent	Specific gravity .841, about 36° B.
Distillate from 250°-300° centigrade, 8.80 per cent	Specific gravity .870, about 31° B.

Pico Well, No. 4.

Crude oil	Specific gravity .825, about 40° B.
Distillate below 100° centigrade, 9.10 per cent	Specific gravity .702, about 69° B.
Distillate from 100°-125° centigrade, 10.40 per cent	Specific gravity .739, about 59° B.
Distillate from 125°-150° centigrade, 9.30 per cent	Specific gravity .762, about 54° B.
Distillate from 150°-200° centigrade, 13.40 per cent	Specific gravity .787, about 48° B.
Distillate from 200°-250° centigrade, 13.90 per cent	Specific gravity .819, about 41° B.
Distillate from 250°-300° centigrade, 8.30 per cent	Specific gravity .847, about 35° B.

Pico Well, No. 9.

Crude oil	Specific gravity .836, about 37° B.
Distillate below 100° centigrade, 13.10 per cent	Specific gravity .710, about 67° B.
Distillate from 100°-125° centigrade, 6.50 per cent	Specific gravity .743, about 58° B.
Distillate from 125°-150° centigrade, 10.00 per cent	Specific gravity .764, about 53° B.
Distillate from 150°-200° centigrade, 13.60 per cent	Specific gravity .794, about 46° B.
Distillate from 200°-250° centigrade, 12.40 per cent	Specific gravity .829, about 39° B.
Distillate from 250°-300° centigrade, 7.20 per cent	Specific gravity .856, about 34° B.

Pico Well, No. 13.

Crude oil	Specific gravity .832, about 38° B.
Distillate below 100° centigrade, 9.70 per cent	Specific gravity .713, about 66° B.
Distillate from 100°-125° centigrade, 8.80 per cent	Specific gravity .742, about 58° B.
Distillate from 125°-150° centigrade, 6.00 per cent	Specific gravity .761, about 54° B.
Distillate from 150°-200° centigrade, 12.00 per cent	Specific gravity .783, about 49° B.
Distillate from 200°-250° centigrade, 11.20 per cent	Specific gravity .812, about 42° B.
Distillate from 250°-300° centigrade, 13.00 per cent	Specific gravity .840, about 37° B.

San Fernando Well—Pico Cañon.

Crude oil	Specific gravity .830, about 38° B.
Distillate below 100° centigrade, 17.30 per cent	Specific gravity .720, about 64° B.
Distillate from 100°-125° centigrade, 11.00 per cent	Specific gravity .753, about 56° B.
Distillate from 125°-150° centigrade, 9.40 per cent	Specific gravity .776, about 50° B.
Distillate from 150°-200° centigrade, 13.30 per cent	Specific gravity .803, about 44° B.
Distillate from 200°-250° centigrade, 10.60 per cent	Specific gravity .839, about 37° B.
Distillate from 250°-300° centigrade, 6.80 per cent	Specific gravity .865, about 32° B.

Puenta Tank—From Wells 3, 4, 5, 6.

Crude oil	Specific gravity .822, about 28° B.
Distillate below 100° centigrade, 10.60 per cent	Specific gravity .717, about 65° B.
Distillate from 100°-125° centigrade, 8.70 per cent	Specific gravity .747, about 57° B.
Distillate from 125°-150° centigrade, 7.70 per cent	Specific gravity .771, about 51° B.
Distillate from 150°-200° centigrade, 10.20 per cent	Specific gravity .803, about 44° B.
Distillate from 200°-250° centigrade, 7.20 per cent	Specific gravity .845, about 36° B.
Distillate from 250°-300° centigrade, 6.00 per cent	Specific gravity .881, about 29° B.

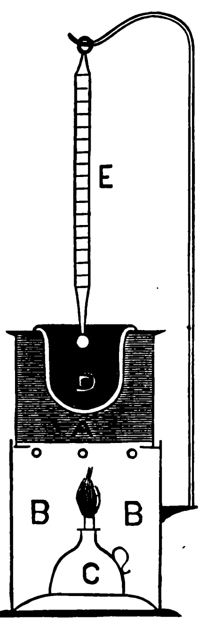
Little Moore Cañon, No. 1.

Crude oil	Specific gravity .910, about 24° B.
Distillate below 150° centigrade, 6.60 per cent	Specific gravity .757, about 55° B.
Distillate from 150°-200° centigrade, 11.20 per cent	Specific gravity .787, about 47° B.
Distillate from 200°-250° centigrade, 7.00 per cent	Specific gravity .821, about 40° B.
Distillate from 250°-300° centigrade, 8.80 per cent	Specific gravity .846, about 35° B.

MONTEREY COUNTY.

Cholame Valley Oil Company.

Crude oil	Specific gravity —, about —° B.
Distillate from 180°-200° centigrade, 9.40 per cent	Specific gravity .840, about 37° B.
Distillate from 200°-250° centigrade, 18.00 per cent	Specific gravity .867, about 31° B.
Distillate from 250°-300° centigrade, 10.40 per cent	Specific gravity .895, about 26° B.



Tagliabue Open Tester.

FLASHING POINT.

The flashing point is the temperature at which the oil gives off inflammable vapors; it differs from the burning point, in that the latter is the temperature at which the oil burns. The flashing point was adopted as a safeguard against the highly volatile oils which gave off their vapors at the ordinary temperature, and made them dangerous to use for burning in lamps.

The following is the American and British Petroleum Act governing the flashing point of petroleum oil, adopted in 1871:

"No petroleum oil should be used for burning in lamps which gives off inflammable vapors at any temperature below 100° F. (38° C.), when tested in an open cup, described in the schedule of the Act."

The most simple apparatus for determining the flashing point, is the Tagliabue Open Tester, of which the following is a description: A is a water-bath of brass, resting upon the stand B, and heated by the lamp C. D is a glass for holding the petroleum. E is the thermometer for taking the temperature of the flashing point. D is filled to the top with petroleum. The water in the bath is gradually heated; and from time to time, until a flash is given, a lighted match is passed over the oil, about half an inch above it.

LOCATING FOR DRILLING, ETC.

It was believed in the early days of our petroleum excitement that where oil was found upon the surface, or seen issuing from the ground, that such points were the proper places to sink for the reservoirs; but experience has taught us the fallacy of early convictions, as the present producing wells have demonstrated. In passing over our oil belt it is noticeable that nearly all of the earlier workings, afterwards abandoned, were in close proximity to the exudations, or in ravines.

In boring for petroleum the prospector should not be discouraged, if at first he fails to meet with success in finding it in paying quantities, for it is beyond the possibility of man to locate, with any amount of certainty, a subterraneous reservoir.

The above is very remindful of the early days of gold and silver mining on the Pacific Coast, in connection with a celebrated litigation. There was a large array of scientific talent on either side, and the testimony pro and con was about equal. The Court was fast losing itself in the maze of scientific lore, and as the standing and integrity of the witnesses were beyond question, the Court was sorely puzzled. The pro experts were sure that a large body of rich ore would be encountered at such an angle, depth, and distance from the given point, whilst on the other hand, the cons were equally decided that sinking and drifting in another direction would be the correct thing. At this juncture an experienced miner was put upon the stand, and his testimony was about as follows: "I have listened with a great deal of interest to the scientific views of some of the gentlemen, and while granting that their geological theories may be correct, I cannot accept for a certainty the large body of rich ore, for in all of my observations and experience I have failed to find the man who had the ken to see an inch before the pick."

It does not follow that because wells have been sunk without finding oil that there is not any in the immediate vicinity, for instances have occurred on the oil belt of Pennsylvania whereof wells sunk but a few feet apart some have been dry and others have yielded handsomely. In fact, an instance is given by Mr. S. H. Stowell, editor of the "Petroleum Reports," where a well which was quite dry at first became a producer upon having the diameter of its bore increased about an inch.

Our oil men in the beginning had much to contend with, such as the high price of labor, costly transportation, and a paucity of knowledge, which, to use a very mild expression, bordered on ignorance. In the beginning the reports from the oil fields caused an excitement that lured many into the labyrinth of financial ruin. The agitation extended over the greater part of the State, but was more particularly concentrated on the fields within the counties of Santa Barbara, San Diego, and Los Angeles, where every foot of ground was located, even to the mountain tops, and wherever a patch of asphaltum was found there it was believed a fortune awaited the locator. Many were the shares of stock that were sold in finds that existed only in the fertile brains of the manipulators, and many of to-day regretfully remember the penalty of their rash precipitation in the petroleum days of 1864 and 1865.

That portion of Santa Barbara County, now Ventura, lying about twelve miles north of the town of San Buenaventura, was the busiest scene of the excitement. Through this section is a mountain ridge, with an altitude of about two thousand feet, running nearly east and west, and some fourteen miles in length. The ground (as it is yet) was largely covered with asphaltum, through which in many places trickled little streams of oil, the latter intensifying the excitement and leading many to believe that an untold wealth awaited them for only a nominal expenditure. Our people were novices in the undertaking; they had not profited by lessons so dearly learned through similar exaggerated reports of fabulous gold finds; it was their wish to believe rather than discredit the magnified stories of the great reservoirs of oil—the outlet of which would be exposed by merely uncovering a few feet of the surface.

About this time, Professor Silliman, Jr., visited our coast in the interest of an eastern syndicate, and wrote of one great well whose exudation had turned into asphaltum which was one yard thick, covering an area of one square mile, and from which could be produced fourteen million five hundred thousand gallons of oil, one third of its weight in coke, and, throwing the coke to one side, the oil would bring to the company a "fabulous" sum of money. The Professor in mentioning the Ojai Ranch, told of the "twenty natural oil wells," some of large dimensions—how the oil escaped from its subterraneous prison, and came to the surface through a multitude of outlets, entered the streams, and flowed "miles and miles" away—and of the ranch's "almost fabulous wealth in the best of oil." This added fresh fuel to the flame of speculation. The stock was dealt in on the street corners; everybody wanted a well, and there not being enough to go around, those of more abundant imaginary resources were forced to locate them in their imagination, and willingly disposed of the stock to the unfortunate purchasers. But so sure as water will find its level, even so sure must such an abnormal state of affairs have an end. After long and weary waiting, no dividends were declared; in most cases the oil barrels lay empty upon the ground; assessment money was not forthcoming; the glowing reports from the fields of "fabulous wealth" began to be discredited, and just then the last smouldering ember of hope was extinguished by Professor Whitney, with the following few lines of opinion: "Within the last year the oil excitement of the Atlantic States has penetrated to the Pacific Coast, and the presence of a small portion of more fluid oil, in connection with the solid asphaltum, has led to unbounded hopes of a vast production of petroleum on the coast ranges of California, creating an excitement which has been skillfully made use of by unprincipled speculators, for their own purposes, by the creation of stock companies, with an immense number of shares, which have been disposed of to a credulous public; nearly the whole proceeds of their sale being clear profit to the promoters of these enterprises, while it is certain that even under the most favorable circumstances, the luckless stockholders will never receive even a moderate return for the money invested."

It took the enterprise many years to recover from the effects of this shock, but, nevertheless, it is now proven that the oil exists in paying quantities, for the undertaking has become a remunerative one.

The quality of petroleum varies considerably, not only that from different countries, but from different wells in the same vicinity. The purest natural product is said to be found at Baku, on the western shore of the Caspian Sea, in some instances being almost white, having just a perceptible yellow tint. The constituent parts of the oil are colorless, yet, with a few exceptions, as exuding from the earth it passes through the various shades, even to the black. Color and odor are indicative, alike, of impurities which most likely consist of organic matter or sulphuretted hydrogen, and when the material is found spread over the surface, around the springs, in a pasty, sticky, or solid form, it has, in addition to the above pollution, become oxidized—in the latter case it is maltha or asphalt.

According to the decision of the New York Produce Exchange crude petroleum for commercial purposes is to be pure, natural oil, having a specific gravity of .782 to .800.

It is estimated that fifty-three thousand wells have been drilled in Pennsylvania and New York since the discovery of petroleum, at a cost of about $200,000,000. These wells have produced three hundred and ten millions barrels of oil, which were sold at the wells for $500,000,000, representing a profit of $300,000,000. The amount of oil exported is calculated at fourteen million eight hundred and thirty-five thousand nine hundred and seventy-four barrels.

The expense of sinking a well in California is considerably more than in Pennsylvania, but that the duration of its production is longer there does not seem to be any doubt.

PREPARING AND DRILLING.

The manner of procedure is best given in Mr. Carll's own language:

"'*Spudding.*'—With rig put in complete running order and conductor sunk to bedrock, the contractor is now ready to commence to drill. But the common boring tools are about sixty feet long, and therefore cannot be operated by the walking-beam in the usual way until the hole is deep enough to allow them to sink beneath the derrick floor. He must 'spud' the first sixty feet then without the aid of the walking-beam. To do this a short cable is run up over the crown pulley in the top of the derrick. One end of it is attached to the ring-socket and screwed to the auger-stem, the other is passed around the bull-wheel shaft two or three times and the end left free. The bull-rope is now put on and the engine started. A man stationed in front of the bull-wheels seizes the free end of the rope coiled around the shaft, a slight pull causes the coils to tighten and adhere to the revolving shaft, the auger-stem rises in consequence until it hangs suspended in the derrick, when it is swung over the hole and lowered through the conductor to the rock. The engine is kept running and the bull-wheels revolve all the while, but the man holding the shaft rope has full control of the tools. When he pulls on the rope the coils at once 'bight' the revolving shaft, the tools rise, when he gives his rope slack they fall, and so long as the coils remain loose upon the shaft it revolves smoothly within them and communicates no motion at all. Thus, then, alternately pulling and slacking the rope, this animated substitute for a walking-beam raises and drops the tools as much or as little as may be required, while the driller turns the drill to insure a round hole.

"*Driving pipe.*—When a conductor cannot be *dug* to the rock, and *drive-pipe* is to be inserted, a mall and '*guides*' must be provided for the purpose. The mall is made of any tough, hard log, that will dress fifteen or eighteen inches square and ten or twelve feet long. Two sides only are dressed: one end being rounded, and encircled by a heavy iron band to prevent its splitting, the other having a strong staple driven into it to tie the cable in. Two pairs of wooden pins are put in each of the dressed sides, one pair near the top, the other pair near the bottom. They are two inches apart, and two inches long, and serve instead of grooves in the mall—the guides fitting in between them.

"*To erect the guides*, draw a line on the derrick floor, through the center of the well and at right angles to the walking-beam; on this line place two two-inch plank perpendicularly, and stay them securely at the bottom and from the sides of the derrick. They are to be fifteen or eighteen inches apart, according to the width of the mall to be used, and may be continued upward by adding two or three more plank, as circumstances require. They are strengthened by spiking a narrower plank on each side, leaving the center one projecting a couple of inches, to enter between the pins in the mall.

"After *spudding* awhile, as above described, to prepare the way for the drive-pipe, the drill is set aside—the pipe to be driven, armed at the bottom with a steel shoe, as shown in Figure 3, Plate XIV, is put in place; the mall is attached to the spudding cable and let down between the guides, where it is alternately raised and dropped upon the casing or drive-pipe by the man at the bull-wheels, precisely the same as in spudding. The casing used is of wrought-iron, screwed together in thimbles the same as tubing. A heavy cap of iron is screwed in the top when driving, to prevent it being injured by the blows of the mall.

"When two or three hundred feet of pipe are to be driven, as is frequently the case in some of our northern valleys, it requires a great deal of skill and judgment to put it in successfully. In these deep drivings, after a sufficient depth has been reached to admit of the introduction of a string of tools, they are put in and operated by the walking-beam in the usual way. The cable (a short one, furnished for the purpose), being coiled upon one end of the bull-wheel shaft, while the other end is left free to work the mall rope on. To facilitate the necessary changes which must be made every time the drill is stopped and pipe driven, the lower part of the guides are cut and hung on hinges some ten or twelve feet above the derrick floor, and when not in use may be swung up overhead out of the way of the workmen.

"*'Stringing' the tools.*—When a sufficient depth has been reached by spudding to admit of the introduction of a full 'string of tools,' the spudding machinery is abandoned.

"Now the coil of drilling-cable is rolled into the derrick and set upon end. The free end in the center of the coil is tied by a connecting cord to the rope just detached from the ring-socket, and by it drawn up over the crown-pulley and down to the bull-wheel shaft, where it is fastened. The bull-rope is put in place, the engine started, and the men carefully watch and guide the cable as it is wound, coil after coil, smoothly and solidly upon the shaft. When this is done the end of the cable depending from the crown-pulley is secured to the rope-socket, as above described, and the full set of tools are attached and swung up in the derrick. After carefully screwing up all the joints (the bull-rope having been unshipped), the tools are lowered into the hole by means of the bull-wheel brake, c. c.; the band-wheel crank is then turned to the upper center; the pitman is raised and slipped upon the wrist-pin, where it is secured by the key and wedges; the temper-screw is hung upon the walking-beam hook; the slack in the cable is taken up by the bull-wheels until the 'jars' are known to be in proper position. The clamps are brought around the cable (after a wrapper has been put on it at the point of contact), and securely fastened by the set-screw; the cable is slacked off from the bull-wheels, and the tools are now held suspended in the well from the walking-beam instead of from the top of the derrick, as before. Some fifteen or twenty feet of slack cable should be pulled down and thrown upon the floor to give free movement to the drill. When the drill is rotated in one direction for some time the slack coils around the cable at the well mouth; if it becomes troublesome the motion is reversed, and it uncoils. Only by this constant rotation of the drill can a round hole be insured.

"DRILLING.

"Having now made all the necessary connections, it only remains to give the engine steam, and the drill will rise and fall with each revolution of the band-wheel, and commence its aggressive work upon the rocks below.

"From this point downward the daily routine of the work is very monotonous unless some accident occurs to diversify it. Day and night the machinery is kept in motion. One driller and one engineer and tool dresser work from noon until midnight (the 'afternoon tour'), and another pair from midnight until noon (the 'morning tour.') Up and down goes the walking-beam, while the driller, with a short lever inserted in the rings of the temper-screw, walks round and round, first this way then that, to rotate the drill. He watches the 'jar,' and at proper intervals lets down the temper-screw as the drill penetrates the rock. When the whole length of the screw has been 'run out,' or the slow progress of the drill gives warning that it is working in hard rock and needs sharpening, he arranges the slack cable upon the floor so that it will go up freely without kinks, and informs the engineer that he is ready to 'draw out.'

"DRAWING THE TOOLS.

"After attending to the needful preliminaries, the driller throws the bull-rope upon its pulley, and quickly steps to the bull-wheel brake, while the engineer commands the throttle of the engine. The walking-beam and the bull-wheel are now both in motion, but at the proper moment one man stops the engine, and the other holds the bull-wheels with the brake just when all the slack cable has been taken up, and the weight of the tools is thus transferred from the temper-screw to the crown-pulley. This is a performance requiring experience and good judgment, for should any blunder be made a break-down must certainly result. To loosen the clamps on the cable, and unlock the pitman from the wrist-pin and lower it to the main-sill, is but the work of a moment. Dropping the pitman raises the end of the walking-beam with the temper-screw attached to it, and throws them back from their former perpendicular over the hole, so as to allow the cable and tools to run up freely without interference with them. Steam is now turned on again, and the tools come up. When the box of the auger-stem emerges from the hole, the engine is stopped. A wrench is slipped on the square shoulder of the bit, and the handle dropped behind a strong pin fixed for that purpose in the floor; another wrench is put on the shoulder of the auger-stem; a stout lever is inserted in one of a series of holes bored in the derrick floor in a circle having a radius a little less than the length of the wrench handle. It is brought up firmly against the upper wrench handle, thus making a compound lever of the wrench, and greatly increasing its power. Both men give a hearty pull on the lever, which 'breaks' the 'joint,' or, in other words, loosens the screw-joint connecting the bit with the auger-stem, so that the bit can be unscrewed and taken off by hand after it has been brought up above the derrick floor. The wrenches are then thrown off, steam is let on again, the bit rises from the hole. Now the driller throws off the bull-rope by operating a lever with one hand, while with the other he catches the bull-wheel with the brake, holding the tools suspended a few inches above the derrick floor. At the same instant the engineer shuts off steam, or else, suddenly relieved of its heavy work by unshipping the bull-rope, the engine would 'run away' with lightning speed. It only remains now to hook the suspended tools over to one side of the derrick, and the hole is free for the sand-pump.

"While the driller is sand-pumping, the engineer unscrews the worn bit and replaces it by one newly dressed, so that there may be no delay in running the tools into the well again when sand-pumping is ended.

"*Sand-pumping.*—The 'line' to which the sand-pump is attached (as before described) passes up over a pulley near the top of the derrick, and thence down to the sand-pump reel, which is operated from the derrick by means of hand-lever V, and connecting levers U and T. While sand-pumping, the pitman remains disconnected, the bull-rope lies slack on its pulleys, and the band-wheel is kept constantly in motion. A slight pressure on lever V brings the friction pulley W in contact with the band-wheel, and the pulley immediately revolves, the slack sand-pump line is quickly wound up, and the sand-pump, which is usually left standing at one side of the derrick, swings out to the center and commences to ascend. Just now the lever is thrown back, and the connection between the friction pulley and the band-wheel being thus broken, the sand-pump commences to descend into the well by its own gravity. If it be likely to attain too great speed in its descent, a movement of the lever to bring the pulley either forward against the band-wheel, or backward against the brake-post previously mentioned, will quickly check it, and thus the speed may be regulated at will.

"As soon as the pump strikes bottom, additional steam is given to the engine, and the lever is brought forward and held firmly while the sand-pump rises rapidly from the well. The sand-pump is usually run down several times after each removal of the tools, to keep the bottom of the hole free from sediment, so that the bit may have a direct action upon the rock.

"*Drilling resumed.*—After the hole has been sufficiently cleansed, the sand-pump is set to one side, the drilling tools are unhooked, and swinging to their place over the well mouth, are let down a short distance by the brake, the wrenches are put on, and the lever is applied to 'set up' the joint connecting the replaced bit to the auger-stem; then removing the wrenches, the tools are allowed to run down to the bottom under control of the bull-wheel brake. Connections are now made as before, the driller commences his circular march, the engineer examines the steam and the water gauges and the fire, and then proceeds to sharpen the tool required for the next 'run,' and thus the work goes on from day to day, until the well is completed.

"THE JARS AND THEIR WORK.

"The jars are of the greatest importance to the driller, as they make known to him immediately any change in the working of the drill.

"J. F. Carll, in the Second Geological Survey of Pennsylvania, III, in a description of drilling tools says: The manner in which the jars perform their work may be best explained, perhaps, in this way: Suppose the tools to have been just run to the bottom of the well—the jars are closed as in figure C—the cable is slack. The men now take hold of the bull-wheels and draw up the slack until the sinker-bar rises, the 'play' of the jars allowing it to come up thirteen inches without disturbing the auger-stem. They watch for the coming together of the cross-heads, which will be plainly indicated by a tremulous motion communicated to the cable, and by the additional weight of the auger-stem. When the jars come together they slack back about four inches and the cable is in a position to be clamped in the temper-screw.

"If, now, the vertical movement of the walking-beam be twenty-four inches, when it starts on the up stroke the sinker-bar first moves; it rises four inches; the cross-heads come together with a sharp blow, and the auger-stem is picked up and lifted twenty inches. On the down stroke the auger-stem falls twenty inches, while the sinker-bar goes down twenty-four inches to telescope the jars for the next blow coming up. This is the theory of the movement, but of course in practice the *spring* of the cable in deep wells and the weight of tools make many modifications necessary. Some writers, in describing the manner of drilling, convey the impression that the sinker-bar is used as a *mall* to drive the auger into the rock; but this, we see, is entirely erroneous. A skillful driller *never* allows his 'jars' to strike together on the down stroke. They are only used to '*jar down*' when the tools stick on some obstruction in the well before reaching the bottom, and in fishing operations.

"An unskillful workman sometimes 'looses the jar' (especially if the well be deep and nearly full of water), and works for hours without accomplishing anything. The tools may be standing on the bottom, while he is playing with the slack of the cable, or they may be swinging all the time several feet from the bottom. If he cannot recognize the jar, he is working entirely in the dark; but an expert will tell you the moment he puts his hand upon the cable whether the drill is working properly or not.

"As the 'jar works off,' or grows more feeble, by reason of the downward advance of the drill, it is 'tempered' to the proper strength by letting down the temper-screw to give the jars more play.

"The *temper-screw*, L, forms the connecting link between walking-beam and cable, and it is 'let out' gradually to regulate the play of the jars, as fast as the drill penetrates the rock. When its whole length is run down, the rope-clamps play very near the well mouth. The tools are then withdrawn, and the well sand-pumped, and preparations made for the next 'run.' With the old fashioned temper-screw, a great deal of time was spent in readjustment, for it had to be screwed up thread by thread, by tedious revolutions of the clamps; but this delay is now obviated. The nut through which the screw passes is cut in halves, one half being attached to the left wing of the screw frame, the other half to the right wing. An elliptical band holding the set-screw L passes around the nut. It is riveted securely to one of the halves, and the set-screw presses against the other half to keep the nut closed. The wings are so adjusted that they spring outward and open the nut whenever the set-screw is loosened. To 'run up' the screw, the driller clasps the wings in his left hand, and loosens the set-screw; he then seizes the head of the temper-screw in his right hand, and, relaxing his grip upon the wings, the nut opens, when he quickly shoves the screw up to its place, again grips the wings and tightens the set-screw—the whole performance occupying less time than it has taken to describe it."

FROM THE STATISTICAL ABSTRACT OF THE UNITED STATES, 1886.

Quantity of Crude Petroleum Produced in and the Quantity and Value of Petroleum Products exported from the United States during each of the Years from 1864 to 1886, inclusive.

Year Ending June 30.	Production, *a*.		Exports.											
			Mineral, Crude (including all Natural Oils without regard to gravity).		Mineral, Refined or Manufactured.						Residuum (Tar, pitch, and all others from which the light bodies have been distilled).		Totals.	
	Barrels (of 42 gallons) Produced.	Gallons Produced.			Naphthas, Benzine, Gasoline, etc.		Illuminating.		Lubricating (heavy Paraffine, etc.).					
			Gallons.	Dollars.	Gallons.	Dollars.	Gallons.	Dollars.	Gallons.	Dollars.	Gallons, *b*.	Dollars.	Gallons.	Dollars.
1864	2,478,709	104,105,778	9,980,654	3,864,187	438,197	154,091	12,791,518	6,764,411	----------	----------	----------	----------	23,210,369	10,782,689
1865	2,424,905	101,846,010	12,293,897	6,868,513	480,947	173,943	12,722,005	9,520,957	----------	----------	----------	----------	25,496,849	16,563,413
1866	3,165,700	132,959,400	16,057,943	6,015,921	673,477	188,825	34,255,921	18,626,141	----------	----------	----------	----------	50,987,341	24,830,887
1867	3,591,900	150,859,800	7,344,248	1,864,001	224,576	34,175	62,686,657	22,509,466	----------	----------	----------	----------	70,255,481	24,407,642
1868	3,613,709	151,775,778	10,029,659	1,564,933	1,517,268	267,873	67,909,961	19,977,870	----------	----------	----------	----------	79,456,888	21,810,676
1869	4,046,558	169,955,436	13,425,566	2,994,404	2,673,094	445,770	84,403,492	27,636,137	*c.* 134,532	51,122	----------	----------	100,636,684	31,127,433
1870	4,411,016	185,262,672	10,403,314	2,237,292	5,422,604	564,864	97,902,505	29,864,193	*c.* 6,871	2,611	----------	----------	113,735,294	32,668,960
1871	5,558,775	233,468,550	9,859,038	1,971,847	7,209,592	746,797	132,608,955	34,138,736	*c.* 59,632	22,660	*c.* 155,474	14,770	149,892,691	36,894,810
1872	5,842,497	245,384,874	13,559,768	2,307,111	8,092,635	932,160	122,539,575	30,566,108	541,419	211,287	438,186	41,724	145,171,583	34,058,390
1873	7,242,343	304,178,406	18,439,407	3,010,050	9,743,593	1,487,439	158,102,414	37,195,735	748,699	277,966	781,074	79,566	187,815,187	42,050,756
1874	11,188,741	469,927,122	17,776,419	2,099,696	9,737,457	1,038,622	217,220,504	37,560,955	1,244,305	404,243	1,827,798	142,299	247,806,483	41,245,815
1875	10,083,828	423,520,776	14,718,114	1,406,018	11,758,940	1,141,440	191,551,933	27,030,361	1,173,473	313,646	2,752,848	187,103	221,955,308	30,078,568
1876	8,823,142	370,571,964	20,520,397	2,220,268	14,780,236	1,442,811	204,814,673	28,755,638	963,442	303,863	2,581,404	193,206	243,660,152	32,915,786
1877	10,822,871	454,560,582	26,819,202	3,756,729	15,140,183	1,816,682	262,441,844	55,401,132	1,601,065	497,540	3,196,620	317,355	309,198,914	61,789,438
1878	14,738,262	619,007,004	26,936,727	2,694,018	16,416,621	1,411,812	289,214,541	41,513,676	2,304,624	639,381	3,968,790	316,087	338,841,303	46,574,974
1879	16,917,606	710,539,452	25,874,488	2,180,413	15,054,361	1,258,780	331,586,442	35,999,862	2,487,681	655,468	3,307,038	210,726	378,310,010	40,305,249
1880	22,382,509	940,065,378	28,297,997	1,927,207	18,411,044	1,192,229	367,325,823	31,783,575	5,162,835	1,039,124	4,767,000	276,490	423,964,699	36,218,625
1881	25,805,363	1,083,825,246	39,984,844	3,065,464	17,292,310	1,693,975	332,283,045	34,317,695	4,852,203	1,054,064	3,247,860	184,411	397,660,262	40,315,609
1882, *d*	28,650,181	1,203,307,602	41,304,997	3,129,511	20,213,098	1,809,143	488,213,033	44,588,854	6,508,100	1,492,396	3,715,362	212,802	559,954,590	51,232,706
1883, *d*	26,662,808	1,119,837,936	52,712,306	3,914,941	17,070,537	1,302,286	419,821,081	36,926,574	10,182,342	2,326,632	6,145,356	442,646	505,931,622	44,913,079
1884	23,744,924	997,286,808	67,186,329	5,302,974	15,045,411	1,072,651	415,615,693	38,195,349	10,515,535	2,179,595	5,297,124	352,679	513,660,092	47,103,248
1885	21,750,619	913,525,998	81,037,992	5,903,833	15,822,853	1,272,290	458,243,192	40,074,827	13,002,483	2,632,883	6,561,660	374,114	574,668,180	50,257,947
1886	22,463,744	943,477,248	80,246,763	5,859,577	12,311,197	997,420	469,471,451	40,634,331	12,526,069	2,519,615	3,226,272	188,901	577,781,752	50,199,844

a. As a given number of gallons of refined petroleum represent the product of a larger number of gallons of crude petroleum, it is necessary to reduce the exports of petroleum to their equivalent in crude oil in order to arrive at a knowledge of the percentage of the total product of mineral oil exported. It has been ascertained, as the result of a careful computation, that the quantity of petroleum, and its distilled products, exported during the year ending June 30, 1878, was equivalent to 407,482,175 gallons of crude oil, or, in other words, that the exports of petroleum constituted about 66 per cent of the production. A larger percentage of the mineral oil product of the country is exported than of any other product, except cotton.

b. Barrels reduced to gallons, at the rate of 42 gallons to the barrel.

c. Estimated.

d. Figures of production for fiscal years 1882, 1883, 1884–5, furnished by S. H. Stowell, editor of "Stowell's Petroleum Reporter."

LOCATING AND PATENTING PETROLEUM CLAIMS.

The following circulars and correspondence will show the ruling of the General Land Office upon the subject of locating lands containing petroleum:

Petroleum claims may be patented under the Mining Act of May 10, 1872.

DEPARTMENT OF THE INTERIOR, GENERAL LAND OFFICE,
WASHINGTON, D. C., January 30, 1875.

J. T. STRATTON, *Esq.*, *Surveyor-General*, *California:*

SIR: With your letter of twelfth of August last, you transmitted a copy of the report of William P. Reynolds, United States Deputy Mineral Surveyor, in regard to the Towsley Petroleum Mine, and you inquire whether land yielding petroleum may be patented under the Mining Acts.

It appears from the report, that D. A. Towsley *et al.*, made location and record of this claim in 1866; and that D. A. Towsley has had uninterrupted possession thereof since eleventh of March, 1865. That said claim yields five hundred gallons of petroleum daily.

Petroleum claims may be entered and patented under the Mining Act of May 10, 1872, upon full compliance with the provisions and requirements of said Act.

Very respectfully, your obedient servant,

S. S. BURDETT,
Commissioner.

[Copp's Land Owner, vol. 1, p. 179.]

MINES AND MINERALS—A. A. DEWEY.

Petroleum.—Land containing deposits of petroleum have been entered as placers and patented as such.

Commissioner McFarland to A. A. Dewey. Central City, Dakota Territory, March 31, 1882 (A. C. B.).

Lands containing deposits of petroleum have been entered as placers and patented as such.

Your inquiries are fully answered, therefore, by stating that lands of that character are subject to entry and disposal according to the law and regulations relating to placer claims.

[Copp's Land Owner, vol. 9, p. 51.]

STATE MINING BUREAU,
SAN FRANCISCO, October 25, 1887.

Hon. WM. A. J. SPARKS, *Commissioner United States General Land Office, Washington, D. C.:*

DEAR SIR: Will you kindly inform me if there has been any alteration of the ruling made by the Department, in locating land yielding petroleum, since the issue of the circular (No. 23), January 30, 1875, S. S. Burdett, Commissioner? (See Sickels' Mining Laws and Decisions, 1881, page 491.)

Very respectfully yours,

WM. IRELAN, JR.,
State Mineralogist.

Department of the Interior, General Land Office,
Washington, D. C., November 5, 1887.

Wm. Irelan, Jr., *Esq.*, *State Mineralogist, San Francisco, Cal.:*

Sir: In reply to your inquiry of the twenty-fifth ultimo, you are informed that public lands containing valuable deposits of oil or petroleum are held to be subject to the operation of the United States Mining Laws relating to placer lands. Downey vs. Rogers, 2 L. D., 707, 4 L. D., 284, is among the later rulings on the subject.

Very respectfully,

S. M. STOCKSLAGER,
Assistant Commissioner.

ASPHALTUM AND ITS USES.

Asphaltum, like the mineral oils, is found in almost every part of the world in regular deposits, and sometimes in a pure state, but more frequently intermixed with fine quartz sand, earthy matters, or small pebbles; its melting point is about that of boiling water.

So far as known California is the only State in the United States of America in which the mineral is found in sufficient quantities to become merchantable.

The principal deposits in our State are in the counties of Santa Cruz, San Luis Obispo, Santa Barbara, Ventura, and Los Angeles.

Although in apparently inexhaustible quantities, it is of an inferior grade, but can be readily refined. It contains, in some instances, a large percentage of sand or fine gravel, from which it is easily separated by melting either with or without water; in either case the mechanical impurities fall to the bottom, and the refined material is skimmed or run off.

The mineral, on account of its mechanical impurities, is known commercially as bituminous rock; it is largely and favorably used for many purposes, though principally for paving, flooring, and roofing, and so popular has it become for these purposes that the demand for it is largely on the increase, and should the future price of transportation permit, there would be no doubt of it finding a ready market in the Eastern States. At present that which is used in the East is imported from several different countries, but more principally from Trinidad Island, where there is a large lake of it, nearly a mile in diameter, the material being hard along the shores but quite soft in and approaching the center.

The ancient Hebrews, the Assyrians, the Arabs, and Egyptians, were well informed as to its uses and important qualities. It is used as a varnish, as a water and an acid-proof paint, as a cement, as a preservative of wood, as an anti-erosive of metals, as a foundation for buildings when mixed with sand or carbonate of lime, and under the same conditions as beds for machinery. Paper wound spirally in several layers around a form and afterward coated with asphaltum, on being removed from the core makes good conducting pipes for various purposes. Houses in which the cellars are floored with asphaltum are more healthful than those in which the flooring is of wood or masonry—as the asphaltic covering is a protection from humidity. The immense anvil in Krupp's works at Essen, Prussia, which receives the stroke of a hundred and fifty ton hammer, rests upon a bed of asphaltum. A sidewalk of asphaltum was put down in Paris as early as 1838. In the same city there are at the present time over three million four hundred and forty-one thousand four hundred and fifty-four square meters of sidewalks covered with it, and above ninety-eight thousand five hundred and fourteen square meters of streets paved with the same material.

In using asphaltum for paving it should be spread only upon a dry foundation; for if spread over a wet or damp bed it does not only, in a great measure, prevent its adherence to the material, but the generation of steam from the underlying damp layer, caused by the spreading and rolling of the hot material, pushes itself to the surface of the asphaltum, making innumerable small holes and blisters.

Illuminating gas softens asphaltum at every point of contact with it, therefore in cities having asphaltum paved streets, arrangements should be made to obviate the danger, for wherever there is a leaky gas pipe the pavement above will become soft and mushy.

LAYING OF ASPHALTUM ON PUBLIC THOROUGHFARES.

The following shortly described method is that used by the Santa Cruz Bituminous Rock Pavement Company, and to be seen in every-day operation in this city.

The material is broken into lumps not to exceed ten pounds in weight and thrown into an iron tank, where it is subjected to a treatment with steam until it becomes semi-liquid or of a pasty consistency. It is then spread evenly, two inches in thickness, over a prepared bed of concrete or other suitable material, and afterwards rolled with a steam roller weighing about ten tons.

The bed, or foundation, for receiving the asphalt dressing, is from six to eight inches in thickness, or, in some instances where broken stones are used, it is preferable to increase the depth to one foot. For sidewalks the foundation consists of broken stones, forming a layer about three inches deep. In either case, the bed, previous to receiving the asphaltic covering, is thoroughly tamped and rolled.

The cost of a first-class bituminous pavement per square foot is: a concrete bed of Portland cement, 16 cents per square foot; bitumen, two inches deep, 16 cents per square foot, making a sum total for a finished street of 32 cents per square foot. A foundation of macadam covered with two inches of bituminous rock costs about 23 cents per square foot. Sidewalks made after the method of their especial description costs from 9 to 11 cents per square foot.

The cost of mining and landing the bituminous rock of the above named company on the wharf at San Francisco is $6 per ton.

RESULTS OF ANALYSES OF CALIFORNIA ASPHALTUM.

The following analyses were made by Dr. W. D. Johnston, Chemist of the State Mining Bureau:

(Bituminous Rock.)—Mendocino County, California.

Volatile carbonaceous matter	11.60 per cent.
Fixed carbon	1.70 per cent.
Residue	86.70 per cent.
	100.00 per cent.

Residue: Coarse sand, containing—

Lime	2.10 per cent.
Magnesia	0.43 per cent.

Physical Characteristics.

The sand is very coarse, and consequently when fractured the readhesion is not as perfect as it should and would be if the sand were finer.

SANTA CRUZ COUNTY, CALIFORNIA—No. 1.

Volatile carbonaceous matter	18.16 per cent.
Fixed carbon	2.58 per cent.
Residue	79.26 per cent.
	100.00 per cent.

Residue: Fine sand, golden-colored mica, and a small amount of magnetite, containing 0.22 per cent of lime.

Physical Characteristics.

Blackish brown; after fracture does not reunite satisfactorily by moderate pressure at ordinary temperatures.

No. 2.

Volatile carbonaceeus matter	13.54 per cent.
Fixed carbon	1.90 per cent.
Residue	84.56 per cent.
	100.00 per cent.

Residue: Coarse-grained quartz, containing only traces of lime and magnesia.

Physical Characteristics.

Black, sticky mass; a coarse-grained quartz which readily reunites upon moderate pressure.

No. 3.

Volatile carbonaceous matter	46.20 per cent.
Fixed carbon	7.56 per cent.
Residue	46.24 per cent.
	100.00 per cent.

Residue: Fine-grained sand, containing $\frac{6}{10}$ of one per cent of lime, and a trace of magnesia.

Physical Characteristics.

Black and brittle, does not reunite on pressure at ordinary temperatures.

ADAMS & NICHOLLS' CLAIM, No. 1 (RANCHO EL PISMO), SAN LUIS OBISPO COUNTY, CALIFORNIA, SEVEN MILES SOUTHEAST OF SAN LUIS OBISPO CITY.

Volatile carbonaceous matter	11.70 per cent.
Fixed carbon	2.46 per cent.
Residue	85.84 per cent.
	100.00 per cent.

Residue: Fine sand, containing only traces of lime and magnesia.

Physical Characteristics.

Black, compact, and tenacious mass.

No. 2.

Volatile carbonaceous matter	9.40 per cent.
Fixed carbon	1.20 per cent.
Residue	89.40 per cent.
	100.00 per cent.

Residue: Coarse sand containing 0.24 per cent of lime.

Physical Characteristics.

Black, firm, and compact sticky mass. The particles of sand are plainly visible.

No. 3.

Volatile and carbonaceous matter	12.80 per cent.
Fixed carbon	1.40 per cent.
Residue	85.80 per cent.
	100.00 per cent.

Residue: Chiefly coarse sand containing 0.14 per cent of lime.

Physical Characteristics.

A black, coarse-grained mass which, when broken, reunites firmly under pressure of the fingers.

JOHNSON AND WARDEN CLAIM, RANCHO CORRAL DE LA PIEDRA, CALIFORNIA, SAN LUIS OBISPO COUNTY.

Volatile carbonaceous matter	11.50 per cent.
Fixed carbon	1.10 per cent.
Residue	87.40 per cent.
	100.00 per cent.

Residue: Coarse sand containing 0.16 per cent of lime.

Physical Characteristics.

A brownish black mass, crumbling under pressure of the fingers.

P. C. HIGGINS' CLAIM, CARPENTERIA, SANTA BARBARA COUNTY, CALIFORNIA.

Volatile carbonaceous matter	14.10 per cent.
Fixed carbon	1.90 per cent.
Residue	84.00 per cent.
	100.00 per cent.

Residue: Fine sand containing traces of lime.

Physical Characteristics.

Soft, sticky, fine-grained black mass, crumbling under pressure of the fingers.

MOORE'S LANDING, SANTA BARBARA COUNTY, CALIFORNIA.—No. 1.—SEVEN MILES WEST FROM SANTA BARBARA.

Volatile carbonaceous matter	18.40 per cent.
Fixed carbon	3.00 per cent.
Residue	78.60 per cent.
	100.00 per cent.

Physical Characteristics.

Firm, compact, and brittle. Does not reunite by moderate pressure at ordinary temperatures.

MOORE'S LANDING.—No. 2.

Volatile carbonaceous matter	42.30 per cent.
Fixed carbon	8.00 per cent.
Residue	49.70 per cent.
	100.00 per cent.

Residue: Fine sand containing 1.20 per cent of lime and a trace of magnesia.

Physical Characteristics.

Firm, compact, glistening, and brittle. Does not reunite by moderate pressure at ordinary temperatures.

SAN FRANCISCO, CALIFORNIA.

Asphaltum pavement corner of Davis and California Streets.

Volatile carbonaceous matter	15.60 per cent.
Fixed carbon	2.50 per cent.
Residue	81.90 per cent.
	100.00 per cent.

Residue: Fine sand containing 0.3 per cent of lime.

LOCATING AND PATENTING ASPHALTUM CLAIMS.

From the following circulars it will appear that the General Land Office holds that deposits of asphaltum may be located under the Act of May 10, 1872:

Mines and Minerals.—Regulations governing the entry of lands containing borax and alkaline earths, sulphur, alum, and *asphalt.* Secretary Teller to Commissioner McFarland, January 30, 1883:

"My attention is called to the fact that these deposits, although valuable, are not of sufficient value to permit their being entered under the mining laws, if the recent circular approved by me September 22, 1882, and its amendment of December 9, 1882, is applicable to entries of lands containing borax and other similar valuable deposits. It was early determined by the department that the Act of May 10, 1872, which describes certain lands containing valuable mineral deposits, was applicable to lands containing deposits of borax, carbonate and nitrate of soda, sulphur, alum, and *asphalt;* and I believe that from the passage of the law until the present time, the definition of the term 'valuable mineral deposits' has been such as to include the minerals and alkaline substances named. I understand that entries of borate lands have been allowed under the provisions of the Act of 1872, and the regulations made in accordance therewith.

"It is the desire of the persons interested that the regulations which were in existence, having special reference to the application for patent for placer claims, namely, the circular of October 31, 1881, should be continued in force so far as they relate to deposits of borax, etc., as mentioned above.

"Believing that practical effect should be given to the mining laws of the United States, I am of the opinion that to apply the new regulations to such entries would result in excluding such lands from sale, and depriving the people of the benefit of the use of these natural deposits. I therefore direct you to permit the entry of public lands containing valuable deposits of borax, the carbonate and nitrate of soda, sulphur, alum, and asphalt in the States of California and Nevada, and the Territories of Arizona, Utah, and Wyoming—in which section of country, I am informed, the deposits are present—under the regulations of October 31, 1881.

"In addition, however, an applicant for patent for public lands containing deposits of borax, etc., as above, must affirmatively show that the lands entered are not valuable for any other purpose than the one for which application is made.

"It will, therefore, follow that the circulars of September 22 and December 9, 1882, are not applicable to entries of the lands thus described and excepted.

["Copp's Land Owner, vol. 9, p. 210."]

The following is an extract from the circular of Secretary Teller to Commissioner McFarland, in the case of Downey vs. Rogers, December 8, 1883:

"My letter of January 30, 1883 (Copp, February, 1883), considered the instructions of September 22 and December 7, 1882, in reference to lands containing deposits of borax, soda, alum, etc., and held that their application to such lands would result in the exclusion of the lands from sale. I therefore allowed their entry under the preceding regulations of October 31, 1881, in certain named States and Territories, requiring, however, an applicant for patent to show affirmatively that the lands were not valuable for any purpose other than that for which application was made. Whether or not the same ruling should apply to oil lands is an undetermined question.

"That the facts may be first ascertained before deciding the same, I direct that you order an investigation as to the character and value of the lands in controversy and the improvements thereon, and that upon report thereof you transmit the same to this department.

["Copp's Land Owner, vol. 10, p. 307."]

NATURAL GAS.

It is doubtful whether natural gas will be found in our petroleum sections, to become of any great economic value, as the rocks in places turned up, as they are, on edge and fractured, preclude the possibility of securing gas in quantities approaching anywhere near the amount found in the Eastern States. The greater portion of the gas that may have existed in the underground reservoirs has long since escaped through the many natural outlets, or fissures, formed during the period when the rocks were turned up and faulted. In sections where the rocks lie in nearly a horizontal position and do not show signs of having been disturbed to any appreciable extent, there is a possibility of finding gas, but, unfortunately, such conditions are very scarce in our petroleum sections. Therefore, under the existing geological conditions, it would seem to be folly to expect that prospecting for gas, along our petroleum belt, would pay interest on the waste of time and money.

It is already proven, along the oil belt, by the scarcity of flowing wells, and the disturbed condition of the country rock, that natural gas, if existing at all, is not of sufficient quantities to warrant the expense of seeking.

Natural gas is widely spread over the Union, and there is scarcely a State where it has not been found; beside direct prospecting for it, it has been encountered in sinking wells for various purposes. The States producing the larger amounts of gas are Ohio, Pennsylvania, and New York—the latter being by far the greatest producer, and where, in the town of Fredonia, it was first used for illuminating purposes as early as 1821. The origin of natural gas is theorized in many different ways, but there seems to be but one conclusion to draw from the broad field of opinions, and that is that like petroleum, the enigma is apparently impossible of solution, and it is just as impossible to tell of the duration of the supply as it is of that of the mineral oils. As to its advantages over coal there is no questionable doubt, for it is a natural product furnishing a heating power which for the same purposes we have to obtain from coal by artificial means, and, beside, there are no ashes or soot, and but a slight percentage of loss in wear or other deteriorations in apparatus in which used.

It is stated that about three hundred millions cubic feet of natural gas are supplied daily to and around Pittsburg from one hundred and fifty wells.

The following is a schedule of charges in Pittsburg for natural gas for the various purposes enumerated, as given in "Pittsburg and its Industries:"

Iron and steel—	
Puddling, gross ton	$1 00
Heating, each heat, gross ton	40 to 60 cents.
Boilers, per month	$50 00 to $100 00
Total gas per ton iron, single heated, gross ton	$1 80 to $2 10
Sheet iron or steel, gross ton	$2 25 to $2 60
Hoop iron or steel, gross ton	$2 25 to $2 60
Open-hearth melting, gross ton	70 cents.
Crucible steel	50 cents.
Hammer furnaces, per day	$1 00 to $1 60
Glass—	
Flint, each ten-pot furnace, per month	$160 00
Each large glory hole, per month	30 00
Each lear, per month	25 00
Each steam boiler, per month	$35 00 to $50 00
Oil stills, per month	$35 00 to $100 00
Brick kilns and drying floors, per M.	$1 00
Fire brick, per M.	$1 00 to $1 40

Domestic use.—This is based on number of square feet heated, the basis being $10 a year for 15 square feet. The charge for heating stoves is $2 50 a month; for open grates, $2.

VALUE OF GAS AS A FUEL.

The Honorable J. P. Lesley, State Geologist of Pennsylvania, gives the following estimate of the value of gas as a fuel:

"One pound of coal weighs 25 cubic feet of gas. One pound of coal has a fuel value of 7½ cubic feet of gas. In 1885, 300 miles of gas mains to the factories and dwellings of and around Pittsburg, furnished heating power equal to 2,000,000 bushels of coal per month—1,000,000 tons of coal per annum. Before the end of 1885 one gas company in Pittsburg reported 335 miles of pipe of all sizes, displacing the use of about 10,000 tons of coal per day, or 3,650,000 tons per annum, the consumption growing rapidly.

"The waste at the wells being at first enormous, there was no economy at the works; but of late precautions have been taken to economize the supply. Probably 5,000 men will be dispensed with.

"The gas is odorless, because free from sulphur, etc. This purity must be taken into account in estimating its value as a fuel. It makes better iron, steel, and glass than can be made with coal gas or coal. It makes steam more regularly, because there is no opening or shutting of doors, and no blank spaces left on grate bars for the entrance of cold air. When properly arranged, its flow regulates the steam pressure, leaving the engine man nothing to do but watch the steam gauge. Boilers last longer, and fewer explosions result from unequal expansion and contraction when cold air strikes hot plates.

"The theoretical value of gas as compared with coals, is stated in the report of S. A. Ford, Chief Chemist of the Edgar Thomson steel works, as 210,069,604 heat units in 1,000 cubic feet of gas, weighing 38 pounds avoirdupois, while the same weight of carbon contains 139,398,896. Therefore 1,000 cubic feet gas=57.25 pounds of carbon, or coke (at 90 per cent carbon) 62.97 pounds, or bituminous coal, 54.4 pounds, or anthracite coal, 58.4 pounds.

"The gas thus compared with coal by Mr. Ford was a gas of average chemical composition. In point of fact gas from one well differs from gas of another well, and the gas from one and the same well varies in its chemical composition continually."

There is very little difference in the cost of boring for gas from that of boring for oil, when the general conditions are about the same.

Until 1884 there was very little use made of natural gas, excepting for illuminating purposes in and around Pittsburg, but after a few successful experiments it came into general use for manufacturing purposes.

COAL-LAND LAW AND REGULATIONS THEREUNDER.

DEPARTMENT OF THE INTERIOR, GENERAL LAND OFFICE,
WASHINGTON, D. C., July 31, 1882.

GENTLEMEN: The following sections of the Revised Statutes provide for the sale of coal lands of the United States:

TITLE XXXII, CHAPTER SIX.

MINERAL LANDS AND MINING RESOURCES.

SEC. 2347. Every person above the age of twenty-one years, who is a citizen of the United States, or who has declared his intention to become such, or any association of persons severally qualified as above, shall, upon application to the Register of the proper land office, have the right to enter, by legal subdivisions, any quantity of vacant coal lands of the United States not otherwise appropriated or reserved by competent authority, not exceeding one hundred and sixty acres to such individual person, or three hundred and twenty acres to such association, upon payment to the Receiver of not less than ten dollars per acre for such lands, where the same shall be situated more than fifteen miles from any completed railroad, and not less than twenty dollars per acre for such lands as shall be within fifteen miles of such road.

SEC. 2348. Any person or association of persons severally qualified, as above provided, who have opened and improved, or shall hereafter open and improve, any coal mine or mines upon the public lands, and shall be in actual possession of the same, shall be entitled to a preference-right of entry, under the preceding section, of the mines so opened and improved; *provided*, that when any association of not less than four persons, severally qualified as above provided, shall have expended not less than five thousand dollars in working and improving any such mine or mines, such association may enter not exceeding six hundred and forty acres, including such mining improvements.

SEC. 2349. All claims under the preceding section must be presented to the Register of the proper land district within sixty days after the date of actual possession and the commencement of improvements on the land, by the filing of a declaratory statement therefor; but when the township plat is not on file at the date of such improvement, filing must be made within sixty days from the receipt of such plat at the district office; and where the improvements shall have been made prior to the expiration of three months from the third day of March, eighteen hundred and seventy-three, sixty days from the expiration of such three months shall be allowed for the filing of a declaratory statement, and no sale under the provisions of this section shall be allowed until the expiration of six months from the third day of March, eighteen hundred and seventy-three.

SEC. 2350. The three preceding sections shall be held to authorize only one entry by the same person or association of persons; and no association of persons, any member of which shall have taken the benefit of such sections, either as an individual or as a member of any other association, shall enter or hold any other lands under the provisions thereof; and no member of any association which shall have taken the benefit of such sections shall enter or hold any other lands under their provisions; and all persons claiming under section twenty-three hundred and forty-eight shall be required to prove their respective rights, and pay for the lands filed upon within one year from the time prescribed for filing their respective claims; and upon failure to file the proper notice, or to pay for the land within the required period, the same shall be subject to entry by any other qualified applicant.

SEC. 2351. In case of conflicting claims upon coal lands where the improvements shall be commenced after the third day of March, eighteen hundred and seventy-three, priority of possession and improvement, followed by proper filing and continued good faith, shall determine the preference-right to purchase. And also where improvements have already been made prior to the third day of March, eighteen hundred and seventy-three, division of the land claimed may be made by legal subdivisions, to include, as near as may be, the valuable improvements of the respective parties. The Commissioner of the General Land Office is authorized to issue all needful rules and regulations for carrying into effect the provisions of this and the four preceding sections.

SEC. 2352. Nothing in the five preceding sections shall be construed to destroy or impair any rights which may have attached prior to the third day of March, eighteen hundred and seventy-three, or to authorize the sale of lands valuable for mines of gold, silver, or copper.

RULES AND REGULATIONS.

Under the authority conferred by said Section 2351, the following rules and regulations are issued for carrying into effect the provisions of said law:

1. Sale of coal lands is provided for—

By ordinary *private entry* under Section 2347.

By granting a *preference-right* of purchase, based on priority of possession and improvement, under Section 2348.

2. The land entered under either section must be *by legal subdivisions*, as made by the regular United States survey. Entry is confined to surveyed lands; to such as are vacant, not otherwise appropriated, reserved by competent authority, or containing valuable minerals other than coal.

3. Individuals and associations may purchase. If an individual, he must be twenty-one years of age, and a citizen of the United States, or have declared his intention to become such citizen.

4. If an association of persons, each person must be qualified as above.

5. A person is not disqualified by the ownership of any quantity of other land, nor by having removed from his own land in the same State or Territory.

6. Any individual may enter by legal subdivisions as aforesaid any area not exceeding one hundred and sixty acres.

7. Any association may enter not to exceed three hundred and twenty acres.

8. Any association of not less than four persons, duly qualified, who shall have expended not less than $5,000 in working and improving any coal mine or mines, may enter under Section 2348 not exceeding six hundred and forty acres, including such mining improvements.

9. One person can have the benefit of one entry or filing *only*. He is disqualified by having made such entry or filing alone, or as a member of an association. No entry can be allowed an association which has in it a single person thus disqualified, as the law prohibits the entry or holding of more than one claim either by an individual or an association.

10. Lands that are sufficiently valuable for gold, silver, or copper to prevent their entry as agricultural lands cannot be entered as coal lands; and you will not allow any entry to be made under the above named provisions of law of lands valuable for their deposits of said minerals.

11. The present rules relative to "hearings to establish the character of lands," contained in General Land Office regulations of October 31, 1881, issued under the mining laws, will, as far as applicable, govern your action in determining the character of lands sought to be entered as coal land.

12. The price per acre is $10 where the land is situated *more* than fifteen miles from any completed railroad, and $20 per acre where the land is *within* fifteen miles of such road. The price of the land, however, must be determined by its distance from a completed railroad at the date of payment and entry irrespective of the preference-right of entry.

13. When application is made to purchase coal-land at the rate of $10 per acre you will in all cases require satisfactory proof that the land applied for is, at date of entry, situated more than fifteen miles from any completed railroad. This proof may consist of the affidavit of the applicant, or that of his duly authorized agent, corroborated by the affidavit of some disinterested credible party showing personal knowledge of the facts.

14. Where the land lies *partly within* fifteen miles of such road and in *part outside* such limit, the *maximum* price must be paid for all legal subdivisions the greater part of which lie within fifteen miles of such road.

15. The term "completed railroad" is held to mean one which is actually constructed on the face of the earth; and lands within fifteen miles of any point of a railroad so constructed will be held and disposed of at $20 per acre.

16. Any duly qualified person or association must be preferred as purchasers of those public lands on which they have opened and improved, or

shall open and improve, any coal mine or mines, and which they shall have in actual possession.

17. Possession by agent is recognized as the possession of the principal. The clearest proof on the point of agency must, however, be required in every case, and a clearly defined possession must be established.

18. The *opening and improving* of a coal mine, in order to confer a preference-right of purchase, must not be considered as a mere matter of form; the labor expended and improvements made must be such as to clearly indicate the good faith of the claimant.

19. These lands are intended to be sold, where there are adverse claimants therefor, to the party who, by substantial improvements, actual possession, and a reasonable industry, shows an intention to continue his development of the mines in preference to those who would purchase for speculative purposes only. With this view, you will require such proof of compliance with the law, when lands are applied for under Section 2348 by adverse claimants, as the circumstances of each case may justify.

20. In conflicts, where improvements have been or shall hereafter be commenced, priority of possession and improvement shall govern the award when the law has been fully complied with by each party. A mere possession, however, without satisfactory improvements, will not secure the tract to the first occupant when a subsequent claimant shows his full compliance with the law.

21. After an entry has been allowed to one party, you will make no investigation concerning it at the instance of any person except on instructions from this office. You will, however, receive all affidavits concerning such case and forward the same to this office, accompanied by a statement of the facts as shown by your records.

22. Prior to entry, it is competent for you to order an investigation, on sufficient grounds set forth under oath of a party in interest and substantiated by the affidavits of disinterested and credible witnesses.

MANNER OF OBTAINING TITLE.

23. When title is sought by *private entry* the party will himself make oath to the following application, which must be presented to the Register:

I, ——— ———, hereby apply, under the provisions of the Revised Statutes of the United States relating to the sale of coal lands of the United States, to purchase the ——— quarter of section ———, in township ———, of range ———, in the district of lands subject to sale at the land office at ———, and containing ——— acres; and I solemnly swear that no portion of said tract is in the possession of any other party; that I am twenty-one years of age, a citizen of the United States (or have declared my intention to become a citizen of the United States), and have never held nor purchased lands under said Act, either as an individual or as a member of an association; and I do further swear that I am well acquainted with the character of said described land, and with each and every legal subdivision thereof, having frequently passed over the same; that my knowledge of said land is such as to enable me to testify understandingly with regard thereto; that said land contains large deposits of coal and is chiefly valuable therefor; that there is not to my knowledge within the limits thereof any vein or lode of quartz or other rock in place bearing gold, silver, or copper, and that there is not within the limits of said land, to my knowledge, any valuable deposit of gold, silver, or copper. So help me God.

——— ———.

24. Thereupon the Register, if the tract is vacant, will so certify to the Receiver, stating the price, and the applicant or his duly authorized agent must then pay the amount of purchase money.

25. The Receiver will then issue to the purchaser a duplicate receipt, and at the close of the month the Register and Receiver will make returns of the sale to the General Land Office, from whence, when the proceedings are found regular, a patent or complete title will be issued; and on surrender

of the duplicate receipt such patent will be delivered, at the option of the patentee, either by the Commissioner at Washington or by the Register at the district land office.

26. This disposition at private entry will be subject to any valid prior adverse right which may have attached to the same land, and which is protected by Section 2348.

27. *Second.*—When the application to purchase is based on a priority of possession, etc., as provided for in Section 2348, the claimant must, when the township plat is on file in your office, file his declaratory statement for the tract claimed sixty days from and after the first day of his actual possession and improvement. Sixty days, exclusive of the first day of possession, etc., must be allowed.

28. The declaratory statement must be substantially as follows, to wit:

I, —— ——, do solemnly swear that I am —— years of age, and a citizen of the United States (or have declared my intention to become a citizen of the United States), that I never have, either as an individual or as a member of an association, held or purchased any coal lands under the provisions of the Revised Statutes of the United States relating to the sale of coal lands of the United States, and I do hereby declare my intention to purchase, under the provisions aforesaid, the —— quarter of section ——, in township ——, of range ——, of lands subject to sale at the district land office at ——, and that I came into possession of said tract on the —— day of ——, A. D. 18—, and have ever since remained in actual possession continuously; that I have located and opened a valuable mine of coal thereon; and have expended in labor and improvements on said mine the sum of —— dollars, the labor and improvements being as follows: (here describe the nature and character of the improvements) and I do furthermore solemnly swear that I am well acquainted with the character of said described land, and with each and every legal subdivision thereof, having frequently passed over the same; that my knowledge of said land is such as to enable me to testify understandingly with regard thereto; that there is not, to my knowledge, within the limits thereof, any vein or lode of quartz or other rock in place bearing gold, silver, or copper, and that there is not within the limits of said land, to my knowledge, any valuable deposit of gold, silver, or copper. So help me God.

—— ——.

29. When the township plat is not on file at date of claimant's first possession the declaratory statement must be filed within sixty days from the filing of such plat in your office.

30. One year from and after the expiration of the period allowed for filing the declaratory statement is given within which to make proof and payment; but you will allow no party to make final proof and payment except on notice to all others who appear on your records as claimants to the same tract.

31. A party who otherwise complies with the law may enter *after* the expiration of said year, *provided* no valid adverse right shall have intervened. He postpones his entry beyond said year at his own risk, and the Government cannot thereafter protect him against another who complies with the law, and the value of his improvements can have no weight in his favor.

32. Each claimant at the time of actual purchase must make affidavit as follows:

I, —— ——, claiming under the provisions of the Revised Statutes of the United States, relating to the sale of coal land of the United States, the right of purchase to the —— quarter of section ——, in township ——, of range ——, subject to sale at ——, do solemnly swear that I have never had the right of purchase under the aforesaid provisions of law either as an individual or as a member of an association, and that I have never held any other lands under its provisions; I further swear that I have expended in developing coal mines on said tract in labor and improvements the sum of —— dollars, the nature of such improvements being as follows: —— —— ——; that I am now in the actual possession of said mines, and make the entry for my own use and benefit, and not directly or indirectly for the use and benefit of any other party; and I do furthermore swear that I am well acquainted with the character of said described land, and with each and every legal subdivision thereof, having frequently passed over the same; that my knowledge of said land is such as to enable me to testify understandingly with regard thereto; that the same is chiefly valuable for coal; that there is not, to my knowledge, within the limits thereof, any vein or lode of quartz or other rock in place bearing gold, silver, or copper, and that there is not within the limits of said land, to my knowledge, any valuable deposit of gold, silver, or copper. So help me God.

——— ———.

33. The application, declaratory statement, and the affidavit required at the time of actual purchase—the forms of which are given above under paragraphs 23, 28, and 32—may be sworn to before any officer authorized by law to administer oaths, but the authority of such officer must be properly shown.

34. Any party duly qualified under the law, *after* swearing to his application or declaratory statement, may, by a sufficient power of attorney duly executed under the laws of the State or Territory in which such party may then be residing, empower an agent to file with the Register of the proper land office the application, declaratory statement, or affidavit required at the time of actual purchase, and also authorize him to make payment for and entry of the land in the name of such qualified party; and when such power of attorney shall have been filed in your office you will permit such agent to act thereunder as above indicated.

35. Where a claimant shows by affidavit that he is not personally acquainted with the character of the land, his duly authorized agent who possesses such knowledge may make the required affidavit as to its character; but whether this affidavit is made by principal or agent, it must be corroborated by the affidavits of two disinterested and credible witnesses having knowledge of its character.

36. Nothing in these regulations shall be so construed as to prevent a party from proving his citizenship or age, or establishing the status of the lands sought to be entered, in accordance with ordinary rules of evidence; and any proof regularly introduced for that purpose that would be competent in a Court or before a Commissioner charged with the ascertainment of facts, may be considered.

37. Assignments of the right to purchase will be recognized when properly executed. Proof and payment must be made, however, within the prescribed period, which dates from the first day of the possession of the assignor who initiated the claim.

38. The "Rules of practice in cases before the United States district land offices, the General Land Office, and the Department of the Interior," approved December 20, 1880, will, as far as applicable, govern all cases and proceedings arising under the sections of the Revised Statutes above quoted providing for the sale of coal lands of the United States.

39. You will report at the close of each month as "sales of coal lands" all filings and entries in separate abstracts, commencing with number *one*, and thereafter proceeding consecutively in the order of their reception. Where a series of numbers has already been commenced by sale of coal lands, you will continue the same without change.

N. C. McFARLAND, Commissioner.

To REGISTERS AND RECEIVERS.

DEPARTMENT OF THE INTERIOR, July 31, 1882.

Approved:

H. M. TELLER, Secretary.

PETROLEUM, ASPHALTUM,

AND

NATURAL GAS.

BY

W. A. GOODYEAR.

WILLIAM IRELAN, JR., *State Mineralogist:*

DEAR SIR: I herewith respectfully submit to you—

First—A report of my field work during the summer and autumn of 1887, devoted chiefly to the petroleums, asphaltums, and natural gas in the counties south of the Bay of San Francisco; and,

Second—A report upon the mineral coals of California.

Respectfully yours,

W. A. GOODYEAR.

PETROLEUM, ASPHALTUM, AND NATURAL GAS.

Contra Costa County.

At a certain locality on what is called "Oil Creek," not far from the corner between Sections 9, 10, 15, and 16 of Township 1 N., Range 1 E., M. D. M., there is a deposit of hydraulic cement rock which appears to be very large. There are, however, several different beds of it, which vary much in physical appearance and probably also in chemical composition. The chances would seem to justify a careful prospecting and testing of this deposit, which may yet prove valuable. Here, also, are two or three very small springs of cold, but strong sulphur water. Furthermore, a well was once drilled here to a depth, it is stated, of about four hundred feet for oil. Whether any oil was obtained here could not be learned with certainty, but there are rumors that this well was "salted," and certainly no oil is visible there now.

Fresno County.

Huron is the present terminus of the branch railroad running westerly from Goshen.

Tar Cañon is about twenty-five miles, by wagon road, southwesterly from Huron. The largest deposit of petroleum and asphaltum found in this cañon consists of a few very small springs (the largest only about three feet in diameter), which produce a very small quantity of water and black maltha, which latter has gradually hardened into a little bed of asphaltum of not more than five or six square rods in area. Barometer here reads one thousand two hundred feet. The place has recently been located as a "placer mine." There is considerable alkali, and probably also some sulphur in the water accompanying this tar. There is said to be a sulphur spring not far south of here. So far as can be seen, the rocks close by the main spring—the so called "Gibbes Spring"—seem to strike northwesterly, and dip northeasterly some 40° to 45°. But, overlying these rocks, and about three hundred or four hundred feet north of the main spring, a heavy and very prominent bed of hard sandstone crosses the cañon, striking nearly east and west, and dipping northerly about 75°. It is filled full of *Turritella* shells, which, however, are not easily gotten out whole. This hard sandstone stratum forms the prominent and ragged crest of a range of high hills for several miles in an east and west direction. About one fourth of a mile north of it are very heavy beds of fine clay shales.

Leaving Tar Cañon, after a few miles travel, we crossed over the ridge into Sunflower Valley. Here, on the south side of the crest, but close up to the head of the cañon going down into Sunflower Valley, and close alongside the road, at a point said to be about six miles east of Tar Cañon, and five miles north of Avenal Creek, there is another spot where there are two or three very small tar springs, of a dark brownish maltha, and also an area of two or three square rods of asphaltum. This locality is about the same distance south of the line of the comb of hard *Turritella* sandstone as that in Tar Cañon. This also has been recently located as a "placer claim." The aneroid here read nine hundred and fifty feet.

East of here, little can be seen of the hard sandstone comb. Came down from here through Sunflower Valley, and stopped for the night, October eighteenth, at Dagny's house at "Lone Cottonwood," which is on Sec. 2, T. 25 S., R. 18 E., M. D. M. Aneroid at Dagny's read five hundred and twenty feet.

Colonel W. N. Leete stated that he has some oil claims on Sections 7, 8, 15, 16, 17, 18, 20, 22, and 29, of T. 19 S., R. 15 E., M. D. M. But these localities were not visited for want of time.

Kern County.

Certain asphaltum and petroleum deposits in the northeastern foothills of the Coast Range, about forty-five miles westerly from Bakersfield, in Kern County, were visited on October ninth.

The old "Buena Vista Refinery" was a very small establishment, which has long since gone to ruin. It was located at some distance from the asphaltum deposits, and was on the N.W. ¼ of Sec. 13, T. 30 S., R. 21 E., M. D. M. At this locality there are several small springs of water, all of which seem to contain more or less sulphur. But one of them furnishes passable drinking water, while the others all contain a good deal of alkali.

On the southeast quarter of the same section, a well was once drilled by H. A. Blodgett, A. Weill, and others, of Bakersfield, to a depth of three hundred feet. At this depth they struck sand with oil, which soon rose about one hundred feet in the pipe. The rocks here are not well exposed, but near the well are much disturbed. It is a common opinion that this well would have paid if they had pumped it, which they never did. The oil, of a dark, brownish-black color, now stands in the pipe up to within about ten feet of the top of the well.

Mr. J. S. Hambleton and others own the N.W. ¼ of the N.W. ¼ and the S. ½ of the N.W. ¼ of Sec. 19, T. 30 S., R. 22 E., and the N.E. ¼ of the N.E. ¼ of Sec. 24, T. 30 S., R. 21 E., M. D. M.

On this tract they are drilling a well, which, on the ninth of October, was five hundred and eighty feet deep, having passed through the following strata: five feet surface soil; thirty-seven feet asphaltum; twenty-eight feet hard black shale, with sulphur water. At seventy feet struck first oil. Then had various colored shales to the depth of two hundred and seventy feet, where the next oil was struck. At four hundred and thirty-five feet passed through two feet of extremely hard rock. At four hundred and fifty feet, another stratum of oil, with soft shales to five hundred and sixty-five feet. Then five feet of shales and sandstones, mixed. The last ten feet was soft black sandstones. There is considerable gas at this well, and when visited, the oil was standing in the outer pipe, within about three feet of the surface of the ground.

At a point about nine hundred feet S. 20° W. from here, the bituminous shales in the gulch strike about N. 60° W., and dip about 80° southwesterly, and Mr. Hambleton says that this is about the general strike and dip in this vicinity wherever the rocks seem to be least disturbed. The exposures, however, are poor, and in many places there seems to have been much disturbance. The upturned edges of the rocks are almost everywhere covered with a more recent surface deposit, much of which is of an ashy consistence, so that one sinks into it ankle deep in walking over it. There is also much calcareous tufa about here, and considerable native sulphur mixed with the dirt in many places. The aneroid here read one thousand three hundred feet.

Large surface deposits of asphaltum are scattered along the hills here for a distance of nearly half a mile in a northeast and southwest direction. About one thousand feet southwest of Hambleton's well, however, nearly all these indications of oil and asphaltum cease. Nevertheless, about half a mile southwest of his well, other parties some years ago sunk a well nine hundred feet deep, but got no oil nor gas.

On Sec. 28, T. 30 S., R. 22 E., another well was sunk five hundred feet deep, which was also a dry hole.

A short distance southwest of this last well, there are in the cañon quite a number of sulphur springs, some of which are warm, having a temperature of probably 100° to 110° F. These springs yield but very little water, which, however, is saturated with sulphuretted hydrogen, and also contains other combustible gases, and a very little oil.

Some distance further down the cañon, *i. e.*, to the north or northeast of the five hundred feet well, there are heavy beds of bituminous sandstone or asphaltum, interstratified with other comparatively recent horizontal beds high up in the cliffs on the left bank of the cañon.

The locality where the old Buena Vista Oil Company used to obtain their crude petroleum, is about three miles southeast of Hambleton's well, and about one thousand three hundred and fifty feet above the sea.

For a good description of these extensive deposits, as well as of the character and extent of the operations of the Buena Vista Oil Company, reference is here made to the Fourth Annual Report of the State Mineralogist, pages 296 and 297. Nothing has been done there for a number of years now, and there is really nothing new to add to the description there given.

At a point some five or six miles northeast of Sumner, near the center of Sec. 2, T. 29 S., R. 28 E., M. D. M., where the Kern River runs N. 30° W., magnetic, the bluffs on the left bank of the river are composed of very recent strata, which lie nearly horizontal, and are forty to fifty feet high. This is at the head of Mr. T. A. Means' ditch, nearly opposite to the place of Mr. R. T. Norris, on the other side of the river.

Here, in the ditch, only one or two feet above the present level (October twelfth) of the water in the river, there is considerable gas bubbling up, accompanied by some green oil, which forms a scum on the water. The upper portion of these bluffs is coarse sandstone, with some gravel intercalated. But the lower beds, so far as exposed in the ditch, are a soft clay-rock, which rapidly disintegrates on exposure to the air.

At a locality about one mile southwesterly from here and close to the line between Sections 3 and 10, in the same township, the river runs about due west. And here the horizontal sandstones in the bluffs on the right—*i. e.*, north—bank of the river are bituminous, and are overlaid by a bed of gravel five to ten feet thick. In some places, however, the bituminous sandstones are directly overlaid by a body of clay, which is sometimes ten feet or more in thickness.

Also, in the bed of Kern River itself, close to Mr. Means' house, he states that he once dug a little hole, not more than two or three feet deep, in the loose sand for water, and that the water which came into it was covered with a film of oil. This is about five miles from Sumner, and close by the head of the Beardsley ditch.

A little above Mr. R. T. Norris' house, on the right bank of the river, close to the water's edge, in the sands, there is a little seepage of oil and a little gas bubbling up; this is on Section 2. Here the hills on the north side are about one mile distant from the river, while on the south side the bluffs come down to the river bank.

Mr. Norris is now (October thirteenth) washing the gravel near the river here for gold, but he has not yet cleaned up, and therefore does not know how it will pay.

In a little hole dug here for clean water, within three feet of the water's edge on the right bank of the river, and not more than two or three feet deep, the water was not drinkable, and was and is covered with a thin scum of oil. Also, close to Mr. Norris' house, a man once dug a well about fifteen feet deep for water, which he got. But just before striking the water, he struck such a quantity of gas that he narrowly escaped with his life.

Mr. Norris also tells me that about six miles above his place there is, on the left bank of the river, and about three hundred feet from it, a very strong, cold sulphur spring. Mr. John Barker lives about ten miles farther up the river than Mr. Norris, and Mr. W. R. McMurdo, County Surveyor of Kern County, states that about three miles above Mr. Barker's, and just at the mouth of the cañon, properly so called, of Kern River, there is an oil spring where the oil can be seen floating on the water.

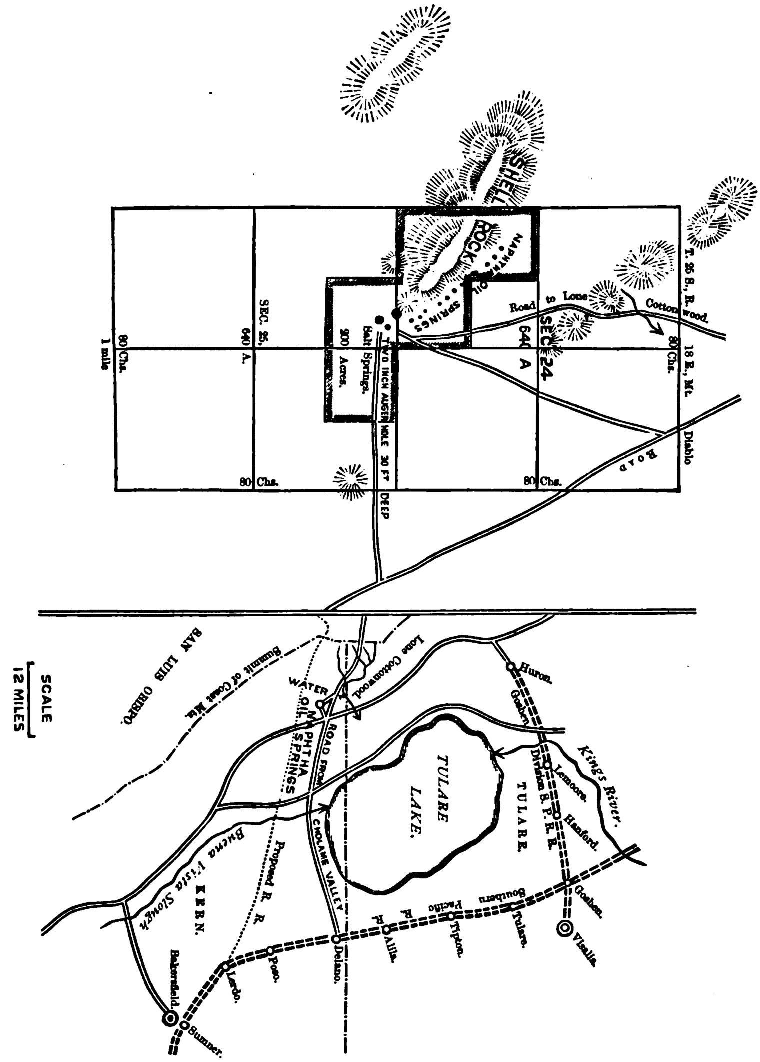
October nineteenth, visited a locality previously indicated by Mr. C. D. Gibbes, on Sections 24 and 25, T. 25 S., R. 18 E., M. D. M. Found here the salt spring, the chief tar spring, and the two-inch auger hole close together, also the string of little asphaltum spots called "naphtha springs," along the northeast side of the hill, and also the "shell rock," all approximately as laid down on the accompanying map. But the spots of asphaltum are none of them more than ten or twelve feet in diameter. There is no naphtha here, and the quantity of black viscid maltha is very small. There is none flowing. But in a few places (perhaps three or four), there is a very little of it to be seen in small holes, none of them over six inches in diameter. There is some sulphur as well as some mineral salts in the water from all the springs, and a *trace* of oil on top of some of them. The rocks here are not well exposed; but the "shell rock" strikes northwesterly and dips some 40° to the northeast. Barometer here at 10 A. M. read four hundred and thirty feet.

Another locality visited in Kern County is in the edge of the foothills of the Coast Range, west of Buena Vista Lake, and from twelve to fifteen miles northwest from the mouth of San Emidio Cañon. It is probably in T. 11 N., R. 24 W., S. B. M. By the wagon road, around the south side of Kern Lake, it is nearly a fifty-mile drive from Bakersfield.

At one place here an old stone chimney, ten or twelve feet high, still remains standing. Close by this chimney is a low knoll, on and about the summit of which there are several maltha springs, which have produced a patch of asphaltum covering the top and sides of the knoll, over an area of, perhaps, fifteen or twenty square rods—say one tenth to one eighth of an acre.

In the western part of this patch, near the foot of the knoll, somebody, years ago, had dug a trench or open cut, some twenty-five or thirty feet in length, and three or four feet wide, with a maximum depth of five or six feet, in the lowest portion of which a quantity (perhaps two or three barrels) of extremely thick and viscid black maltha had accumulated. The largest of the natural springs in this patch of asphaltum was exactly on top of the knoll, and though irregular in form, had a maximum length of some three feet, and a width of eighteen inches to two feet. The maltha in this spring also was black, and very thick and viscid.

Seeing that this little asphaltum patch was perfectly isolated, in a desert, where fire could not spread, I set fire to the spring on top of the knoll at 9 A. M., November first, not thinking it would burn over one or two hours. It burned furiously for awhile, sending up a huge column of dense black



smoke, through which the flame darted and leaped, at times twenty feet high or more. At the same time the fire gradually spread over the surface of the knoll till an area thirty feet in diameter was all aflame, and as there was a very light easterly breeze, the flame crept on towards the trench above mentioned, at the western foot of the knoll, which it at last reached. I stayed and watched the fire for about an hour, within which time it had begun to decidedly develop a peculiar mode of action, which will be described a little further on. From here we drove about five miles further west, within which distance we saw three other patches of asphaltum, all of them small, which we did not stop to examine much. I may as well explain here that we did not find the particular spot for which we were hunting, because of the inadequate directions previously given by its owners to my guide, Mr. J. E. Chittenden, of Sumner. And as the day was waning, and we were in the desert, far from anywhere, it became imperative for us to seek some place to camp for the night, where we could find water and feed for the horses as well as something for ourselves to eat. So we came back by the road, passing the springs, etc., to which I had set fire, reaching there somewhere about 3 P. M. They were still burning, and we stopped half an hour or so more to watch them, inasmuch as their peculiar, spasmodic mode of burning was then well developed at every spring on the knoll, as well as in the trench at its western foot, where it was at that time most intense. Taking the spring on top of the knoll as an example, the way of it was this:

After burning furiously for awhile all over the surface of the spring, the flame died down. Meantime the flame had heated the pitch two or three inches deep below the surface, and set it boiling. As the boiling increased, the flame diminished, owing to steam being generated from the water beneath; which steam formed a large part of the bubbles issuing from the boiling mass, and gradually quenched the flame. The stuff would rise in the hole as a mere froth or scum, till it slightly overflowed, the flame meantime not entirely dying out, but continuing to burn with short flashes around the outer edges of the hole. After a few minutes the boiling would diminish, the overflowing cease, and the mass would gradually sink down three or four inches below the rim of the hole. A little later, the flame would begin once more to gradually creep over the whole surface, till another dense column of black smoke and flame arose. Then the fierce boiling would be recommenced, and the whole business repeated over and over again. How many times this took place I cannot guess. I only know that the next day (November second), when we were some ten or twelve miles away from there in an air line, considerable smoke was still arising at 10 A. M.

Los Angeles County.

PETROLIA.

The most southeasterly locality in this county (or indeed, so far as yet learned, in the State), where any considerable quantities of asphaltum can be seen, or where much boring has been done for oil, is the place called "Petrolia," which lies in a little valley on the southern side of the Puente range of hills, about ten miles northeast of the town of Anaheim, and some three or four miles southeast of the Puente Wells, which will be described hereafter.

Here, on the S.W. ¼ of Sec. 5, T. 3 S., R. 9 W., S. B. M., and close to where the line between Sections 5 and 8 intersects the eastern boundary of the Rancho San Juan Cajon de Santa Ana, a well has been sunk by Messrs. Hardison and Stewart, to a depth of eight hundred and fifty feet. Some samples of the drillings from this well, which were exhibited to me at Los Angeles, showed the following:

At three hundred and twenty feet.—Soft, and very fine-grained sandstone, with some gas, but no oil.

At four hundred and thirty feet.—Coarse sand. No gas nor oil.

At five hundred and thirty-five feet.—Very coarse sand, with some oil.

At five hundred and sixty feet.—Very fine sand.

At five hundred and seventy feet.—A somewhat clayey sand rock, containing grains as large as one eighth of an inch in diameter, with oil.

At six hundred and five feet.—Very fine sand, mixed with pebbles, some of them as large as one half inch in diameter.

This well has now been idle for some time. The oil is said to rise in it to within a few feet of the surface of the ground. But it has never been pumped; and it is the intention of the parties to sink it deeper. It is the most westerly of all the existing wells at Petrolia.

Very close to this well, two others were once sunk between one hundred and two hundred feet deep, both of them dry holes.

Within one hundred feet or so of the same well, still another one is said to have been drilled some years ago by Mr. B. Chandler, to a depth of four hundred or four hundred and fifty feet, when the casing caved in, and it was abandoned.

On the N.E. ¼ of Section 8, in the same township, Messrs. Mackey & Bentz drilled a well about three hundred and sixty feet deep, which is now idle; but from which there are said to have been shipped in the past somewhere between twenty and thirty carloads of about one hundred and thirty barrels each, of heavy oil, about 18° or 20° B.

On the N.W. ¼ of Section 9, Messrs. Chandler & Maxwell have sunk a well, which is now idle, but is three hundred and twenty-five feet deep, with an eleven-inch casing, and is to be sunk deeper as soon as they get heavier machinery. This well has not yet struck any notable quantity of oil.

About one hundred yards southeast of Chandler & Maxwell's well just noticed, they, last year, drilled a hole about three hundred and eighty feet deep, but got no oil, and only a very little gas. At this depth they struck something that turned the drill one side and made a crooked hole, so that they had to abandon it.

An old well, sunk by Mackey & Bentz, on the N.E. ¼ of Section 8, some nine hundred to one thousand feet northeasterly from their well above described, is about six hundred feet deep. This well they were obliged to abandon because their last string of casing in the bottom of the well was too small (being only three inches in diameter) to allow them to put another string inside of it in order to go deeper.

This makes eight wells in all that have been drilled at Petrolia, to depths ranging from one hundred to eight hundred and fifty feet, without, as yet, having yielded any profit; the two wells of Chandler & Maxwell on the N.W. ¼ of Section 9 being the most easterly ones of all.

These wells are scattered along a belt of tar springs and superficial asphaltum deposits, which stretches for more than a mile in a nearly east and west direction, but is quite narrow, being probably nowhere more than a hundred yards in width. The asphaltum is everywhere largely mixed with sand and pebbles. It is "refined" by melting it in large iron kettles, when the sand and pebbles sink to the bottom, and the clean asphaltum is ladled off the top of the kettle. It is shipped to Los Angeles, where it is used for coating iron pipes, and for other purposes. In places, the deposit is at least eight or ten feet thick, and the quantity available is very great.

This belt of asphaltum deposits, however, seems to terminate towards the east at about the locality of Chandler & Maxwell's wells. At one point, however, about a half mile farther east, there is said to be another small patch of it some thirty or forty feet long, and, perhaps, twenty feet wide, where a hole has been dug some four feet deep, out of which some five or six barrels of oil were taken in the course of one summer.

The exposures of the rocks here, along the asphaltum belt and in the immediate vicinity of the wells, are very few and poor. But, so far as can be seen, they seem to generally strike northeasterly, and dip northwesterly at varying angles. In some places they appear to lie nearly horizontal.

They consist of sandstones and conglomerates, the latter sometimes containing bowlders of granite and other rocks of considerable size. According to the aneroid, the altitude of this locality is about six hundred and forty-five feet.

Some half or three quarters of a mile northwesterly, and over the hill from Hardison & Stewart's well in Petrolia, lies the bed of "Bréa Cañon," which is the name given to the upper part of the main branch of Coyote Creek. It is needless to say that there are many "Bréa Cañons" and many "Coyote Creeks" in California. But this particular "Bréa Cañon" can be easily enough recognized from this description; and its general course in this immediate locality is about S. 60° W., magnetic. It is several hundred feet deep, and extends up almost entirely through the Puente Hills to the edge of the valley toward the east. The whole of it lies to the south and southeast of the Puente wells, hereafter described. So far as I could see and judge, the rocks in this vicinity, on the northwest side of Brea Cañon, seem to strike northeasterly and dip northwesterly. But on the southeast side of it they appear to dip towards the south. The exposures on this side, however, are very poor.

Going west from Hardison & Stewart's well at Petrolia, the belt of asphaltum deposits enters the Rancho San Juan Cajon de Santa Ana, and gradually ascends the southern slopes of the hills till at a point about a mile to the west, it crosses the crest, and then descends into Bréa Cañon, where there are again large bodies of it. The direction from Chandler & Maxwell's latest well to Hardison & Stewart's well is N. 74° W., magnetic, and the western prolongation of the Petrolia asphaltum belt follows nearly the same course. Yet the strike of the rocks, wherever seen in this ridge between Petrolia and Bréa Cañon, is generally from N. 50° E. to E., magnetic, and their dip, oftener than otherwise, to the north or northwest, though sometimes it is to the south or southeast. This state of things suggests a possibility of a series of faults having thrown the rocks in such a way as to arrange them "*en echelon.*"

At one locality on top of this range of hills, about a mile westerly from Hardison & Stewart's well, there is a large patch of superficial asphaltum with numerous small tar springs. Here a hole was dug some six or eight feet square and five or six feet deep, which has become partially filled with a viscid black maltha. A short time previous to my visit, a good sized sheep had fallen into this hole, and being unable to get out, had perished there; and the partly decomposed carcass, floating in and soaked with the tarry liquid, was a seething mass of fat maggots half an inch or so in length, many of which were also disporting themselves at their apparent ease in the surrounding maltha to distances of a foot or two away from the carcass. And I will here mention the fact that, so far as my observation extends, wherever tar springs occur in Southern California, it is usually easy, with a little search, to find spots where very small maggots are quite numerous in the liquid or semi-liquid petroleum. What they subsist on in many such cases, I do not know; nor do I know of any other living thing that can exist in this material. But the maggots certainly do live in it, and do not seem to be inconvenienced by it.

As well as could be judged from a partial exposure of the rocks near where this sheep lay, their strike at this point appears to be about N. 30° E., magnetic. But the dip is uncertain.

Going westerly from here, the course of the chief line of superficial asphaltum deposits, for a distance of a quarter of a mile or more, is S. 60° W., magnetic, though there are, here and there, some other patches which are not in this line.

At a point one eighth of a mile S. 75° E. from the dead sheep, where the belt of asphaltum deposits first reaches the top of the southern brow of the hills, the sandstones are somewhat exposed, and strike N. 75° to 80° W., and dip steeply to the northeast.

PUENTE.

From "Puente Station" on the Southern Pacific Railroad, some twenty miles east of Los Angeles, it is about five miles southeasterly to the oil wells of Messrs. Lacy & Rowland, situated on Puente Gulch, a branch of Coyote Creek. The locality of the wells is on the north side of the main crest of the Puente range of hills; but a little farther west, Puente Gulch turns south, breaks through that crest, and joins Coyote Creek. The wells are partly on the southeast corner of La Puente Rancho, and partly on Sections 34 and 35, T. 2 S., R. 10 W., S. B. M.

There are now (May 31, 1887) six pumping wells in operation here, all within a distance of some six hundred or eight hundred feet along the cañon, which here runs about west, magnetic. Of these wells, Nos. 1, 2, and 3 furnish a rather thick maltha, of about 20° B., and the others a lighter oil of 30° to 32° B. The first three wells are all pumped into the same tank, whence the oil is barreled and shipped to Los Angeles, where it is used for lubricating purposes, and for mixing with asphaltum for coating iron pipes, and for other purposes.

These three wells furnish some forty or fifty barrels per month, which is worth $5 per barrel. The lighter oil, from Nos. 4, 5, and 6, is worth $1 50 per barrel. It is all pumped and mixed together in the same storage tanks at the wells, and is again pumped from them into a tank on the top of the hill, one fourth of a mile or so to the north, and several hundred feet above the wells, whence it runs by its own gravity, through a two-inch pipe, a distance of about five miles, to a tank alongside the railroad, not far from Puente Station. It is thence discharged into tank-cars, in which it goes to Los Angeles.

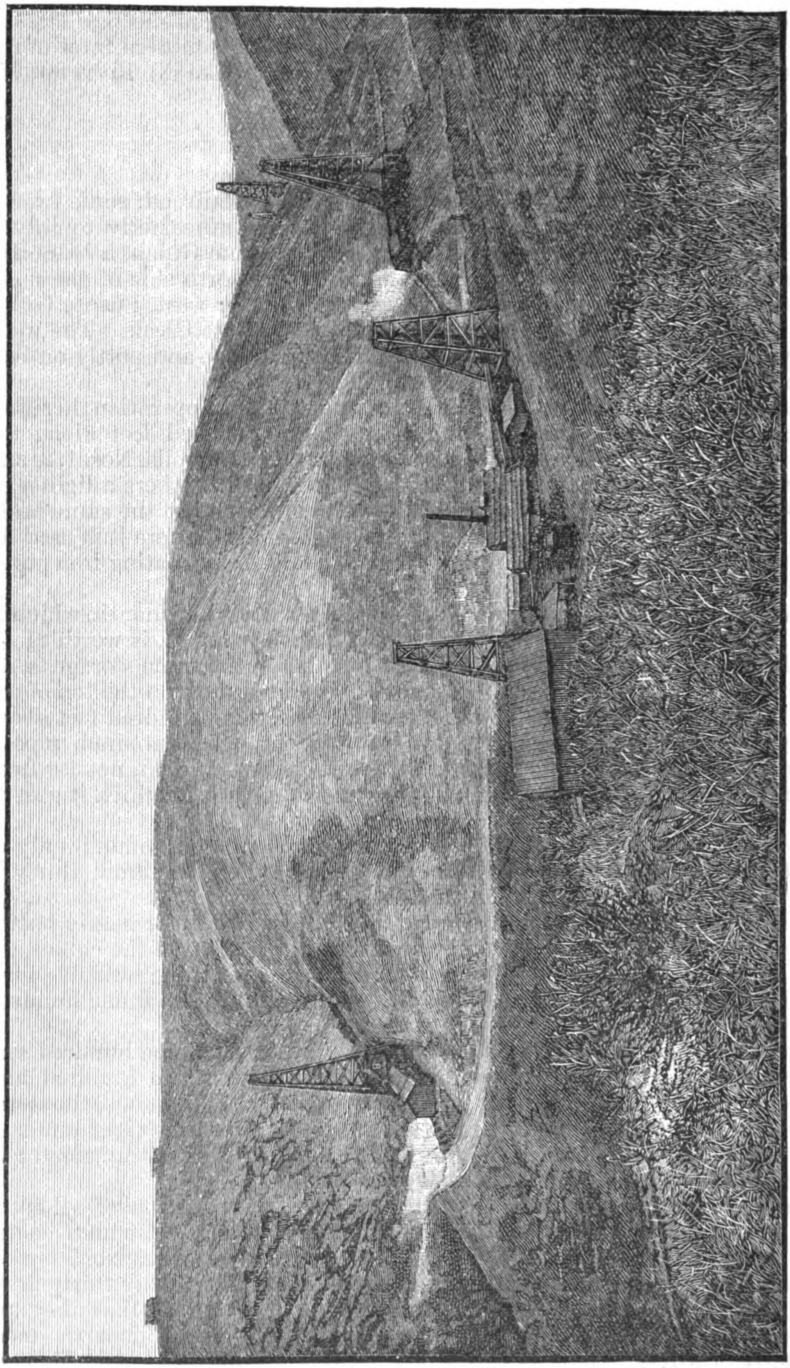
Wells Nos. 1, 2, and 3, are old wells, and are situated some twenty or thirty feet south of the bed of the gulch. The others are from thirty to two hundred feet north of it, on the hillside.

A streak of little croppings of bréa and maltha follows for nearly half a mile about an east and west course, just north of the bed of the cañon.

The largest tank at the wells has a capacity of something over five hundred barrels, and the smaller one in the same building holds one hundred and thirty barrels.

Nos. 1 and 2 were sunk previous to 1882, and are each one hundred and fifty feet deep. No. 3 began pumping in 1882, and is two hundred and sixty feet deep. No. 4 has a twelve-inch casing at top, is one thousand feet deep, and began pumping in January, 1886. No. 5 is eight hundred feet deep, and began pumping in July, 1886. No. 6 is eight hundred feet deep, and began pumping in January, 1887.

Since No. 6 was started the average aggregate production of all these wells has been about one hundred barrels per day, most of which comes from Nos. 4, 5, and 6, No. 4 being the most productive well. No. 7 is now drilling, with a thirteen-inch top casing, and is to-day (May thirty-first) down about one hundred and seventy-five feet. They say that they are making an average of about forty feet per day with it. This is the most westerly of all the wells here. Moreover, the grading is already done at the site of No. 8, which will soon be started, and will be the most easterly one of all.



PUENTE OIL WELLS, LOS ANGELES COUNTY, CALIFORNIA.

The rocks throughout this region are unaltered sandstones and shales, which often contain a good deal of lime. They generally strike about east and west, though in some places they are greatly disturbed and crumpled. On the south side of the cañon, where, however, the exposures are very few and poor, they seem generally to dip to the south, while on the north side, where the exposures are somewhat better, and where all the most productive wells are, they dip to the north at angles ranging from 60° to nearly horizontal, though the general average seems to be about 45°.

At a point in the bluff on the south side of the cañon, about opposite Well No. 7, the sandstone seems to strike about N. 65° E., and dip northwesterly about 25°. But, in the brow of another bluff of about the same height, some three hundred or four hundred feet farther west, they again strike about east and west, and dip 40° or 45° to the south.

As already stated, very few exposures of rock can be seen on the south side of the cañon. But it seems pretty certain that the general dip there is to the south, so that the cañon itself here occupies the place, either of a fault of considerable magnitude, or else of a sharp anticlinal fold in the rocks, the productive oil wells being on the north side of it where the dip is northerly.

The oil-bearing rock itself, in all these wells, is sandstone. There is no record of the strata passed through in the shallow wells, Nos. 1, 2, and 3. But in the deeper wells a layer of asphaltum, or bituminous rock, was passed through before reaching the oil-bearing rock.

The depths at which this asphaltum and the oil-bearing rock were struck in Wells Nos. 4, 5, and 6, respectively, were as follows:

	Asphaltum.	Oil Sand.
Well No. 4	100 feet	335 feet.
Well No. 5	180 feet	430 feet.
Well No. 6	230 feet	480 feet.

From the vertical depths here given, it is easy to compute the approximate actual thickness of the strata passed through, the average dip being about 45° to the north. None of the wells have passed entirely through the oil-bearing sandstone here, though Well No. 4 has penetrated to a vertical depth of six hundred and sixty-five feet into it.

Immediately overlying the oil-sand there are a number of thin layers of fine-grained, hard, and compact sandstone, while the oil-sand itself is somewhat coarser grained and softer. All the wells furnish some gas, but very little gas is found until the top of the oil-sand is reached. The total quantity of gas furnished by Wells Nos. 4, 5, and 6 is about the equivalent, as fuel, of five barrels of oil per day. In addition to this gas, they also consume under the boilers about two barrels of oil per day in making steam.

Mr. John Youle, Superintendent of these wells, thinks that four barrels, or about one thousand one hundred pounds, of this oil are about equal in value as fuel to one ton (two thousand pounds) of good coal. The gas ordinarily issues from the wells under very slight pressure, owing to the fact that its quantity is small and it is drawn directly from the wells to the furnaces. But Mr. Youle states that in Well No. 5, when it was once cased in tight and none allowed to escape for awhile, the pressure rose to at least one hundred pounds per square inch.

They estimate that the total cost of sinking and fitting up the three deepest wells, Nos. 4, 5, and 6, was about $30,000, an average of $10,000 each, or a general average of $11 54 per foot of depth for all three wells.

From the Puente wells the town of Anaheim bears S. 10° E., magnetic.

Mr. Youle estimates that the total yield of all the wells throughout the State for the years 1884, 1885, and 1886 was as follows: 1884, an average of 511½ barrels per day; 1885, an average of 564½ barrels per day; 1886, an average of 658 barrels per day.

The difficulty in burning petroleum under boilers with a blast of air only, is that, if sufficient air is not furnished, the combustion is very incomplete, and dense clouds of black smoke issue from the stack; while on the other hand, if sufficient air is furnished to insure complete combustion and produce no smoke, then the flame is very short, and the heat is concentrated under the front end of the boilers to such an extent as to rapidly burn out and destroy the iron. Instead, therefore, of a blast of air alone, a jet of steam is used, which atomizes the petroleum and delivers it into the furnace in the shape of an exceedingly fine spray, mixed with both air and steam, the further effect of the latter being to considerably retard the rapidity of combustion, thus producing a far longer, though smokeless flame, and preventing the excessive concentration of the heat under the front end of the boilers.

By this method, of course, a certain amount of heat is carried off by the steam and lost. But this loss is small in comparison with the great advantage gained, of a far better distribution of the heat and the preservation of the boilers, while at the same time effecting a complete combustion.

Considerable gas continues to escape from the petroleum for some time after it issues from the ground; and it appears that the gas thus evolved is capable, under some circumstances, of redepositing some liquid petroleum from it.

At various localities between Los Angeles and the Puente wells, a little asphaltum and an occasional small tar spring may be found; but nothing of any considerable extent or quantity.

In a cut on the road at the reservoir in East Los Angeles there is a sharp, beautiful, and perfect anticlinal fold, the strike being northeast and southwest, and the dip about 45° each way from the axis. But at a point less than two hundred yards northwest of this locality, the dip is unmistakably to the southeast, proving that there is also a synclinal fold somewhere between these two points.

At a number of other points in East Los Angeles, and also in the northern part of the city proper, the strata are seen to strike northeast, but with varying dips. In the vertical banks, over twenty feet high, exposed in grading for new buildings on New High Street, just back of the Post Office and the St. Elmo Hotel, the soft, yellow, fine sand and clay shales strike N. 50° E. and dip about 50° southeast. There is here considerable selenite in thin streaks parallel with the stratification, and in a few spots the shales are stained nearly black with carbonaceous matter; but there is no sign here of liquid oil or asphaltum.

Mr. McGinnis once sunk a well some three hundred feet deep on Boyle Heights, and another some five hundred or six hundred feet deep at Santa Monica, but struck nothing of any value.

At the Protestant Orphans' Home, in the northern part of the City of Los Angeles (called "Sonora Town"), a well was sunk, in which, at the depth of sixty feet, a considerable volume of gas was struck. The pipe was seven inches in diameter, and when the gas was lighted, it burned a solid flame six feet high for over an hour.

Another well, near Temple Street, was sunk by Mr. A. Polhemus, in 1865, to a depth of three hundred and ninety feet, through alternating layers of soft and hard sandstone. This well yielded water and some gas. The latter, when ignited, gave a flame, half an inch in diameter and several feet long, which would burn all night. The dip of the sandstones here is to the southeast.

Near the Southern Pacific Railroad station, in the bed of the Los Angeles River, a well was drilled eighty feet deep, at the bottom of which they struck asphaltum, with some gas in sandstone.

Just back of the United States Hotel is another well, in which they passed through soft materials to the depth of about eight hundred and fifty feet, where they struck hard rock, and below that again soft shale, with salt water strongly impregnated with sulphuretted hydrogen and other gases.

In the outskirts of the City of Los Angeles, some three miles southwest of the City Hall, the crests of some low rolling hills are covered, over an area of several acres, with a deposit of asphaltum mixed with sand. At one place the bituminous strata are exposed for a distance of perhaps one hundred feet, in a bank some four or five feet high, and consist of fine-grained and extremely thin bedded, sandy shales, which strike about N. 70° E., and dip 60° to 65° southeast. The upturned edges of these shales are covered over with a deposit of recent soil and gravel, through which the maltha, which issues from the shales, slowly percolates upwards to the surface, where it gradually hardens into asphaltum. There are many little pools, most of them not more than one or two feet, but a few as much as five or six feet in diameter, of black and very viscid maltha, like very thick and sticky tar. Bubbles of gas, an inch or more in diameter, may occasionally be seen on the surface of this maltha.

At one point here a well was drilled by Mr. A. Polhemus, in 1865, to the depth of four hundred and forty feet, with three-inch casing. It went through fifteen feet of asphaltum and sand, and then through black shales to the bottom. It yielded salt water and a little oil. The tools are said to have been lost in the well. The latter is now full of maltha which, on May fifteenth, stood in the pipe (which rises about two and a half feet above the surface of the ground) at a level of about one and a half feet below the top of the pipe. But at times it rises and overflows the top of the pipe, and has formed around it quite a pool of maltha which is considerably more liquid than that of the other little pools which come from the little surface springs. To the north of this locality, for a distance of two miles or more, there are scattered small deposits of asphaltum and little springs of tar.

About four miles northwesterly from the Los Angeles Court House, a well was drilled some years ago by Ivan A. Weid, concerning which the following information was obtained: Struck surface water in gravel at twenty-eight feet. Went down about one hundred feet in soft formations. Put in eight-inch casing. Went through a slate formation, requiring no casing, five hundred and fifty feet. At three hundred and fifty feet struck a streak of oil and bréa in a sandstone formation. At five hundred and seventy-five feet casing became necessary. The sandstone continued to six hundred and fifty feet. From six hundred and fifty to eight hundred and twenty feet in slate, with streaks of soft sandstone and bréa, the last thirty feet, from seven hundred and ninety to eight hundred and twenty feet, being in very soft sand rock requiring casing. At four hundred and fifty feet water commenced flowing from top of well with gas and oil. There were several streaks of soft sand at intervals with indications of oil; but no sufficient quantity of oil to be of any value.

At La Bréa Rancho, described in the Fourth Annual Report of the State Mineralogist, page 287, the strata are but very little exposed anywhere, the ranch lying in the nearly level valley, several miles from the foot of the hills in any direction. From what little could be seen at one or two points, however, they seem to lie nearly horizontal, and to consist of soft sandstones and shales, with some gravel; the pebbles being sometimes an inch or so in diameter, and all, more or less, impregnated with bitumen.

Considerable gas escapes here from the excavations which have been made in digging out the asphaltum, and also from some of the tar springs which are scattered over the asphaltum deposit.

A deep well has also been drilled here for oil without success, by Messrs. Stewart & McFarland. Samples seen at Los Angeles, and said to have come from this well, were as follows:

At eighty-one feet—Coarse gray sand.
At eighty-three feet—Very fine-grained, black, bituminous shale.
At four hundred and twenty feet—Coarse-grained, pebbly sand, yellowish-brown in color.
At four hundred and seventy-nine feet—Dark brown bituminous shale.
At six hundred and fifty-one feet and at six hundred and fifty-eight feet—Black, sticky, bituminous shale.

But Mr. McGinnis, who drilled this well for Messrs. Stewart & McFarland, gives from memory the following statement of the strata through which he passed, beginning at the surface:

Fifty-three feet—Black sand and bréa.
Forty-five feet—Quicksand.
Eighteen feet—Hard shale.
Two hundred and forty-eight feet—Black sand and bréa.
Eighteen feet—Hard shale.
Six hundred and eighteen feet—Sand and bréa.
Three hundred and twenty feet—Soft, blue mud.
Thirty feet—Oil-sand.
One hundred and thirty-five feet—Soft, blue mud.

Making the total depth of the well one thousand four hundred and eighty-five feet. At nine hundred and eighty-eight feet struck water, and at one thousand feet the well began to flow salt water from the top. There was also considerable gas here, but no valuable quantity of oil.

To the south of here, and between the Rancho La Bréa and the hills lying south of the Rancho La Cienega, a number of other wells have been sunk to depths ranging from eighty to two hundred feet, and in which, at various depths, sulphur water and gas were found, but no oil of any value.

About ten miles, a little north of west from the City of Los Angeles, on the northern part of the Rancho Rodeo de las Aguas, and just at the foot of the Santa Monica Range of mountains, there are some tar springs and patches of asphaltum, and Mr. A. H. Denker has drilled a well here to the depth of five hundred and twenty feet through the following strata:

90 feet—Soft and loose materials.
100 feet—Slate and quartz sand rock.
100 feet—Black sand rock.
10 feet—Slate.
100 feet—Sandstone, with a little oil.
65 feet—Sandstone, with tar and sulphur water.
15 feet—Very fine and hard sand.
15 feet—Sand, with a little oil.
25 feet—Black slate, with pyrites.
—
520

The first water in this well was struck at twenty-five feet. At four hundred and sixty-five feet strong sulphur water containing some gas was found. The mouth of this well is about five hundred feet above the sea. The course from here to the well at La Bréa Ranch is S. 68° E., magnetic—

distance, about four and one half miles—while the Puente wells, near thirty miles distant, bear S. 85° E.

There are no good exposures of the rocks in this vicinity. In the gulch, close by the well, the surface rock is seen to be a micaceous clay slate, dark colored and soft, but its strike and dip could not be determined.

At a locality visited on the Buenos Ayres Ranch, some two and one half or three miles west of Denker's well, and at about the same height above the sea, there is an exposure of heavy-bedded sandstones with streaks of soft clay shales intercalated. These sandstones are soft and unaltered, and strike about N. 60° E. and dip 12° to 15° to the southeast.

At the time of my visit to Denker's well there was trouble with the casing, which they were trying to draw out. But I was afterwards informed that they did not succeed in getting it out, and so abandoned the hole and started a new one.

The present variation of the magnetic needle at Los Angeles, as given by Mr. Hadler, the United States magnetic observer there, is 14° 29′ E.

About eleven miles south of Los Angeles, in what is known as the "Rosecranz Tract," and on the S.E. ¼ of Section 18, T. 3 S., R. 13 W., S. B. M., Mr. Milton Thomas has a well drilled one hundred and thirty-five feet deep, in which at the depth of eighty-five feet quite a strong flow of gas was struck. The well was drilled by Mr. Putney, who states that when the gas was first lighted at the mouth of the seven-inch pipe it burned right straight along, a solid flame not less than ten feet high.

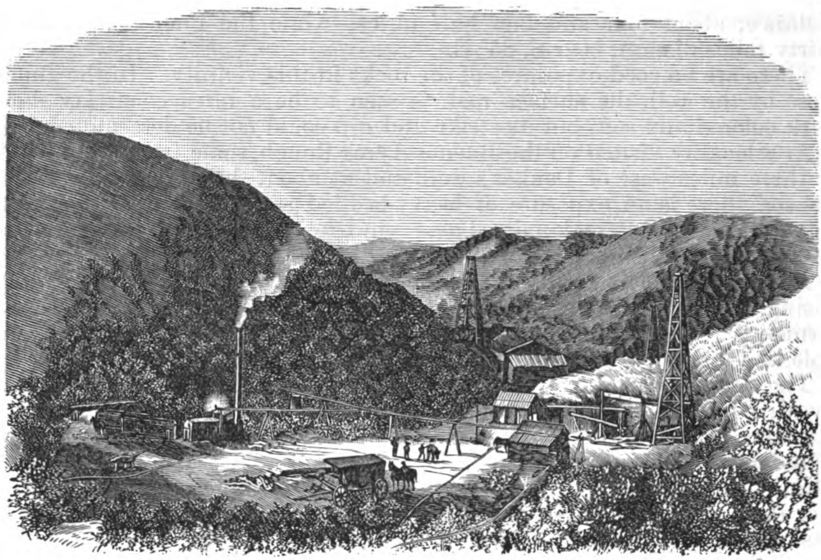
Mr. Thomas now has it cased in, and is using the gas for all domestic purposes in his house. I should judge the well would furnish now one thousand cubic feet or more of gas per hour under a pressure of perhaps half a pound to one pound per square inch.

Along the seabeach, from near the town of San Pedro to Point Firmin, and it is said for some eight or ten miles west of there, the bituminous shales and sandstones are exposed in cliffs fifty to one hundred feet or more in height. So far as seen, they are all sandstones, varying, however, from a very fine-grained, dark bluish, soft rock, whose whole mass is impregnated with bitumen, to a coarse-grained, light yellow sandstone, in which the bitumen appears only in spots and seams. These rocks are more or less disturbed and bent, and sometimes faulted. Their strike ranges from N. 30° W. to N. 60° W., and their dip from 10° to 30° to the northeast. I did not learn of any deep wells having been drilled in this vicinity.

PICO CAÑON.

At the present time, the most productive petroleum locality in Los Angeles County is at Pico Cañon, of which some description is given in the Fourth Annual Report of the State Mineralogist. The wells are situated in and about the head branches of Pico Cañon, which runs northerly out of the San Fernando Range of mountains to the Santa Clara Valley. In all, something over thirty wells have been drilled here to various depths, ranging from five hundred to two thousand three hundred and thirty feet. The product is a green oil whose gravity is from 40° to 42° B. There is here a storage tank of twenty thousand barrels capacity. The oil from the different wells is all mixed together and piped from here to Newhall, whence most of it goes by rail to the refinery at Alameda. There is only one flowing well; all the rest are pumping wells, though some of them would flow more or less if they were not pumped.

As to the flowing well, the experiment of pumping it has also been tried, but this did not increase its production sufficiently to justify the expense.



WELLS AT PICO CAÑON.

All the wells produce also some gas, the whole of which is utilized under the boilers, except in the case of two wells, where there is a surplus, which escapes from two iron pipes into the open air and burns with constant flames from two to four feet long.

Nearly all the oil is found in a light-gray, porous sandstone, and the deepest wells have none of them reached the bottom of this sandstone. The coarsest grains in the drillings from this rock range from one thirty-second to one sixteenth of an inch in diameter.

The rocks here have been greatly plicated, crushed, and broken, and there is either a sharp anticlinal fold, or else a large fault of unknown magnitude, running for some distance nearly east and west, on the north side of which the rocks dip to the north with an average pitch of about 70°, and on the south side of which they dip to the south at steep but varying angles. To the south of this "line of break," as it is called, no productive well has ever yet been found, though five or six holes have been drilled there, one of them to a depth of fifteen hundred feet.

In the western part of this field there is another disturbance, and the rocks there dip between W. and S.W., at angles of from 30° to 45°. There are one or two productive wells here in these southwesterly dipping rocks.

Within the productive belt here, it is not true, as a general rule, that the best wells are either on the south or north edge of the belt. Nor is it true that the best wells are either the deepest or the shallowest.

The rocks exposed at the surface here consist of an exceedingly complex series, so far as their physical characteristics are concerned. They range from the very finest and thinnest-bedded clay shales, up through various grades of sandstones and fine gravel rocks to very coarse conglomerates. But Mr. Craig states that, within the most productive area here, they have as a general rule, struck any given stratum at about the depth at which they might have expected to strike it, taking the surface strike and dip as a guide; thus showing that *within this small area* the rocks are not greatly faulted.

They pump here steadily day and night, and Sundays also, and run their pumps more rapidly than they do at Puente; though the speed of the pumps varies somewhat at the different wells.

The general rule is that each well is more productive for a short time after it is first drilled than it is afterwards. But Mr. Craig states that these wells are more permanent than the Pennsylvania wells, and though their daily product is comparatively small, yet he thinks their ultimate gross production will, before final exhaustion, prove to be greater than the average of the wells in Pennsylvania.

The following description of these wells was furnished by Mr. Craig:

The well furthest up the main branch of the cañon, *i. e.*, furthest to the south, is known as "Pico, No. 11." It is in the bed of the cañon, about two hundred or two hundred and fifty feet south of the "break," is fifteen hundred feet deep, and developed nothing except some water, a little tar, and a little gas. The water has a slightly bituminous taste, but does not seem to contain any noticeable quantity of mineral salts.

"Pico, No. 10" is in the bed of the cañon, one hundred or one hundred and fifty feet south of the "break." It was sunk nine hundred feet deep, when the tools were lost in it, and it was abandoned. A very little oil flows from it, but not enough to be of any value.

"Pico, No. 2" comes next below No. 10, in the bed of the cañon. It is about nine hundred feet deep, and pumps about five barrels per day of oil of about 40° B. This well is right *in* the "break," and the oil was struck at about seventy-five feet depth. It was drilled in 1875.

"Pico, No. 1" is next in order down the cañon, is right in the "break;" is seven hundred feet deep, and also pumps about five barrels per day. In this well also, the oil was struck at a depth of about seventy-five feet.

"Pico, No. 4" comes next below No. 1 in the cañon. It was sunk in 1876 to the depth of about one thousand feet. It is probably one hundred feet north of the "break," and is pumping about thirty barrels per day. It at first yielded about seventy-five barrels per day, being then only six hundred feet deep. But it gradually fell off till it gave only fourteen barrels per day, when they drilled it deeper.

"Pico, No. 5" is the next well below No. 4, in the bed of the cañon. It is some three hundred feet north of the "break;" is one thousand one hundred feet deep, and pumps about twenty-five barrels per day.

"Pico, No. 9" is in the bed of the cañon below No. 5. It is nearly five hundred feet north of the "break;" is one thousand five hundred and fifty feet deep, and pumps about thirty-five barrels per day.

The foregoing are all the wells situated in the bottom of the main cañon.

Going westerly up the branch cañon from "Pico, No. 1," we find successively "Pico, No. 8," "Pico, No. 12," and "Pico, No. 13."

"Pico, No. 8" has three different holes close together—one five hundred feet deep, one one thousand feet deep, and the other one thousand five hundred feet deep. This is on the south side of the "break," and probably one hundred and fifty or two hundred feet from it. The one thousand feet hole produced for awhile some five or six barrels per day; but is now practically dry. The other two holes were both dry.

The other two wells, "Pico, No. 12," and "Pico, No. 13," are both of them north of the "break."

"Pico, No. 12" is one thousand three hundred feet deep, and pumps about eighteen barrels per day.

"Pico, No. 13" is one thousand six hundred feet deep, and pumps forty barrels per day.

The last two wells both produce a rather heavy oil, said to contain more paraffine than that from any of the other wells. They also produce a larger quantity of gas than any of the other wells, only a portion of which is required to make steam for pumping them, the balance being allowed to escape and burn in the open air.

"Pico, No. 14" is still farther west. It is one thousand five hundred feet deep, but is a dry hole. It is probably south of the "break," the course of which at this locality seems to be about N. 75° W.

About one thousand or one thousand two hundred feet west of "Pico, No. 14," there is another dry hole called "Simi, No. 1," which is one thousand three hundred feet deep.

"Pico, No. 6" is on the hillside, about four hundred feet due west from "Pico, No. 4," and about one hundred feet above it. It is one thousand five hundred feet deep, and pumps about twenty-five barrels per day.

"Pico, No. 7" is on the hillside some three hundred feet east of No. 4, and some fifty feet higher. It is one thousand two hundred feet deep, is a *flowing* well, and yields about forty barrels per day.

About four hundred feet, a little north of west from "Pico, No. 5," and one hundred and fifty feet above it, is the "H. & S. Star" well "No. 1," which is one thousand six hundred and fifty feet deep, and pumps about thirty barrels per day.

About six hundred feet east of "Pico, No. 2," and two hundred and seventy-five feet above it, is "San Fernando, No. 1," which is one thousand two hundred feet deep, and pumps twenty barrels per day.

Three hundred and fifty feet further east, and still fifty feet higher, is "San Fernando, No. 2," which is one thousand four hundred and fifty feet deep, and pumps forty barrels per day.

About five hundred feet, a little east of north from "San Fernando, No. 1," and two hundred feet lower, is "San Fernando, No. 4," which is one thousand five hundred and fifty-five feet deep, and pumps about eighteen barrels per day.

Some five hundred feet east of the last well, and fifty feet higher, is "San Fernando, No. 5," which is one thousand six hundred feet deep, and pumps fifteen barrels per day.

About six hundred feet east of "San Fernando, No. 2," and some forty or fifty feet lower, is "San Fernando, No. 3," which is one thousand three hundred and seventy-five feet deep, and pumps twenty-five barrels per day.

Five hundred feet northeast from "San Fernando, No. 5," and seventy-five to one hundred feet lower, is "San Fernando, No. 7," which is one thousand nine hundred feet deep, and is a dry hole.

About three hundred feet northwest of "San Fernando, No. 1," and one hundred feet lower, is "San Fernando, No. 8," which is one thousand three hundred and twenty-five feet deep, and pumps sixty barrels per day.

About four hundred feet northeast of "San Fernando, No. 3," and about one hundred feet lower, is "San Fernando, No. 6," which is two thousand three hundred and thirty feet deep, and pumps ten barrels per day.

Three hundred feet a little north of east from "San Fernando, No. 3," and nearly at the same height, is "San Francisco, No. 4," which is one thousand five hundred and fifty feet deep, and pumps forty barrels per day.

About five hundred and fifty feet south of "San Francisco, No. 4," and some seventy-five feet lower, is "San Francisco, No. 2," which is fifteen hundred feet deep, and pumps five barrels per day.

About six hundred feet northeast of "San Fernando, No. 6," and about one hundred feet lower, is "San Francisco, No. 3," which is thirteen hundred feet deep, and is a dry hole.

About four hundred feet northeast of "San Francisco, No. 2," and some fifty feet lower, is "H. & S. Hill, No. 3," which is one thousand six hundred feet deep, and pumps five barrels per day.

About eight hundred feet a little north of east from the last preceding well, and two hundred and fifty feet higher, is "H. & S. Hill, No. 1," which is eighteen hundred feet deep, and is a dry hole.

About five hundred feet southeast of "H. & S. Hill, No. 1," and some fifty feet higher, is "H. & S. Hill, No. 2," which is one thousand two hundred feet deep, and is a dry hole.

This shows a total of thirty-three wells (counting the three holes at "Pico, No. 8," separately), of which two are unaccounted for, eleven are dry holes, and twenty are productive wells, yielding an aggregate of four hundred and seventy-one barrels per day.

The dry holes range from five hundred to one thousand nine hundred feet in depth, and their aggregate length is fourteen thousand four hundred feet.

The productive wells range from seven hundred to two thousand three hundred and thirty feet deep, and their aggregate length is twenty-seven thousand nine hundred and eighty-five feet.

All the productive wells are contained within an area three thousand eight hundred feet long, east and west, by one thousand two hundred feet wide, north and south, and bounded on the south by the line of the "break." To the south of this line the exposures are so few and poor that it is impossible to say with certainty whether the "break" is really a great fault, or only a sharp anticlinal fold of the rocks. So far as can be judged from appearances, however, it seems most probable that it is a fault.

Both east and west of the productive area the rocks are irregularly and greatly disturbed.

The pump rods work in two-inch tubing, which generally runs down to within about one hundred feet of the bottom of the well. The casing usually extends only part way down the well, as the sand rock in which the oil is found is hard enough to stand alone.

The quantity of water encountered in drilling these wells was not large.

The oil pipe to Newhall is two inches in diameter and seven and one fourth miles long.

In June, 1886, a torpedo of thirty pounds of Hercules powder was exploded at a depth of nine hundred feet in "Pico, No. 4," but produced no effect whatever upon its yield. "Pico, No. 1" was sunk in 1875; No. 2 in 1875; No. 3 in ——; No. 4 in 1876; No. 5 in 1880; No. 6 in 1880; No. 7 in 1882; No. 8 in 1882; No. 9 in 1882; No. 10 in 1882; No. 11 in 1882; No. 12 in 1882–1883; No. 13 in 1882–1883; No. 14 in 1883. "Simi, No. 1," was sunk in 1883–1884. "H. and S. Star, No. 1" was sunk in 1883. "San Fernando, No. 1" was sunk in 1882; No. 2 in 1882; No. 3 in 1882; No. 4 in 1882; No. 5 in 1882; No. 6 in 1882; No. 7 in 1882; No. 8 in 1886–1887. "H. and S. Hill, No. 1" was sunk in 1883; No. 2 in 1883; No. 3 in 1883. "San Francisco, No. 2" was sunk in 1881; No. 3 in 1883; No. 4 in 1883.

The first five hundred or six hundred feet, in nearly all the wells, consist of alternating beds of sandstones and shales; but below about this depth, only solid sandstone is met with. The shales are often very thin-bedded and fragile, and casing is required down through them into the sandstone. In "Pico, No. 9," however, they had soft shales as deep as nine hundred feet.

The altitude of these wells above the sea ranges from eighteen hundred to about two thousand three hundred feet. The altitude of Newhall Station is about one thousand two hundred and fifty to one thousand three hundred feet.

Most of the above information concerning these wells was kindly furnished by Mr. M. R. Craig, the General Superintendent and Manager.

The tank at Newhall holds two thousand barrels. The following is a tabular recapitulation of some of the most important data concerning the Pico Cañon wells:

Name of Well.	Date when Drilled.	Depth in Feet.	Product in Barrels per day in July, 1887.
Pico, No. 1	1875	700	5
Pico, No. 2	1875	900	5
Pico, No. 3	----------	----------	----------
Pico, No. 4	1876	1,000	30
Pico, No. 5	1880	1,100	25
Pico, No. 6	1880	1,500	25
Pico, No. 7—*flowing*	1882	1,200	40
Pico, No. 8	1882	500 1,000 1,500	0
Pico, No. 9	1882	1,550	35
Pico, No. 10	1882	900	0
Pico, No. 11	1882	1,500	0
Pico, No. 12	1882–1883	1,300	18
Pico, No. 13	1882–1883	1,600	40
Pico, No. 14	1883	1,500	0
Simi, No. 1	1883–1884	1,300	0
H. and S. Star, No. 1	1883	1,650	30
San Fernando, No. 1	1882	1,200	20
San Fernando, No. 2	1882	1,450	40
San Fernando, No. 3	1882	1,375	25
San Fernando, No. 4	1882	1,555	18
San Fernando, No. 5	1882	1,600	15
San Fernando, No. 6	1882	2,330	10
San Fernando, No. 7	1882	1,900	0
San Fernando, No. 8	1886–1887	1,325	60
San Francisco, No. 1	----------	----------	----------
San Francisco, No. 2	1881	1,500	5
San Francisco, No. 3	1883	1,300	0
San Francisco, No. 4	1883	1,550	40
H. and S. Hill, No. 1	1883	1,800	0
H. and S. Hill, No. 2	1883	1,200	0
H. and S. Hill, No. 3	1883	1,600	5

In Little More Cañon, about two miles east of Pico Cañon, two wells were sunk by Messrs. Hardison & Stewart in 1882 and 1883. These wells are, according to Mr. Craig, about half a mile north of the apparent course of the "break" in the rocks in Pico Cañon. No. 1 is about one thousand feet deep, and in it they found a small quantity of heavy black maltha, which looks like that from the Puente wells. A very small stream of it is now trickling out from the mouth of the well; but there was not enough of it to be of any value.

No. 2 is a short distance farther down the cañon, is only about seven hundred feet deep, and is a perfectly dry hole.

Wiley Cañon is about three miles east of Pico Cañon. Here there seems to be a similar fault or "break" in the rocks to that in Pico Cañon. But in Wiley Cañon there is a much greater quantity of extremely thin-bedded shales, and the local disturbances seem to be much greater. There are some very queer contortions of these shales here.

From what appears to be the line of "break" in this cañon, there have been two tunnels driven southerly, one of them three hundred or four hundred feet in length. These tunnels struck some water and a little oil; but not enough of the latter to pay for saving it. A very small quantity of tarry oil is constantly flowing from them now.

Two wells have also been sunk here, one about nine hundred feet deep, and the other one thousand three hundred and twenty-five feet deep. Neither of these wells gave oil in paying quantities, though both of them gave a little rather heavy oil, about 36° B., of a dark green color.

At the nine hundred feet well, which is just on the south edge of the "break," the water and oil stand in the pipe at the surface of the ground, and there is a very small overflow from it. There is also some gas bubbling up from it.

At the one thousand three hundred and twenty-five feet well, which is just on the north edge of the "break," the water and oil stand some ten or fifteen feet below the surface of the ground, and there is a small seepage from it into the immediately adjacent cañon. Here also there is some gas.

The water from both these wells is impregnated with various mineral salts, and that from the one thousand three hundred and twenty-five feet well has formed small stalactites on the hillside.

A short distance below these wells, in the cañon, there is a sulphur spring, whose waters are also impregnated with various alkaline salts.

Some of the local foldings of the rocks, more especially of the thinner shales, in Wiley Cañon, even within such short distances as ten to fifteen feet, are extremely complex.

The surface indications of either oil or asphaltum in all these cañons are very small; especially so in Pico Cañon, where extremely little of it can now be seen, whatever may have been the case previous to the sinking of so many wells.

It is stated in the Fourth Annual Report of the State Mineralogist, p. 294, that oil oozes from the ground in Casteca Cañon, a branch of the Santa Clara River coming in from the north, and nearly opposite to Pico and Wiley Cañons on the south. But I could not learn that any drilling had ever been done there, and, therefore, did not spend time to visit the locality.

There is also said to be some asphaltum in a cañon called "Dapple Cañon," some two and a half or three miles northeast of Camulos, and close to the boundary line between Los Angeles and Ventura Counties.

Furthermore, there is said to be asphaltum with some seepages of petroleum in the mountains some six or eight miles southeast of Newhall, but this locality was not visited for want of time.

Monterey County.

The deposit of bituminous sandstone owned by Mr. Godfrey was visited on September ninth. It is on the S.W. ¼ of Section 35, T. 24 S., R. 10 E., M. D. M., on the right bank of San Antonio Creek, west of Bradley's Station, in Monterey County. No developments have been made yet at this locality. But there is a belt of bituminous sandstone visible, some twenty or twenty-five feet thick, which strikes about N. 15° W., magnetic, and dips about 70° to the east. So far as can be seen, the rock does not seem to be generally very rich in bitumen. The sandstone alternates with grits and conglomerates. In the hill, about a quarter of a mile northwest of here, on the opposite side of the creek, the sandstones and shales strike about N. 65° W., and dip 50° or 60° N.E.

There are no springs of liquid petroleum, nor pitch, to be seen here. This locality is close to, and the bituminous rock crosses, the old stage road from San Luis Obispo, *i. e.*, the old "Coast Line" road. Some two hundred yards, about N. 50° W. from the first outcrop mentioned, and on the opposite side of the creek, the bituminous sandstone shows again in the bank of the creek. At a point N. 60° W. from the first locality, the same heavy body shows again in the bluff one hundred and fifty or two hundred feet above the creek. Overlying the mass above mentioned at the first locality, there is first forty or fifty feet of barren sandstone, and then a bed of richer material some twenty feet or so in thickness. The pebbles in the conglomerate, which is interstratified with the sandstones, are chiefly quartz, flint, granite, and occasionally volcanic rocks, much water-worn and smoothly rounded. In the sandstone there are many angular fragments of white clay rock and flinty shale, of which very heavy bodies underlie the sandstones. Underlying this heavy body of bituminous rock in the shales on the opposite side of the creek, there is to be seen in one place in the bluff another streak of bituminous sandstone from two to five feet thick, between which and the first mass described, there is a thickness of one hundred and fifty or two hundred feet of barren shales. About a quarter of a mile farther up the creek there is a cold sulphur spring, somewhat alkaline. There are also beds of the clayey and flinty shales overlying the first heavy mass of bituminous rock. There is said to be also an outcrop of the bituminous sandstone about two miles a little east of south from here, on the Nacimiento Creek, where it lies nearly horizontal.

One quarter of a mile below here, and thence all the way to the Salinas River, a distance of some five miles, the more recent rocks lie nearly horizontal. No shells have been found here. But on the Nacimiento there are said to be several beds which are full of them. The heavy deposit of bituminous sandstone on San Antonio Creek can be traced for about a quarter of a mile southerly up the hill, when it disappears under surface materials till it reappears on the Nacimiento.

At Bradley's station the Salinas River runs just about west, magnetic; and on the north side of the valley the rocks seem to dip northerly at not very high angles.

On a little creek, two or three miles about S. 80° W. from San Ardo station, there is considerable asphaltum and some little ooze of pitch for a distance of about two hundred and fifty or three hundred feet along the creek. The sandstone here strikes about N. 68° W., and dips about 65° to the northeast, and is overlaid by a bed of soft recent breccia, in which the stones are almost exclusively sharply angular fragments of nearly white clay rock, the deposit varying in thickness from four to ten feet or more. Immediately on the southeast side of the creek is a rather heavy outcrop of bituminous sandstones, which furnish the seepages in the creek.

The rocks whose strike and dip are given above overlie the bituminous sandstones. The latter strike N. 50° to 60° W., and dip 65°, or so, to the northeast. The whole belt of them is probably one hundred feet or so in thickness; but they seem to be in three or four different beds, which, perhaps, have barren beds between them. The rock exposed on the surface is nearly all of it rather poor in bitumen, its color being brown. But it must be richer in depth to have furnished the seepages in the creek. Barometer here read six hundred and twenty feet. Barometer at San Ardo read five hundred feet. It is reported that somewhere about three or four miles southeast of here there is another deposit of similar material in the hills southwest of San Ardo. Just above the bituminous sand rock, above described, there is in the gulch a cold, white sulphur spring.

Not far from Godfrey's, but on the south side of San Antonio Creek, there is said to be more bituminous sand rock. Mr. Chas. Romie used to own the land where the bituminous outcrops occur west of the town of Soledad, in Vaquéro Cañon, a branch of Release Cañon, which is a branch of Arroyo Seco, which latter comes into the Salinas River from the west, about one mile above the town of Soledad. He states that there is a small quantity of asphaltum to be seen on the surface of the ground here, but not much, and that there is one small hole dug here in which there is some petroleum to be seen, but not much. The distance from Soledad is some twelve to fifteen miles. Mr. Romie also says that the rocks there are much crushed and broken up, and that there are sulphur springs near by. All the white sulphur springs in this region seem to contain more or less alkali.

The bluffs on either side of the Salinas River, for many miles northwest from Bradley's to near Salinas, are from twenty to fifty or more feet high, and look as if their accumulation had been due to causes perfectly similar to those now at work in the bed of the Salinas River, as they seem to consist of masses of wind-drifted sand, irregularly stratified, and alternating with deposits made by shifting currents of running water.

The pavement in front of the railroad station at Castroville is of bituminous sand rock from near Santa Cruz. It has now been down some seven or eight months, and is in perfect condition.

CHOLAME VALLEY.

During the past few months there has been some little excitement in the newspapers and elsewhere about reputed discoveries of petroleum in the Little Cholame Valley. This locality was visited on the nineteenth of October.

Cholame Creek flows southeasterly for a number of miles through a valley of the same name in the southeastern corner of Monterey County, in the mountains between the Salinas River and the Tulare Valley.

"Cholame Store," at the lower end of the main valley, is in San Luis Obispo County, but all the upper part of the valley is in Monterey County.

The barometer at Cholame Store read eleven hundred feet. About six miles below, *i. e.*, southwesterly from here, the main Cholame Creek joins La Estrella Creek, which then flows to the Salinas River. From "Cholame Store," it is about fifteen miles up the valley in a northwesterly direction to the junction of the "Main" and "Little" Cholame Creeks. The former comes in at the junction from a westerly direction, while the latter comes in from the northwest. The town of Parkfield is in the Little Cholame Valley, less than a quarter of a mile above its junction with the Main Cholame. It is on Sec. 26, T. 23 S., R. 14 E., M. D. M. Barometer here read one thousand three hundred and thirty feet. In the valley here, there are several square miles of nearly level fertile land, rather heavily timbered with scattering old oaks, which this year are loaded with acorns, and which probably gave the name of "Parkfield" to the town.

I was not able to obtain any definite information concerning any deposits of asphaltum or petroleum in the Main Cholame Valley, except the statement that if such exist they are few and small. But in and about the Little Cholame there are several localities where they occur.

About one and a half miles northerly from Parkfield, in Joaquin Cañon, along the southern foot of Table Mountain, there is some surface asphaltum, and a number of small springs of black maltha. The lower part of the mountain here is a heavy mass of serpentine; while the upper portion is unaltered and very heavy-bedded sandstone, which probably dips northeasterly. The petroleum seems to issue from these sandstones and then to seep for some distance down the mountain side through the loose debris overlying the serpentine before it finally appears at the surface. Along with the maltha there is more or less sulphur water and a very little gas. At one sulphur spring there is a barrel set about on a level with the line of maltha springs, where the barometer read one thousand nine hundred feet. This is on Sec. 13, T. 23 S., R. 14 E., M. D. M. So far as could be learned, it appears that this body of serpentine is a completely isolated one, and not more than a quarter of a mile in diameter in any direction.

Mr. John Fisher lives in the Little Cholame Valley, about five miles above Parkfield, and he states that for a distance of one or two miles along the low hills on the southwest side of the valley, near his house, there are small seepages of maltha in almost every gulch. But there are none in this vicinity among the hills on the northeast side of the valley. Some two or two and a half miles above Fisher's house, there is a little gulch coming into the valley from a direction of S. 20° W., magnetic. This locality is on the southeast quarter of Sec. 31, T. 22 S., R. 14 E., M. D. M. A short distance up this gulch there is a somewhat extensive though isolated mass of granite exposed in place, some of which is much decomposed and soft, while other portions of it are yet quite hard. And at one point in the bed of the gulch, there is a little seepage of tar, which issues directly out of the granite itself, into the seams of which it has undoubtedly found its way from some of the near adjacent rocks. The surface wash about here is heavy and deep, and the rocks are but little exposed. But at one point a few hundred feet above the maltha seepage, in the southeastern branch of the gulch, there is a very small exposure of soft clay shales which seem to dip northerly—*i. e.*, towards the granite—but are evidently much disturbed. Their angle of dip, where visible, is some 12° or 15°. In this same gulch, about fifty feet above, *i. e.*, southerly from the maltha seepage, there were noticed a few pieces, seemingly loose bowlders, of coarse-grained and apparently pretty pure crystalline limestone. This is called the "Loomis Claim." Below here, and immediately at the mouth of the gulch, there is a body of soft sandstone, whose stratification, however, could not be determined.

Further up the valley, and probably on the northwest quarter of Section 31, there are soft bituminous clay shales which are not well exposed, but which seem to strike northwesterly and dip very gently, perhaps 4° or 5° southwesterly, and a small quantity of black maltha seeps out of these shales at different points for some little distance along the bed of the creek.

Here also in the bed of the creek were seen some fragments of a soft and very fine-grained white marble. The barometer here read one thousand eight hundred feet.

Many claims have been located within the last few months in the hills and gulches about the Little Cholame Valley for oil, the surface showing of which, however, is on the whole extremely small.

Petroleum springs are, it is true, quite numerous through a belt at least six or eight miles in length, which seems to cross the Little Cholame Valley diagonally in a northwest and southeast direction; but the quantity which they discharge is very small. No wells have yet been sunk here, and no other work had been done up to the time of my visit (October twenty-first), except the digging of some small holes only a few feet in depth. The exposures of the rocks are generally poor; but there is evidence that they are much disturbed.

It is utterly impossible to foretell what the drill may develop here beneath the surface. But the region is an interesting one, and remarkable in the presence of the serpentine at one end of the belt and granite near the other end; and as a matter of scientific interest at least, it is to be hoped that whether profitable or not, some wells may yet be drilled here, and complete records of them kept.

Leaving the head of the Little Cholame Valley, we wound around the southwestern flank of the range lying between the head of the Little Cholame and the Tulare Valley; gradually ascending till we crossed the summit, where the barometer read three thousand and sixty feet.

For the last two or three miles before reaching the summit, the whole country is serpentine with a good deal of jasper associated with it. But, within a quarter of a mile northeast from the summit, the serpentine disappears entirely and is replaced by unaltered sandstones.

Santa Barbara County.

There are, so far as known at the present time, no oil wells producing anything in Santa Barbara County, though several have been sunk there.

But there are great deposits of asphaltum and other bituminous matters at several localities in the county. "El Rincon" Creek, some three or four miles east of Carpinteria is, for some little distance near the coast, the boundary line between Ventura and Santa Barbara Counties. At Rincon Point, on the shore, just west of El Rincon Creek, the railroad company has recently done some heavy grading in the construction of their road.

Amongst other unaltered rocks here, which dip towards the north, they have cut through a heavy body of bituminous shales, which contain a sufficient quantity of bituminous matter, so that, when once ignited, they continue to burn for a long time like the waste heaps from a coal mine—and the embankments are still burning in this style at several points along the line of the road.

The ranch of Mr. P. Clark Higgins, mentioned as the "Carpinteria bed" in the Fourth Annual Report of the State Mineralogist, is only about one mile east of the new Carpinteria railroad station. The bluffs here fronting the seabeach are fifty to seventy-five feet high. The lower portion of them consists of tertiary rocks, out of which the petroleum oozes, which strike about N. 47° W., magnetic, and dip northeasterly from 40° to 60°. These are overlaid, by a recent deposit, from ten to twenty feet thick, which lies about horizontal. This deposit consists of sand and gravel, the former sometimes very thinly bedded, and the soil on the top of the hill is a black, fine, sandy loam, mixed in places with some semi-liquid petroleum. Anywhere within one quarter of a mile or more back from the edge of the bluffs it is no uncommon occurrence for the plow to turn up bituminous matter. The underlying calcareous and bituminous sandstones and shales are, many of them, extremely thin-bedded. The outcrop of asphaltum and other bituminous matters in the bluffs extends for a distance of three quarters of a mile along the shore and to within half a mile or less of the new railroad station at Carpinteria. But towards the west the underlying tertiary rocks are broken up, and strike and dip in various directions. At the extreme west they also sink beneath the surface, and the covering of recent horizontal strata grows thicker and is filled with bitumen, so as to form a tough, sticky mass, which, in tearing it open, exhibits fine, spider-web-like, and more or less elastic threads of bitumen. It is very dirty, but probably might be used for street pavements.

On Ortega Hill, about six miles east of Santa Barbara and near half way between there and Carpinteria, Mr. H. L. Williams has drilled a well. The locality is within five hundred or six hundred feet of the seashore, and is two hundred and fifty-five feet above tide. Mr. Williams here went down four hundred and fifty-five feet. The first seventy feet was surface soil and gravel. Then came two hundred feet of sandstone and shale, much mixed. Then struck water in a blue shale. This shale is one hundred and fifteen feet thick, and is too soft to stand without casing; then struck quartz sand, saturated with heavy black oil, twenty-four feet thick; then nine feet of blue mud containing sea shells and rotten wood; then another streak of blue shale, thirty-seven feet thick.

This shale is very close, and contains neither water nor oil. The sand above was free from water. But the oil which it contains makes it act like a quicksand, and it rose one hundred feet in the pipe. Below the last shale, another body of sand was struck, much like the first, but containing a much lighter oil, and in greater quantity. This sand also acts like quicksand, and they did not penetrate any depth into it, but only just struck the top of it.

In attempting to draw the casing in order to substitute drive-pipe for it, the casing parted in the upper sand, and they could not get the lower part of it out, and were therefore obliged to abandon the hole. Then they swung the derrick around about ten feet, and started another one. This hole is now down (August third) three hundred and ninety-two feet. In the old hole, the first oil was struck at three hundred and forty-two feet; in the new one at three hundred and thirty-six feet six inches. But the first sand was struck at the same depth in both holes, viz., at three hundred and eighty-five feet.

About a quarter of a mile east of here, on the flat at the foot of the hill, a well was sunk about ten years ago to a depth of probably about one hundred and eighty feet. It is said that in this well they also struck quicksand with oil, but no rock at all.

Just northwest of Ortega Hill, in the Montecito Valley, two little creeks join, and just below their junction there is a small outcrop of asphaltum in the bank.

About three quarters of a mile northeast of the well there is a seepage of oil marked on an old map made by the County Surveyor of Santa Barbara County some twenty-five years ago, but Mr. Williams has never seen it.

At the foot of the hills, on the shore, a quarter of a mile east of the well, the rocks are exposed at low water, and it looks as if there were an anticlinal fold here. There is also some seepage of oil from these rocks, and Mr. Williams states that after a slight earthquake shock one night in 1883 a jet of oil "as large as a man's arm" spurted out here for a little while, but did not last long. Considerable gas also escapes from these rocks. Their strike is about east and west. Mr. Williams' wells are just about on the line of the anticlinal axis in these rocks, while the old well at the foot of the hill is on the north side of it.

A little over one mile east of here a low bluff makes out a short distance into the sea, and there also is some seepage of oil. There are also said to be extensive seepages in "Oil Cañon" and one other cañon in the Santa Ynez Range of mountains, some three miles in an air line northeast from Ortega Hill.

In 1885 the "Santa Barbara Oil Company" sank two wells some five hundred or six hundred feet deep in "Oil Cañon," at a point one thousand four hundred or one thousand five hundred feet above tide. There was much gas here. But at last, either by accident or malice, the tools were lost in one of the wells and the work was abandoned.

It is also said that about three or four miles north of Carpinteria a well was sunk about five hundred feet, and was then purposely and maliciously plugged and destroyed by somebody dropping a reamer into it bottom end upwards.

Moore's Landing is near the village of Goleta, about seven miles west of the city of Santa Barbara. Easterly from the landing, for a distance of a mile or so along the shore, the bluffs are forty to seventy-five feet high, of light gray sandstone, which generally dips 10° to 15° towards the northeast, though in some places it lies very nearly level. In this sandstone there are enormous quantities of asphaltum, which occurs in all imaginable forms. There are occasional well defined *veins* of it, from the thickness of a sheet of paper up to two or three feet thick, which extend for short distances through the heavy-bedded sandstone, and then run out completely. Again it occurs in heavy masses twenty or thirty feet and more in diameter. In some places very heavy beds of it run nearly parallel with the stratification of the sandstone, while on the other hand many of the small *veins* of it cut straight through and across the bedding at all angles. Most of it is largely mixed with sand and pebbles; but there are large quantities of it which look very pure. No liquid oil is visible here, nor any soft pitch either, except what is washed up in small flakes by the surf on the beach from beneath the waters of the sea.

Something like a mile to the west of the landing there is a place in a creek in the salt marsh where a good deal of gas bubbles up; and two or three miles farther southwest is Salinas Point, which projects some distance into the sea, and about half a mile outside of which is one of the large and famous petroleum springs beneath the ocean. The depth of the water where this spring issues was asserted by one man to be only about fifty feet, but by another one to be fifty fathoms. The latter is more probable. About eighteen miles off shore here in the channel, and some two miles north of the island of Santa Cruz, there is also said to be another very large oil spring under the water.

Both tin and quicksilver are reported to exist in the mountains north of Santa Barbara.

Mr. H. C. Hobson, of San Luis Obispo, states that there are very large quantities of asphaltum on the Sisquac Ranch, in the northern part of Santa Barbara County, on one of the upper branches of the Santa Maria River. Sisquac Creek joins the Santa Maria River at Fugler's Point, some fifty miles south of San Luis Obispo.

San Bernardino County.

Going east from the Puente and Petrolia wells of Los Angeles County, the range of hills widens out and covers a broad area extending east a considerable distance into the Chino Ranch in San Bernardino County, and southeast as far as the Santa Ana River, their highest summits ranging from one thousand two hundred to one thousand four hundred feet above the sea. They everywhere consist of unaltered tertiary sandstones and shales, with occasional beds of coarser grits and conglomerates, all of which have been upturned and tilted at greatly varying angles of dip, and in many places much crushed and broken. At a point not far from a mile northwest of the Petrolia wells, Bréa Cañon forks into two branches of about equal length, the southernmost of which heads in the eastern edge of the hills on the Chino Ranch, and the other one a mile or two further north.

San Antonio Creek, coming out of the San Gabriel Range of mountains, flows south into the valley, where it usually sinks. But in times of heavy freshets, it continues on entirely across the valley to Chino Creek, which, running southeasterly across the Chino Ranch, empties into Santa Ana River.

The original Chino Ranch lies entirely in San Bernardino County, the western boundary of the grant forming at this locality the county line between Los Angeles and San Bernardino Counties.

This ranch is now the property of Mr. Richard Gird, who has also purchased a large area of what were formerly Government lands lying in the hills immediately to the west of the ranch in Los Angeles County. Within the limits of this very extensive property, which was visited during the month of December, there are several localities where asphaltum and petroleum occur; though no wells have yet been drilled here for oil. Before describing these localities, however, it may be stated that in Bréa Cañon above where it forks, the surface showing of asphaltum seems to be entirely confined to the southern branch of the cañon, where large patches of it are scattered along for some distance above the forks, while none of it was seen anywhere along the north branch. This "Bréa Cañon"—as stated elsewhere in this report—is really the upper portion of Coyote Creek, a stream which runs southwesterly to the bay of San Pedro.

In the eastern and northeastern portion of this region of hills, fronting towards Pomona and the Chino Ranch, though the exposures of the rocks are not numerous and usually not very good, yet so far as could be judged, they do not seem to be quite so badly contorted and crushed as they are in some other localities, and the prevailing or most frequent strike is northeasterly, with a northwesterly dip.

The Chino Ranch House is in the edge of the valley at the eastern foot of the hills, about seven and a half miles southeasterly from Pomona. It is on Section 28, T. 2 S., R. 8 W., S. B. M.

The first bituminous locality visited on the Chino Ranch was in a small gulch, a little southeast of the head of the south fork of Bréa Cañon, and not far from the corner between Sections 23, 24, 25, and 26, T. 2 S., R. 9 W. Here a bed of bituminous sandstone, some twenty feet thick, is exposed, striking about N. 10° W., magnetic, and dipping 12° or 13° to the east. The aneroid barometer here read eight hundred and eighty feet. The rock is, most of it, rather a coarse-grained sandstone containing much mica. So far as visible it is not rich in bitumen, being generally brown instead of black in color. There is no liquid petroleum or pitch to be seen here now, and scarcely any asphaltum, though a very little oozing has taken place at some time in the past at two or three points along the gulch.

The second locality was on the S.W. ¼ of Section 25, T. 2 S., R. 9 W., at the head of a little gulch which runs south to "Carbon Cañon," the latter lying to the south of Bréa Cañon, and running westerly for several miles till it comes out into the Anaheim Valley, just south of the Petrolia wells. Here the barometer read one thousand one hundred feet; and there is a bed of bituminous sandstone exposed at least ten or twelve feet thick, which strikes about N. 60° W., magnetic, and dips northeast. The exposure was not such as to permit of an accurate determination of the angle of dip, but it probably is between 15° and 20°. Much of this rock seems to be fully saturated with bitumen, and would probably make a good street paving material. Immediately underlying this sandstone is a bed of shale some three feet thick, out of which there is some seepage of liquid petroleum at various points. Beneath this comes another bed of sandstone in which only the cracks and seams are filled with petroleum, the rest of the rock containing little or none of it; while in the upper sandstone the bitumen saturates the whole mass of the rock. The length of the exposure here along the strike is some four hundred or five hundred feet. At one point forty or fifty feet higher up the hill another heavy bed of bituminous rock is also exposed. This, however, does not seem to be so rich in bitumen as the lower bed. This would seem to be a promising locality in which to drill for oil.

A third locality visited is probably on the S.W. ¼ of Sec. 32, T. 2 S., R. 8 W. It is in and near the head of a little gulch about one quarter of a mile southwest of the old "Stewart house," and the aneroid read seven hundred and fifty feet.

There is nothing liquid visible here now, except a very little water. But in the past, several small petroleum springs have produced a deposit of asphaltum some four or five feet in width, and stretching some forty or fifty feet along the bed of the gulch. The rocks at this particular spot are not exposed. But in the bluff about seventy-five feet to the northeast, there is a poor exposure of sandstones which seem to strike about north, magnetic, and dip some 45° to the west; though this is somewhat uncertain. At a point about one hundred and fifty feet southwest of the springs, very heavy-bedded sandstones, with a streak of shale running through them, strike N. 65° E., magnetic, and dip 35° to the northwest. This course and position would make the streak of shale overlie the beds from which the petroleum has issued, but with no great thickness of rock between them. The sandstone immediately underlying the shale is slightly bituminous so far as exposed. At a point on top of the hill about one quarter of a mile S. 20° W. from the springs, sandstones and shales strike about N. 45° E. and dip 20° to 35° to the southeast.

A fourth locality is near the old "Frenchman's house," on the S.W. ¼ of the N.W. ¼ of Sec. 5, T. 2 S., R. 9 W. Here in the gulch just opposite the house, there is a very minute seepage of oil from bituminous sandstones which strike northeasterly and dip northwesterly, and a very little asphaltum has formed here, but its quantity is extremely small.

Rice's Cañon is in the southwestern part of Mr. Gird's property, and runs southerly towards the Santa Ana River. Mr. Rice's house in this cañon was blown into small fragments and scattered over five or six acres of ground by the wind during the night of December thirteenth and fourteenth. From half a mile to a mile below where the house stood, thin-bedded and slightly carbonaceous shales are exposed in the hills along the left bank of the cañon. The best exposure, which is also the upper one, is about one hundred feet in length, and shows a thickness of ten or twelve feet of extremely thin-bedded, fine-grained, sandy, and slightly carbonaceous shales, which strike nearly east and west, and dip very gently, perhaps 4° or 5° to the north. These are overlaid by ten or twelve feet more of alternations of shales and sandstones, above which the rocks do not show. The lower shales contain much gypsum, which occurs not only in little bunches and in thin sheets running parallel with and intercalated between the layers of the shales, but also frequently in the nature of little veins, rarely over one fourth of an inch thick, which cut through the stratification at all sorts of angles. There are two or three exposures of the same rocks farther down the cañon, but none of them so good as this one.

Santa Clara County.

About one fourth of a mile westerly from Mr. J. P. Sargent's house, a few miles southwest of Gilroy, there are some tar springs, and a well was sunk in the first part of 1887, about two hundred and fifty feet deep, with no other result than a little sulphur water, a little gas, and a very little thick, black, tarry oil. The tar issues from a bituminous sandstone, much of which is full of fragile fragments of *Turritella* and other shells. But immediately north of the well, and within fifty feet of it, is the outcrop of a heavy body of serpentine. The sand rocks are not well enough exposed to show their strike and dip.

About two miles farther up Tar Spring Creek (barometer at 9:45 A. M. read four hundred feet), there is an area of some three or four acres, which is chiefly covered with asphaltum and very copious seepages of black tar, like those in the Ojai Valley. The rocks here seem to be sandstones and breccias, which are not, however, well enough exposed to show their strike and dip, and are generally covered with adobe soil. I saw here within a radius of fifty feet, the carcasses of one yearling, four calves, and two skunks, which had got stuck in the pitch, and died there.

Afterwards on the other side of the gulch I saw in a pool of pitch the carcass of a one or two-year old colt. There are scattered tar springs for half a mile above here along the gulch. From the head of this gulch we crossed over the hill to Pescadero Creek, down which we came, stopping at the sulphur springs (cold, white) on the way. Mr. Sargent states that about one mile farther up Pescadero Creek than the point where we struck it, there is another bunch of tar springs, not so large as the one we saw, but accompanied by a deposit of asphaltum, which is purer and of better quality. In the gulch, a short distance above the group, which we saw on Tar Spring Creek, very fine-grained and nearly white sandstone strikes about east and west and dips 70° to 90° to the south. Mr. Sargent has a chromic iron mine in Penitencia Gulch, a few miles out and northeast from San José.

In Moody's Gulch, which is a branch of Los Gatos Creek, at Wells Nos. 1 and 2, which are only about one hundred feet apart, the gulch runs about N. 20° E., magnetic. Barometer here read one thousand one hundred feet. At the bridge, a little above here, fine-grained sandstones and shales strike about N. 60° W., and dip about 65° S.W. Within two hundred feet east of this bridge, and seventy-five feet or more above the bed of the gulch, is Well No. 4. About one hundred and fifty feet farther east, and still higher up the hill, is Well No. 5. East of this, and yet higher, is Well No. 8, which is still drilling. On the opposite side of the gulch, and about two hundred feet from it, is Well No. 7. Northwest of No. 7, and some three hundred feet distant from it, is "Logan, No. 1." They are now making preparations to drill "Pyley, No. 1," about three hundred feet S. 20° W. from "Logan, No. 1." Barometer at "Logan, No. 1," at 1:45 P. M., read one thousand three hundred and twenty feet. All the oil obtained here is said to be green oil of about 44° B. It is piped a distance of about one mile from the wells to the railroad station.

The tank to which the oil is piped is at the mouth of Moody's Gulch, right opposite the "Half-way House," kept by Mrs. H. F. Riecke. She says there is much oil around the mouth of the cañon. Also, she has a well at the house, forty feet deep, from which they can not drink the water because of the oil.

Mr. R. C. McPherson, Superintendent and Manager of the oil wells in Moody's Gulch, says that he was the first man who ever drilled a successful deep oil well in California, and that this well was drilled in 1875, in Pico Cañon, Los Angeles County. Exactly which well it was, could not be learned—for some of the wells have changed names; but it was probably one of the three now known as "Pico, No. 1," "Pico, No. 2," or "Pico, No. 3."

Mr. McPherson kindly furnishes the following information concerning the wells in Moody's Gulch, from records kept by him.

"Moody, No. 1," struck oil at about eight hundred feet. No further record of it is available.

"Moody, No. 2" was drilled in October, 1879. It started in slate with streaks of rotten sand. At three hundred and eighty feet, better sand twenty-five feet thick. Afterwards ran in slate and shale, until striking second sand at six hundred and thirty feet, twenty feet thick, with oil all through it. After this, sand very shelly* with streaks of shale and slate. Struck third sand at seven hundred and sixty-five feet. Well began to fill up with oil. Drilled her eight hundred feet. Pumped her here thirty barrels per day.

"Moody, No. 3" was sunk to a depth of one thousand and eighty feet, and showed some oil and gas at that depth; but she then caved in and was lost.

"Moody, No. 4" was sunk in August and September, 1880. Started in shale and soft sand. At two hundred and sixty feet, struck first regular sand thirty feet thick. Afterwards, streaks of slate and shale until reaching second sand forty feet thick at depth of six hundred and eighty-five feet. Then streaks of slate, shale, and shells. Struck "stray sand" twenty feet thick, dark gray in color, at depth of nine hundred and eighty feet, carrying considerable oil. Believe at this depth in this case she would pump ten barrels per day. After this sand, ran through hard shelly formation all the way until reaching third sand at one thousand and forty feet. This sand is first class oil-bearing sand carrying pebbles. On sinking "one screw" (*i. e.*, five feet) into this sand, she began to fill up rapidly, and within twenty-four hours there were three hundred feet of oil in the hole. At one thousand and fifty-five feet, struck more oil which seemed to be increasing very rapidly. At one thousand and seventy-five feet she made her first flow. At one thousand and eighty-five feet she flowed one hundred barrels per day, flowing nearly all the time. From here to one thousand and ninety-five feet, the sand grew finer and harder. Drilled to one thousand one hundred and three feet, still in the same sand. As the well was flowing in such manner, concluded to stop at this depth. Within the first ten days, she flowed one thousand and twenty-five barrels.

"Moody, No. 5." Started in slate. Struck first sand rock, twenty feet thick, at depth of four hundred and sixty-five feet. After this ran in slate and shale till at the depth of six hundred and thirty feet, struck second sand ten feet thick. Then ran in shale to nine hundred and thirty feet, where we struck the third sand fifteen feet thick. The well made two flows. Pumped her for awhile, but she proved a small well, yielding only about ten barrels per day. Concluded to drill her deeper. Went through slate all the way to one thousand four hundred and twenty-five feet. No change. Shut her down, and pumped her at seven hundred and thirty feet, pumping ten barrels per day. No increase by drilling her deeper.

"Moody, No. 6." Showed a little oil at one thousand one hundred and twenty feet. Went one thousand four hundred feet deep, but was never pumped.

"Moody, No. 7." Drilled in 1880. Started in slate. First regular sand twenty feet thick, at two hundred and seventy-five feet. Then ran in shale and slate until striking second sand fifty feet thick at six hundred and twenty-five feet. Afterwards in slate, shale, and shells. At nine hundred and fifty feet struck "stray sand" fifteen feet thick, with some oil in it. After this, very shelly, with shale and streaks of slate. At one thousand and fifty feet, fifteen feet of hard shells run into twelve feet of slate. Afterwards shell and sand. More sand, with oil and gas. At one thousand

*I may as well state here that I do not know exactly what is meant by the word "shelly" in this connection. I do not think it always means a rock containing shells. I suspect that it relates to the structure of the rock, and that *shaly* might be a better word. G.

and ninety feet, better sand with more oil. At one thousand one hundred feet, well began to fill up with oil. At one thousand one hundred and twenty-five feet, pumped her thirty barrels per day. Afterwards drilled her to one thousand two hundred feet, and increased her at that depth to forty barrels.

"Logan, No. 1." A twelve-inch hole. Drilled in 1880. Started in slate and sand. Struck first sand twenty feet thick at two hundred and eighty feet. Then slate and shales to second sand, thirty feet thick, at six hundred and fifty feet. Then shale and shells mixed. At eight hundred and eighty-five feet, "stray sand" with some oil and gas. Afterwards more shells with streaks of sand. At nine hundred and fifty feet, more sand and better. At nine hundred and eighty feet, well filling with oil. Two hundred feet of oil in her. At one thousand feet, filled with oil. Put tubing in and pumped fifteen barrels per day. Drilled her to one thousand one hundred feet and increased her some. Sand all the way.

It should be stated here that the foregoing information so kindly furnished by Mr. McPherson regarding the Moody's Gulch wells was not written by him, but by some one in his employ, and whom he trusts. The whole thing is copied almost *verbatim* from the notes which Mr. McPherson furnished. It is evident enough from the terms and phraseology employed, especially those of the "first," "second," "stray," and "third" sands, so frequently used, that the writer is a man who is familiar with oil wells in the East, and whether he knows anything of the geology of California or not (a question which I will not discuss here), the facts which he gives are very valuable, and ought to be placed on record. It is rare that so full a record as this is obtainable of any wells yet drilled in California.

Under date of December 19, 1887, Mr. McPherson states that the well called "Pyley, No. 1," is now three hundred and eighty feet deep. It first passed through seventy-three feet of "rotten rock," and then through sandstone to a depth of one hundred and eighty feet, where a band of slate two feet thick was found; then soft sandstone to the depth of two hundred and twenty feet; then two feet more of slate, and then sandstone to the bottom, the last ten feet of sandstone being very hard. The well already yields some gas and a little oil.

Santa Cruz County.

Mr. I. L. Thurber's bituminous sand rock quarry, about five miles N. 75° W. from Santa Cruz, was visited August twenty-third. Barometer here at 4:30 P. M. read one thousand and seventy feet.

There is here a body of bituminous rock ten feet or so in thickness, underlaid by a moderately coarse-grained, clean, soft, quartz sandstone. The hill rises about one hundred feet to the southeast above the quarry, and no one yet knows how heavy the mass of bituminous rock may be. It lies nearly horizontal, but dips very slightly to the south. The sand of which this rock is made is chiefly quartz, like that of all the other bituminous rock yet seen in Southern California. Barometer on top of hill read one thousand one hundred and fifty feet. Rock on top of hill is a very fine-grained, white, clayey sandstone. At a point where the bituminous rock is opened up a little farther west, it shows a thickness of twenty to twenty-five feet of good material; and there are strong indications that farther back in the hill it is much thicker still. At a point about three and one half miles northwest of town, Mr. P. T. Stribbling has a gold quartz mine on the Rancho "El Refugio," near the Ben Lomond road. Here there is a shaft some twenty or twenty-five feet deep, exposing an irregular body of quartz, in places two or three feet thick, which, in the pan, prospects richly in rather coarse gold. The country rock is a rather coarse-grained quartz sandstone, considerably metamorphosed, and containing some mica.

San Diego County.

Small prospects of petroleum and asphaltum are reported to have been found at various localities near the coast. But so far as known, no discoveries of this kind have yet been made in San Diego County which give any reasonable promise of becoming commercially valuable.

San Luis Obispo County.

From Santa Barbara the writer came by steamer August ninth to Port Harford, not stopping at this time to examine several localities where large quantities of asphaltum are said to exist in the northern part of Santa Barbara and the southern part of San Luis Obispo Counties.

At and in the immediate vicinity of Port Harford there are extensive bodies of serpentine.

At a point near the railroad in the valley of San Luis Creek, about six miles south of San Luis Obispo, and half a mile or so in an air line from the seashore, a well has recently been drilled by Judge Frank Adams and Dr. G. B. Nicholls, to a depth of nine hundred and twenty-eight feet, in quest of oil. But oil they did not get. They did, however, strike a fine flow of warm sulphur water (temperature, 103° F.); so they have built bathhouses and a hotel, and intend making a sanitarium and pleasure resort of it. Considerable hydrocarbon gas accompanies the sulphur water, which is said to have been first struck at the depth of about six hundred feet. There is an old tunnel in the gulch here above the well, which, however, never produced anything of value. The aneroid at the mouth of this tunnel read two hundred and thirty feet, while on top of the hill a short distance to the south, it read six hundred and ninety feet.

From here we traveled several miles around the ocean beach and through the hills in a general easterly direction; saw two or three little tar springs at different points in the more or less bituminous sandstones, and at last reached the great deposit of bituminous sandstone now being worked by Messrs. Adams and Nicholls on the "Rancho El Pismo," about seven miles southeast of San Luis Obispo.

Here the rocks strike about east and west, and dip about 40° toward the south. The sand and grit of which they are made up are chiefly quartz of various colors, and the different strata vary in character from extremely fine-grained sandstones to a somewhat coarse grit, which is filled with very smoothly water-worn little quartz pebbles, the largest of which are about half an inch in diameter.

Great quantities of all these rocks at this locality are saturated with bitumen. There are, it is true, places where the rock is free from bitumen, and other places where the percentage which it contains is small. But the greater portion of it, where the quarry has been opened, is about as full of bitumen as it can hold, and the quantity easily available here is practically inexhaustible. A short sidetrack from the Pacific Coast Railroad runs directly to the quarry. The latter, at the time of our visit (August eleventh), presented a face thirty to forty feet high and one hundred feet or more in length. Blasting is required, and the quarrying is at times not altogether a safe business; for the rock is extremely tough, and a heavy shot often shatters much more than it actually throws down, and in such a case the shattered portions will continue to cling for awhile to the face of the cliff, though slowly and gradually pulling themselves away from it all the time, till they at last drop suddenly and without warning, sometimes in blocks of many tons at a time. They are now shipping this rock both to Los Angeles and San Francisco for street pavements, for which it seems to be admirably adapted. The present cost of freight to either Los Angeles or San Francisco is about $6 per ton. And the contract price, which they receive for street pavement laid in the City of Los Angeles, is 25½ cents per square foot, the contractors agreeing to keep the pavement in order for five years without further cost to the city. Casts of several fossil species of marine shells are not unfrequently found in the richest bituminous rocks of this quarry.

At a point about three quarters of a mile S. 53° E. from Messrs. Adams & Nicholls' quarry, there is another large deposit of bituminous sandstone, very heavy-bedded, but which seems to strike about N. 65° W. and dip some 40° to the northeast. This locality is called "Oak Park." It is owned by Captain C. B. Johnson and L. M. Warden, and is on the "Corral de Piedra" ranch. It is close alongside the railroad and close to the foot of a high peak, with a nearly vertical bluff which faces the southeast and which seems to consist of similar sandstones and grits, striking and dipping in about the same directions, and almost all of them more or less bituminous. But very little work has yet been done at this locality, and the exposures are not so good as might be desired.

Mr. J. J. Schiefferly also has a ranch of one thousand three hundred and forty-four acres, about one mile westerly from Adams & Nicholls' quarry, where the hills are, most of them, full of bituminous sand rock. There is probably enough of this material within an area of a few square miles in this vicinity to pave all the cities of the United States. There is also on Mr. Schiefferly's ranch a large quantity of infusorial siliceous rock, which strikes N. 76° W., magnetic, and dips 45° southwesterly. A piece of this rock presented to the Bureau by Mr. Schiefferly effervesces with acid, and therefore probably contains some lime. The block measures twenty-eight inches by twelve inches by six and one half inches, and weighs ninety-three pounds. Its specific gravity is therefore about 1.188. Mr. Schneider found in it, under the microscope, some diatoms and some spiculæ of sponges.

Mr. H. C. Hobson, of San Luis Obispo, states that there are also great quantities of infusorial silica near the residence of Don Juan Arianos, not far from the coast, on the old "Coast Road," between Point Sal and Los Alamos.

Mr. A. B. Hasbrouck, whose Post Office address is "Music, San Luis Obispo County," owns a ranch called "Ranchito" in the Santa Lucia Range of mountains, about twenty-two miles southeast of the city of San Luis Obispo and on the headwaters of the Arroyo Grande. He states that on his place there are large quantities of asphaltum, with some petroleum springs and much sulphur water. Some of the sulphur springs are warm and some are cold. He also states that the so called "onyx" locality is about twenty-seven miles southeast of town. This material, some of which is very handsome, is, however, not "onyx," but arragonite. Some cinnabar is also reported to have been found there, and there are said to be large quantities of the great fossil oyster, "*Ostrea Titan*," together with *Pectens* and numerous other fossil shells. But this locality was not visited for lack of time.

Don Luis Flores lives on the southern flank of the Santa Lucia Range of mountains, about one thousand six hundred and fifty feet above the sea and at a distance of about four miles in an air line, or six and one half miles by the wagon road, N. 30° W. from San Luis Obispo. On first striking the hills we find a broad belt of serpentine, then calcareous rocks and shales with geodes of chalcedony and jaspery quartz, etc.; then some sandstones, and then another belt of serpentine, in which some chromic iron occurs. I went northerly from Flores' house to the summit of the Santa Lucia Range, which is here about two thousand five hundred feet high, thence easterly for some distance along the crest, and afterwards down around the southern flank of the range, back to the house. The whole top of the range here is serpentine. Small quantities of chromic iron were seen in many places, but no very large body anywhere. At the "Pick and Shovel" mine, however, a tunnel has been driven about five hundred feet into the hill, and struck, near its face, a body of ore from which a considerable quantity (it is said two thousand to three thousand tons) has been shipped. This region is about the head of "El Chorro" Creek.

The porphyry of which the Court House steps in San Luis Obispo are made, is a good and durable building stone. It came from Charles Lee's ranch, at the foot of the "Picacho de Romualdo," about four miles N. 75° W. from the city. Course from here to Don Luis Flores' place about N. 10° E., magnetic. The whole mass of the Picacho de Romualdo consists of the same kind of rock. It is several hundred feet high, and is a very sharp cone. It is about one and one half miles westerly from "Obispo" Peak. "San Luis" Peak is east of "Obispo" Peak, and between it and the city of San Luis Obispo. All these peaks consist of the same kind of porphyritic rock. "El Moro" also probably belongs to the same eruptive group which comprises all these conical hills running from "El Moro" southeasterly for many miles through the valley, to and beyond San Luis Obispo, including "Romualdo," "Obispo," "San Luis," "Buena Vista," and other hills.

Took aneroid barometer readings on stage trip from San Luis Obispo to Templeton, as follows:

At San Luis Obispo	310 feet.
At El Salto	700 feet.
At Summit	1,540 feet.
At Bean's	1,280 feet.
At Pat Murphy's ranch	1,080 feet.
At watering place	1,000 feet.
At Templeton	910 feet.
At Paso Robles	850 feet.

The warm sulphur springs at Paso Robles are said to discharge about four thousand five hundred gallons per hour.

San Mateo County.

September twelfth, took stage from San Mateo to Spanishtown and Pescadero. On the road going down the hill from the summit into the cañon of Pilarcitos Creek toward Spanishtown, there is a large body of rather soft, decomposed granite.

Distances on the road are stated as follows:

From San Mateo to Spanishtown	14 miles.
Thence to Purissima	4 miles.
Thence to Lobitas	2 miles.
Thence to Tuñitas Creek	1 mile.
Thence to San Gregorio	5 miles.
Thence to Pescadero	7 miles.
Total	33 miles.

Reached Pescadero at 4:15 P. M.

Part of the way along the coast are broad benches of recent strata lying nearly horizontal, and ending in precipitous bluffs on the beach. Between San Gregorio and Pescadero the road runs over the hills a mile or so back from the shore; and there are many exposures here of partially metamorphosed shales and blocky sandstones, which in places are more or less broken up and crushed, and sometimes dip northwest or north, though their prevailing dip seems to be northeasterly towards the axis of the range. The angle of the dip generally ranges from 30° to 50°.

On Tuñitas Creek, about two miles east of Lobitas, four wells have been sunk to different depths. No. 3 is lowest down the creek. It was commenced in June or July, 1885, and finished in September, 1886, to a depth of about eight hundred feet. When it was about three hundred and fifty feet deep, they pumped for awhile from it about two and a half barrels per day of a dark green oil, with gravity 49° or 50° B.

No. 1 is just above No. 3. It is about five years old, and is nearly six hundred feet deep. When it was first sunk they used to bail from three to five barrels per day from it.

No. 2 is a little farther up the cañon than No. 1. It was sunk about four years ago, and is a little over five hundred feet deep. It showed some oil, but never yielded much. All three wells are within a distance of one hundred and fifty or two hundred feet. They are all of them idle now. The rocks sunk through were soft shales, with an occasional little streak of sandstone, but no large body of it.

About half a mile above here there is another well, sunk about three years ago by Messrs. Bodwell & Dewey, of San Francisco, to a depth of about six hundred feet. This well is said to have shown a little oil, though it was substantially a dry hole. The above information is from Mr. David White, who lives at the wells. Barometer at his house, one hundred and thirty feet. The property is in litigation and nothing has been done here now since last May. Just above Well No. 1, very soft clay shales strike about N. 50° W. and dip about 35° S.W. These wells furnished considerable gas, about enough to make the requisite steam for pumping. It was also used for domestic purposes in the house. About one hundred yards below the wells there is a small white sulphur spring coming out of a somewhat hard clay-rock which strikes N. 55° W. and dips 30° S.W.

About one quarter of a mile below the wells, and just below the bridge which here spans the creek, there are in the bluff fossil clams which seem to be identical with a species now living on the coast. About one quarter of a mile above the wells there is also another locality where they are plenty; and a few of them may be found here and there all the way between.

On Purissima Creek, about one mile from the village of the same name, a well has been sunk, with a five and five-eighths inch casing, to a depth of seven hundred and seventy-two feet. Struck first oil at two hundred and forty feet. The well was begun in April, 1884, and sunk five hundred and seventy feet, at which depth it remained for awhile, but was afterwards sunk two hundred feet deeper. It has been standing idle now since

October, 1885. The largest yield when pumping was about four or five barrels per day. They have pumped, however, but very little. There is a two hundred and sixty-five-barrel tank here. While sinking the last two hundred feet, they used to take out about two barrels of oil with the sand-pump each morning, which sufficed to run the engine through the day. This is known as "Lane's Well." The oil is of about the quality as that in Tuñitas Cañon. It is said that over $10,000 were expended here. There is no asphaltum here, but there are slight seepages of oil along the creek. The rocks do not show on the surface, but Mr. Schurtz states that they consist of shales of varying hardness, though generally rather soft, and that they dip to the southeast or south. There are sulphur springs also in this cañon, both below and above the oil well. All of them are cold. They struck some fossil clam shells in this well itself, at the depth of about two hundred and forty feet. William Schneider, 1230 Mission Street, San Francisco, is the man who drilled this well, and he is said to have a record of it. The clams are the only fossils that Mr. Schurtz knows anything about in this cañon. Some fossil bones of whales and large land animals are said to have been found in Tuñitas Cañon. Mr. H. Dobbel says that at a point about three miles south of Spanishtown, and only some three hundred or four hundred feet back from the seabeach, David Gottmann, of San Francisco, about two years ago sunk two wells, one about six hundred feet deep, and the other about three hundred feet deep, but found nothing of any value, though some oil oozes out all the time at various points along the beach.

Ventura County.

The oil region of Ventura County lies in the mountains to the north of Santa Clara River, and stretches from about the eastern boundary of the county westerly as far as the San Buenaventura River. The wells are mostly situated from three to six miles north of the edge of the Santa Clara Valley, in and about a series of cañons which run southerly to the Santa Clara River. The names of these cañons in order, from east to west, are as follows: Piru Cañon, Hopper Cañon, Sespe Cañon, Santa Paula Cañon, Adams Cañon, Saltmarsh Cañon (a branch of Adams Cañon), Wheeler Cañon, West Wheeler Cañon (a branch of Wheeler Cañon), Sulphur Cañon (a branch of the Cañada Larga), Coche Cañon (a branch of the Cañada Larga). There are also a few wells in the Ojai Valley.

Westerly from Santa Paula Creek, between the Ojai Valley on the north and the Santa Clara Valley on the south, there extends an unbroken mountain ridge whose highest crest is about two thousand feet above the sea, as far west as the San Buenaventura River. This ridge is called "Sulphur Mountain," and all the cañons above named to the west of Santa Paula Cañon lie on the southern flank of Sulphur Mountain.

This region was carefully examined, and in describing it the various cañons will be taken in order as above from east to west, beginning with the most easterly one.

PIRU CAÑON.

From Camulos Station it is about two miles westerly to the mouth of Piru Cañon at the railroad bridge. From there it is about two miles northerly up Piru Cañon to the mouth of Bréa Cañon, and thence about two miles westerly up Bréa Cañon to the well of Messrs. Rhodes & Baker, which is situated in the latter cañon close to the head of it.

There is here exposed a well defined, sharp anticlinal fold in the rocks, whose axis runs about N. 77° E., magnetic. On either side of this axis the rocks dip north and south at angles of 45° to 50°.

The well is about two hundred and fifty feet north of the anticlinal axis, and is now (July twelfth) seven hundred and fifteen feet deep. It is in sand rock all the way down. At the depth of three hundred and thirty feet they struck water with a little oil, which continued down to the depth of five hundred feet; below which, to the present bottom of the well, they have had dry sand rock, with neither water nor oil. The water contains some salt, and probably also some sulphur. They have stopped drilling this well for awhile, because their water supply for the engine gave out. There is a moderate quantity of gas in the water from this well.

From two hundred to three hundred feet south of the well, *i. e.*, about on the line of the anticlinal axis, there is an extensive deposit of asphaltum mixed with surface sand, and numerous little springs of black maltha scattered over perhaps an acre of ground. The oil from the well is dark brown in color.

This is said to be the only well in or about Piru Cañon. And certain it is that in the Piru Cañon itself the visible surface indications of bituminous matters are very slight.

In Bréa Cañon, about half a mile below the well, there is a strong sulphur spring; and a short distance farther down there are two or three small patches of asphaltum, and one place where a little liquid petroleum issues from the bank a little above the road.

Next west of Piru Cañon comes—

HOPPER CAÑON.

At the mouth of Hopper Cañon, not far from Buckhorn Station on the railroad, a well was drilled in 1877, by M. W. Beardsley, to a depth of three hundred feet. Except about ten feet of surface gravel, this well was in solid sandstone all the way down. Water was struck, with some light oil, at about one hundred and fifty feet. The well was sunk to this depth by contract, and the work was then stopped because the company had no further funds with which to go deeper. Mr. Hugh Waring states that Mr. Beardsley afterwards said to him that if, even at that depth, the water had been cased off, and the well pumped, it would probably have yielded three or four barrels per day of light green oil. From this well, in an air line, a little east of north, to the other wells in this cañon, is about one and one half miles; but, following the windings of the cañon, it is probably at least two and one half. Here are two wells about two hundred feet apart. The lower one is ninety feet deep, and was abandoned because the hole became irretrievably crooked. There was here a good deal of heavy black oil. The other well is a new one just started, and is now (July fourteenth), only thirty feet deep; yet they have a little heavy black oil on the tools even now.

All the way from here down to the mouth of the cañon there is liquid oil floating on top of the water in the creek. Some of it is green, and some of it is black. The aggregate quantity of oil which thus oozes out and floats away on the water is of course not large, nevertheless it is greater in this cañon than in any other cañon yet seen in Southern California.

The general rule as to the strike of the rocks in this vicinity seems to be that it lies somewhere between east and west, and northeast and southwest; yet it often goes outside these limits in both directions. As to the dip, it is impossible to describe it better than by saying that at different points it is in both directions and at all possible angles.

In fact, the heavy masses of unaltered sandstones and thin-bedded shales are everywhere crushed and thrown into short, sharp folds, with frequent breaks and faults, like masses of crumpled and torn paper, and the confusion is indescribable. Sulphur springs are numerous, and close by the upper wells there is a nice soda spring in the right hand edge of the bed of the cañon.

Rhodes & Baker's well, above described, in Bréa Cañon, is nearly due east from here, and distant in an air line over the hills only about one and one half miles.

About two and one half miles farther up Hopper Cañon there is said to be a large deposit of asphaltum and also a considerable discharge of heavy black petroleum. In an air line, the distance, a little east of north, would be only about one and one half miles. The air-line distance westerly across the hills to the Sespe Cañon is said to be about three miles.

The old well at the mouth of Hopper Cañon is on the S.E. ¼ of Sec. 23., and the two upper wells are on the N.W. ¼ of Sec. 13, T. 4 N., R. 19 W., S. B. M.

Waring's house is perhaps one fourth of a mile east of the mouth of Hopper Cañon.

About opposite Waring's house, in the hills on the south side of the Santa Clara Valley, on the Simi Ranch, and on the northern slopes of the San Fernando Range of mountains, there is a large deposit of asphaltum, together with extensive outflows of liquid petroleum, where some years ago a man gathered for awhile about ten barrels of oil per day. Oil men believed that, with the expenditure of a moderate amount of labor, a surface flow of forty barrels per day could be obtained there. This information is from Mr. Hugh Waring, who further states that this is the most westerly point where asphaltum is found in the San Fernando Range. He also says that east of there, in the hills somewhere to the south of Camulos, he has seen cattle mired and dead in pools of viscid and muddy maltha.

SESPE CAÑON.

Sespe Creek, occupying the cañon next west of Hopper Cañon, is the largest and longest northern branch of the Santa Clara River in Ventura County. It heads far back in the mountains, to the north of the Ojai Valley, and at first flows nearly east for a number of miles, passing entirely around the head branches of Santa Paula Cañon and then curves around so that its general direction for the last ten or twelve miles of its course in the mountains is nearly south. The mouth of the cañon is something like ten miles east of the town of Santa Paula. "Tar Creek" and the "Little Sespe" are two different branches of the main Sespe Cañon, both of them coming in from the east, the mouth of Tar Creek being several miles above that of the Little Sespe. The latter is a short cañon, not more than four or five miles in length, but Tar Creek is a longer stream, and heads in the extremely rough region to the north of the head of Hopper Cañon.

From Santa Paula, by a good wagon road, to the mouth of Little Sespe Cañon, the distance is called fifteen miles. Then, up the Little Sespe itself to the locality of the old "Los Angeles Wells," is a distance of two or three miles, and from there to the new wells, on the upper branches of "Tar Creek," is some five or six miles more over a rough country, and a mountain road which, though built for wagons, nevertheless has, for considerable distances, grades which exceed *one foot in four*.

These new wells were visited July twenty-fourth. On that date the aneroid barometer at the wells, at 11 A. M., read two thousand three hundred and seventy feet above the sea.

Near the mouth of the main Sespe Cañon one small oil spring occurs in the bed of the cañon. In the "Little Sespe" there is a nice little stream of water and occasional small oil springs and seepages.

The rocks in the lower part of the "Little Sespe" are chiefly dark brown sandstone and shales. Some of the sandstones are heavy-bedded, and would probably make a good building stone. The strata about the mouth of the Little Sespe strike and dip in various directions, the dip being generally steep and sometimes nearly vertical. Heavy bodies of them dip to the north 30° to 40°; others dip 40° to 70°, or more, to the southeast, etc.

About one quarter of a mile north of the mouth of the Little Sespe, in the main Sespe Cañon, a well was once sunk, called the "Kentuck," which is said to have been about three hundred feet deep, and to have yielded some three or four barrels per day of heavy oil. But it has been abandoned.

In the "Little Sespe" are the so called "Los Angeles" wells, of which there are two. One of these is about one thousand five hundred feet deep, and is said to have at first yielded for some time about one hundred and fifty barrels per day. But about the year 1882, in the course of a "freeze out" game amongst the owners, while still yielding some forty barrels per day, it was maliciously plugged by somebody, and thus ruined. The other one went down about two hundred feet, when the hole became crooked. A second hole was then started close alongside of it, which went down to about the same depth, when it also became crooked, and was abandoned.

The present wells of the "Sespe Oil Company" are scattered about the upper branches of Tar Creek, which runs in a general westerly direction for several miles to the main Sespe. Of these branches "Oil Creek" and "Irelan Creek" are the most important.

Well No. 1 is on the right bank of the main Tar Creek. It was begun January 26, 1887, and finished February 12, 1887; is one hundred and ninety-six feet deep, and pumps about forty barrels per day of a very dark colored greenish-brown oil. This well was in sandstone all the way down. The water was shut off at eighty-two feet. It did not flow from the mouth of the well, but would have pumped about two hundred barrels of water per day. This well first started off at about one hundred barrels of oil per day, but afterwards fell off to about forty barrels, its present yield.

Nos. 1, 2, and 4 are all nearly in a straight line, which runs about N. 20° W., magnetic.

No. 2 is about three hundred feet southeasterly from No. 1. It was drilled in April, 1887, and is two hundred and six feet deep. It first started off at about one hundred and fifty barrels per day, but afterwards fell off, and flows at this date (July twenty-fifth) about seventy-five barrels per day of dark green oil. It also produces considerable gas. The water and strata were about the same as in No. 1.

No. 4 is probably one thousand two hundred feet northwesterly from No. 1, and is a new well for which they are now sinking the "conductor hole," and have not yet begun drilling.

No. 5 is on Oil Creek, about a quarter of a mile southerly from No. 2. Here, also, they have as yet only sunk the "conductor hole," and have not begun drilling.

No. 3 is about a quarter of a mile still further south. It is now down about five hundred feet, without any valuable quantity of oil, and they are still drilling.

No. 6 is located some five hundred feet easterly from No. 1. Here the grading has been done and a few of the timbers are on the ground, but the derrick has not yet been erected.

All the foregoing statements concerning these wells refer to their condition at the time of our visit, viz.: July 25, 1887. But, under date of September 26, 1887, Mr. W. L. Hardison gives me the following information:

Sespe No. 2 has lately been pumping instead of flowing. It began to pump about August first at the rate of two hundred and twenty-five barrels per day, and is now pumping about one hundred and forty barrels per day.

No. 4 is now about four hundred feet deep and pumping twenty-five barrels per day.

Nos. 3 and 5 both went down about seven hundred feet, were both drilled entirely through the sandstone into a red rock which here underlies it, and are both dry holes.

The gravity of the oil from these Sespe wells is said to be 34° or 35° B.

There are no wells yet on Irelan Creek. But this creek forks into four or five different branches, in all of which there are patches of asphaltum and numerous tar seepages, and at the time of our visit they were building roads in there preparatory to sinking wells.

This region is an extremely rough one, the hills being very steep and generally covered with dense chaparral.

The prevailing strike of the rocks, where exposed in the vicinity of the wells, is about N. 70° W., magnetic, and their dip to the northeast from 30° to 40°. But in the surrounding higher mountains the strike and dip seem to vary considerably. In the high ridge a mile or two east of the wells, the rocks seem to dip 20° to 30°, in a direction about E.N.E.

The rocks are sandstones and shales, with occasional bands of limestone, and there are many localities where they contain fossil shells of *Pecten*, *Turritella*, etc. But these are generally very fragile, and it is difficult to get good specimens.

SANTA PAULA CAÑON.

This cañon was formerly called "Mupu Cañon." The group of wells which it contains are called the "Scott" wells, and are situated in a little branch on the west side of the main cañon, about four and one half or five miles from the town of Santa Paula. They are from three to ten years old. There were eleven or twelve of them in all, some five or six of which only are now producing an aggregate of about eleven barrels per day. They range from two hundred to one thousand feet deep. The oil is black.

ADAMS CAÑON.

From the Scott wells southwesterly over the hill to the nearest wells in Adams Cañon is a distance of about half a mile.

The Adams Cañon wells are about the head of the cañon, and most of them strung along a very narrow belt about three quarters of a mile long, which runs about northeast and southwest along the southern foot of Sulphur Mountain.

There is considerable asphaltum on the surface of the ground in Adams Cañon. The largest patch covers probably one or two acres of ground and contains numerous little springs of black maltha.

Adams Well, No. 1, was drilled as early as 1875, directly in this bed of asphaltum, to a depth of only one hundred and eighty feet. For ten years or more it produced from twenty to twenty-five barrels per day, till Well

No. 3 was drilled within one hundred and fifty feet of it, which tapped it and stopped its production.

No. 2 is about two hundred feet south of No. 1. It is two hundred feet deep and is a dry hole.

No. 3 was drilled in 1885. It is two hundred feet deep, and now produces about ten barrels per day.

No. 4 is one thousand feet east of No. 1, is five hundred feet deep, and is a small well, yielding three or four barrels per day.

No. 5 is about four hundred feet east of No. 4, is eight hundred and fifty feet deep, and is a dry hole.

No. 6 is about one hundred and fifty feet south of No. 5, is two hundred and fifty feet deep, and produces two or three barrels per day.

No. 7 is about one thousand feet south of No. 1, was drilled in April, 1886, struck oil at two hundred and forty feet, and went three hundred and ninety feet. This well at first *flowed* seventy-five barrels per day. It now pumps about fifty barrels per day. There was no water at all in this well. The gravity of its oil is 28½° B.

No. 8—also called "Wild Bill"—was begun June 3, 1886, and struck no water at all from top to bottom. Struck oil at four hundred and twenty feet, about twenty barrels per day. Second streak of oil at seven hundred and thirty-five feet. Total depth of well, eight hundred and forty feet. It started off when finished, June 29, 1886, pumping one hundred and twenty-five barrels per day, and still keeps up the same production. Gravity of oil, 28½° B. This well is one thousand five hundred feet south of No. 7.

No. 9 is some two thousand five hundred to three thousand feet northwest of No. 8, was drilled in July and August, 1886, and struck water at one hundred and fifty-five feet. Shut the water off down to one hundred and seventy-five feet. Struck heavy oil at three hundred and seventy feet capable of yielding three barrels per day. Shut that off at four hundred and fifty-four feet with a five and five eighths inches casing. Total depth of hole, one thousand two hundred and sixty-one feet. No other oil struck.

No. 10 is about one thousand feet southeasterly from No. 9, is about six hundred and twenty-five feet deep, and gave water but no oil.

No. 11 is about eight hundred feet south of No. 7. It was drilled in April, May, and June, 1887, and is one thousand four hundred and ninety-four and one half feet deep, and is a dry hole. It is somewhat remarkable that this well, which is almost in the same straight line with the very productive wells Nos. 7 and 8, and just about half way between them, and much deeper than either of them, is nevertheless a dry hole.

No. 12 is a new well just finished, and is not yet (July twenty-ninth), producing any oil. It is four hundred and forty feet deep, and they did not get the water shut off.

No. 13 is four hundred and twenty-five feet west of No. 7; is still drilling, and now down (July twenty-ninth), five hundred feet. The water is shut off at one hundred and fifty-five feet, with eight and five eighths inches casing.

About one thousand eight hundred feet northwesterly from No. 1, and some four hundred or five hundred feet higher up on the flank of Sulphur Mountain, there is another well, drilled by Benj. W. Feldt, in 1879, to the depth of one hundred and eighty-one feet. This well now produces about five or six barrels per day of oil of about 27° B. Mr. Feldt tells me that it first started out with a production of forty-two barrels per day, which it continued for three months or more, after which it gradually fell off during a year or more till it finally reached its present production, which it has since maintained. It is a curious fact that the oil from this well, heavy as it is, is nevertheless of a light *apple-green* color. It is the lightest colored oil yet seen anywhere in Southern California. Most of the green oils are dark in color, rarely lighter than olive-green, and ranging from that through still darker shades of green and brown to black.

At Well No. 1, in Adams Cañon, the barometer read one thousand and thirty feet.

Along the belt where most of the wells in this cañon are located, the rocks are very rarely visible. But at one point in the gulch just below the largest asphaltum bed, sandstones and shales can be found, which strike northeast and dip northwest.

All along the southern flank of Sulphur Mountain, however, the rocks, consisting of alternating sandstones and shales, with occasionally some coarser grits intercalated, are well exposed, and around the head of Adams Cañon they strike about northeast, and dip about 70° to the northwest. They are here much less broken and distorted than is usual in the oil regions of California. A mile south of here, however, the rocks show again, and there the dip is southeasterly, and still further south for some five or six miles, all the way to the mouth of the cañon, it continues to be so. There is, therefore, a sharp anticlinal somewhere in this region, and the oil wells are mostly on the northwest side of it; while it seems not improbable that the chief beds of asphaltum and tar springs may be very nearly along the line of its axis; though the exposures are not sufficient to determine this with certainty.

Mr. Harvey Hardison states that the general average cost of drilling all the wells hitherto in Adams Cañon, has been about $10 per foot.

The following is a tabular résumé of the wells in Adams Cañon up to July 29, 1887:

Name of Well.	When Drilled.	Depth in Feet.	Product in Barrels per day.
No. 1	1875, or earlier	180	0
No. 2		200	0
No. 3	1885	200	10
No. 4		500	3
No. 5		850	0
No. 6		200	3
No. 7	April, 1886	390	50
No. 8, or "Wild Bill"	June, 1886	735	125
No. 9	July and August, 1886	1,261	0
No. 10		625	0
No. 11	April, May, and June, 1887	1,494½	0
No. 12	July, 1887	440	0
No. 13 (still drilling)	July, 1887	500	
Green Oil Well	1879, or earlier	181	6
			197

Under date of September 26, 1887, Mr. W. L. Hardison furnishes the following additional information:

No. 12 has now been pumped a little, but not much. On the first pumping it yielded thirty barrels.

No. 13 went down about six hundred and fifty feet, and then began producing about August tenth, at the rate of one hundred and seventy-five barrels per day, and is now pumping about one hundred and fifty barrels per day.

No. 14 has been drilled three hundred feet deep; about two hundred feet north of No. 1; was finished about August twenty-fifth, and is said to be pumping about fifty barrels per day.

No. 15 has also been started about five hundred feet northeast of No. 14; is now down about three hundred feet, and is still drilling.

SALTMARSH CAÑON.

This cañon, named after John Saltmarsh, is a branch of Adams Cañon coming in from the west. It has some oil in it, but is not now producing. At the head of the cañon there is some natural seepage, and here also is a tunnel said to be five hundred feet long, which is closed up and inaccessible now, but from which a little oil and water flows. There is not, however, enough of the oil to be of any value. Next west of Saltmarsh Cañon, comes the

WHEELER CAÑON.

The asphaltum deposits and seepages of maltha all around the head of Wheeler Cañon are numerous and extensive. The rocks here all strike nearly east and west, and dip to the north. Some of them consist of exceedingly fine-grained and thin-bedded sandy shales, which split almost like roofing slate.

Three wells have been sunk to various depths in this cañon; but none of them are now producing anything. No. 1 is high up on the southern flank of Sulphur Mountain. It was drilled in January, 1887, and is five hundred and fifteen feet deep. They had water with some oil in it all the way down; but did not get the water shut off, and the quantity of oil was small.

The other two wells are farther down the cañon, and no details were gathered concerning them.

An old tunnel driven into the flank of Sulphur Mountain, about on a level with the mouth of Well No. 1, furnishes a stream of, perhaps, one miner's inch of water, which is saturated with sulphuretted hydrogen, and contains a little oil, but nothing of any value. A little higher up the mountain, another old tunnel is five hundred and seventy-five feet long, and produces nothing.

Lower down the cañon they are now driving another tunnel which will tap Well No. 1 at a depth of two hundred and fifty feet, and will be about six hundred and fifty feet long. It was on July twenty-sixth about three hundred feet long, and was then producing about twelve barrels of oil per day. But Mr. Hardison states, on September twenty-sixth, that it is now in about five hundred feet, and is producing sixty barrels per day. There is also a tunnel in West Wheeler Cañon about three hundred and fifty feet long, yielding about four barrels per day of light green oil.

Six or seven miles west of Wheeler Cañon is Sulphur Cañon, a branch of the Cañada Larga, which latter stream runs westerly to the San Buenaventūra River. Following up Sulphur Cañon a distance of some three or four miles from its mouth, we find near the head of the cañon some asphaltum with seepages of dark green oil. A tunnel was driven here forty-seven feet long. A tank was also built and a little oil saved, but not much. In the immediate vicinity of this asphaltum bed there are very extensive deposits of calcareous tufa, and at one locality in the tufa there is a considerable body of impure native sulphur, which was mined to some extent a number of years ago, though not with profit. Several strong sulphur springs also still exist here. The locality is about twelve miles by wagon road from the city of San Buenaventura, and is about one thousand two hundred feet above the sea. The sandstones and shales here strike northeasterly and dip northwesterly, but they are in some places much disturbed.

One or two miles west from here is Coche Cañon, also a branch of the Cañada Larga, in which three wells have been drilled for oil. The upper one is nine hundred and eighty feet deep, and produced nothing but a small quantity of sulphur water, which still flows from it.

The next well is one hundred and twenty-five feet deep, and furnishes some oil of good quality mixed with a large quantity of sulphur water which flows.

The third well is something over two hundred feet deep, and is tapped at a depth of about forty feet by a tunnel two hundred and fifty feet long, from which a little oil mixed with a good deal of sulphur water flows. Some horizontal holes, from forty to sixty feet long, have also been drilled in this cañon without much result. The present total product of the cañon is about two barrels per day of a dark colored and rather heavy lubricating oil. The barometer at the highest well here read one thousand two hundred and fifty feet. At the tank, it read nine hundred and sixty feet. The rocks here generally strike about N. 25° or 30° E., and stand nearly vertical, though in places they are much crushed and broken. Many of the shales are exceedingly thin-bedded.

Coyote Cañon, a branch of the San Buenaventura River, drains the Lower Ojai Valley, and the locality called "Pinafore" is in a little cañon coming in on the left of Coyote Cañon, *i. e.*, from the southeast, out of the west end of Sulphur Mountain. A well was once drilled here, but it is for all practical purposes a dry hole, though it even yet flows a very little water mixed with a very little oil and gas. Two tunnels were also driven here; one two hundred and twenty-five feet long, and the other one hundred and seventy-five feet long. From the latter a can of thick, viscid, dark green maltha was obtained. The quantity of it visible here, however, is very small. There is a large area of asphaltum and considerable surface seepage here. It is asserted that this well, as well as some others of the older ones now dry on the Ojai Ranch, would have paid, but that they were maliciously plugged up and destroyed in the course of the fights and contests which have taken place in years gone by about these oil lands.

From the Santa Paula Cañon on the east to the San Buenaventura River on the west, Sulphur Mountain (which is well named on account of the numerous sulphur springs on all sides of it) is some twelve or thirteen miles long. As already stated, its highest crests are about two thousand feet above the sea. Immediately north of Sulphur Mountain, and between it and the San Rafael Range of mountains, lies the Ojai Valley, whose length is about coextensive with that of Sulphur Mountain. The Ojai Valley is divided near the middle of its length into two portions, the westerly part being called the "Lower Ojai Valley," and the easterly part the "Upper Ojai Valley," for the very good reason that there is between these two different parts of the valley a difference of from two hundred to four hundred feet in altitude above the sea. The Upper Ojai Valley is drained towards the east by Sisar Creek, which flows easterly to Santa Paula Cañon; while the Lower Ojai is drained by Coyote Creek, which flows westerly to the San Buenaventura River.

It was stated by different parties that only one deep well has ever been drilled on the *top of Sulphur Mountain.* According to Mr. B. W. Feldt, this well, which was not visited by us, is one fourth to one third of a mile westerly from the Coche Cañon wells; while, according to Mr. W. L. Hardison, it is directly north from the "Green Oil Well" in Adams Cañon—a difference of localities of some eight or ten miles.

Wherever this well may be, it was, so far as oil is concerned, a dry hole. Mr. Feldt states that it was one thousand six hundred feet deep, and cost some $50,000. They struck water at one hundred and twenty-four feet, and pumped for awhile between two hundred and three hundred barrels per day of sulphur water. The well was called the "Rotten Egg Well."

On the extreme eastern end of the Ojai Ranch, north of the east end of Sulphur Mountain, and in the right hand edge of the bed of Sisar Creek, there is one of the prettiest cold sulphur springs that the writer ever saw, flowing some two or three miner's inches of beautiful water.

About a mile farther up Sisar Creek, and on the north side of the Upper Ojai Valley, is located a group of oil wells called collectively, "Ojai, No. 6." There are here now five or six old wells pumping an aggregate of some eight or nine barrels per day of a very dark, greenish-brown oil, which is piped to the Mission Transfer Company, at Santa Paula.

These wells are in the midst of extensive asphaltum deposits and tar springs. Their depth varies from one hundred and twenty-five to something over five hundred feet. But there is one dry hole here about one thousand two hundred feet deep.

The Adams Cañon wells are two or three miles over the east end of Sulphur Mountain, a little east of south from here.

The rocks at this locality, where visible, consist chiefly of very heavy-bedded sandstones, and dip to the north. But they are not well exposed.

There are two tanks here which hold two hundred and fifty barrels each.

The northern slope of Sulphur Mountain is heavily timbered with oak.

It must be remembered that this group of wells—"Ojai, No. 6"—is on the *north* side of the valley, near its eastern end, where it is probably not over half a mile wide, though further west it increases to several miles in width.

But a short distance (less than a quarter of a mile) west of "Ojai, No. 6," the belt of asphaltum deposits and tar springs seems to cross the valley, and appear again on its south side, *i. e.*, in the northern foothills of Sulphur Mountain. From here west, all along the northern flanks of Sulphur Mountain, and on the south side of the Ojai Valley, to the San Buenaventura River, tar springs are very numerous, and the areas and depths of the surface asphaltum deposits aggregate something enormous. It is doubtful if there is anything of its kind equal to it in magnitude anywhere else in the State.

There have been probably six or eight wells, some of them deep ones, sunk within the last twenty-two years, along the southern edge of the Ojai Valley. But none of them are producing anything now. Why not, I could not learn, beyond the statement that some of them had been plugged up.

At "Ojai, No. 6," the rocks, so far as exposed, dip to the north.

The last well drilled on the Ojai Ranch was sunk in Gibson's field, near the spring, in September, 1886, three hundred and fourteen feet deep. They went through soft material only, except that at the depth of two hundred feet they struck a "tar bed" fifty feet thick. The well gave nothing but a small flow of water.

The barometer (aneroid) at the group of No. 6, Ojai wells, read one thousand one hundred and forty feet; at Mr. Hobart's place one thousand one hundred and thirty feet; at Mr. Gibson's place, one thousand two hundred and sixty feet. All these places are in the "Upper Ojai Valley." But a short distance northwest of Mr. Hobart's place there is a steep descent of several hundred feet into the "Lower Ojai Valley," in which, further west, is the town of "Nordhoff."

At Mr. Gally's place, in the Lower Ojai, about one mile east of Nordhoff, the barometer read eight hundred and thirty feet. On the north side of the Ojai Valley, in the San Rafael Mountains, the exposures are good, and the strata generally dip to the north. On the south side of the valley, however, the exposures are few and poor.

It is true that the farmers occasionally lose cattle in these asphaltum beds. The cattle lost, however, are not drowned in liquid petroleum; but get stuck fast in the thick, strong tar, and, being unable to pull themselves out, stay there till they starve to death.

All the oil now obtained in Ventura County is handled by the "Mission Transfer Company," of which Mr. F. E. Davis, of Santa Paula, is President.

The wells in Santa Paula, Adams, and Wheeler Cañons are owned by the "Hardison & Stewart Oil Company." Those in Pico Cañon are owned by the "Pacific Coast Oil Company."

A two-inch pipe line was once laid from Pico Cañon to Santa Paula, but it is now disconnected and disused. Barometer at Santa Paula read two hundred and sixty-five feet.

The oil from the Sespe, Santa Paula, Adams, and Wheeler Cañons, and the Ojai Ranch, is piped directly by the Mission Transfer Company to their large storage tank at Santa Paula. This tank, built by G. J. O'Brien, of Finley, Ohio, was called by him a thirty-five thousand barrel tank; but the oil men here call it a thirty-two thousand barrel tank. Its dimensions, however, are stated to be ninety-three feet diameter, and twenty-four feet seven inches high, which give for its maximum capacity twenty-nine thousand seven hundred and forty-three barrels of forty-two United States standard gallons each. The pipes leading from the wells to this tank are two-inch pipes, and there are altogether about seventy miles of them. From this tank a four-inch pipe runs a distance of eighteen miles to another tank of the same size, recently finished at Hueneme, whence most of the Ventura County oil is shipped by sea to its various destinations. From the Hueneme tank to the landing, a distance of about one mile, there is a six-inch pipe.

The cost of the tank at Santa Paula is stated to have been $7,400. The one at Hueneme cost a little more, probably about $7,700. Both these tanks, however, were purchased in the East at second hand. A new seven thousand barrel tank has been contracted for in San Francisco at $5,200.

Two-inch pipe line here costs about 25 cents per foot *laid in place*. Tank cars holding about one hundred and thirty barrels each cost, delivered in Los Angeles or Ventura Counties, about $1,000 each.

There is a small tank, holding about three thousand barrels, at San Buenaventura. There is here also a so called "refinery," owned by the "Paraffine Paint Company" of San Francisco, which handles a certain quantity of the Ventura County oil. The only "refining" which they do, however, consists of a simple distillation at a temperature of about 600° F. (a little less than the melting point of lead), the distillate being returned to the tanks of the Mission Transfer Company, while the black residue, which, when cold, is brittle, but when somewhat warm is tough and elastic, though not sticky unless the temperature is pretty high, is shipped to San Francisco, where it is used in the manufacture of paint and for some other purposes.

The following statement of the quantity of oil handled by the Mission Transfer Company during a period of thirteen months was furnished from the books of the company by Mr. Manning, the Secretary, in barrels of forty-two gallons each:

Month.	From Adams Cañon.	From Wheeler Cañon.	From Scott Wells, Santa Paula Cañon.	From Ojai Ranch.	From Sespe Region.	Distillate.	Total.
1886—June	2,562.38	320.62	331.38	373.69		218.86	3,806.93
July	5,102.55	312.86	178.83	201.40		134.12	5,929.76
August	4,018.45	302.00	232.14			501.55	5,054.14
September	4,172.87	143.66	165.82			156.32	4,638.67
October	4,375.73	588.26	194.63	56.12		792.04	6,006.78
November	3,406.43	468.02	220.88	66.31		441.80	4,603.44
December	2,855.10	171.70	178.84	50.00		581.23	3,836.87
1887—January	3,215.69	319.76	176.21			581.21	4,292.87
February	3,287.47	474.14	52.60			347.14	4,161.35
March	5,004.47	327.09	228.52	27.97			5,588.05
April	2,988.51	332.32	268.19				3,589.02
May	3,707.06	340.90	261.74				4,309.70
June	4,229.27	480.63	273.22		5,514.29		10,497.41
Totals	48,925.98	4,581.96	2,763.00	775.49	5,514.29	3,754.27	66,314.99

In order to obtain from this table the actual quantity of crude petroleum produced, the 3,754.27 barrels of distillate, which were returned to the tanks from the refinery at San Buenaventura, must be deducted from the total as given. Bearing this in mind, we find the average daily product for the year from June 1, 1886, to June 1, 1887, to have been as follows:

From Adams Cañon	122.46 barrels.
From Wheeler Cañon	11.24 barrels.
From Santa Paula (Scott Wells)	6.82 barrels.
From Ojai Ranch	2.12 barrels.
Total	142.64 barrels.

But a portion of the 5,514.29 barrels credited to the Sespe region for the month of June, 1887, is really due to the previous months of February, March, April, and May, since the Sespe Well, No. 1, finished drilling on February twelfth, and No. 2 was drilled in April.

The average gravity of the oils from various cañons is stated to be as follows: From Adams Cañon, 26° to 27° B.; from Santa Paula Cañon, 23° B.; from Ojai Ranch, 19° to 20° B.; from Sespe region, 31° B.

Dr. S. P. Guiberson, of Santa Paula, states that infusorial siliceous rock occurs in large quantities throughout Township 3 N., of Ranges 19, 20, and 21 W., S. B. M., in the San Fernando Range of mountains, and that the rocks there dip 40° to 45° towards the south. He also exhibited a piece of obsidian, which, he said, came from the same range of mountains, about four miles southeast of Santa Paula.

Mount San Cayatana, five miles northeast of Santa Paula, in T. 4. N., R. 21 W., S. B. M., is said to be near five thousand feet high. Mount Topotopo, north of Santa Paula, and northeast of the Adams Cañon wells, in T. 5 N., R. 21 W., S. B. M., is somewhat higher, and Hines' Peak, to the north of Topotopo, is said to be over six thousand feet high.

The following letter, from the Hardison & Stewart Oil Company, is self-explanatory:

"Santa Paula, Cal., November 29, 1887.

"W. A. Goodyear, *Geologist*, *San Francisco*, *Cal.:*

"Dear Sir: Your favor of the twenty-third instant at hand.

"Adams, No. 15, is located six hundred feet east and two hundred feet north of No. 14. Abandoned October twenty-fifth, was drilled one thousand feet deep and dry. No. 16 is located about four hundred feet west of No. 8, and is flowing one hundred barrels per day. Completed November twenty-sixth.

"Saltmarsh, No. 1, is located about a mile west of Adams, No. 16, and is flowing about two hundred barrels per day. Completed November fifteenth.

"The Tunnel was completed at six hundred and fifty feet and the increase in oil did not more than keep up the decline while finishing, was completed November tenth.

"Sespe, No. 6, is situated a little south of east of No. 1, was drilled nine hundred feet deep and dry, finished October twenty-eighth.

"Sespe, No. 7, is located about eight hundred feet northwest of No. 5, nearly east of No. 2, about one thousand two hundred feet distant; is pumping about seventy-five barrels per day, is three hundred and seventy-five feet deep, and finished October fifteenth.

"No. 8 is located about one thousand eight hundred feet northwest of No. 4, and is pumping one hundred and fifty barrels, is three hundred and seventy feet deep, and finished November second.

"No. 9 is located between No.'s 1 and 4, about four hundred feet from No. 4, and pumping seventy-five barrels, drilled three hundred and forty feet. Completed November twelfth.

"No. 10 is located about four hundred feet south of No. 7, and is drilling at two hundred feet, and showing for a seventy-five barrel well.

"No. 11's rig is up ready for drilling, is located between No.'s 4 and 8, and one thousand four hundred feet northwest of No. 1.

"Yours very truly,

"HARDISON & STEWART OIL COMPANY.

"By W. P. STEWART."

A telegram received from Mr. Hardison just as this report is going to press, and dated December 20, 1887, states that in Adams Cañon, well No. 16 is now seven hundred and twenty feet deep; that it struck oil on the ninth instant, sent the oil seventy feet into the air, and has *flowed eight hundred barrels per day.*

Miscellaneous Remarks.

The total cost of the outfit, *i. e.*, derrick, engine, boiler, and all tools, etc., required for drilling a well in California, is stated at about $3,000.

It then usually requires four men to drill the well, *i. e.*, one professional driller, at $4, and one helper, at $2 50, for each shift (or "tour" as it is called) of twelve hours per day, running day and night.

They now generally start the drilling with a twelve-inch bit, and finish with a five-inch bit.

The casing most employed is lap-welded, and screwed together; though at some wells sheet-iron casing is used.

The total cost of drilling a well, reckoned per foot, will of course depend greatly upon its depth. But in California, it will depend perhaps even more upon the character and position of the rocks drilled through. In the East the oil rocks lie nearly horizontal, and extensive experience has developed much valuable information concerning the character of the rocks which must be drilled through in a given oil region. Here it is not so. The rocks are generally greatly crushed, and broken, and upturned at various angles, and no man knows beforehand what he may strike at a moment's notice. It is difficult drilling in such rocks, which dip anywhere from 30° to 85°, and where you may at any moment strike a hard stratum which will throw your drill aside and give you a crooked hole, or else lose your tools and have no end of fishing; or where you may strike quicksand, or many other troubles. These are the reasons why it costs so much more to drill for oil in California than it does in Pennsylvania. The average ratio is probably about three to one.

As to what it may cost to sink a well to any given depth in any part of California, no man can tell beforehand. If you are favorably situated and lucky, you may, perhaps, get a well one thousand five hundred feet deep at a cost of $5 or $6 per foot. If you are unlucky, it may cost you $40 or $50 per foot or more, and you may have a dry hole at last. But the general average cost for many wells for some years past has been somewhere in the neighborhood of $10 per foot.

On one point the writer can not entirely agree with Professor S. F. Peckham, whose extremely valuable report on "The Bituminous Substances Occurring in Southern California," was published in "The Geology of California, Vol. II, Coast Ranges, Appendix," by J. D. Whitney, 1882. Professor Peckham there makes the following statement, page 50:

"The source of the bitumen is invariably found to be a bluish slate or shale, more or less firmly indurated, and containing a variable proportion of fine quartzose sand. This rock when mined and suddenly exposed to atmospheric influence, in the majority of instances, rapidly disintegrates, and becomes, when wet, a mixture of plastic clay and sand. It also contains more or less protoxide of iron, which causes it to weather of all shades, from dirty white to brown, and, when metamorphosed by heat, to assume, by peroxidation of the iron, all the shades of ochre and brick red. Bitumen is sometimes seen issuing from crevices in sandstone, but, in such instances, underlying or overlying strata of argillaceous rocks are invariably its original source. Bitumen is not always found where rocks possessing these mineralogical characters are exposed, but the presence of bitumen invariably indicates such rocks as its source. Sandstone, *per se*, is, in no instance that has come under my observation, an indication of the proximity of bitumen."

I have quoted the whole of the foregoing paragraph, in order that I may do its eminent author no injustice. I comment as follows: his description of the character of the "bluish slate or shale," which occurs in such large quantities in the oil regions, is very full and accurate.

But the many deep wells which have been drilled in Southern California since that report was written (1866), have demonstrated the fact that, as a general rule, the oil is found to exist there, *not in the shales, but in the sandstones.* To such an extent is this true, that we find one experienced well driller at Moody's Gulch, Santa Clara County (see above), talking of "first," "second," "stray," and "third sands," just as he would in Pennsylvania, though the Pennsylvania oils are Devonian, and the California oils are Tertiary, and there is room for no sort of comparison between the two localities. And it is just as true throughout Los Angeles and Ventura Counties, that the oil has been chiefly found in *sandstone*, as it is at Moody's Gulch. This being the case, I can see no good reason for assuming (for it is nothing more than assumption) that the oil always *originated* in the clay shales.

Sandstone, however, *per se*, is, of course, in no case, any indication of the proximity of bitumen.

Another item of interest, however, is this: sulphur water or sulphur springs, warm or cold, are, in no instance, indications of the proximity of bitumen. But, *vice versa*, the presence of bitumen *is* a strong indication of the probable proximity of sulphur springs. There are many sulphur springs scattered through the length and breadth of the "Coast Range," where there are no indications of hydrocarbons. But, so far as my observation goes, wherever petroleum or asphaltum is found, there sulphur will be found, in some shape close at hand.

COAL.

COAL.

In 1877 Mr. W. A. Goodyear published an exhaustive report entitled "The Coal Mines of the Western Coast of the United States." Up to the time of its publication it was the most complete report of the coast on the subject.

The author has given permission for the use of that portion relating especially to the State of California, and has made additions and corrections to make the work complete to date.

PREFACE.

In writing this little book, the object which I have had in view has been not so much to discuss the geological character of the Pacific Coast coal fields, as to give, what has never yet been published, a full and intelligible description of the mines themselves as they exist to-day. To what extent I have succeeded in accomplishing this, the reader must judge.

I regret that my acquaintance with the mines of British Columbia, which are for the most part confined to Vancouver Island, is not sufficient to justify me in attempting to give any particular account of them. I have, therefore, excluded them from this work, although they are of no little importance, and are rapidly increasing their annual production.

The volume, in its present form, is mainly the result of my own work, travels, and observations, extending over a period of nine or ten years, during which period it is safe to say I have done more work in, and have been personally more familiar with the actual condition and workings of, the various coal mines of the Pacific Coast than any other engineer has done.

In addition to this, however, I am also greatly indebted, as the text will show, to the labors of my friend and former partner, Mr. Theodore A. Blake, M.E., who is even more intimately acquainted with the mines of Washington Territory than I have been myself, and whose early investigations of the Seattle coal field, in particular, were exceedingly thorough and valuable. I desire, furthermore, to express my obligations especially to Mr. P. B. Cornwall, President of the Black Diamond Coal Company; and, in general, to the officers and Superintendents of the other coal companies throughout the country, for the liberality with which they have not only furnished all such information as I have directly asked from them, but also freely placed at my disposal every other facility for acquiring a full and thorough knowledge of their respective mines.

W. A. GOODYEAR.

SAN FRANCISCO, March, 1877.

CHAPTER I.—CALIFORNIA.

The coal fields of the western coast of North America are limited in extent, and of comparatively recent geological origin. They are none of them of the Carboniferous Age, and, indeed, so far as yet known, none of them date back of the Cretaceous Period. They mostly furnish a noncaking, bituminous coal, which belongs to the class of lignites, or brown coals. Vancouver Island, however, produces caking coal, and some caking coal of good quality has also been found in Washington Territory. Small quantities of anthracite have been found on Queen Charlotte's Island, and probably also in Washington Territory. But no workable mine of anthracite has ever been discovered on the coast, and the little that has been found has always proved, on investigation, to have been the result of local and special metamorphism. Of the two States and one Territory which border the Pacific Ocean between Mexico and British Columbia, Washington Territory is by far the most liberally supplied with coal. Oregon comes next, and California last. In fact, California is decidedly unfortunate in the extent and the character of her coal fields. For, although it is easy to find coal at many localities in the Coast Range, from one end of the State to the other, as well as at certain points in the western foothills of the Sierra Nevada, yet it generally happens that its quality is poor, or its quantity is small, or else that it is situated in the heart of the mountains, so far from market that the cost of transportation alone would far exceed the value of the coal.

I begin this treatise, however, without further prelude, by giving a description of the only field within the State where coal has hitherto been profitably mined, viz.:

THE MOUNT DIABLO COAL FIELD.

The extent of the Mount Diablo coal field may be stated in broad terms to be some ten or twelve miles along the line of outcrop of the beds running through the northern part of T. 1 N., R. 1 E., and the northwestern and central portions of T. 1 N., R. 2 E., M. D. M.

The details of this line of outcrop are, in many places, very irregular, and especially so in the western portion of the field, where the hills are high, and the cañons are deep and steep. But its general course may be described as follows: It is curvilinear, and convex towards the north. Beginning in the northeast quarter of Section 7, T. 1 N., R. 1 E., it runs at first northeasterly, but curves rapidly to the east till it reaches a point in the northwest quarter of Section 8, from whence it follows for almost three miles a nearly true east course across the northern portions of Sections 8, 9, and 10, and close to the northern edges of these sections. But in going easterly across Section 11, it bends to the south, and crossing the south half of Section 12, enters the southwest quarter of Section 7 in the adjoining township. From thence it follows an irregular southeasterly course across the northwestern and central portions of the township as far as the "Brentwood Mines," upon the Rancho de Los Meganos, and near the line between Sections 22 and 27 of T. 1 N., R. 2 E. Beyond this locality, to the southeast, the beds have not been traced with any certainty. The dip, throughout, is in a northerly direction; but it varies in amount at different localities from 12° or 15° up to 32° or 33°, being generally highest in the western portion of the field.

A range of high hills, whose culminating points on Sections 8 and 9 reach altitudes of fifteen hundred to seventeen hundred feet above the sea, runs in a general east and west direction across the northern half of T. 1 N., R. 1 E., and is separated by a narrow valley on the south side from the still higher mountainous region which culminates in the double summit of Mount Diablo itself, three thousand eight hundred and fifty-six feet in height.

In going east, however, from Section 9, the hills diminish in height, and following the line of the coal beds southeasterly across the next township, they gradually fall lower and lower, till we reach the level of the valley at the "Brentwood Mines," which are situated in the edge of the San Joaquin plain, at an altitude of only between one hundred and two hundred feet above tidewater. In its higher portions, this range of hills is deeply scored by cañons in all directions, and it is among these cañons in the northern slopes of the range, that the hitherto paying mines are located.

The strata have been considerably disturbed at numerous localities by faults of greater or less magnitude; and the coal beds themselves are subject, within short distances, to so great variations in thickness and quality of coal, as well as in the character of the rocks which inclose them, that it is not possible with present knowledge to certainly recognize any single bed in the eastern portion of the field as being the same with any one of those which have been so extensively worked in the western portion.

By the phrase, "Mt. Diablo coal field," as here used, must be understood not merely the actually productive region, but the whole extent of the belt through which there has been found some definite evidence of probability that the beds were once continuous, or nearly so, and within which sufficient discoveries have been made to lead to the expenditure of any considerable sums of money in explorations and attempts to develop new mines. The area within which the mines have hitherto been profitably worked, however, is far more limited in extent. It lies among the higher hills in the western portion of the belt above described, and includes a distance of only about two miles and a half along the strike of the beds, from the western limits of the Black Diamond Company's workings in the northeast quarter of Section 7, where the beds either split up and run out, or become too much crushed and broken to pay for working, to the most eastern limits of the Pittsburg Company's workings in the southwest quarter of Section 3, and the northwest quarter of Section 10, where they are stopped by the wall of a great fault which intervenes between them and Stewart's mine on the east.

The "Central (*i. e.*, Stewart's) Mine" is not here included within the profitably productive limits, for the simple reason that while it has produced considerable coal (its shipments having been sometimes as high as a thousand tons per month), it is more than probable that its production has been at a loss, instead of a profit, to its owners.

Within the productive limits above indicated, the chief openings of the mines, as well as the dwellings of the miners, and other buildings, are, owing to the topography of the country, concentrated at two considerable villages, about a mile apart. The first of these villages, known as "Nortonville," is located on the southeast quarter of Section 5. The second one, known as "Somersville," is chiefly on the southeast quarter of Section 4, T. 1 N., R. 1 E. Each village is in the bottom of a sort of amphitheater among the hills, and at the head of a deep cañon, which runs northerly some three miles to the edge of the San Joaquin plain, from which point the distance north across the plain to the river is also in each case about three miles. Down each of these cañons there runs a railroad of the ordinary gauge (four feet eight and one half inches), to points of shipment on the San Joaquin River, just above its junction with the Sacramento. Each railroad is, therefore, about six miles in length, the Black Diamond Railroad running to the Black Diamond Landing (otherwise known as New York Landing), and the railroad from Somersville (called the "Pittsburg Railroad") running to Pittsburg Landing, some two or three miles further up the river. The height of the villages themselves above tidewater ranges from seven hundred to eight hundred and fifty feet.

In the northwest corner of the southeast quarter of Section 5, a round-topped hill rises to a height of one thousand three hundred and forty-eight feet above low water, and near the middle of the line between the northwest and southwest quarters of Section 4, a similar hill rises to a height of about one thousand five hundred feet. Each of these two hills (between which runs the cañon of the Black Diamond Railroad) is connected with the hills to the south, in which lie the mines, by a saddle some three hundred or four hundred feet lower than its own summit—the saddle between Nortonville and Somersville being some three or four hundred feet higher than the village of Nortonville itself.

There are few points in the hills containing the mines which rise to a greater height than the higher of the two hills just described. At Nortonville, as well as at Somersville, the cañon at the head of which stands the village forks into numerous branches which spread upwards in all directions to the south, southeast, and southwest, among the hills, thus cutting up the surface of the mining ground by rough and precipitous gulches, often two hundred to three hundred feet in depth, so that the line of outcrop of the beds, as already stated, is at this locality very irregular in detail and deeply indented by the gulches. The rocks which inclose the mines consist of unaltered grayish and reddish silicious sandstone, generally not very hard, alternating with occasional strata of rather soft clay-rock, the whole belonging to the latest formations of the cretaceous period.

The coal beds, which have been profitably worked to a greater or less extent, are three in number, and are known respectively as the "Clark Vein," the "Little Vein," and the "Black Diamond Vein." Of these, the Clark Vein is the highest in stratigraphical position; next in order below it comes the Little Vein; while the Black Diamond Vein is the lowest, and underlies both the others. The beds lie nearly parallel with each other, all dipping to the north; and at the immediate localities of the villages, both of Nortonville and Somersville, the amount of dip is from 30° to 32°.

In the Clayton Tunnel, at Nortonville, the level distance from the floor of the Clark Vein south to the roof of the Black Diamond Vein is six hundred and ninety-six feet; the dip here being about 31°, it follows that the total thickness of the strata, including the Little Vein, between the Clark and Black Diamond Veins is, at this locality, about three hundred and fifty-nine feet. At certain points the level distance between the beds is somewhat less than it is here, while in other places it is considerably greater. This is due mainly to changes in the degree of dip of the beds; though it is more than probable that the actual thickness of the strata between them also varies somewhat at different localities.

All the valuable mining ground here for a distance of nearly two miles and a half is now owned and controlled by three different companies, viz.: the Black Diamond Coal Company, the Union Coal Company, and the Pittsburg Coal Company. The Black Diamond Company owns the south half of Section 5, the north half of Section 8, and the northwest quarter of Section 9. The Union Company owns the southwest quarter of Section 4, and used to lease and mine the coal also in an adjoining strip to the east, between six hundred and seven hundred feet wide, on the southeast quarter of Section 4. The Pittsburg Company owns the balance of the southeast quarter of Section 4, together with an additional tract which covers portions of the northeast quarter of Section 9, the northwest quarter of Section 10, and the southwest quarter of Section 3.

The Clark Vein.

The only bed which has been worked continuously throughout the whole distance controlled by these companies is the Clark Vein. This bed varies in thickness at different points from a minimum of eighteen or twenty inches to a maximum of four feet and a half, or a trifle over. The greatest variations in the thickness of this bed, however, do not occur within the limits of the Black Diamond Company's property, the minimum thickness in that property being twenty-eight or twenty-nine inches, and the maximum thirty-eight or thirty-nine; while the average for the whole mile of the Clark Vein controlled by this company, and as deep as the workings have yet extended, is thirty-two or thirty-three inches. On going east from the section line, however, into the southwest quarter of Section 4, the bed grows rapidly thinner, and for a considerable distance in the western portion of the Union Company's ground its thickness ranges under twenty-four inches, being sometimes as low as eighteen. But in the eastern portion of the Union Mine it again increases in thickness, and maintains across the southeast quarter of Section 4 a thickness of from three to four feet, reaching its maximum in the Pittsburg Company's ground not far from the line between Sections 3 and 4, where, as already stated, it is sometimes a little over four and a half feet thick. The Clark Vein is generally free from interstratification of slate or dirt of any kind, and with the exception of a certain portion in the western part of the Black Diamond Company's mines near the southwest corner of Section 5, where, for several hundred feet it has been rather badly crushed by movements and bendings of the strata, the whole of it makes good, clean coal. Its roof and floor are also generally very good, so that it requires but little timbering. The floor is everywhere good solid sandstone, and the roof throughout the Black Diamond Company's mines, and in the western portion of the Union Company's ground, with few and small exceptions, consists also of the same material. But where the coal begins to increase in thickness in the eastern part of the Union Mine, a thin stratum of rather soft clay rock makes its appearance on top of the coal and between it and the overlying sandstone. Further east, this clay stratum is nearly continuous, forming, generally, the immediate roof of the coal throughout the Pittsburg Company's ground, and seeming, as a rule, to be thickest where the coal is thickest. It reaches, in places, a maximum thickness of from two to two and a half feet, and as it separates easily from the overlying sandstone, it causes, of course, some extra trouble and expense, and occasionally more or less danger in mining the coal. But it is nothing very serious.

The chief openings to the Clark Vein are, first, the Black Diamond Company's openings, which are three. Of these the first is what is known as the "Little Slope," or the "Hoisting Slope;" the second is the "Mount Hope Slope," and the third is the Black Diamond Shaft. Second, the Union Company's Slope. Third, the slope of the old "Eureka Company," which formerly owned a tract about eleven hundred feet wide immediately adjoining the Union Company on the east, and now belonging to the Pittsburg Company. Fourth, the Pittsburg Slope. Fifth, the "Independent Shaft," situated on ground formerly owned by the old "Independent Company," but now also belonging to the Pittsburg Company.

The mouth of the "Hoisting Slope" of the Black Diamond Company is situated in the bottom of a deep ravine which runs up southerly and southwesterly among the hills, and is eight hundred and thirty-three feet above low water in the San Joaquin River. This slope, which is ninety-eight feet long, goes down to the south with a pitch of about 35° through the strata overlying the Clark Vein. From its foot, a level gangway, known as the "Clark Vein Main Gangway," has been driven east and west on the Clark Vein throughout the company's property, and is over a mile in length across the southern part of Section 5. The slope is furnished with a double track, and a steam hoisting engine whose cylinder is 14″×30″. Through this slope has been hoisted nearly all the coal which has come from the Clark Vein within the limits of the Black Diamond Company's property above the level of the Clark Vein Main Gangway, besides all the coal which has come from the Black Diamond Vein through the Clayton Tunnel.

The mouth of the "Mount Hope Slope" is situated about four hundred and fifty feet northeasterly from that of the "Hoisting Slope," and is seven hundred and ninety-seven feet above low water. The slope is two hundred and ninety-three feet long to the Clark Vein, and has an inclination, or pitch, of 37° 15′ to the south. From its foot, the "Mount Hope Gangway" runs east and west on the Clark Vein through the property, and is also over a mile in length. The height of the "lift" between the Mount Hope and the Clark Vein Main Gangways (*i. e.*, the slope distance measured on the dip of the coal bed from center to center of these gangways), is in the vicinity of the Mount Hope Slope about three hundred and six feet. But in the western portion of the property the height of this "lift" increases considerably, owing to a decrease in the dip of the bed, the gangways being driven nearly level, or with only so much grade, about one in one hundred, as is necessary in order to drain them, and to facilitate the hauling out of the loaded cars. The Mount Hope Slope is provided with a double track and a hoisting engine, with cylinder 14″×30″. From a point on the Mount Hope Gangway eighty-five feet east of the foot of the Mount Hope Slope, a double tracked counter-slope runs down on the coal with a pitch of about 31° to the north, a distance of three hundred and seventy-seven feet to the "Lower Mount Hope Gangway," which is the lowest gangway yet opened on the Clark Vein by the Black Diamond Company. The coal from this lower gangway, until they began to hoist through the shaft, was hoisted up the counter-slope by an underground hoisting engine 16″×30″, placed at the head of the counter-slope, and supplied with steam from the boilers at the surface by a pipe leading down the Mount Hope Slope.

The Black Diamond Shaft is distant about six hundred and twenty feet in a direction a little north of west from the mouth of the Mount Hope Slope. It is a vertical shaft, heavily and well timbered, and measures twenty-two feet four inches by eleven feet ten inches from out to out, being divided into three compartments, viz.: one pumping compartment five by nine feet, and two hoisting compartments, each six by nine feet in the clear, inside of timbers. The mouth of the shaft is eight hundred and thirty-nine feet above low water, and its present depth to the level of the Lower Mount Hope Gangway is four hundred and fifteen feet, and the foot of the shaft is about fifty feet south of this gangway. The shaft is furnished with two iron, double-decked safety cages, each cage raising two loaded mine cars at a time, and each car containing about a ton of coal. The hoisting power for this shaft consists of a pair of large steam engines working directly on the winding shaft, each engine having a twenty-four-inch cylinder, and five foot stroke. The cables used here are flat wire ropes winding on spools.

The mouth of the Union Company's Slope is situated very close to the line between the southeast and southwest quarters of Section 4, and is eight hundred and sixty-six feet above low water. The slope itself is four hundred and seventeen feet long to the Clark Vein, with a pitch of 37° 45′ to the south. From its foot a gangway runs east and west on the Clark Vein through this company's property. From a point on this gangway two hundred and forty-four feet west of the foot of this slope, a counter-slope runs down on the bed with a pitch of 28° 23′ to the north, three hundred and four feet to a second gangway, and then about three hundred feet further to the third or lowest gangway in this mine. Each of these slopes was worked by a steam hoisting engine placed at its head, the underground engine at the head of the counter-slope being supplied with steam from boilers at the surface, as in the case of the Mount Hope and its counter-slope.

The old Eureka Slope was about two hundred and ninety feet long, with an average pitch of about 43° 15′ to the south. It was furnished with a three-rail track and a hoisting engine 10″×24″. Its mouth is seven hundred and eighty-six feet above low water. There was also a counter-slope fifty-five feet west of the foot of the surface-slope, which went down some six hundred feet or more, and was furnished with a double track and a hoisting engine, 12″×24″. The whole of that portion of the Clark Vein originally owned by the Eureka Company has already, however, been worked out and exhausted, and these openings are therefore now abandoned.

The Pittsburg Slope is in the southeast corner of Section 4. Its mouth is eight hundred and thirty-eight feet above low water. It goes down in a direction somewhat to the west of south, with a pitch of 25° 50′, and is about two hundred and forty feet long to the Clark Vein. It is furnished with double track and steam hoisting engine, 12″×24″. From its foot a gangway runs both ways on the bed through the company's property. From a point on this gangway twenty-five feet west of the foot of the surface-slope, a counter-slope runs down on the dip about eight hundred feet with a pitch of about 31° 30′ to the lowest gangway in the mine. There are, however, two intermediate gangways, one at a point three hundred feet and the other at a point five hundred and seventy-nine feet down from the head of the counter-slope. The slope is double-tracked and is worked by a steam engine, 14″×30″, at its head.

In the eastern part of this mine and distant nearly a quarter of a mile from the foot of the surface-slope, there is another counter-slope running down from the upper gangway to the second one. This slope is also double-tracked and furnished with a hoisting engine. Both the underground engines are furnished with steam through pipes conducting it from the boilers at the mouth of the surface-slope.

The Independent Shaft is a vertical shaft sunk by the now defunct Independent Company about the year 1865, at a point a little southwest of the center of the northeast quarter of the southeast quarter of Section 4. The size of this shaft from out to out is nearly sixteen feet by ten, and it is divided inside the timbers into three compartments, viz.: one pumping compartment, three feet by seven feet eight inches, and two hoisting compartments, each four feet by seven feet eight inches in the clear. Its mouth is seven hundred and nineteen feet above low water, and it is seven hundred and ten feet deep.

Some curious engineering was displayed in connection with the sinking of this shaft. It was represented, for example, at the time of its commencement, that it would strike the Clark Vein at a depth of from four hundred to four hundred and fifty feet; yet the position of the Clark Vein, and the amount of its dip in this vicinity, were at that time already well known, and a little simple measurement and computation would have demonstrated then as well as now the fact that a vertical shaft to the Clark Vein at that locality, must be in the neighborhood of nine hundred and fifty feet in depth instead of four hundred or four hundred and fifty. However, they went down seven hundred and ten feet, and then getting tired of sinking, left about twenty-four feet in the bottom of the shaft for a sump, and started a level tunnel to the south, at the depth of six hundred and eighty-six feet, for the coal. They drove this tunnel to the Clark Vein, its length proving to be (according to the best accounts afterwards obtainable) about four hundred and twenty feet. When within about one hundred and fifty feet of the coal, they struck a large stream of water, which necessitated heavy pumping machinery, and a steam engine was erected and a Cornish pump put in. But the foundations for the engine were bad, and it was never firm upon its bed. Moreover, the only available water was that from the mine, which was so heavily charged with a mixture of various sulphates, with probably some free sulphuric acid, as to be exceedingly destructive to the boilers. Nevertheless, the Clark Vein was at last reached, and a gangway driven, and a considerable area of coal worked out above its level, stretching upward towards the lower workings of the Eureka Company. But the work was done at a heavy loss, and it was finally abandoned, the parties who inaugurated it becoming bankrupt. It is said that the amount of money expended here before the coal was reached was over $150,000. While the work was in progress a connection was made with the lower Eureka workings by a shoot driven up along the coal for purposes of ventilation. This shoot afterwards answered the purpose of a water-drain for the Eureka Mine; and the Eureka Company, having in the course of time purchased the Independent property, employed the Independent Shaft, at considerable expense, for a year or two, merely as a pumping shaft, in which the water was held at a certain level, which just sufficed to drain the lower workings of their own mine. But after having exhausted the Clark Vein in their own property down to the top of the old Independent workings, the Eureka Company, in its turn, stopped work, and subsequently sold both the Eureka and Independent properties to the Pittsburg Company, which now owns them. The Independent shaft is now abandoned and idle. It will be noticed, however, that the level at which the tunnel from the foot of this shaft struck the Clark Vein is at a considerably greater depth than any other point which has yet been reached in the Mt. Diablo mines.

As a general rule, the coal close to the surface of the ground is not of good quality in any of the beds. The outcrop of the Clark Vein is, in many places, nothing more than a soft clay shale, light brown in color, and very slightly carbonaceous. At a few points there was good coal in the Clark Vein very close to the surface, but the depth at which the coal in this bed first becomes marketable generally ranges from one hundred to two or three hundred feet, measured on the dip of the bed.

The height to which the coal has been worked in the hills up towards the outcrop varies greatly, of course, at different localities, depending on the configuration of the surface, which the ravines have scored so deeply, and at one point depending on another circumstance, viz.: the fact that immediately to the south of the "Little Slope" of the Black Diamond Company, and extending for a considerable distance, both east and west of it, there was an area of several acres in which the coal was entirely wanting, and which presented every appearance of having been, at some time in the past, on fire and burned out. The maximum height, however, to which the coal has been mined on the Clark bed, within the limits of the Black Diamond Company's property above the Clark Vein Main Gangway, is about six hundred and seventy-five feet, and a fair statement for the *average* height of the workings above this gangway, for the whole distance of a mile across the southern part of Section 5, would be about five hundred feet.

The height of the "lift," also about one mile in length, between the Mount Hope and the Clark Vein Main Gangways, varies from a minimum of three hundred and six feet in the eastern portion of the mine to a maximum of about five hundred in the western portion, owing to a decrease in the dip of the bed going west. Probably a fair average for the height of this lift for the whole mile would be about three hundred and fifty feet. The height of the next lower "lift," and the present lowest one on the Clark Vein, in the Black Diamond Company's mines, *i. e.*, the lift between the Mount Hope and the Lower Mount Hope Gangways, increases going west from three hundred and seventy-seven feet in the eastern part of the mine to about four hundred and fifty in the western part. This "lift" is now only about four thousand three hundred feet long, the Lower Mount Hope Gangway not having been driven so far to the west as the upper gangways have been.

The Clark Vein at the present time (1877) may be said to be practically exhausted throughout the Black Diamond Company's property down to the level of the Lower Mt. Hope Gangway, the quantity of coal which yet remains to be extracted from above that level being very small; but below this gangway it is all untouched and solid.

In the Union Mine they have worked above their Clark Vein Gangway No. 1 (*i. e.*), the gangway at the foot of their surface-slope, for a height of about six hundred feet up to the old Manhattan Gangway. The latter gangway (driven by the old Manhattan Company, which formerly owned the northwest quarter of Section 9 and afterwards sold it to the Black Diamond Company), started on the outcrop of the Clark Vein in the bed of a gulch in the southwest part of the southeast quarter of Section 4, and was driven westerly on the Clark Vein some twenty-four hundred or twenty-five hundred feet, extending for most of this distance into and along the southern edge of the southwest quarter of Section 4. Some coal was extracted here by the Manhattan Company, and their workings are said to have extended in places as high as about three hundred feet above this gangway. But these old workings have long been caved and closed, and there is no very reliable information obtainable now as to their exact extent. The Manhattan Company also drove a tunnel from this gangway south to the Black Diamond Vein, and opened several hundred feet of a gangway on that bed, but never took out much coal from there.

The height of the lift in the Union Mine, between the Clark Vein Gangway No. 1 and the Clark Vein Gangway No. 2, is about three hundred and four feet; and throughout the Union Mine the Clark Vein is now exhausted down to the level of this latter gangway, which is only a few feet higher than the Lower Mt. Hope Gangway of the Black Diamond Company. Furthermore, the Union Company have continued their counter-slope some three hundred feet further down the dip and driven from its foot another gangway (their Clark Vein Gangway No. 3), from which, in 1876, they were working an additional lift of about three hundred feet of coal. This gangway was driven west only about eighteen hundred feet from the foot of the counter-slope when the mine was abandoned and closed in December, 1876.

There are no accurate records now obtainable of the extent of the workings in the upper part of the old Eureka Mine. But the Clark Vein was entirely cleaned out here as far up as it would pay to work towards the outcrop, and it is evident from the situation of the slope and the shape of the hills at that locality that these workings must have extended in places to a height of some five or six hundred feet above the gangway which runs at the foot of their surface-slope. The Eureka Company also worked out through their counter-slope two additional lifts, aggregating some six hundred feet or more below this gangway, and cleaning out everything down to the top of the old Independent workings, from which point the distance down through the latter to the gangway at the level of the tunnel from the foot of the Independent Shaft must have been in the neighborhood of four hundred feet, since the total distance measured on the dip of the bed from this lowest gangway up to the gangway at the foot of the Eureka surface-slope was between one thousand and eleven hundred feet. Thus, for a certain distance here in the ground formerly owned by the Eureka and Independent Companies, the Clark Vein is practically exhausted to the depth of fifteen hundred or sixteen hundred feet measured on the dip of the bed from the outcrop down to the tunnel from the foot of the Independent Shaft. But a direct comparison of this distance with the distances down from the outcrop at other localities will not give the correct differences of absolute height between the bottoms of the mines, since the hills along the line of outcrop vary a good deal in height and rise considerably higher in the Union and Black Diamond properties than they do here in the old Eureka. In fact, the distance on the dip of the bed from this lowest gangway of the old Independent Company up to the level of Lower Mt. Hope Gangway of the Black Diamond Company would be about seven hundred and forty feet.

In the Pittsburg Mine the coal on the Clark Vein has been worked to heights ranging from six hundred feet, or less, to a maximum of between nine hundred and a thousand feet on the dip above the gangway which runs at the foot of their surface-slope, and above the highest of these workings the additional distance up, through soft and worthless coal and shale to the outcrop itself, is from two hundred to three hundred feet. Below the foot of the surface-slope there have been worked through the counter-slope in the Pittsburg Mine, three additional lifts, of three hundred, two hundred and seventy-nine, and two hundred and twenty-one feet respectively, making the total maximum depth worked on the Clark Vein in this mine, measured on the dip, between seventeen hundred and eighteen hundred feet; and below the lowest Pittsburg Gangway it will still be about five hundred and thirty feet farther down the dip, to the level of the tunnel from the foot of the Independent Shaft.

The Little Vein.

Before speaking of the workings on the "Little Vein," it will be well, for the sake of clearness, to describe two tunnels in the Black Diamond Company's property, which are driven from daylight south into the hills, and run nearly level through the superincumbent strata to the Black Diamond Vein. The first of these is known as the Upper Black Diamond Tunnel. This is the highest and the oldest of all existing openings to the Black Diamond Vein. Its mouth is in the right hand or southeast side, and near the bottom of the same ravine in which is situated lower down the mouth of the Clark Vein Hoisting Slope. It is distant from the latter a little over eight hundred feet, in a direction somewhat to the west of south, and is one thousand and thirty-four feet above low water level. It is also some little distance to the south of the line of outcrop of the Clark Vein. The tunnel is straight, and runs in a direction about 2° east of true south for a distance of four hundred and twenty-two feet to the Black Diamond Vein. At a point one hundred and twenty feet from its mouth, it cuts a seam of coal, which is at this locality fourteen inches thick. At a point one hundred and ninety-six feet from its mouth it cuts another and smaller seam. These two are the only seams of coal exposed in the Upper Black Diamond Tunnel above the Black Diamond Vein; the rest of the strata consisting of sandstones and shales.

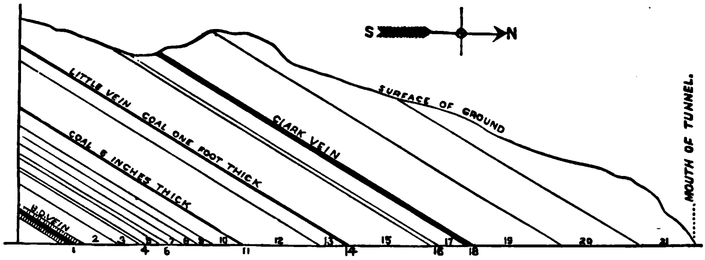
The second of the two tunnels now in question has been already mentioned, and is known as the Clayton Tunnel. Its mouth is in the bottom of the ravine, about one hundred and sixty feet southwesterly from the mouth of the Mt. Hope Slope, and is seven hundred and ninety feet above low water. This tunnel is also straight, and runs about $4\frac{1}{2}°$ to the west of south, a distance of nearly eleven hundred feet to the Black Diamond Vein. It has an ascending grade of about one foot in a hundred going in. The distance in from its mouth to the point where it cuts the center of the Clark Vein is three hundred and sixty feet.

The following sketch shows a section of the strata as exhibited along the line of this tunnel. The various strata are numbered in the sketch to correspond with the numbers in the first column of the tabular description which immediately follows. The dip here being about 31°, the actual thickness of the strata is a trifle over one half the distances which they occupy respectively along the level floor of the tunnel. In the last two columns of the tabular description, both these figures are given; the first one containing the respective level distances along the floor of the tunnel, and the last one the actual thicknesses of the various strata in feet and decimals of a foot:

Section of Strata on line of Clayton Tunnel.

Description.	Distance on Floor of Tunnel, in feet.	Actual Thickness of Strata, in feet.
1. Black Diamond Vein, forty inches coal, with seven or eight feet of bone above and below	35.0	18.0
2. Heavy-bedded sandstone—dry	66.5	34.2
3. Heavy-bedded sandstone—wet	40.0	20.6
4. Thin-bedded and ferruginous sandstone	4.0	2.0
5. Heavy-bedded sandstone—wet	31.0	16.0
6. Thin-bedded carbonaceous shales—dry	10.0	5.2
7. Numerous alternations of sandstones and thin shales; some of the latter carbonaceous—dry	35.0	18.1
8. Heavy-bedded sandstone—dry	20.0	10.3
9. Alternations of sandstone and thin shales, the latter sometimes carbonaceous—wet	25.0	12.9
10. Same alternations as in 9, but dry	45.0	23.2
11. Coal, five or six inches thick	1.0	0.5
12. Alternations of sandstones and thin shales—dry	139.0	71.6
13. Heavy-bedded sand-rock—dry	48.0	24.7
14. Coal, about one foot thick, with six inches of bone on each side of it	4.0	2.0
15. Heavy-bedded sand-rock—dry	146.0	75.2
16. Heavy-bedded sand-rock—dry	18.0	9.3
17. Coarse-grained sand-rock, generally heavy-bedded	64.0	33.0
18. Clark Vein, thirty-four inches of coal	5.5	2.8
19. Same sandstone as in 17	137.5	70.8
20. Fine-grained, bluish, and clayey rock, moderately heavy-bedded, with occasional bands of coarser sand-rock a few inches thick	127.0	65.4
21. Thin-bedded clay shales, to mouth of tunnel	93.0	47.9

Between 15 and 16 in the above section there is a streak of carbonaceous shale one foot thick, and also a second one of about the same thickness between 16 and 17.



SECTION OF STRATA ON LINE OF CLAYTON TUNNEL.

As there are two little seams of coal above the Black Diamond Vein in the Upper Black Diamond Tunnel, so also there are two little seams in the Clayton Tunnel between the Black Diamond Vein and the Clark Vein. But it will be seen, on closer inspection, that the positions of the upper and lower little seams in the two cases do not correspond to each other respectively. In fact, their distances from the middle of the Black Diamond Vein are such that the lower seam in the Clayton Tunnel corresponds closely in position with the upper seam in the Upper Black Diamond Tunnel; while there is no seam in the Clayton Tunnel corresponding to the lower one in the upper Black Diamond Tunnel; and furthermore, the mouth itself of the latter tunnel appears to be further south by some sixty feet than the proper position at this level for the upper seam of the Clayton Tunnel. Therefore, as the distance between these two tunnels in the direction of strike of the beds is only some three or four hundred feet, and as no faults of any magnitude have been discovered within this distance in any of the workings on either the Clark or the Black Diamond Vein, it is extremely probable that the lower seam in the Clayton Tunnel is really identical with the upper one in the upper Black Diamond Tunnel, in spite of the fact that if we considered the respective thicknesses of the seams alone we might be induced to draw an opposite inference. Moreover, the entire disappearance of the lower little seam of the upper Black Diamond Tunnel within the short distance of less than four hundred feet between it and the Clayton Tunnel, and the decrease in thickness of the upper little seam of the upper tunnel within the same distance, from fourteen inches to five or six inches only, are in perfect keeping with numerous other cases throughout the Mount Diablo mines, in which considerable variations in thicknesses of strata within short distances are matters not of doubt but of certainty, having been fully exposed by the underground workings.

It has been previously stated that the number of beds which have been profitably worked at the Mount Diablo mines is three; but it will be seen presently that there is a strong probability that at different localities two separate and distinct beds have been confounded under the general name of "Little Vein," and that the whole number of beds which have been more or less worked with profit, should therefore be stated at four.

There have been no "Little Vein" workings in the property of the Black Diamond Company, for the reason that in this portion of the field none of the little seams where cut by tunnels between the Clark and Black Diamond Veins have been of sufficient thickness to pay for working. But in the eastern part of the Union Mine, and also in the western part of the old Eureka Company's ground, one of these little seams reached a thickness ranging from sixteen to twenty-four inches of good coal, and has therefore been quite extensively worked, yielding an aggregate of perhaps from forty to fifty thousand tons of coal. This vein is, in all probability, identical with the upper little seam in the Clayton Tunnel; for the total thickness of the strata between it and the Clark Vein in the Clayton Tunnel is about one hundred and twenty feet, while the thickness between the Clark Vein and the "Little Vein," which has been worked in the Union and Eureka, as shown by the workings at two different localities, is in the Union ground about one hundred and seventeen feet, and in the Eureka ground about one hundred and nineteen feet. There can be no question about the Little Vein in the Eureka ground being identical with that in the Union, for the workings have actually connected with each other under ground. But at a point considerably farther east, in the Pittsburg Mine, and in the northeast corner of the northeast quarter of Section 9, a "Little Vein" has been worked to a considerable extent by means of a little slope driven down to it through the Clark Vein, at a point a few hundred feet southwest of the mouth of the main Pittsburg Slope already described. And here the thickness of strata as exposed in the little slope below the Clark Vein, and above the Little Vein, is about two hundred and fifteen feet. It is probable, therefore, that this "Little Vein" is a different seam from the one in the Union and Eureka grounds, and that it underlies the latter.

The Black Diamond Bed.

The chief openings to the Black Diamond bed, with the exception of the two tunnels already described, do not run directly out to daylight, but are in the shape of tunnels entirely underground, driven south from various gangways on the Clark Vein.

The Black Diamond Company has four such tunnels. Two of these run south directly from the Black Diamond Shaft. The first or upper one, known as the "Black Diamond Tunnel, No. 2," is at the level of the Mount Hope Gangway, which it intersects at a point two hundred and sixty feet south of the center of the shaft. The second, and lower one, known as the "Black Diamond Tunnel, No. 3," starts from the foot of the shaft at a point about six feet higher than the level of the Lower Mount Hope Gangway, so that the cars from this tunnel will run on to the upper platform of the double-decked cage which receives at the same time on its lower platform the cars from the Lower Mount Hope Gangway.

From the south ends of these tunnels, gangways are driven both east and west on the Black Diamond Vein, and are known respectively as the "Black Diamond Gangway, No. 2," and the "Black Diamond Gangway, No. 3." The gangway described hereafter, at the south end of the Clayton Tunnel, and formerly known as the "Lower Black Diamond Gangway," being now called the "Black Diamond Gangway, No. 1."

About two thousand one hundred to two thousand two hundred feet west from the shaft, two other tunnels are driven south to the Black Diamond Vein, one from the Mount Hope, and the other from the Lower Mount Hope Gangway. These tunnels are known respectively as the "West Black Diamond Tunnel, No. 2," and the "West Black Diamond Tunnel, No. 3."

In the Union Mine, a tunnel runs south from the Clark Vein Gangway at the foot of the surface-slope, and in line with that slope to the Black Diamond Vein; and a lower tunnel to the same vein runs south from the gangway on the Clark Vein next below the one at the foot of the surface-slope, and is about seventy-five feet east of the counter-slope already described in this mine. From the south end of the upper one of these tunnels a gangway was driven a few hundred feet to the west; but the driving of this gangway was stopped when it was found that it was south of the section line, and therefore in ground belonging to the Black Diamond Company. From the south end of the lower tunnel, a gangway has been driven a long distance west, and a considerable lift of coal worked out above it and between it and the section line.

From the south end of the upper Black Diamond Tunnel already described, in the ground of the Black Diamond Company, a gangway was driven a few hundred feet to the east, and over three fourths of a mile to the west.

From the south end of the Clayton Tunnel the Black Diamond Gangway, No. 1 (formerly known as the "Lower Black Diamond Gangway"), was driven west considerably over three fourths of a mile, and east a little less than three fourths, making the total length of this gangway something over a mile and a half. This is the longest single continuous gangway which exists in the Mount Diablo mines. For a short distance at its eastern end, it runs along but a few feet below the level of the old Manhattan Gangway on this bed, already mentioned, and driven many years ago; and this part of the Black Diamond Gangway, No. 1, was only driven for the sake of making a connection with the old Manhattan Tunnel for purposes of ventilation.

The Black Diamond Vein is everywhere a much more expensive bed to work than the Clark Vein. This is owing to the bad character of the immediate roof and floor of the coal. The whole thickness of the Black Diamond bed varies in different localities from six or eight to eighteen or twenty feet. But the greater portion of this thickness consists of interstratified clay—slate, and "bone"—the last word being a miner's term to designate a very impure, slaty, and worthless coal, which forms a weak roof and a bad floor, requiring much timbering and gradually swelling so badly on exposure to the air as to crush the timbers, and necessitate frequent cutting down of the bottoms of the shoots and the gangway floors. The workable coal, wherever it extends in the Black Diamond Vein, lies nearly in the middle of the mass forming the thick bed just described, and has bone and shale both above and below it. It generally attains its maximum thickness at those localities where the whole bed reaches its maximum development, or, in other words, where the workable coal is thickest; there, also, the "bone" and slate are thickest, both above and beneath it, and *vice versa*, where the total thickness of the bed is least, there the workable coal thins out or even disappears entirely and the whole bed becomes worthless. The coal itself, however, in this bed, wherever thick enough to be worked with profit, is generally clean and free from interstratified slate or "bone," and there have been considerable areas in the Black Diamond Vein which have yielded rather better, because harder coal than most of that produced by the Clark Vein.

Throughout the whole length of the upper Black Diamond Gangway, except for a little distance in the extreme western portion of the mine, the coal was good, and its thickness averaged about forty-four inches, though varying at different points from thirty-six to fifty-four.

The maximum height of the lift worked out above this gangway was about five hundred and seventy-five feet. But its average height was much less than this, amounting to not far from three hundred and fifty feet.

The height of the lift between the upper Black Diamond Gangway and the Black Diamond Gangway, No. 1, varied from a minimum of about four hundred and twenty feet at a point some four or five hundred feet west of the upper Black Diamond Tunnel, to a maximum of a little over five hundred and fifty feet in the western part of the mine. This increase in the height of the lift towards the west is due here, as well as on the Clark bed, to a decrease in the amount of dip as we go west.

There was a small patch of good coal left unworked above the top of the highest workings above the upper Black Diamond Gangway, which is now inaccessible from below, but which may possibly be worked out hereafter by means of a new and shallow opening from the surface of the hills; and there are also a few acres of good coal not yet worked out in the northwest quarter of Section 9, above the level of the Black Diamond Gangway, No. 1. But with these two exceptions, the Black Diamond Vein is already exhausted down to the level of the latter gangway.

The height of the lift between the Black Diamond Gangway, No. 1, and the Black Diamond Gangway, No. 2, at a point about five hundred and ninety feet east of the Black Diamond Tunnel, No. 2, is three hundred and fifteen feet. At the south end of the Black Diamond Tunnel, No. 3, the height of the lift from there up to the Black Diamond Gangway, No. 2, is three hundred and eighty-two feet.

From the south end of the Clayton Tunnel, westerly, along the Black Diamond Gangway, No. 1, the coal was worked continuously all the way, and the whole lift exhausted as far west as the gangway was driven. For a few hundred feet, however, to the west of the tunnel, the coal was not quite so thick as it was in the upper gangway, the average for the first eight hundred feet here being only about thirty-four inches; and at a point one thousand and sixty feet west of the tunnel there was a small fault, beyond which, for a distance of some three hundred feet, the coal was rather soft. But west of this the coal again was good and hard, and with an average thickness of probably forty inches, reaching in places a maximum of four feet and a half.

To the east of the Clayton Tunnel, the coal on this gangway was thinner, but maintained an average (though gradually diminishing) thickness of twenty-nine inches for a distance of some three hundred and thirty feet, becoming gradually, however, more and more streaked with "bone." Within the next fifty feet, it dwindled rapidly to only eight or ten inches in thickness, becoming entirely worthless, and at the same time so dirty as to be called no longer "coal," but "bone." From thence, eastward, for a distance of between eight hundred and nine hundred feet along this gangway, there was no coal of any value whatever, and the total thickness of the bed for a portion of the way was only some five or six feet, consisting entirely of slate and bone. But at a point about twelve hundred and fifty feet east of the tunnel, the coal again comes in, and then continues of fair quality and with a thickness ranging from two and a half to three and a half feet, for a distance of something like two thousand feet in the northwest quarter of Section 9. This quarter-section covers a massive hill, which rises to a height of a little over fifteen hundred feet above tide-water; and it is probable that the good coal in this hill, at about the central part of the quarter-section, extends to a height of nine hundred or one thousand feet on the dip of the bed above the present gangway. But it has yet been worked to a height of only about three hundred feet above the gangway; though at one point a shoot was driven up to test its quality some seven hundred feet above the gangway, and it was found to be good as far up as this shoot extended.

At a considerable distance to the east of the old Manhattan Tunnel, two or three other openings have been made to the Black Diamond Vein by means of tunnels and slopes driven by the old Eureka and the Pittsburg Companies in ground now belonging to the latter company, but the coal was not found thick enough and good enough to pay for working, and no mining of any account has been done there. It is only within the mile and a half already described, which is traversed from end to end by the

Black Diamond Gangway, No. 1, that the Black Diamond Vein has ever been worked with any profit.

FAULTS AND DISTURBANCES.

Throughout the Mount Diablo coal mines the beds are frequently more or less disturbed by faults and dislocations. Within the two and a half miles of profitable working, some seven or eight of these faults are of considerable magnitude, involving throws of from ten or fifteen feet to one hundred and fifty feet or more, and immediately outside of this two miles and a half, both on the east and on the west, there are disturbances of still greater magnitude. But besides these larger faults, the smaller disturbances scattered throughout the mines and involving well marked dislocations, or throws, of from five or six feet down to as many inches or less, are extremely numerous. These disturbances are generally most sharply defined, and may be most easily studied in the Clark Vein. Many of the smaller ones are entirely local in character, and extend but very short distances; and it is only a very few of the largest ones which appear to extend through the whole mass of strata between the Clark and Black Diamond Veins with sufficient uniformity in character and direction to render it possible to recognize with certainty the same fault in both the veins.

The longest distance which occurs anywhere in the mines without any fault or disturbance of noticeable magnitude, is a distance of about two thousand feet on the Clark Vein, stretching east from the Black Diamond Shaft into the western portion of the Union Mine. The foot of the Black Diamond Shaft itself, however, is immediately opposite the point where a fault, involving a throw of from fifteen to twenty feet down to the west, crosses the Lower Mount Hope Gangway. This fault, like most of the larger ones in the Mt. Diablo mines, has a northeasterly and southwesterly course, and its plane dips at a steep angle towards the northwest. It shows through all the upper works on the Clark Vein, and its position may be traced upon the mine-map by the sudden changes in the directions of the three successive gangways on that vein, where it crosses them. It is also probable, though not certain, that this fault extends through the intervening strata to the Black Diamond Vein, as there is a fault of several feet down to the west in the latter vein, which crosses the upper Black Diamond Gangway eight hundred feet west of the upper tunnel, and the Black Diamond Gangway, No. 1, at a point one thousand and sixty feet west of the Clayton Tunnel, running northeasterly and southwesterly, and in such a position that although not exactly in line with this fault upon the Clark Vein, yet by curving slightly, as it is very likely to do, through the intermediate strata, it may very easily connect with it.

To the west of this, for a distance of over three thousand five hundred feet there is no single fault upon the Clark Vein which equals it in magnitude, though there are many smaller ones.

In the Union Mine there are five large faults. One of these is to the east of the Union Slope; one is just west of it, and is a considerable downthrow to the west; the three others are still further west, two of them being upthrows to the west, and one, the largest of all of them, a downthrow of sixty or seventy feet to the west. Some of these faults, doubtless, also run through to the Black Diamond Vein; but they show themselves there in such modified forms that among the multiplicity of minor disturbances it is not easy to recognize them.

In the eastern part of the old Eureka Company's ground there is a large fault which, so long as this company continued to work, formed practically the dividing line between its underground workings and those of the Pittsburg Company.

At a point in the eastern part of the Pittsburg Mine, about nine hundred feet east of the foot of the Pittsburg Slope, a fault crosses the gangway larger than any of the preceding, and consists of an upthrow of something over one hundred and fifty feet to the east; and at the extreme eastern limit of the Pittsburg Company's workings, the gangway terminates at the wall of another fault, which has never yet been thoroughly explored, and perhaps never will be, but which, judging from the position of the outcrop of the Clark Vein, at points further east toward Stewart's Mine, must consist of an upthrow to the east of not less than three hundred to four hundred feet, and possibly more.

It would be both impracticable and useless to describe all the smaller disturbances scattered through these mines. But, as an illustration of the frequency with which they sometimes occur, the following description is given from actual measurement of a somewhat remarkable "trouble" which extends for some distance along the Clark Vein Main Gangway, in the western part of the Black Diamond Company's mines: beginning at a point about twenty-one hundred and ten feet west of the foot of the Little Hoisting Slope, we have first a jump of seven inches down to west; then—

20 feet further west, a jump of 17 inches up to west.
7½ feet further west, a jump of 6 inches up to west.
12½ feet further west, a jump of 12 inches down to west.
2 feet further west, a jump of 12 inches up to west.
6½ feet further west, a jump of 22 inches down to west.
34½ feet further west, a jump of 7 inches up to west.
2 feet further west, a jump of 16 inches up to west.
10 feet further west, a jump of 12 inches up to west.

Then for a short distance the ground is *very* irregular, and the coal entirely disappears, with the exception of a thin and irregular seam, which bends first up and then down to the west, to where the coal comes in on the gangway again, which it does with a jump down to west at a point about seventeen feet west of the twelve-inch jump last noted. We then have—

5 feet further west, a jump of 10 inches down to west.
4 feet further west, a jump of 29 inches up to west.
12 feet further west, a jump of 4 inches down to west.
2 feet further west, a jump of 4 inches up to west.
3 feet further west, a jump of 2 inches up to west.
2 feet further west, a jump of 5 inches down to west.
3 feet further west, a jump of 31 inches down to west.
14 feet further west, an irregular roll and jump resulting in a change of 30 inches up to west.
8 feet further west, a jump of 31 inches up to west.
22 feet further west, a jump of 42 inches down to west.

This was the last jump measured; but there were more of them, and the "trouble" extended some little distance further west. Throughout its whole extent, both coal and sandstone were of course very badly crushed, some of the latter being just ready to fall to powder and run like loose sand, and very little coal was obtained from here till, on going farther west, the faults became less frequent.

It sometimes happens that the same fault in different portions of its course varies considerably in the amount of its throw, showing that the displacement in such cases has involved a twisting of the strata. There is one notable instance of this kind in the eastern part of the Union Mine. In the upper workings here a fault of considerable magnitude runs about northeast and southwest, and at the highest point of the workings exhibits itself as an upthrow of sixteen feet to the east. But it curves gradually to the north in going down, thus being convex to the east, while at the same time the amount of its throw gradually diminishes, until, at the point where it crosses the present lowest gangway in the mine, its course is about north and south, and its upthrow is only eighteen inches to the east.

With reference to the direction of throw in the faults, the general law holds pretty well throughout these mines, that, where the plane of a fault is inclined from the vertical, it is the hanging wall of the fault which has gone down. But this law, though general, is not universal, and cases are occasionally found here in which the throw is in the opposite direction.

The general line of strike of the beds, in spite of all faults and disturbances, is very straight for a distance of nearly a mile and a half in a direction about N. 86° W. (true course), from the Pittsburg Slope to a point about as far west as the middle of Section 5; and within this distance the dip does not vary greatly from 30°, ranging in general from 28° to 32°.

But, going west from the middle line of Sections 5 and 8, the beds and the strata *curve* far around in a gradual sweep to the south, while at the same time their dip gradually diminishes until it does not exceed 20°; and in the western part of the Clark Vein Main Gangway there were places where it was only 15°. The general form and shape of the beds as they lie in this part of the mines, therefore, is that of *warped surfaces.* And this state of thing produces, of course, a gradual divergence of the gangways of each bed from each other, and a gradual increase in the height of all the "lifts" in going west.

This great curve of the beds to the south, in the western part of the mines, is evidently preliminary to a great and sudden disturbance of the strata, which is proven by other evidence to exist in the eastern halves of Sections 6 and 7, and within a short distance to the west of where the mines have stopped. But none of the gangways, on either the Clark or Black Diamond Vein, wêre driven far enough west to actually encounter this great disturbance. They were stopped because, for various reasons, it was not profitable to drive them further. In the upper Black Diamond Gangway, the coal still kept its place and thickness, but had grown rather soft and friable, and in this expensive bed, with the disadvantages of a dip of only 18° to 20°, and nearly a mile of underground haulage, it would not pay to go further for coal of so poor a quality. The face of the Black Diamond Gangway, No. 1, struck a fault, the magnitude of which was not known; and though the coal here was of good quality, and over four feet thick up to the fault, yet the dip here, as well as in the upper gangway, was low, and the underground haulage was over a mile. So it was not considered advisable to drive further, upon the chances, in the face of the additional fact that the near proximity, though not the exact locality, of great disturbance to the west, was certain. In the Clark Vein Main Gangway the work was finally stopped because of a somewhat interesting fact of altogether a different kind. Here the Clark Vein gradually split into two portions, which grew thinner and thinner until they almost disappeared. At a point, probably a thousand feet back from the final face of the gangway, an almost imperceptible seam or parting first made its appearance in the middle of the bed. This parting at first was not thicker than a knife-blade, and it ran a considerable distance before it presented any further special change. But then it begun slowly to increase in thickness, and gradually developed itself into a little layer of clay-slate. This change went on slowly for some distance, the coal above and below the slate being still good, but decreasing slightly in thickness, till at a point four hundred and eighty-five feet from the final end of the gangway, there were two streaks of coal, each about one foot thick, with a few inches in thickness of slate between them.

Here the gangway struck the first jump of a series of small faults and rolls which continued for some distance, and there was a sudden increase in the thickness of slate between the two bands of coal. The gangway was still driven on, however, in the hope that the coal might come in again; but with prospects which only grew worse and worse—the coal growing thinner and the slate growing thicker—till at last the upper seam of coal was only about three inches thick, and the lower one six inches, while the clay-rock between them had increased to a thickness of about five feet. The work was then abandoned.

The exact condition of the face of the Mt. Hope Gangway when abandoned is not known to the writer; but it is evident in any case that it was driven far enough to the west, so that in the light of the development already made in the gangway next above, it was not likely to pay to drive it further. It probably went to the first of the series of little faults and rolls described above; for it stopped only about five hundred feet short of the Clark Vein Main Gangway itself.

To the east of the Pittsburg Slope a similar state of affairs exists in the strike and dip to that above described in the western part of the Black Diamond Company's mines, but on a somewhat smaller scale, and in an opposite direction. Though broken in the middle by a large fault, the gangways here run far to the south of east, and the dip also in the eastern part of the Pittsburg Mine is considerably less than it is in the vicinity of the slope. Moreover, as already stated, the works at the end here abut directly against the wall of a great upthrow of some three or four hundred feet to the east.

Ventilation.

In mines situated as these are, with a general dip of about 30°, among high hills and deep cañons, there is rarely much difficulty in securing good ventilation, if the matter be properly attended to, and the only artificial means in general use to aid the natural ventilation at the Mount Diablo mines is the keeping of fires at the bottoms of the ventilating shafts. In only one instance has mechanical ventilation been resorted to on any considerable scale. In the Lower Mount Hope Gangway, to the westward of a point about twenty-two hundred and fifty feet west of the Black Diamond Shaft, all the water (and its quantity is considerable) which issues from the roof and floor of the Clark Vein, besides being a solution of sulphates, is supersaturated with sulphuretted hydrogen to such an extent that on exposure to the air it rapidly forms white deposits of sulphur everywhere, while the excess of gas escaping contaminates the air so much as to cause serious trouble by its effect upon the eyes, which it quickly renders sore, inflamed, and almost blind, probably by reason of its decomposition with the formation of minute quantities of sulphurous and sulphuric acids in contact with the moisture of the eyes. It was found impossible, with the ordinary means of ventilation employed here, to send a sufficient volume of air through this portion of the mine to keep it clear enough of sulphuretted hydrogen to enable the men to work more than a very few hours at a time without becoming nearly blind. The trouble at last became so serious that the men absolutely refused to work there without better air.

The experiment was tried for a few days of keeping chloride of lime exposed to the air throughout that portion of the gangway affected, with a view to decompose and absorb the deleterious gas; but for some reason it appeared to fail to accomplish the work, while the men complained that the pungent odor of the chloride of lime, in addition to the sulphur gas, only made matters worse. Then one of the largest sizes of Root's patent rotary blowers was obtained, and, driven by a small steam engine, was set to forcing air through a pipe down the Black Diamond Shaft and into that part of the mine, the air afterwards finding its exit from the mine through a ventilating shaft connecting with the western part of the Mount Hope Gangway. This made a decided improvement, but was yet far from being satisfactory. The action of the blower was therefore reversed, and it was made to exhaust the air, which then entered the mine through the ventilating shaft just mentioned. This did much better, and the work in this part of the mine was resumed and continued, though slowly and with difficulty; for the blower, after all, only partially removes the gas, enough of which still remains to make it very troublesome.

There is a little fire-damp in all the beds of the Mount Diablo mines, and there are now and then localities which it is necessary to watch pretty closely. But the quantity of this gas has never been great enough to necessitate the general use of the safety-lamp in the workings; and it has, therefore, only been used as a precautionary means for testing the presence of the gas in certain localities where it was known that small quantities of it were liable to collect. Numerous small casualties, resulting in the more or less severe burning, and occasionally in the death of one or two men have, however, occurred here from time to time, from explosions of fire-damp, nearly all of which have originated in the gross carelessness of the sufferers themselves in going with naked lights into the top of blind shoots or other places which had been standing idle for awhile, and where they knew, or ought to have known, that fire-damp was liable to be present. But besides these minor casualties there have also occurred, during the history of the mines, three or four explosions of greater magnitude, which cannot be said to have resulted from the special ignorance or carelessness of individual miners. None of these explosions did much damage to the mines; but one or two of them have resulted in serious loss of life.

The worst one of all was the explosion, or more properly the burning, of July 24, 1876, on the Black Diamond bed, in the lower and eastern part of the Black Diamond Company's mines, which resulted in the death of eleven men. This was occasioned by a "blown out" shot. There was no explosive mixture present where this disaster occurred previous to the firing of the shot, for the men were working all along there with naked lights, and the ventilation was good and strong. But on the firing of this shot (which was a pretty heavy one, being a two and a quarter inch hole charged probably with from twenty to twenty-four inches of black powder) the flame traveled between two and three hundred feet along the face of the coal, following a crooked course through crosscuts, etc., developing a hardly noticeable amount of explosive force, but badly burning all the men whom it caught in its course and then asphyxiating both them and others by the after-damp which followed the flash. The cause of this explosion was probably twofold. First, it is well known that in coal seams containing fire-damp any diminution in the atmospheric pressure, whether sudden or gradual, is accompanied by a correspondingly sudden or gradual liberation of increased quantities of fire-damp from the face of the coal. It is more than probable, therefore, that the recoil, which in an elastic medium like the air, and especially in confined localities, must instantly follow the first impulse of the heavy concussion of such a shot, would liberate suddenly from the adjacent face of the coal a certain quantity of fire-damp, which might issue forth quickly enough and be sufficient in quantity to catch fire either from the flash of the shot itself or from burning particles of coal dust ignited by that flash. Second, the part of the mine where this accident happened was very dry, and the shot itself must have raised in its immediate vicinity a dense cloud of fine coal dust. Now, recent experiments have shown that a mixture of fire-damp and air which contains far too little fire-damp to be capable of either exploding or burning by itself alone becomes readily explosive if mixed with a sufficient quantity of impalpably fine coal dust. There is every reason, therefore, to believe that the propagation of the flame in this instance was effected by an intimate mixture of the air with a certain quantity of fire-damp and a dense cloud of coal dust, the presence of the last two of which was mainly due to the concussion of the shot itself; and the whole affair is strongly illustrative of the danger of the use of powder in coal seams where fire-damp is known to exist.

The Mt. Diablo coal is liable, under favorable circumstances, to spontaneous combustion; and, in the Black Diamond bed, it is always necessary to shut up the old workings so as to prevent access of air to the gob, which would otherwise heat and eventually take fire; but in the Clark bed, with its freedom from "bone" and its good sandstone roof and floor, no such precaution has been found necessary.

Haulage, Storage, and Transportation.

The gauge of the mine-tracks is different in the different mines. In the Pittsburg Mine it is twenty-six inches; while in the Black Diamond Mines it is three feet. The size and shape of the mine-cars employed also varies somewhat in the different mines. The inside dimensions of those used by the Black Diamond Company are six feet six inches long, two feet six inches wide, and two feet eight inches high. These cars are built of wood, banded with iron, and hold about a ton each of loose coal.

In the Black Diamond Company's mines, the underground hauling is done entirely by horses and mules, but in some of the other mines, and especially in the Union and Eureka, a great deal of it has been done by hand, the men pushing the cars.

No coal-breaking machinery has ever been used or needed here. In fact, one serious trouble with this soft coal is that it crumbles too easily and makes too much slack without any other breaking than that which it necessarily gets in mining and handling.

The bunkers at the mines are furnished with screens which separate the marketable coal into two sizes only, known as "coal" and "screenings," respectively. But this screening is often very imperfectly done. The slack which falls through the finest screen is generally thrown away, though within the last few years considerable of it has been burned under the boilers at the mines, and occasionally a little of it has been sold for various purposes. The Black Diamond Company's bunkers are also furnished at the top with automatic dumping arrangements, so that the mine cars dump themselves into the bunkers. The size of the bunkers varies, of course, with the requirements of the different mines. The largest one ever built here is that which receives the coal from the Black Diamond Shaft. This bunker has a capacity of about sixteen hundred tons, *i. e.*, eleven hundred tons of coal and five hundred tons of screenings. It stands at a distance of some five hundred feet or more from the mouth of the shaft, and the loaded cars are hauled to it and the empty ones hauled back to the shaft by an endless wire rope worked by a clip pulley, which is driven by a small steam engine. The floor of this bunker has a pitch of 33°, and the vertical height between the mine car track above it and the railroad track beneath it is eighty-four feet.

The Black Diamond Railroad is a trifle over five and eight tenths miles in length. Of this, the first two and eight tenths miles from the river to the edge of the hills is straight and has a grade which, though not uniform, being less near the river than it is near the hills, nevertheless averages for the whole two and eight tenths miles about sixty feet to the mile. The remaining three miles in the cañon, from the edge of the hills up to Nortonville, is very crooked, and has an average grade of about one hundred and ninety feet to the mile. The maximum grade, however, is much heavier than this, and is situated at the upper end of the road nearest the mine, where, for a distance of five eighths of a mile, the uniform grade is two hundred and ninety-three and three fourths feet to the mile. The minimum radius of curvature in this road is three hundred and twenty-one and one fourth feet, corresponding to about an 18° curve. This, also, is at the upper end of the road, leading to one of the bunkers. Its use was necessitated by the position of the bunker and the narrowness of the cañon. It is just about as sharp a curve as the locomotives employed here will travel on without leaving the track.

The cars now employed on this road have flat wooden bottoms, with rectangular sheet-iron sides and ends strengthened with angle iron. One of the ends consists of a door, hung from a bolt which runs across the top, and furnished with a strong latch on each side. The cars are four-wheeled. Each car occupies about ten feet of track, and stands about six feet two inches high above the rails. The interior dimensions of the car body are as follows: length, eight feet; width, six feet four inches; height, three feet four and one half inches. These cars weigh, on the average, about four thousand pounds apiece, and each car carries from ten thousand to eleven thousand pounds, or a trifle over four and one half tons of coal. From twelve to sixteen of these cars form an ordinary coal train. The locomotive merely hauls the empty cars up to the mine. When loaded, the train runs down to the landing by its own gravity, and it needs, of course, careful attendance at the brakes to prevent it from running too fast. Indeed, whenever the track is muddy and slippery, as is often the case in the rainy season, it is found necessary, in addition to the most careful handling of the brakes, to sand the track to a greater or less extent before the descent of every train over that portion of the road which has the heaviest grade.

The Pittsburg railroad is of nearly the same length as the Black Diamond, and is very similar to it both in the distribution and in the amount of its grades and curvatures. The cars used upon this railroad are of iron, but of somewhat less capacity than those above described, and also somewhat different in construction, being arranged to dump through trap-doors in the bottom of the car, while the Black Diamond cars run on to a special dumping arrangement at the end of the wharf, which then tips up with the car upon it till the floor of the car makes an angle of 35° or so with the horizon, when the door at the lower end being unlatched, the coal runs out.

Pumping and Drainage.

There has never been any general system of drainage for the Mount Diablo mines; but each company has pumped out its own water independently of all the rest. In the year 1869 I made a careful survey to ascertain what could be done in the way of a drain tunnel, and found that a tunnel about seven thousand feet in length from a point in the Somersville Cañon to the Clark bed would drain all the mines of Nortonville and

Somersville to a depth of only about three hundred feet above low water in the San Joaquin River, or in other words, to a point a little below the lowest levels ever yet reached by the workings in any of the mines, excepting those from the bottom of the Independent Shaft.

This tunnel might have been driven for a cost of only about $50,000, and at the time when the survey was made there was talk of doing it. But the different companies to be benefited by it could not agree as to the exact proportion of its cost which ought to be paid by each of them respectively; and so after talking awhile to no purpose, the matter was dropped; since which time the Black Diamond, the Union, and the Pittsburg Companies have all three of them been lifting their water to points over five hundred feet vertically higher than the level at which this tunnel would have drained them all; and it is safe to say that from then up to the present time the aggregate cost of the item of pumping alone has been at least four or five times what the total cost of the tunnel would have been. And this is not, by any means, the only instance in which the existence and rivalry of so many different companies within so small a field, combined with short-sighted policy, and bad management in other ways, have caused the expenditure of large sums of money which are practically wasted, and which might otherwise have been saved to the owners of the mines. The Independent Shaft was a bad job, as well as a bad speculation, from beginning to end; and the new Black Diamond Shaft itself, with all its machinery, although a splendid piece of workmanship, was an unnecessary expense, inasmuch as the Mount Hope Counter-slope, which is large, commodious, well-timbered, protected by heavy pillars on either side, and furnished with a double track, and a pumping compartment besides, was already down to the same level as the present foot of the shaft before the sinking of the shaft was begun; and it would have been easy to have hoisted through this slope, at no greater expense than it will now cost to hoist through the shaft, all the coal that is likely to ever come up through the shaft.

It would be easy to point out many other ways in which money has been wastefully spent at the Mt. Diablo mines; but I will only mention here one other matter in this connection. Situated as these mines are, their whole extent from the eastern limit of the Pittsburg to the western limit of the Black Diamond Company's workings, was none too great for a single colliery; and if, in the early history of the mines, the various companies had combined into a single organization to control and manage the whole, then not only the Black Diamond Railroad itself, but also the whole establishment of shaft, slopes, and machinery for pumping and hoisting at the village of Nortonville would have been needless and superfluous, and their entire cost might have been saved; for a single railroad in the Somersville Cañon would have amply sufficed to transport all the coal which these mines have ever furnished, or ever will furnish; while, at the same time, every ton of it could have been brought to daylight in this cañon more cheaply than it has been brought to the surface at the various openings through which it has actually been extracted.

For this purpose; the tunnel above referred to as a proposed drain tunnel, which was never driven, should not only have been driven, but should have been made a large sized working tunnel and furnished with a double track and all other facilities for the rapid extraction of coal.

I do not think it is too much to say that if this had been done, and if the general management of the mines had been at the same time placed in the hands of a competent engineer, then the total production of these mines up to the present time (which amounts approximately to one and three-quarter million tons) might have been furnished at an average cost price of one dollar less per ton than under existing circumstances its actual average cost has been. In other words, I believe that up to the present time the aggregate sum of one million seven hundred and fifty thousand dollars could have been saved to the owners of the Mount Diablo coal mines, if all the natural advantages which the situation of the field presented had been utilized with the best economy.

Peacock and San Francisco Mines.

To the west of the Black Diamond Company's mines, for a distance of a mile or two, there has been, in the past, considerable prospecting done for coal among the hills, and a number of slopes and tunnels have been driven some distance underground, at different points, upon the outcrops of small seams of coal. But nothing has ever been discovered here of any value, and the only two localities worth mentioning now are the old "Peacock," and "San Francisco" Mines.

The first of these was unquestionably upon the Black Diamond bed, and is situated about a quarter of a mile southwesterly from the extreme western limit to which the Black Diamond Company pushed their old "Upper Black Diamond Gangway." This gangway, at its face, when abandoned, was running S. 46° 30′ W., true course, or about S. 30° W., magnetic, and the dip of the bed at the same point was about 20° to the northwest. It will also be remembered that the "Lower Black Diamond Gangway," as well as the corresponding levels on the Clark bed, in this portion of the Black Diamond Company's mines, all show the same great curve of the strata here to the south in going west. Yet there is no sudden break of any considerable magnitude so far as those works extend. But at the Peacock Mine, only about a quarter of a mile distant, we find the bed striking S. 75° W., magnetic, and dipping to the north at an angle of 45°, thus proving that within this short distance there is a great disturbance of some kind, resulting in a sudden change of some 45° in the direction of the strike, and an increase of about 25° in the amount of dip.

I am not informed as to the full extent of the work which was done in the "Peacock," as it was already abandoned before I first saw it in 1868. But a slope was sunk for ventilation, and a tunnel was driven at least some eight hundred or nine hundred feet in length. The ground, however, was found to be badly broken and crushed, and the coal was soft and worthless.

The San Francisco Mine is situated about half a mile to the west of the Peacock. A slope was sunk here about three hundred feet, on a bed whose dip is about 41° at the surface of the ground, but increases to 50° at the depth of one hundred and sixty feet, from which point a gangway was driven east two hundred and seventy-five feet, and west about seventy-five feet. At the eastern face of this gangway the coal was about two feet thick, and had a course of N. 70° E., magnetic, and a dip of 65° to the north. Below this stratum of coal there was about six feet of soft clay-rock, and then another stratum of coal about one foot thick. Above it there was also another small streak of coal separated from it by a layer of clay-slate. Small faults were very numerous here, and the coal was soft and friable, and never paid to mine. A little of it was once hauled to the village of Pacheco, for sale. But as early as 1869, the work was already abandoned. It is very probable, though not certain, that this mine also is on the Black Diamond bed.

Central Mine.

Passing now to the eastward from Somersville, the first mine which we encounter is the "Central," better known, perhaps, as "Stewart's Mine." This mine is situated in a steep and narrow ridge, which runs nearly east and west across the northern part of Section 10, and the mine itself is in the northeast quarter of this section. It was originally opened by a level tunnel driven northerly from a point considerably beneath the line of outcrop of the beds in the steep and almost precipitous southern face of the ridge.

The course of this tunnel is just about north, magnetic, and its length to the Clark bed is about one thousand and thirty feet. It of course cuts through the underlying beds. The tunnel is not at right angles to the gangway, the course of the latter being somewhat to the north of west, magnetic. There are exposed in this tunnel, beneath the Clark bed, four distinct seams of coal, none of which, however, are here of any value. Starting from the Clark bed and going south along the tunnel towards its mouth, we find these seams as follows: The first one at a distance of one hundred and thirty feet shows eighteen inches of impure coal. The second one, about one hundred and fifty-seven feet further south, shows twenty-two inches of similar material. The third one, seventy-three feet further south, is nineteen inches thick; and the fourth one, supposed to be the Black Diamond bed, is one hundred and eighteen feet still further south. There can be no reasonable doubt, in spite of differences and diminished thickness in the section of the strata between them, that the two beds here called the Clark bed and the Black Diamond bed, respectively, are in reality the same beds as those which bear these names at Nortonville and Somersville. In this mine, some of the small beds between the two contain considerable gypsum in thin sheets and scales, filling seams in the soft and worthless coal. On the Black Diamond bed a gangway was once driven here some distance both east and west from the tunnel, and it is said that the bed was from three to four feet thick, and that about a thousand tons of coal were extracted from it, which, however, was of very poor quality, being both soft and "bony." It had been entirely abandoned previous to my first examination of the mine in 1869.

In April, 1870, a gangway had been driven here, on the Clark bed, two hundred and seventy-five feet east, and three hundred and seventy-five feet west from the tunnel, and a good deal of coal extracted, the bed averaging about thirty-nine inches in thickness, and dipping to the north at an angle of 28° or 29°. Just west of the tunnel, a large fault, consisting of an upthrow to the west, estimated at eighteen feet, crosses the gangway very obliquely, running northwest and southeast. To the west of this there were no more faults so far as the gangway was then driven, and the coal was bright and clean, but soft and friable. To the east from the tunnel there was a constant succession of small and irregular jumps all the way to the face of the gangway, and the coal here was badly crushed and very soft. Above this gangway the breasts had then been worked to a maximum height of about four hundred and fifty feet, the total distance on the dip of the bed, up to the outcrop, being about seven hundred feet. And some of the best, *i. e.*, the hardest, as well as the cleanest coal ever taken from the mine had come from the top of these breasts, up nearest the surface of the ground.

In connection with the popular fancy that coal must of necessity improve indefinitely in quality with indefinite increase of depth beneath the surface, it may be well here to state the fact that at Nortonville, the mines have never, even from their lowest depths, produced any better or harder coal than was a great deal of that which came from the top of the very highest workings on the Black Diamond bed, more than five hundred feet above the old "Upper Black Diamond Gangway." And this is not all: It is true, as a general rule, throughout all the Mt. Diablo mines, that when a depth of from one hundred to three hundred feet is attained, measured on the dip of the bed from the outcrop, there is after and below that no further improvement in the quality of the coal which can be shown to be to any extent dependent upon or connected with the additional increase in the depth.

Since 1870, a tunnel has been driven in Stewart's Mine from the Clark bed northerly entirely through the ridge and out to daylight on its northern side. Since the completion of this tunnel all the coal mined has been taken out through it, thus saving some two miles of cartage around and over the hill.

It is not probable that this mine has ever been a profitable one to work. And though it has produced in the aggregate a considerable quantity of coal, it has not been worked continuously, but irregularly and spasmodically, sometimes lying idle for many months, and then again producing as high as from nine hundred to one thousand tons of coal per month. After this sort of fitful life for some eight or ten years, it has recently again shut down, and it is doubtful whether it will ever be much more worked hereafter.

Going east from Stewart's Mine, we next find in the bottom of a cañon near Cochrane's house and close to the center of Section 11, the outcrops of two beds, which in all probability represent the Clark bed and the Black Diamond bed respectively. At this point the beds run very nearly east and west, and dip to the north at an angle which Cochrane states to be about 32°.

Some prospecting was done at this locality years ago, but the coal was not found good enough to warrant mining.

Beyond Cochrane's, as we go east, the thickness of the strata and the characteristics of the various beds themselves change so much that, though there is, of course, no lack of positive opinion on the subject among some of the men who are pretty familiar with the ground, and though there are here and there a few facts known which really do point to some probability in the matter with reference to certain beds, yet it is impossible, in the light of all the developments hitherto made, to recognize anywhere, with any certainty, a single bed as being identical with either the Clark or the Black Diamond bed of the Mount Diablo mines.

The next development to the east of Cochrane's, is in the northeast part of the southwest quarter of Section 12. Here a slope was sunk about two hundred feet, some years ago, in a direction of north 16° west, magnetic, upon a bed of coal with a pitch of about 27°. There was no coal visible here at the surface of the ground, but only a slightly carbonaceous shale for the first eighty or ninety feet. But then the coal began to come in, and at the bottom of the slope there is said to have been three feet of pretty clean, though rather soft, coal, with a good sandstone roof. It is also said that two small schooner loads were once shipped from the bottom of this slope.

Empire Mine.

The next development is at the locality now known as the "Empire Mine." This is in the southwest part of the southeast quarter of Section 12.

A slope was originally sunk here about two hundred feet in 1860 or 1861, when the work was stopped by the influx of water which the parties had not the means to handle. There was visible here at the surface of the ground only a little streak of soft clay-shale about eight or ten inches thick, which was of rather a light yellowish hue, being but very slightly colored by carbonaceous matter, and having sandstone immediately above and below it. This could not be called a very promising outcrop, certainly. But, on going down, it was found that this streak of shale increased steadily and rapidly in thickness, and also grew rapidly more and more carbonaceous, till, at the depth of one hundred feet slope distance, it had already developed into a four and a half foot bed of what might very properly be called coal, though it was still impure and very soft and friable. Its quality still continued to improve rapidly to the bottom of the slope. It was, however, abandoned.

But in the year 1875, Mr. George Hawkshurst, the Superintendent of the Union Mine, at Somersville, in connection with one or two other parties, again took hold of this old slope, cleaned it out, enlarged it, furnished it with a double track, put up pumping and hoisting machinery, and sunk it to the depth of six hundred feet (slope distance), and then drove a gangway both ways from its foot.

My last visit to this property was December 11, 1876. At this time the gangway was driven about three hundred feet west and nearly four hundred feet east from the slope, with a general course of N. 75° E., magnetic, the dip of the bed being about 23°, and the direction of the slope itself being N. 6° E., magnetic.

The coal along this gangway ranges from three feet six inches to a little over four feet in thickness. At the west face of the gangway it was four feet three inches thick. Of this, the upper twelve inches was tolerably clean coal; the next twelve inches was "bony," and the lower two feet three inches was clean coal, though rather softer than the average Mount Diablo coal. The floor of the bed is sandstone. Along the roof of it there runs a stratum of from five to eight inches of soft clay-slate, which, however, is not continuous, the solid sandstone sometimes coming down to the coal. Above this little streak of slate there is everywhere good solid sandstone. In the eastern part of the gangway there is one fault, which consists of a downthrow to the east of just about the thickness of the vein. West of the slope, there are only one or two little jumps, of a few inches each.

From a point a few feet east of the foot of the slope a tunnel was driven south some three hundred feet through the sandstone, in order to strike an underlying bed which had been previously discovered by a little shaft sunk about ninety feet south of the mouth of the slope, and one hundred feet deep. This bed, as seen in the shaft, is said to consist of three feet of good, clean coal, like the bottom bench of the upper bed, without any "bone," and with good sandstone roof and floor. This bed they had not yet reached in the tunnel at the time of my visit, though at a distance of a little less than two hundred feet from the upper bed they had passed through a small coal seam, about eighteen inches thick. Since that time, however, they have struck the lower bed in the tunnel, and found it, as I am told, to consist here of a bottom bench of twenty-two or twenty-three inches clean coal, overlaid by about fourteen inches of worthless "bone." The appearance of this "bone" at the depth where the tunnel strikes it, while there was no "bone" at the bottom of the little shaft so much nearer the surface of the ground, is not an encouraging fact with regard to the future prospects for a mine upon this bed.

At a point some six hundred feet south of the mouth of the slope, and very close to the section line between Sections 12 and 13, there has been another little shaft sunk about ninety feet, and from the bottom of it a drill-hole was pushed some thirty feet lower. They are reported to have passed through several little streaks of coal in this shaft, and at the bottom of the drill-hole to have struck something which they believe to be the Black Diamond bed, as they assume the bed upon which the slope is sunk to be the Clark bed, and the one struck in the tunnel to be one of the "Little Veins" between the two. But this assumption, though not improbable, is, as already stated, by no means proven.

A recent survey shows that the mouth of the Empire Mine is about four hundred feet above tide-water, and that a railroad from there to the village of Antioch, on the San Joaquin River, will be about five and a half miles long, and will have two tunnels, aggregating something over one thousand feet in length. It is the present intention of the owners to build this road.

Teutonia Mine.

Next east of the Empire Mine comes the old "Teutonia." This is in the south part of the southwest quarter of Section 7, T. 1 N., R. 2 E., the mouth of the mine being only about one hundred aud fifty feet north of the section line. This mine was furnished with steam hoisting and pumping machinery. But at the time of my first visit to it in September, 1869, it had already been idle and abandoned for some two years, and nothing has been done there since. According to the best information which I have been able to obtain, however, relating to this mine, the slope, which was furnished with a double track and with sheet-iron mine-cars, went down upon a bed of coal about four hundred feet, with a pitch of about 26°. From the bottom of the slope a gangway was driven east something like one hundred feet. Just west of the slope the bed was broken by a large fault jumping up to west, beyond which the work was never carried. The bed was about thirty-six inches thick, the lower half of it being bright, clean, shelly coal, not very hard, and the upper half being "bony." It will be noticed that this description of the bed itself is remarkably like that of the bed which was struck by the tunnel in the Empire Mine in the latter part of December, 1876; and it is indeed not at all unlikely that it may be in reality the same bed.

The fact is worth noticing here that on October 11, 1875, before the underlying bed had been found at the Empire Mine, Mr. J. Cruikshank (who is well informed as to the early work which was done in this region), in some notes which he gave me, placed the Teutonia Slope on a bed underlying the "Clark Vein," and located the outcrop of the "Clark Vein" itself at a point some distance to the north of the mouth of the Teutonia Slope.

On the northeast quarter of Section 18, T. 1 N., R. 2 E., there is another old slope, known as the "Israel Opening." This slope is said to be some two hundred feet deep, with a pitch of about 25°. It is said, furthermore, that at its bottom there was three feet of clean and tolerably hard coal, and that some rooms were opened and several cargoes of coal once shipped from here. It is supposed that this slope is on a bed which underlies the one on which the Teutonia Slope is sunk.

On the northwest quarter of Section 16, T. 1 N., R. 2 E., there are several small openings, only one of which is worth mentioning now. This is a slope which runs down about north magnetic with an average pitch of 21°. It is said to be about two hundred feet deep, and also that at the bottom of it there were three feet of clean coal, with sandstone roof and floor. In December, 1876, the lower part of this slope was full of water, down to the surface of which it was one hundred and thirty-five feet, and at this depth there was nothing like good coal to be seen, but only a streak of dirty "croppings" about one foot in thickness.

Rancho de Los Meganos.

On going still further to the east from here, there is for some distance hardly any exposure of the rocks at the surface, and there have never been any holes sunk until we reach the southeast quarter of Section 22, and the northeast quarter of Section 27, upon the Rancho de Los Meganos, in T. 1 N., R. 2 E. Here there are known to exist at least three beds of coal of workable thickness, associated with heavy deposits of a good quality of fire-clay.

A small shaft in the south part of Section 22, known as the "Hoisting Shaft," and eighty-eight feet in depth, shows the following section of the strata, the measurements being vertical, and beginning at the top or mouth of the shaft:

	Ft.	In.
Clay and clayey material	34	4
Black clay	14	8
Coal	2	4
White clay, hard and somewhat sandy	4	8
Coal	0	4
Blue fire-clay	5	0
Coal	3	6
Clay (with three regular coal seams, about one foot thick each)	8	0
Coal	7	0
Clay	3	0
Coal	1	2
Clay	4	0

There has been mined here, chiefly from the "seven-foot" and the "three and a half-foot" beds, through shallow slopes and shafts, without the use of other power than that of hand and horse, an aggregate of probably somewhere between five thousand and ten thousand tons of coal, most of which has been used under the boilers at the "Engine Shaft."

The general course of strike of the beds here is about N. 72° W., magnetic, and their dip to the northeast, but so far as yet explored, somewhat variable in amount, ranging from 16° to 26° at different points.

The "Engine Shaft" is sunk at a point about eleven hundred feet northeasterly from the line of outcrop of the beds, is about three hundred and eighty feet deep, and is divided into three compartments, two hoisting and one pumping, each compartment being eight feet by five feet clear, inside of timbers. The shaft is well timbered and is a good piece of workmanship. At its bottom there is a seven-foot bed of coal upon which a gangway was driven west in 1868, to a distance of two hundred and seventy-five feet from the shaft. No gangway was ever driven east from the shaft, and the foot of the shaft itself is in a fault which appears to be an upthrow to the east of considerable magnitude. Very little coal was ever mined from here, and what was taken out was burned under the boilers at the shaft. The quantity of water to handle here was pretty large, and the shaft was furnished with a Cornish pump, the pumping engine having a twenty-two-inch cylinder with forty-eight-inch stroke, and being geared four to one. The hoisting engine has $16'' \times 48''$ cylinder and is geared three to one.

It was but a few months after reaching the coal at the foot of this shaft, when, the company which owned the property getting into financial trouble, the work was suspended, and the shaft allowed to fill with water. Since that time it has been once again pumped out, and kept clear of water for a month or two, when, owing to similar causes, it was again allowed to refill.

And in this condition it has remained up to the present time, the water standing about forty feet below the mouth of the shaft.

It is believed by Mr. R. F. Lord, the engineer in charge of this property since 1871, as well as by Mr. Clarence King, mining geologist, who made a report upon it in 1874, to Mr. S. E. Lyon of New York, that the seven-foot bed at the foot of the engine shaft is entirely a different and separate bed from any of those upon which any mining has been done in the shallow workings near the outcrop, and that the latter beds, denominated by King the "Lord Series," underlie the former, the vertical thickness of the strata between the upper and lower seven-foot beds being supposed to be about one hundred and twenty-five feet.

But while this theory is not *a priori* particularly improbable, it is yet far from being proven to be true, and it is based upon facts which, after a recent careful examination of the ground by myself, and with my experience of over nine years of intimate acquaintance with the coal mines of the Mount Diablo region, I consider to be of very questionable import, and of little value.

It would be nothing wonderful if this seven-foot bed at the foot of the engine shaft (which bed consists, by the way, of three distinct benches of coal, separated from each other by two layers of clay-slate a few inches each in thickness) should eventually turn out to be identical with, and at this depth the only representative of, the whole series of beds which has been called the "Lord Series." But it is a question upon which the paucity and the doubtful significance of existing developments render speculation idle, and which additional underground explorations alone can finally settle. Whatever the fact may prove to be, however, in this respect, there can be no question in any case that the quantity of coal in the Rancho de Los Meganos is great. And, though I have never seen any coal in this property which was quite so hard, or which would bear handling and transportation so well as the average of the Mount Diablo coal, nevertheless, as it can be cheaply mined and cheaply sold, there is good reason to believe that it will pay to open up and work this mine, so soon as the property shall be freed from legal complications and a clean title shall be vested in some party who has both the money and the intelligence which it will certainly require to handle it properly.

With the Rancho de Los Meganos, the Mount Diablo coal field may be said to terminate, no explorations to the east or southeast of here having ever developed anything in the shape of coal worth mentioning until we come to another field, viz.:

The Corral Hollow Coal Field,

In the hills to the south of the Livermore Pass. There is a general description of this coal field, together with the developments which had been made here in the way of exploring and mining for coal up to the year 1862, in the volume of "The Geology of California," published by the State Geological Survey in 1865, pages 34 to 38, to which the reader is also referred.

In the year 1870 I visited the locality myself, in the employment of the State Geological Survey. In the eight years which had then intervened since Mr. Brewer's last visit, there had been considerable work done and a good deal of money expended in prospecting and mining for coal in the Corral Hollow Cañon, the results of which had only tended, however, to confirm the accuracy of the opinion expressed on page 36 of "The Geology of California," that "the disturbances of the strata in this district were so extensive that it was to be feared that these coal beds would not be made available;" while the quality of the coal itself had also been proven to be somewhat inferior to that of the Mount Diablo mines, inasmuch as it is softer and more friable, and crumbles worse upon exposure to the atmosphere.

At the old Pacific Mine (otherwise called the "Eureka Mine," and "O'Brien's Mine,") no work had been done since 1862. Farther down the cañon, though my notes of the trip show many detailed observations of the strike and dip of the strata, as well as of the other visible surface indications, the only mention it is worth while to make of them here is the fact that they all confirm the statement that the strata are greatly disturbed. All the lower mines were already, at the time of my visit, in August, 1870, entirely closed and abandoned; and the best information I could obtain respecting the underground developments in them was from Mr. Carroll, who had lived here for some years, and was pretty familiar with the work that had actually been done. According to his statements, the old shaft of the "Commercial Company" (which is situated on the south side of the creek, some half or three quarters of a mile below the shaft of the old "Coast Range Company," described on pages 37 and 38 of "The Geology of California," was sunk about two hundred feet, and a tunnel was driven from its bottom about one hundred and eighty feet to the south. This shaft was not in coal, and the tunnel from its foot did not strike coal. A short distance below this point there is another shaft sunk to a depth of about eighty feet by Mr. Meader. This also was not on coal, and no drifting was done from it.

The next opening which we come to is the "lower shaft" of the Commercial Company. This shaft is in the coal, is about three hundred feet deep, and furnished all the coal which came from the Corral Hollow mines during the years 1869 and 1870. But at the time of my visit the hoisting works had recently been burned down, and the mine itself, as well as its waste heaps, was on fire. The dip in this mine was very steep to the south.

At the Almaden Mine, a little further down the cañon, there is a shaft about three hundred feet deep, and a tunnel was driven southerly from its foot about seven hundred feet, but no coal was found, except two or three seams of no value. Carroll thinks there is coal here to the north of the shaft. The dip here is southerly.

While this work was going on previous to 1870, the Western Pacific Railroad Company had also expended a few thousand dollars in laying down a track from Ellis Station to the mouth of Corral Hollow Cañon, in the hope of getting coal from these mines for use upon their locomotives, in which hope they were, not unnaturally, disappointed.

I have not heard of any further mining for coal in Corral Hollow Cañon since 1870; and the total amount of coal ever sent to market from this locality has been very small.

But outside of Corral Hollow Cañon, and yet within the limits of what may be properly called the Corral Hollow coal field, there has been some prospecting and a little mining done.

The Livermore Mine.

Within about a mile to the west of the Pacific Mine, and on the west side of the crest of the watershed which here divides the waters of the Livermore Valley from those of the San Joaquin Valley, there is situated the "Livermore Mine." At this mine, when I visited it in July, 1875, they had sunk a slope of about three hundred and eighty feet upon a bed of coal whose strike was just about east and west, magnetic, and whose dip, though somewhat variable, averaged to the bottom of the slope about 40° to the north.

At the surface of the ground, there was visible here only a little black dirt; but the coal began to come in at a point about fifty feet below the mouth of the slope. At the bottom of the slope, when I saw it, the bed was about five feet thick, but contained three or four little streaks of clay, from half an inch to three inches thick. The coal itself was soft, and crumbled on exposure, like that of the mines of Corral Hollow Cañon. Some further work was done here in the latter part of 1875. A steam hoisting engine was erected, and bunkers were built, and some drifting was done underground, but the work has since been abandoned.

It is reported that since 1875 another coal discovery has been made at the so called "Summit Coal Mine," a short distance to the northeast from the Livermore Mine, and that considerable prospecting work has been done there, with promising results. But of this I cannot speak positively, not having seen the ground.

Other Coal Localities.

Outside of the Mount Diablo coal field there are numerous localities besides Corral Hollow scattered throughout the Coast Range of mountains from San Diego to Crescent City, and a number of localities also in the western foothills of the Sierra Nevada, in California, where more or less coal has been found. None of these localities have yet proven themselves to be of any financial value here, and the great majority of them would be utterly worthless in any country. I proceed, however, to mention a few, which either from their own intrinsic merit, or else from the noise which has been made about them, are worthy of special notice.

First—In the southern part of Los Angeles County, at a locality about twelve or thirteen miles easterly from the town of Anaheim, in the mountains on the south side of the Santa Ana River, not over a mile from the river, and at an altitude of some fourteen hundred or fifteen hundred feet above its bed, there are exposed in the precipitous mountain side some ten or twelve thin seams of impure coal, distributed through something like a hundred feet in thickness of shales and sandstones, no single coal seam being over about one foot thick. I visited this locality in 1872. The whole thing is worthless.

Second—It is said that there is a locality upon Los Gatos Creek, in the eastern flank of the Coast Range, in the southern part of Fresno County, where there are exposed no less than four or five beds which show in their croppings from three feet to four and one half feet respectively of a good quality of coal, which it would pay well to mine if it were within reasonable distance of a market. This locality I have not seen.

Third—There is in the hills on the south side of the little valley called Vallecitos, in the western part of Fresno County, and distant some five or six miles in a northwesterly direction from the New Idria Quicksilver Mine, a bed of coal which strikes N. 85° W., magnetic, and dips 80° to 85° to the south. This bed is certainly over seven feet in thickness, as, at the time of my visit in April, 1871, it had already been pierced to that extent by a tunnel which had not yet gone through it. This tunnel struck the bed at a depth only about forty feet below the surface of the ground. So far as exposed at that time, the coal was pretty uniform in quality throughout, and appeared but little contaminated with earthy matter. It, however, contained considerable gypsum in thin scales filling its seams, and it was soft and friable. But its quality was good enough, on the whole, to warrant a belief that it might, with proper arrangements, be used to some extent with advantage in the reduction of quicksilver ores at the New Idria Mine, where wood is scarce and expensive, though whether since then it has actually been so utilized, I am not informed.

Fourth—On the Middle Fork of the Eel River, about seven or eight miles south of the village of Round Valley, in Mendocino County, and in the northeast corner of Section 11, T. 21 N., R. 13 W., Mt. Diablo meridian, there is a bed of coal exposed, crossing the channel of the river in a direction N. 45° W. to N. 50° W., magnetic, and dipping from 20° to 30° northeast.

This bed is from fourteen to fifteen feet thick, and is all good coal with the exception of a single streak of shale in the middle of it, about five or six inches in thickness. The coal is immediately overlaid and underlaid by heavy beds of very fragile shales.

The shales above the coal are not far from seventy-five feet thick, and are overlaid by very hard and highly metamorphic rocks, containing large quantities of jasper and other silicious matter.

The shales beneath the coal are about twenty feet thick, and are underlaid by a bed of unaltered sandstone some ten or twelve feet thick, which again rests upon the same hard, metamorphic rocks which overlie the shales above. The whole thickness, coal and all, therefore, of the belt of unaltered strata which includes this coal bed, is at this locality only about one hundred and twenty-five feet.

The quality of the coal itself is a little better than that of the Mt. Diablo mines. In fact, it is the best coal which I have seen from anywhere in California, while at the same time this is the thickest bed of a marketable quality of coal that is yet known to exist within the State. Two causes, however, combine to render it improbable that it will ever furnish coal for the San Francisco market. In the first place, there is plenty of evidence close at hand that the rocks in that neighborhood have been greatly disturbed, and it is very uncertain how far the bed could be followed without being found crushed and broken up by faults, while at the same time extensive metamorphism of the rocks has been peculiarly localized and capriciously distributed throughout this region, and very irregular patches and belts of highly metamorphosed rocks alternate in all directions with no less irregular belts and patches which seem to have almost entirely escaped the metamorphic action. And, in the second place, the locality is in the heart of the Coast Range of mountains, and in order to reach it it would be necessary to construct a railroad for a long distance through a very rough region, which would render the cost of transportation so great that coal can be laid down in San Francisco from Washington Territory or Vancouver Island for less cost per ton than from here. There are said to be several other localities to the west and southwest from Round Valley where some croppings of coal have been found, but none of these are of any special interest.

Fifth—In the eastern part of Shasta County there is among the western foothills of the Sierra Nevada a region of considerable extent, including portions of several townships, where the volcanic materials which cap the mountain spurs and ridges are generally underlaid by a body of coal-bearing strata of recent origin. These strata consist of soft and unaltered shales and sandstones, and they are spread out unconformably over the upturned edges of the metamorphic gold-bearing slates which form so large a part of the mass of the Sierra. Their general position is not far from horizontal, though at different points they dip gently in various directions, the angle of dip rarely, if ever, exceeding 6° or 8°. The aggregate thickness of these strata is probably not over one or two hundred feet, and they belong to that geological period which immediately preceded the commencement of volcanic activity in that portion of the range.

At a point in the northwest quarter of Section 20, T. 33 N., R. 1 W., Mt. Diablo meridian, there was in September, 1874, an open cut in a hillside, thirty-five feet long, beyond which a tunnel had been driven fifteen feet underground; and in this tunnel there was exposed a coal bed whose total thickness was twelve feet. This thickness was made up as follows, beginning at the top:

	Ft.	In.		Ft.	In.
Coal, slaty and worthless	1	6	Slate	0	4
Slate	0	6	Coal	0	4
Coal	0	7	Slate	0	2
Slate	0	5	Coal	1	10
Coal	0	11	Slate	0	4
Slate	0	3	Coal	0	4
Coal	1	2	Slate	0	3
Slate	0	3	Coal	0	6
Coal	0	1		—	—
Slate	1	10	Total	12	0
Coal	0	5			

What is here designated as "coal," however, was itself more or less impure, being often traversed by still thinner sheets of clay and dirt, whose thickness ranged from that of a sheet of paper up to half an inch, or so. It was also soft and friable, and disintegrated rapidly on exposure to the air. This to be sure was very close to the surface of the ground.

When I again visited the same locality, in April, 1876, this tunnel had been driven some thirty feet further underground, and then allowed to cave, and the place was inaccessible. I was told by Mr. Kincaid, who did the work, that at the face where he last stopped the coal was somewhat harder, and contained less slate than where I saw it in 1874. But heavy as this bed is, its quality at the best, so far as yet explored, is such that unless it improves very materially on driving further into the hill, it is not likely to pay to mine.

In the near vicinity of this point, also, there has been considerable other prospecting work done, and one tunnel has been driven some four or five hundred feet in length. But none of this work has developed so much coal as the open cut and tunnel just described.

I also saw more or less of coal croppings at various other localities scattered about through this region. For example, on Section 3, Section 7, Section 8, and Section 21, of this same township, also on Section 12, T. 33 N., R. 2 W., and also at a point which is probably in Section 9, T. 34 N., R. 1 W. Croppings are said to be exposed also in Section 27 and Section 28, T. 33 N., R. 1 W. But very little work has been done, however, at any of these localities, and no coal has yet been found which it would pay to mine.

Sixth—In Ione Valley, at the western edge of the foothills of the Sierra Nevada, in Amador County, there is a coal bed which has attracted some attention, at a locality which I visited incidentally in November, 1871, while more especially engaged in studying for the State Geological Survey the ancient auriferous gravels, which are so widely distributed over the western flanks of the Sierra.

This coal is also of very recent origin; quite probably, indeed, not older than some of the auriferous gravels themselves. The bed lies nearly horizontal, and ranges at different points from five or six to twelve or fifteen feet in thickness. It is overlaid and underlaid by a very soft clay-rock, and its depth beneath the surface of the ground is small, being sometimes not more than thirty or forty feet. The material itself is strictly a lignite, still showing a good deal of the woody texture. It is not black nor lustrous, but of a dull earthy brown color, very soft and friable, and makes a large quantity of ash. Nevertheless, it burns very freely with a bright flame, and the ashes do not form any troublesome clinker. It has been employed for years as fuel for a flouring mill at Ione City, the distance to haul it being about three quarters of a mile. At the time of my visit, this mill, driven by a steam engine of fourteen-inch cylinder and thirty-six-inch stroke, was using no other fuel, and was consuming of this, as Mr. Hall, the proprietor, informed me, about three tons per day, costing less than a dollar and a half per ton at the mill. This was certainly very cheap fuel; and the Ione Valley coal will be likely to continue for many years to supply a certain moderate local demand for various purposes; but it will not bear transportation to any great distance, and it is not likely to ever compete with other coals in the general market. Since the beginning of 1876, a new mine has been opened here, and there has been a good deal of talk about it; but whether the quality of its coal is in reality any better or poorer than was obtained from the earlier workings I do not know, not having yet seen the mine myself.

Seventh—At the village of Lincoln in the Sacramento Valley, in the southwestern part of Placer County, there is also a coal deposit, of which great expectations have from time to time been entertained. I have never examined this deposit and do not know the extent of the work which has been done. But I have seen some of the coal which it has furnished, and such of it as I have seen was decidedly inferior in quality even to the Ione Valley coal; so poor, in fact, as to be practically worthless.

Eighth—At American Cañon, in the southwestern part of Solano County, there are, for some distance in the bluff along the right bank of the cañon, heavy but irregular croppings of black carbonaceous shale, containing streaks from one inch to eight or ten inches in thickness of coal. Most of these croppings, however, are not in place, as there has been more or less land-sliding nearly all the way along the steep face of the bluff.

The attempt has been made once or twice to organize a company to mine here for coal. But there has never yet been sufficient work done here to prove what lies in the solid hill back of the croppings. The locality would also be rather an expensive one to prospect satisfactorily, and the surface indications are not on the whole particularly promising. With reference, however, to transportation and proximity to market, the situation is a very favorable one if ever a good mine be found here.

Ninth—There have been occasional paragraphs in the newspapers, within the last year or two, with reference to the discovery of what has been asserted to be a heavy bed of a superior quality of coal in the range of hills next east of the Santa Rosa Valley in Sonoma County. But I am not aware that this discovery has yet proven itself to be of any value.

Tenth—In addition to all the foregoing, there have been numberless "coal discoveries" reported in the newspapers from time to time, in almost every corner of the State; but more especially in the Coast Range of mountains, and more particularly still in the counties of Santa Cruz and Monterey, and in the Contra Costa hills which stretch southeasterly from Carquinez Straits through Contra Costa and Alameda Counties, and in the foothills which skirt the southern and western flanks of Mount Diablo itself. And in very many, probably indeed in nearly all of these numerous localities, a little coal of some sort has actually been found. But none of them all have yet proven to be of any practical value, and the statement still remains true to-day, as it has done in the past, that the only locality in California where coal has ever yet been mined with profit to any noteworthy extent, is at the old Mount Diablo mines.

But it is furthermore true to-day, of the Mount Diablo mines themselves, that all of them which have been profitable in the past have already seen their best days and are now rapidly declining; while outside of these old mines the most promising region yet known in the State is the eastern and yet unworked part of the Mount Diablo coal field, in which the most promising developments yet made are at the Empire Mine, and at the Rancho de los Meganos.

Chapter IV.—Miscellaneous.

Cost of Production at Mt. Diablo Mines.

The cost of mining and transporting the Mt. Diablo coal has varied very greatly, not only between the different mines, but also at different times and under varying circumstances for the same mine. The differences in this respect have been so great, indeed, that any single statement of the actual cost for any particular mine at any definite time would be of no value whatever as an index of the cost at the same time for a different mine, or for the same mine at a different time. This fact is well illustrated by the history of the Black Diamond Company. At their mines, the monthly averages of the cost per ton for labor alone in mining the coal and putting it into the bunkers at the mines, exclusive of the cost of timber and all other supplies, have ranged at different times since 1867 from a minimum of about $2 37 to a maximum of very nearly $4; or say, including supplies, from about $2 75 to $4 50, or a little more, per ton. Within the same time, the monthly averages of the cost of the railroad transportation from the mines to the landing have ranged from 25 or 30 cents to over $1 per ton; while the cost also of water transportation from the landing to San Francisco has varied between 37 cents and $1 25 per ton.

But then, again, these three items of cost for mining, for land transportation, and for water transportation, have rarely or never reached either their maxima or their minima values simultaneously, and consequently the actual highest or lowest figures of total cost for the mining, transportation, and delivery of the Mt. Diablo coal at any particular time would not be obtained by adding together separately either the highest or the lowest of the figures given above.

This total cost, however, has varied at different times since 1866, from a minimum of about $5, or possibly a little less, to a maximum of somewhere between $6 50 and $7 per ton. But for a general estimate of the total average cost of all the Mt. Diablo coal which has ever been sent to market, the sum of $5 75 per ton may be taken as a fair approximation.

It may also be stated in this connection, that the average loss of coal in the pillars and in waste of one kind and another in the working of the Mount Diablo mines has been, as nearly as it can be estimated, not far from 25 per cent. In other words, only about three fourths of the coal which the beds contained has been extracted and utilized throughout the whole extent of the works.

Statistics of Production and Trade.

In order to show as nearly as may be the growth and magnitude of the coal production and trade of the Pacific Coast up to the present time, I first present the following table which is here reprinted from the columns of the "San Francisco Commercial Herald and Market Review" for January 18, 1877, without further change than the omission of some insignificant items from Queen Charlotte's Island, Sitka, Saghalien, Fuca Straits, and Japan, which aggregate altogether only fifteen hundred and sixty-four tons:

ANNUAL RECEIPTS OF COAL AT SAN FRANCISCO.

YEARS.	Mount Diablo —Tons.	Coos Bay —Tons.	Belling-ham Bay —Tons.	Vancouver Island —Tons.	Chile —Tons.	Australia —Tons.	English —Tons.	Cumberland —Tons.	Anthracite —Tons.	Seattle —Tons.	Rocky Mountain —Tons.	Total —Tons.
1860	....	3,145	5,490	6,655	1,900	7,850	6,640	5,970	39,985	....	....	77,635
1861	6,620	4,630	10,055	6,475	12,495	23,370	23,565	2,975	26,060	....	....	116,245
1862	23,400	2,815	10,050	8,870	5,110	12,590	16,055	4,970	36,685	....	....	120,545
1863	43,200	1,185	7,750	5,745	1,790	16,890	14,660	5,670	38,660	....	....	135,550
1864	50,700	1,200	11,845	12,785	2,323	21,160	18,330	7,275	41,680	....	....	167,298
1865	60,530	1,500	14,446	18,181	1,410	17,610	9,655	4,230	22,585	....	....	150,147
1866	84,020	2,120	11,380	10,852	1,480	53,700	7,400	9,524	12,124	....	....	192,601
1867	109,490	5,415	8,899	14,829	14,949	26,619	7,302	12,177	48,518	....	....	248,925
1868	132,537	10,524	13,866	23,348	8,511	31,590	29,561	2,292	29,592	....	....	282,025
1869	148,722	14,824	20,552	14,880	1,114	75,115	17,386	11,536	24,844	....	....	328,973
1870	129,761	20,567	14,355	12,640	7,350	83,982	31,196	9,322	21,320	....	....	320,493
1871	133,485	28,690	20,284	15,621	4,161	38,942	54,191	6,060	7,231	4,918	1,025	315,194
1872	177,232	32,562	4,100	26,008	3,682	115,332	29,190	10,051	19,618	14,830	1,862	434,467
1873	171,741	38,066	21,211	31,435	400	96,435	52,616	8,857	18,295	13,572	1,904	454,582
1874	206,255	44,857	13,685	51,017	....	139,109	37,826	15,475	14,263	9,027	433	531,947
1875	142,808	32,869	10,445	61,072	....	136,869	57,849	10,328	18,810	67,106	53	538,209
1876	108,078	41,286	21,335	100,965	3,150	131,695	121,948	12,520	11,871	95,314	226	648,388

This table requires, however, a few explanatory remarks. In the first place, with reference to all the coal which comes here by sea from outside the Golden Gate, *i. e., to all the coal which arrives here, except the Mount Diablo and the Rocky Mountain*, the figures in this table have been generally obtained by taking the reports of the vessels on their arrival, and before discharging, as to the quantity of coal they had on board; and these reports vary slightly in almost every cargo from the amount as actually weighed when the vessel comes to be discharged. These differences are, of course, small, and are sometimes in one direction and sometimes in the other. But on the average, and in the long run, it is probable that the first reports are slightly in excess of the actual quantities as weighed.

In the second place, it will be noticed that this table purports to give only the "*receipts of coal at San Francisco*," and this is what it actually does give with a good degree of accuracy for all the other coals excepting that from the Mount Diablo mines.

But the figures which it gives for these mines do not represent either the actual "receipts at San Francisco," or the total product of the mines. What they do represent, with a fair approach to accuracy, is *the total quantity which has been shipped away from the mines.* There is, and always has been, a large proportion of the product of the Mount Diablo mines which has been delivered on board of steamers and other vessels at Pittsburg and New York Landings, and which has been partly burned in steamers on the bay and rivers, and partly sent direct to Sacramento, Stockton, Vallejo, and other places, without ever coming to San Francisco; and all the coal so disposed of is included in those figures. But, on the other hand, they do not include the large item of consumption at and in the immediate vicinity of the mines themselves.

With reference to the mines of Oregon and Washington Territory, the figures in this table, being the receipts at San Francisco, represent pretty nearly nine tenths of the total production of the mines, the aggregate consumption at and in the vicinity of the mines, and also upon ocean steamers, being not far from 10 per cent of the production.

In the case of the Vancouver Island mines, the figures probably do not represent quite so large a proportion as nine tenths of the production; for, besides the town of Victoria and some smaller settlements, which draw their supplies almost entirely from these mines, the quantity of Vancouver Island coal which has been burned on ocean steamers is considerably larger than of Washington Territory or of Oregon coal.

With these explanations, the above table may be taken, except in the case of the Mount Diablo mines, for as good a general exhibit of the statistics of the coal production and coal trade of the Pacific Coast from 1860 to 1876, inclusive, as it is possible now to compile.

But, with reference to the Mount Diablo mines, having had better facilities than any mere statistician has had for knowing the truth about the mines and their operations, I have compiled the following table, which, with the accompanying explanations and remarks, may be relied upon as furnishing a more accurate statement, and a closer approximation to the total production of these mines than has ever yet been published, or than is likely to be compiled or published hereafter, for the first sixteen years of their existence.

It should be mentioned that in this table, as well as in the preceding one, all the figures are in tons of two thousand two hundred and forty pounds avoirdupois:

Years	Black Diamond	Union	Pittsburg	Eureka	Independent	Manhattan	Central (approximate only)	Estimated additional product	Total production
1861	1,370	-	-	-	-	-	-	5,250	6,620
1862	10,672	-	-	-	-	-	-	12,728	23,400
1863	14,232	-	-	-	-	-	-	28,968	43.200
1864	12,421	-	-	-	-	-	-	38,279	50,700
1865	14,491	11,187	-	-	-	-	-	34,852	60,530
1866	16,009	14,224	9,599	7,391	15,678	65	-	21,054	84,020
1867	38,368	24,167	21,909	10,908	14,338	-	3,000	12,000	124,690
1868	70,100	21,641	22,920	15,815	-	-	3,000	10,200	143,676
1869	79,548	17,274	27,938	16,945	-	-	4,729	10,800	157,234
1870	70,668	20,563	23,958	10,246	-	-	5,055	11,400	141,890
1871	75,536	17,209	22,339	18,194	-	-	7,215	12,000	152,493
1872	103,008	21,494	26,714	16,831	-	-	9,612	13,200	190,859
1873	104,596	22,600	32,362	4,075	-	-	8,578	14,400	186,611
1874	117,804	30,002	43,546	-	-	-	9,000	15,000	215,352
1875	83,645	26,365	33,628	-	-	-	8,000	15,000	166,638
1876	63,048	24,000	21,801	-	-	-	3,000	16,200	128,049
	875,516	250,726	286,714	100,405	30,016	65	61,189	271,331	1,875,962

In the column here headed "Black Diamond" there is given, from the books of the Black Diamond Coal Company, the total production of their mines, excepting the amount consumed for hoisting and pumping under the boilers at the mines. It includes the local sales by the superintendents at the mines and at the landing, and the consumption by the locomotives on their railroad, as well as by their tug upon the river and bay.

The rest of the mines named in this table, with the exception of the "Central," all are located at Somersville.

The first shipments of coal from the Mount Diablo mines were in 1861, and besides the old companies at Nortonville, which were all afterwards purchased by the Black Diamond Company, and whose product is therefore included in the column headed "Black Diamond," several of the Somersville companies also began to ship coal in the same year, all the coal at this time and for several years afterwards being hauled to the landings by teams. The Pittsburg Railroad first began to carry coal from Somersville in March, 1866, and with the single exception of the Union Mine from the beginning of 1865, the best information which can now be obtained respecting the production of the Somersville mines prior to the completion of this railroad must be gleaned from the newspaper statistics, the old account books of these various companies, some of which were very loosely kept in the first place, having been long ago scattered about, and many of them destroyed.

In the column headed "Union," the production of that mine for the years 1865 and 1866 is given from the books of the Union Coal Company. The figures given for that mine subsequent to 1866, together with all the figures given for the Pittsburg, the Eureka, the Independent, and the Manhattan Coal Companies, are from the books of the Pittsburg Railroad Company, and show the quantities transported over the railroad from the different mines respectively. These quantities, however, do not represent the total production of the mines, inasmuch as they do not include, first, the local sales at Somersville and at Pittsburg Landing; second, the quantity consumed by the locomotives on the Pittsburg Railroad; and third, the consumption under the boilers for pumping and hoisting at the various mines of Somersville. The Manhattan Company shipped no coal after 1866; the Independent Company shipped none after 1867; and the

Eureka Company none after 1873. The Union Mine was also closed and abandoned about the first of December, 1876. The Central Mine stopped work in the early part of the year 1876.

In the column headed "Central (approximate only)," there is given, as nearly as it can now be ascertained, the product of the Central Mine. The figures in this column for the years 1869 and 1870 are accurate and from the books. For the remaining years they are estimates based upon the best information obtainable, and are "approximate only."

The figures in the column headed "Estimated Additional Product," are estimates intended to cover the following items: *First*—The total production from 1861 to 1864, inclusive, of all the mines except the Black Diamond, together with the local sales and consumption under boilers for those years at the mines of that company. *Second*—For 1865, the total production of all the mines except the Black Diamond and the Union, together with the local sales and consumption at the mines of those two companies. *Third*—For 1866, the quantity hauled by teams in the first three months of that year from all of the Somersville mines except the Union, the local sales at Somersville, the consumption by the locomotives of the Pittsburg Railroad, and the consumption under the boilers at all the mines; also, the production in that year of the San Francisco, the Peacock, the Central, and the Teutonia Mines. *Fourth*—From 1867 to 1876, inclusive, the consumption under boilers at all the mines, the local sales at Somersville and Pittsburg Landing, the consumption by locomotives on the Pittsburg Railroad, and the total product of all mines other than those specified in the table.

It will be noticed that the figures in this column from 1861 to 1866, inclusive, are such as to make the total production for those years equal to the amounts given for the same years in the table of the "Commercial Herald and Market Review." I have made them so, because I am disposed to believe that for these six years during which no very accurate accounts were kept, the figures in that table, though purporting to show only the "receipts at San Francisco," are, nevertheless, in all probability, large enough to cover the whole product of the mines.

In the estimate of sixteen thousand two hundred tons for 1876, there is included the product of the Empire Mine for that year, which, I am informed by one of its owners, was about three thousand tons. With this single exception, more than nine tenths of all the quantities given in this column of estimates for the ten years subsequent to 1866, were burned under the boilers at the mines for pumping and hoisting purposes, the items of local sales and consumption on the railroad being comparatively very small. The estimates are based upon a good general knowledge of the character and comparative magnitude of the operations at the different mines, and upon the fact that for several years past, although no accurate account of it has been kept, the consumption beneath the boilers at the mines of the Black Diamond Company alone is known to have averaged not far from six hundred tons per month.

Relative Values of Different Coals.

As the proximate analysis of a coal does not give the means of computing its calorific power, and as it furnishes at best but an imperfect means of estimating its practical value, I have not thought it worth while to reproduce here a table of hitherto published analyses of Pacific Coast coals. Those who are interested in these analyses will find them in the State Geological Survey Report—"Geology of California," vol. 1, p. 30, and in a table compiled by Mr. Archibald R. Marvine, in the Annual Report for 1873, of the United States Geological and Geographical Survey of the Territories, by F. V. Hayden, pp. 113, 114. I will only present here two hitherto unpublished proximate analyses of Seattle coal, of which No. 1 was made for Goodyear & Blake, by Falkenau & Hanks, in April, 1868; and No. 2 has been furnished me by the President of the Seattle Coal and Transportation Company, and was made by Mr. H. G. Hanks, in May, 1875. They are as follows:

No.	Water.	Combustible Bituminous Substances.	Fixed Carbon.	Ash.	Sulphur.	Total.
1	11.66	35.49	45.98	6.44	0.43	100.00
2	6.70	38.32	47.99	6.49	....	99.50

Believing, however, that the results of careful working experiments upon a large scale, with reference to the relative practical values of the various coals which come to this market for steam purposes, would possess no little general interest and value, I have endeavored to gather as much reliable information of this kind as it was possible for me to obtain. In this direction I have not succeeded so well as I could wish. But I present the best information which I have, not because it is satisfactory, for it is not, but because it is all which I have been able to obtain, and because I believe that such as it is, and being reliable so far as it goes, it will not be without interest.

The most comprehensive information which I have upon this subject is embodied in the following table furnished me by the courtesy of Mr. Charles Elliot, the City Superintendent of the Spring Valley Waterworks, and giving the results of a series of experiments made at the pumping works of the Spring Valley Water Company, under his supervision at various times, extending over a period of between seven and eight years.

In this table, the first column shows the kind of coal employed. The second column shows the date, *i. e.*, the month and year, and in a few cases the day of the month of the experiment. The third column shows the duration of the experiment in all cases where such duration was noted, where it was not noted, the duration was in most cases a single day. The fourth column shows the "duty" performed; *i. e.*, the number of foot-pounds of useful mechanical effect produced by each hundred pounds of coal; or, in other words, as stated at the head of the column, the number of pounds of water raised one foot high by the combustion of each hundred pounds of coal:

Kind of Coal.	Date of Experiment.	Duration of Experiment,	"Duty," *i. e.*, No. of lbs. Raised 1 foot high by each 100 lbs. of Coal.
Mt. Diablo (Eureka) screenings	June, 1869		23,678,000
Nanaimo coal (V. I.)	July, 1869		32,317,600
Mt. Diablo (Pittsburg)	Feb., 1870		24,850,450
Anthracite (Philadelphia)	Feb., 1870		37,600,000
Sydney coal (Australia)	May, 1870		40,032,000
Sydney coal (Australia)	June, 1870		36,350,000
Sydney coal (Australia)	Aug., 1870		37,036,184
Mt. Diablo (Union) screenings	Sept., 1870		25,588,636
Mt. Diablo (Union) screenings	Sept., 1870		26,333,557
Anthracite	Nov., 1870		40,657,500
Mt. Diablo (Black Diamond)	Dec., 1870	1 week	25,754,400
Mt. Diablo (Union) screenings	Jan., 1871	24 hours	28,102,173
Mt. Diablo screenings	May, 1872	24 hours	23,000,000
Bellingham Bay, screenings	June, 1873	23 hours	29,048,600
Sydney coal (Australia)	June, 1873		38,215,700
Seattle coal	June, 1873		29,630,000
Sydney coal (Australia)	Nov., 1873	1 month	36,660,000
Welsh coal	Dec., 1873	24 hours	40,880,000
Welsh coal	Dec., 1873	1 day	37,252,000
Welsh coal	April, 1874		34,300,000
Sydney coal (Australia)	June, 1874	30 days	38,000,000
Sydney coal (Australia)	July, 1874	7 days	38,889,200
Sydney coal (Australia)	Feb., 1875	7 days	38,681,250
Mt. Diablo (Black Diamond)	June, 1876	1 week	25,120,000
Welsh coal	Dec., 1876	234 hours	36,596,000

It is needless to remark upon one fact which all well informed engineers will promptly recognize on looking over the above table, viz.: that the pumping engines of the Spring Valley Water Company are very far from being up to the standard of the best pumping engines of the present day, so long as they yield less than forty-one million foot-pounds of useful effect for each hundred pounds of good anthracite coal.

But there is valuable information in the above table; and the experiments which it shows are, in spite of some rather wide variations, none the less valuable because of the internal evidence which they bear of being a true record of the best results actually obtained under the existing circumstances.

It will be seen that the "duty" of the same kind of coal varied largely at different times and in different experiments; that of the Sydney coal ranging from thirty-six millions three hundred and fifty thousand to forty millions and thirty-two thousand, and that of the Mount Diablo from twenty-three millions to twenty-eight millions one hundred and two thousand one hundred and seventy-three foot-pounds. It is safe to assume in general that the shorter the duration of the experiment, and the fewer the number of experiments with any given kind of coal, the less reliable will be the results respecting that coal. But the variations in this table are such as cannot be satisfactorily accounted for by differences in the duration of the experiments only. For instance, of two experiments with Sydney coal, each of which extended over one month's time, one gave a duty of thirty-six millions six hundred and sixty thousand, and the other a duty of thirty-eight million foot-pounds. It is, therefore, evident, either that the actual quality of the same denomination of coal varied considerably in the different experiments, or else, as in the light of the two consecutive experiments of December 1 and 2, 1873, with Welsh coal, seems not improbable, that there was some irregularity in the performance of the engines themselves, which was due to causes that are not explained by the table.

If, now, without regard to the duration of the separate experiments which is stated in only twelve out of the twenty-five experiments given in the table, we take for each coal the sum of the duties, as given in the table for all the experiments with that particular kind of coal, and dividing this sum by the number of experiments, thus obtain a mean value for the duty of each of the different kinds of coal; if, then, we compare these mean values with each other, assuming for purposes of comparison that the value of the Mount Diablo coal is unity, and stating the values of the others in unity and decimals, we obtain the following relative values for the various coals included in the above table:

Mount Diablo coal (screenings)	1.000
Seattle coal	1.171
Sydney coal	1.502
Welsh coal	1.472
Bellingham Bay coal (screenings)	1.148
Nanaimo coal	1.277
Anthracite	1.546

In this statement of the relative values of the different coals, the figures which relate to the Mount Diablo and the Sydney are evidently the most reliable, as the experiments with these two varieties were the most numerous, there having been eight experiments with each. Next in order of reliability comes the Welsh coal with four experiments, then the Anthracite with two, and finally the Seattle, the Bellingham Bay, and the Nanaimo, with only one experiment each.

In addition to the preceding, Mr. Elliott has also furnished the following results of some very recent trials between the Seattle (W. T.) and the Wellington (Vancouver Island) coals at the same works. These experiments consist of five days' run with each of the two coals. The results could not be determined in foot-pounds, for the reason that the pumps were working under somewhat variable conditions of pressure-head, etc. For the same reason, the results of a comparison between any two single days' works only would not be very reliable. But the comparison of the means for the whole five days gives probably a very fair result. The experiments were as follows:

First, with Wellington coal, at $6 50 per ton:

11 hours run, cost	$5 25
12 hours run, cost	5 80
14 hours run, cost	6 38
11 hours run, cost	4 51
11 hours run, cost	5 80

Second, with Seattle coal, at $6 50 per ton:

14 hours run, cost	$8 00
13½ hours run, cost	7 40
14 hours run, cost	8 12
13 hours run, cost	7 45
13½ hours run, cost	7 45

It appears from this that with the Wellington coal the pumps ran fifty-nine hours, at a total cost of $27 74, or an average cost of 47.017 cents per hour for coal, while with the Seattle coal they ran sixty-eight hours, at a total cost of $38 42, or an average of 56.500 cents per hour.

This shows a relative difference in value between these two coals of about twenty per cent in favor of the Wellington over that of the Seattle coal. Or, if the Mount Diablo coal be considered as unity, the Seattle being 1.171, then the Wellington will be 1.407.

The following experiments, made under the steam boilers at the foundry of W. T. Garratt, in July, 1876, by Mr. H. M. McCartney, for the Seattle Coal and Transportation Company, have been kindly furnished me:

TRIAL OF COAL AT GARRATT'S FOUNDRY, SAN FRANCISCO.

JULY 27, 29, AND 31, 1876.

Coal.	Run.	Total Coal used.	Total Water used.		Total Ash.	Average Coal per hour.	Average Water per hour.		Amount of Coal required to evaporate one gallon or one pound of Water.		Amount of Water evaporated by one pound of Coal.		Per cent of Ash in Coal.
	Hours.	Pounds.	Gallons.	Pounds.	Pounds.	Pounds.	Gallons.	Pounds.	For one gallon of water—Pounds.	For one pound of water—Pounds.	Gallons.	Pounds.	
Wellington	9	1,581	1,175	9,778	135	175.67	130.56	1,086	1.346	.162	.743	6.185	8.54
Nanaimo	8½	1,576	1,208	10,053	164	185.41	142.12	1,183	1.304	.157	.766	6.379	10.41
Seattle	9	1,765	1,186	9,870	196	196.11	131.78	1,097	1.488	.179	.672	5.592	11.11

The time given in the "run" does not include the noon hour, but only the time during which the machinery was in motion. The Wellington coal made no clinkers to speak of, the Seattle very few, and the Nanaimo most of all. The latter was the only one which ran together and "caked" on the grates.

From these experiments, the Nanaimo coal would appear to be rather better than the Wellington, and if we still suppose the Mt. Diablo to be unity and the Seattle to be 1.171, we shall now find the Nanaimo to be 1.335 and the Wellington 1.295.

A comparative trial was made in December, 1874, as I am informed by the President of the Seattle Coal and Transportation Company, on one of the largest ferryboats in the bay of San Francisco, between Seattle and Mt. Diablo coal, with the following result: The boat first ran fourteen days with Mt. Diablo coal, of which it consumed in that time three hundred and seven thousand three hundred and eighty pounds. She then ran fourteen days with Seattle coal, doing the same work as before, with a consumption of two hundred and sixty-one thousand two hundred and eleven pounds. According to this test, the value of the Seattle coal, that of the Mt. Diablo coal being unity, is 1.177, a result which agrees very closely with that obtained for these two coals from the experiments of Mr. Elliot.

The foregoing are all the definite results of comparative experiments of this kind upon any considerable practical working scale which I have been able to obtain.

It is well known that with certain coals the Central Pacific Railroad Company has made such experiments with care and upon an extended scale, for its own benefit, upon its locomotives as well as upon its steamboats. But I regret to say that, upon applying to the company for the definite results of these experiments, with the permission to make them public, I met with a polite but positive refusal, upon the ground that, as this company is the largest single purchaser of coal upon this coast, they did not deem it right for them to place upon record any tests or experiments from which, perhaps, a standard might be established to the detriment of some and the benefit of others who are dealers in coal.

I confess that I am not able myself to understand the full force of this objection, well knowing, as I do, the fact that all the heavier dealers in coal in San Francisco already know the relative values of the different coals for steam with a sufficiently close approximation to the truth to guide their action in the matter of prices, or of anything else relating to the market, as fully and as surely as any mere publication of the exact figures could do it.

But, though I could obtain no definite information from the railroad company itself, I may state that I have good reason to believe that some of their recent experiments with Seattle coal on locomotives have shown a difference, as between it and the Mount Diablo, of over thirty per cent in favor of the Seattle coal. How reliable these experiments may be, of course I do not know; but if reliable tests have furnished this result, then from the results already given of the tests at the Spring Valley Waterworks and on the ferryboat, it would seem to follow, either that the Seattle coal compares more favorably with Mount Diablo for locomotive use than it does for use under stationary boilers and on steamboats, or else that there has been within the last two years a very marked improvement in the quality of the coal furnished to this market from the Seattle mines. It is claimed by the owners of the mines that the latter is the fact; and it is worth noticing that the two analyses above given, the one by Mr. Hanks in 1875, and the other by Falkenau and Hanks in 1868, seem to add probability to this claim, as the later analysis shows only 6.70 per cent of water against 11.66 per cent in the earlier one.

If, now, we collect in tabular form the results of all the above experiments, we shall have the following table of relative values of different coals for steam, the value of the Mount Diablo coal being assumed as unity:

RELATIVE VALUES OF DIFFERENT COALS FOR STEAM.

Kind of Coal.	Value.	Remarks.
Mount Diablo	1.000	
Seattle	1.171	Experiments at Spring Valley Waterworks.
Sydney	1.502	Experiments at Spring Valley Waterworks.
Welsh	1.472	Experiments at Spring Valley Waterworks.
Bellingham Bay	1.148	Experiments at Spring Valley Waterworks.
Nanaimo	1.277	Experiments at Spring Valley Waterworks.
Anthracite	1.546	Experiments at Spring Valley Waterworks.
Wellington	1.407	Experiments at Spring Valley Waterworks.
Nanaimo	1.335	Experiments at Garratt's foundry.
Wellington	1.295	Experiments at Garratt's foundry.
Seattle	1.177	Experiment on ferryboat.
Seattle	1.330	Probable results of tests on C. P. R. R.

The cause of the difference between the results obtained at the waterworks and those at Garratt's foundry for the relative values of the Seattle, Nanaimo, and Wellington coals, I cannot explain, but merely give the figures as I obtained them.

Conclusion.

To him who has carefully read the foregoing pages, it will be apparent that the days of the old Mount Diablo mines are numbered. Even within the few months which have elapsed since the preparation of this volume was begun, the operations of these mines have been considerably curtailed. At the time of the strike against a reduction of wages there in October, 1876, the Pittsburg Company ceased operations upon the Clark bed entirely, and withdrew the pump from their lowest level on that bed. Since that time their mining has been confined entirely to the "Little Vein," in the old Eureka ground, and to the Black Diamond bed. It is not unlikely that they may hereafter resume their work upon the Clark bed for a sufficient length of time to enable them to extract the coal which yet remains above their present lowest level. . But it is not probable that they will ever sink their works any deeper upon this bed.

At about the first of December, 1876, the Union Mine was finally closed, its pumps and machinery taken out, and the working of the mine entirely abandoned. It is not probable that the Union Company will ever resume work.

Of the old companies, therefore, there now remain actually at work only the Pittsburg and the Black Diamond Companies. The mines of the Black Diamond Company are in much better condition, generally, than that of the Pittsburg, and will undoubtedly hold out considerably longer, a fact which is largely due to the sound management of their able mining Superintendent, Mr. Morgan Morgans. But, in the face of their necessarily heavy and constantly increasing costs of mining, they too must, ere many years, succumb to the better quality, and eventually the lower costs of production and transportation of the coals of Washington Territory and British Columbia.

Whether the hitherto unworked eastern portion of the Mount Diablo coal field can, under existing circumstances, be worked at a profit, remains to be seen. But outside of this, there is no other coal field yet known in

California which gives reasonable promise of being able to compete, to any considerable extent, with the northern mines.

Neither is it probable that the mines of Coos Bay (the only ones yet worked in Oregon), will be able many years longer to continue work at a profit in the face of the Washington Territory coals. For though the distance from San Francisco to Coos Bay is only about one half as great as it is to Puget Sound, yet the shallow and often unsafe character of the bar at Coos Bay, the small size of the vessels which can go there at all, and the uncertainties which oftentimes attend the movements of even these small vessels, are such that the rates of freight from Coos Bay have generally ranged as high, and have often been actually higher than they were from Seattle; while it is more than probable that a company which owned and ran its own suitable steam colliers could transport coal from Seattle to San Francisco at a considerably lower cost per ton than they could do from Coos Bay. Moreover, the cost of mining at Coos Bay is greater than it is at Seattle; while at the same time the quality of the Coos Bay coal, for domestic purposes as well as for steam, is decidedly inferior to that of the more northern coals.

It is unquestionably to the mines of Washington Territory and of British Columbia that this Pacific Coast must look hereafter, both for its chief domestic and its nearest and most reliable foreign supplies of that indispensable necessity of all civilized communities—a good article of coal.

1887.

Mr. P. B. Cornwall has been kind enough to furnish the following statement of the quantities of coal shipped from the Black Diamond Coal Company's mines at Nortonville, Contra Costa County, since 1876:

In 1877	75,094 tons.
In 1878	63,373 tons.
In 1879	71,451 tons.
In 1880	80,130 tons.
In 1881	60,173 tons.
In 1882	61,722 tons.
In 1883	55,965 tons.
In 1884	52,529 tons.
In 1885	6,262 tons.

In 1884 and 1885 there was for many months a glut of coal in the California markets, and the best of foreign coals were very cheap. The Black Diamond Company, therefore, then decided to close down their Mount Diablo mines, and accordingly they stopped work there early in 1885, removed all their extensive plant of machinery and materials, allowed the mines to fill up with water, and took away their railroad track from the mines to the landing; thus verifying the prediction made ten years ago by the present writer, that "ere many years," those mines "must succumb to the better quality, and eventually the lower costs of production and transportation of the coals of Washington Territory and British Columbia."

Previous to the stoppage of work here, the great vertical shaft of the Black Diamond Company was sunk nearly to the Black Diamond bed, or to a total depth of about seven hundred and fifty feet, and a large extent of ground was worked out at this level from the Black Diamond bed. But Mr. Cornwall states that the "Clark Vein" is still solid and untouched everywhere below the level of what was known ten years ago as the Lower Mount Hope Gangway.

There is, therefore, a vast amount of coal yet remaining in these mines, which, though it cannot be profitably mined under existing present conditions, can and probably will be made available at some time in the future, whenever a foreign war or any other great emergency shall arise to render coal scarce and high for any considerable length of time in California.

Mr. M. W. Belshaw, who has worked the old "Empire," and the "Central" (or Stewart) mines extensively for the past ten years, states that during this period he has been turning out a general average of about three thousand tons per month, the several monthly products ranging all the way from two thousand to four thousand tons.

Both of these mines, however, are now pretty nearly worked out down to the "Nine Hundred Feet Level." This means nine hundred feet measured on the dip of the beds below their datum line, which is at or somewhere near the surface of the ground. On this lowest, or nine hundred feet level, they have a large quantity of water to handle, and under present conditions, it will not pay them to go deeper there.

Immediately southeast of the old "Empire Claim," however, there is a piece of ground which Messrs. Belshaw & Co. have recently purchased, and which contains a good many thousand tons of coal which they can extract at a profit.

The following statement from Mr. J. E. Nourse, Weigher for the Pittsburg Coal Company at Pittsburg Landing, is here added:

Coal shipments from the Somersville mines from January 1, 1873, to December 1, 1887:

Year.	Tons.	Lbs.
1873	60,739	1,090
1874	73,548	2,190
1875	59,994	930
1876	45,801	1,020
1877	26,784	1,560
1878	37,501	840
1879	32,475	660
1880	51,009	2,100
1881	29,609	2,080
1882	15,634	1,790
1883	17,176	830
1884	5,636	1,220
1885	11,938	1,540
1886	18,712	100
1887	18,455	1,720
	505,019	1,750

December 6, 1887.

J. E. NOURSE, Weigher.

It is deemed well to reprint here from the "San Francisco Journal of Commerce" its annual review of the coal trade for the year 1886, as follows:

Annual Review for 1886.

The supply of coal in San Francisco from all sources for 1886 most undoubtedly falls short of the demand. That demand increases yearly at the rate of 5 per cent, so that the total imports for the present year should be a round million tons. As, however, up to December first they were only in round figures eight hundred and seventy-five thousand tons, it is evident that by the close of the year they cannot exceed nine hundred and fifty thousand tons. This, therefore, leaves us short fifty thousand tons, which shortage has to be drawn from stocks on hand, depleting them to that extent. It should, therefore, make the market have an upward tendency, and this it most certainly has. The cause of this shortage was twofold: the strike in Washington Territory early in the year, and the peculiar condition of the freight market. Owing to these causes combined there has, during the past six months, been a material change in the price of imported foreign coals. This is, as already intimated, due: first, to the depressed condition of the wheat market; second, to the unprecedentedly low rates of freight to Europe; third, because the prospects of Australian wheat, wool, and other products have enabled English ship owners to realize better business from Australia than from California. With coal at low rates here, and wheat at low rates from here to Europe, the quantity of Australian and English coal for shipment to this market is less than known for several years. This, of course, will make an extra demand for coast coals which is already making its effect felt. The colleries are all preparing to meet the augmented demand by the free chartering of vessels. This has given rise to some slight rise in rates of freight. Previously rates from the northern colleries have been lower than ever before known. This has arisen from the large number of vessels coming to Puget Sound from China in ballast and with tea cargoes. Rates of freight on coal to San Francisco have been as low as $1 75 per ton. Besides this, numbers of wheat vessels preferred to make a trip or two in coal at low rates while waiting for a possible improvement in wheat charters. The condition of the market is strong. The outlook at present is better than it has been in twelve months.

IMPORTS OF FOREIGN COAL FOR TWENTY-ONE YEARS.

Years.	British Columbia.		Great Britain.		Australia.		Chile.		Other Countries.		Total.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.	Tons.	Value.
1866	9,066	$46,887	8,220	$34,091	51,551	$144,659	2,200	$9,312	1,048	$5,222	72,085	$240,171
1867	14,653	166,793	4,564	22,391	25,165	81,773	11,136	44,440	5,591	24,197	61,109	239,594
1868	22,790	123,214	28,859	94,260	31,701	89,056	8,213	34,473	742	3,348	91,563	341,003
1869	16,779	97,784	13,446	38,983	70,319	159,796	....	....	433	1,607	100,977	298,170
1870	13,979	84,457	28,673	79,142	84,251	182,753	7,350	34,244	2,612	21,155	136,865	401,751
1871	16,004	92,093	55,478	152,013	38,751	84,125	4,179	21,972	345	998	114,757	351,201
1872	23,574	133,772	28,059	131,234	110,111	255,465	2,644	10,823	1,826	12,234	166,214	543,528
1873	32,327	178,504	57,156	281,715	91,100	310,401	400	2,255	1,519	10,429	182,502	783,304
1874	62,672	324,362	46,932	199,447	107,010	403,860			1,252	7,950	217,866	935,119
1875	62,110	326,588	65,932	228,188	139,164	522,792	....	....	183	1,138	267,100	1,078,706
1876	101,572	522,555	116,836	317,927	129,097	502,102	3,203	9,799	696	3,840	351,404	1,356,223
1877	98,842	4[illegible]6,004	*76,750	193,214	92,768	345,943	7,259	†26,731	....	....	‡275,619	1,021,892
1878	143,241	607,427	46,722	120,935	137,684	517,186	....	....	9	31	327,656	1,245,579
1879	165,102	643,380	31,911	74,899	77,522	318,613	....	....	....	....	274,535	1,036,890
1880	178,334	638,990	61,779	103,019	51,137	195,620	....	....	....	....	291,150	937,629
1881	153,541	488,641	267,940	593,298	125,780	351,373	....	....	....	....	547,261	1,483,312
1882	144,816	496,692	163,643	403,881	165,353	487,905	....	....	....	....	473,812	1,388,478
1883	117,822	423,831	155,102	363,676	150,318	447,407	....	....	6,895	8,655	430,137	1,243,569
1884	254,202	1,039,997	138,295	322,238	153,192	457,967	....	....	790	2,611	546,479	1,822,813
1885	217,848	854,799	182,998	476,058	167,567	413,164	....	....	....	....	568,413	1,744,021
1886	183,056	787,419	166,937	311,202	198,081	604,394	....	....	....	....	548,074	1,703,015

* Exclusive of some cargoes arriving and not clearing, and some not entered.
† Exclusive of some not entered.
‡ Exclusive of several cargoes not entered.

EASTERN.

Year.	Cumberland.	Anthracite.	Total.
1860	4,069	34,683	39,032
1861	2,157	26,960	39,032
1862	3,354	36,648	40,002
1863	3,816	36,657	40,483
1864	5,661	44,676	50,393
1865	2,516	25,759	28,285
1866	2,891	19,787	22,678
1867	7,987	62,507	70,104
1868	2,427	31,413	34,340
1869	9,774	33,316	43,590
1870	3,402	22,548	31,940
1871	5,667	11,480	17,147
1872	8,151	14,709	22,860
1873	8,857	18,285	27,152
1874	16,172	12,671	28,843
1875	14,100	12,026	30,126
1876	11,711	12,661	25,373
1877	11,500	22,306	32,806
1878	9,900	11,737	93,937
1879	1,778	22,795	24,543
1880	20,720	19,185	39,903
1881	13,620	13,123	26,745
1882	15,874	24,304	39,273
1883	16,555	76,725	43,200
1884	25,047	13,486	33,533
1885	8,035	21,000	29,035
1886	12,243	5,115	17,358

PACIFIC COAST.

Year.	Seattle.	Bellingham Bay.	Coos Bay.	Rocky Mountain.	Mount Diablo.
1860	----------	5,488	3,143	----------	----------
1861	----------	8,136	4,628	----------	6,620
1862	----------	11,245	2,815	----------	23,402
1863	----------	9,175	1,186	----------	43,198
1864	----------	9,736	1,300	----------	37,458
1865	----------	12,270	1,615	----------	60,540
1866	----------	11,475	1,753	----------	84,024
1867	----------	8,615	5,235	----------	109,990
1868	----------	13,886	10,594	----------	133,839
1869	----------	20,552	14,758	----------	148,722
1870	----------	13,976	2,171	----------	129,760
1871	4,546	20,924	26,731	----------	133,484
1872	14,120	4,100	30,321	1,809	163,322
1873	13,572	11,210	37,898	1,904	170,000
1874	7,848	17,499	48,581	363	205,256
1875	62,119	10,440	29,078	53	142,808
1876	86,047	21,280	39,965	194	108,846
1877	101,088	10,475	30,296	134	97,674
1878	113,005	2,720	29,023	20	122,411
1879	136,012	Carbon	43,297	----------	134,739
1880	120,473	Hill.	36,905	55	160,400
1881	145,173	18,357	20,621	----------	114,000
1882	146,181	54,120	15,215	----------	102,356
1883	163,986	137,420	24,525	----------	76,162
1884	174,131	136,896	25,217	----------	77,485
1885	170,938	157,241	27,699	----------	5,920
1886	174,561	144,579	42,168	----------	25,000

TOTAL PACIFIC COAST.

Year.	Tons.	Year.	Tons.
1861	19,384	1874	279,547
1862	37,462	1875	244,498
1863	53,559	1876	256,332
1864	48,494	1877	239,667
1865	74,425	1878	267,179
1866	97,232	1879	314,048
1867	123,840	1880	318,833
1868	158,299	1881	298,151
1869	184,032	1882	317,872
1870	145,907	1883	403,093
1871	185,685	1884	413,729
1872	213,672	1885	361,798
1873	234,584	1886	386,308

GRAND TOTALS.

Year.	Tons.	Year.	Tons.
1861	112,579	1874	526,248
1862	118,346	1875	541,724
1863	124,459	1876	632,122
1864	145,508	1877	564,012
1865	165,722	1878	622,094
1866	192,015	1879	613,289
1867	255,053	1880	643,116
1868	328,599	1881	872,155
1869	314,713	1882	830,992
1870	284,632	1883	876,510
1871	317,589	1884	987,941
1872	403,752	1885	959,246
1873	454,238	1886	1,011,867

In his annual report for 1886, J. W. Harrison has the following: The importation of coal this year foots up larger than ever before, clearly demonstrating an increase of consumption for domestic and manufacturing purposes; there can be no stronger indicator of prosperity than this article, hence there is good cause for congratulation. Prices have ruled low all through the year; in fact the average has been the lowest known, and it is questionable if it will ever be repeated. The fallacious figures published of our grain crop of 1886 induced tonnage to seek this port, anticipating freights outward from here would reach fancy figures, hence coal was carried at nominal rates; besides the Australian fleet had no choice, they were forced to come, the Australian harvest proved a failure (wheat was shipped from here), and ship owners chartered for coal at eight shillings per ton from Newcastle, and five shillings from Sydney. Present rates from Australia are fully four shillings higher.

The extremely low figures of foreign coal have worked a hardship on our coast collieries, as with very few exceptions their monthly workings showed a loss for the first nine months of the year; the recent improvement will help their annual showing, which at best will be a poor one. The East Wellington colliery, after a struggle of several years, reports a six-foot vein, and will henceforth become a regular shipper.

The following table of prices will show the monthly fluctuations of foreign coals for "spot" cargoes. The average price is given for each month:

Months.	Australian.	English Steam.	Scotch Splint.	West Hartley.
January	$5 87	$5 75	$6 75	$7 50
February	5 55	5 55	6 75	7 50
March	5 50	5 50	6 75	7 50
April	5 75	5 62	6 75	7 50
May	5 75	5 62	6 75	7 50
June	5 75	5 62	6 75	7 50
July	5 75	5 62	6 62	7 25
August	5 87	5 62	6 50	7 00
September	5 87	5 62	6 50	7 00
October	6 12	5 75	6 50	7 00
November	6 20	5 90	6 50	7 00
December	6 25	6 12½	6 50	7 00

The various sources from which we have derived supplies are as follows:

	1884—Tons.	1885—Tons.	1886—Tons.
British Columbia (Wellington and Nanaimo)	291,546	224,298	252,819
Australia	190,497	206,751	287,293
English and Welsh	108,808	170,656	160,869
Scotch	21,143	29,228	19,795
Eastern (Cumberland and Anthracite)	38,124	29,834	19,517
Seattle	125,000	75,112	57,552
Carbon Hill	122,060	157,251	124,527
Green River, Cedar River, Mount Diablo	77,485	71,615	90,664
Renton, Newport, and South Prairie	60,413	67,604	73,654
Totals	1,035,076	1,023,339	1,087,690

The arrivals at Wilmington and San Diego are computed in the above figures.

As our manufacturing interests are enlarging annually, and the population increasing, we can safely estimate an increase of coal consumption in 1887, and it is to be hoped that the northern collieries will find a market for their products which will leave them remunerative returns.

I. Steuart, in his annual report, says: The foreign coal trade, during the year now ended, has been, on the whole, satisfactory to those engaged in it, from the fact that a lower level of values was fully established and recognized by importers and buyers. The low price of Australian coal, while affecting prices of all kinds of foreign coal, was caused by an excess of tonnage from there seeking this port, and loading coal at low rates of freight, there being no wheat to load in consequence of the failure of the Australian crops, while the crop prospects here at that time were very good, with every appearance of the likelihood of there being a large amount of wheat for export from here. It may, therefore, be safe to take the prices prevailing during the earlier part of 1886 as a guide to the lowest figures Australian coal is ever likely to touch in future, while the small list of tonnage from Australia now on the way and loading there for this port, with the probable large amount of wheat Australia will have for export in the season, may point to prices during the earlier part of 1887 being comparatively high, and should our own season be a dry one, will probably be marked as a guide to extreme figures for foreign coal.

Coal during the year was obtained from the undernoted sources:

	1886—Tons.	1885—Tons.
Australian	209,028	168,138
English and Welsh	104,556	157,196
Scotch	16,550	21,322
Eastern Anthracite and Cumberland	15,929	27,084
British Columbia	176,618	206,207
Seattle, Green River, and Cedar River	106,325	130,024
Carbon Hill	174,551	152,200
South Prairie	32,682	51,459
Coos Bay	41,000	27,800
Totals	877,239	941,430

The following table shows the highest and lowest price per cargo of various kinds of foreign coal:

	1886.		1885.	
	Highest.	Lowest.	Highest.	Lowest.
Australian Wallsend	$6 45	$5 50	$6 75	$5 50
Cardiff	6 50	6 00	7 25	6 50
West Hartley	7 25	6 87½	7 75	7 37½
Brymbo	6 00	5 30	6 70	6 25
Scotch Splint	6 50	6 12½	6 87½	6 37½

The receipts from the coast mines have not been as heavy as their proprietors may have wished, as the low prices prevailing for foreign coal during the greater part of the year necessitated quotations which left little profit for coast mine owners.

Coke.

The importations this year foot up twenty-six thousand two hundred and ninety-three tons, as against twenty thousand six hundred and eleven tons in 1885, and ten thousand six hundred and ninety-five tons in 1884, thus showing a steady increase annually. A few years since the coke consumption was confined entirely to foundrymen; now it is distributed among ore smelters in Arizona and Utah, as well as locally, its freedom from sulphur making it specially advantageous for their purpose.

The following information concerning the coals of California was gathered by Mr. Goodyear in the course of his field-work in the summer and autumn of 1887:

Fresno County.

On Section 14, T. 22 S., R. 13 E., M. D. M., where the barometer read two thousand six hundred and thirty feet, the Southern Pacific Railroad Company are now prospecting a heavy bed of coal.

Tunnel No. 1 has been driven about five hundred feet on this bed, which here strikes about S. 65° E., magnetic, and dips 80° to 85° or more northeasterly.

There are several small breaks or faults within the length of this tunnel. For a distance of about one hundred and fifty feet in from the mouth of the tunnel, and to a depth of at least forty or fifty feet beneath the surface, the coal of this bed has actually been *burned out in place* at some time in the past, leaving a red ash mixed with large quantities of thoroughly melted cinder or slag.

About one fourth of a mile farther up the cañon, is Tunnel No. 2, about three hundred and fifty feet long in a direction N. 85° E., magnetic, on the same bed, which here also stands nearly vertical, dipping about 85° towards the north.

The bed itself is from twelve to fourteen feet thick, and most of it seems to be tolerably clean coal, which strongly resembles the appearance of that which used to come from the "Black Diamond bed" of the old Mount Diablo mines. In both tunnels the hanging wall, *i. e.*, the wall on the north or northeast side of the bed, has the appearance of what may be called a sandstone conglomerate, *i. e.*, a conglomerate in which the pebbles and bowlders themselves consist of unaltered sandstone. But no such appearance as this is visible in the rock at the few points where I saw it cropping on the surface of the ground, and it is a matter of some little doubt in my mind whether this rock is really a conglomerate, or whether it is simply a sandstone in which incipient metamorphism has developed nodules of all sizes and shapes which give it the appearance above described. In either case, it is a tolerably strong rock, and will make a fair wall for a mine. The foot-wall, on the other hand, is a very soft, clay-rock, which is full of "slickensides," and will make a very bad and dangerous wall for a bed which stands so nearly vertical as this one does.

At a point about one thousand feet down the cañon from "Tunnel No. 1," the same coal bed dips only about 32° towards the north. They have here gone down about ninety feet with a slope, and found the bed so far considerably rolling and irregular, and are getting considerable water. The foot-wall here also is a soft, nasty clay-rock. Between the coal bed and the serpentines and jaspers, which are not far off on the south, there is a heavy bed of metamorphic, fine-grained, blocky sandstone.

Whether this mine can ever be made to pay is, in my judgment, to say the least, a very doubtful question. Heavy as the bed is, and good as the quality of the coal seems to be, there are nevertheless great disadvantages connected with it:

First—The dip of the bed, standing nearly vertical as it does in the two tunnels, is anything but desirable for the cheap working of a heavy coal bed.

Second—This position of the bed renders the bad character of the foot-wall a far more difficult and dangerous thing to cope with in mining than it might otherwise be.

Third—There is plenty of evidence that the rocks here are greatly disturbed and faulted, and it is not likely that the bed will be found continuous for any considerable distance with any uniform strike and dip.

Fourth—The locality is in the heart of the mountains, two thousand six hundred feet above the sea; and, speaking not too roughly, it may be said to be to-day nearly fifty miles from anywhere.

Mr. J. Richards, the present Superintendent of this mine, states that he owns in the Livermore Valley a coal mine in which there are six feet of good coal, which he worked down to water level, when his means to go deeper failed him. I think this mine must be the one referred to as the "Summit" Coal Mine on page 73 of my book on "The Coal Mines of the Western Coast," but am not quite sure, never having seen the mine myself. We spent the night of October twenty-first at the house of Mr. James Frame, in a cañon about thirty miles from Huron, where the barometer read one thousand five hundred feet.

On the twenty-second, visited the coal mine of Messrs. Robinson & Rawlins, which is situated on the west half of Section 26, T. 20 S., R. 14 E., M. D. M. At this locality the barometer read one thousand and sixty feet. It is about nineteen miles from Huron.

The lower tunnel starts in the cañon near the boarding house. The upper tunnel is about one quarter of a mile further up the cañon, and runs in on the vein about five hundred feet. The strike of the vein is about N. 35° W., magnetic, and the dip will average about 30° to the northeast. The thickness averages about three and a half feet of clean coal. Immediately beneath the coal in this tunnel there is about a foot of very thin-bedded brown shale, below which comes heavy-bedded sandstone. The roof immediately over the coal is slate, black and hard. Of this there is from two to three feet. Over that comes sand rock. The coal resembles in appearance that of the Clark Vein at Mount Diablo, but is softer, and slacks much more on exposure to the air. Barometer at mouth of upper tunnel read one thousand two hundred and thirty feet. There are no faults nor breaks of any kind within the length of this tunnel. Between the two tunnels the rocks on the surface in the gulch are at one or two points more or less disturbed. The lower tunnel cuts across the strata. It first runs perfectly straight S. 50° W. for one thousand feet, the strata for this distance being perfectly regular without fault or break of any kind. The total length of the tunnel is some fourteen hundred or fifteen hundred feet; but for the last four hundred or five hundred feet the strata are more or less irregular and the tunnel somewhat crooked. The strike and dip for the first one thousand feet are about the same as in the upper tunnel. In the lower tunnel, at a point about one hundred and sixty-five feet from its mouth, they cut through a stratum of sandy shales, about eight feet thick, saturated with bitumen. The same shales outcrop in the bank alongside the road a little above the mouth of the tunnel. A little maltha also oozes from them. In the last four hundred or five hundred feet of the lower tunnel they passed through some half dozen thin streaks of coal, the largest being about one foot thick. The ground in there is also soft and bad.

On Section 22, of the same township, Mr. William Strader, of Huron, informs me that he also has a coal mine. A gulch here runs easterly, and a tunnel has been driven here about four hundred feet in a southeasterly direction, having coal all the way except for the first thirty or forty feet. But the coal is much broken and varies greatly in thickness, the maximum being about three and a half feet. On the opposite side of the gulch, a tunnel runs northwesterly thirty-five feet in coal, which averages three and a half feet thick. Two slopes have also been sunk about thirty feet, in each of which the coal is regular, and three and a half feet thick.

San Diego County.

The new little town of Elsinore is situated on the eastern shore of a lake of the same name, which lies at the eastern foot of the Sierra de Santa Ana, in the northwestern part of the county, and not far from one thousand four hundred feet above the sea. In summer the lake has no outlet; but in times of heavy rains it discharges its surplus waters into Temecula Cañon, a branch of Temescal Creek, which runs to the Santa Ana River. At the time of my visit (June 18, 1887) the lake was about seven miles long and three miles wide. Its maximum depth in the northwestern part is said to exceed three hundred feet. But the greater portion of it is very shallow, and it varies greatly in area and depth at different seasons and in different years, depending upon the quantity of rain. In the later summer, or whenever it gets low, it is slightly salty and alkaline.

At Elsinore there is a fine, warm, sulphur spring, with a temperature of about 117° F., and a good bath-house over it. About half a mile northwest of this spring, there is in the valley another warm sulphur spring; and within fifty feet of it, a pure, cold, fresh water spring.

In the vicinity of Elsinore, I also visited the coal field referred to in the Fourth Annual Report of the State Mineralogist, page 269, as being "four and a half miles from Laguna Station, on the California Southern Railroad;" a later analysis of a sample of the coal from here being also published in the Sixth Annual Report, part 1, page 117.

The name of the railroad station has been changed from "Laguna" to "Elsinore," though it is distant one or two miles from the new village of Elsinore proper.

The mines are about four and half miles northwesterly from the station in an air line, or about six miles by the wagon road.

At the time of my visit (June, 1887) the following parties owned the lands:

Messrs. Dolbeer & Hoff owned:

The whole of Sec. 27	640 acres.
The fractional south ½ of Sec. 26	240 acres.
On the N.W. ¼ of Sec. 35	20 acres.
On the northern corner of the Laguna Ranch	100 acres.
Total	1,000 acres.

Messrs. Collier & Cheney owned:

The E. ½ of Sec. 22	320 acres.
The E. ½ of the S.W. ¼ of Sec. 22	80 acres.
The N. ½ of the N.W. ¼ of Sec. 26	80 acres.
Total	480 acres.

All these lands are in T. 5 S., R. 5 W., S. B. M.

On the S.W. ¼ of Sec. 26, the new town of "Terra Cotta" has been laid out, and there also is Dolbeer & Hoff's coal mine, where a shaft has been sunk eighty feet deep, which, according to the statement of Mr. H. T. Blackwell, the mining Superintendent, passed through the following strata, beginning at the surface:

17 feet—Red clay.
8 feet—Red sandy clay.
2 feet—White sand.
3 feet—Sandy fossil formation.
10 feet—Jointy, sandy clay.
12 feet—Sand and clay mixed with fossils.
16 feet—White sand.
2 feet—Sand and bowlders.
4 feet—Fire clay.
½ foot—Slate.
1 foot—Shale.
½ foot—Slate.
2 feet—Coal.
1 foot—Fire clay.
½ foot—Coal.
½ foot—Black shale and sand to the bottom.

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They have started southwesterly from the foot of this shaft, and driven some two hundred or three hundred feet, going down somewhat on the dip. The strike is northwesterly and the dip southwesterly, about the same as in the Cheney Mine. And though they had only two feet six inches of coal at the bottom of the shaft, Mr. Blackwell tells me they now (June eighteenth) have about four feet six inches of coal in the face of the drift. Here, also, they have encountered a little water. The roof in this drift is very weak and unsafe, and requires close timbering and planking. The coal also, at the time of my visit, was very soft and dirty, contained large quantities of iron pyrites, and clinkered badly.

Overlying the coal in the Dolbeer & Hoff Mine there is a bed of bituminous shale which, at the time of my visit, showed a thickness of about eighteen inches. This shale somewhat resembles the Australian shale in appearance, is rich in volatile bituminous matter, and may prove of value in the manufacture of illuminating gas.

At the Cheney Mine a tunnel is driven in a northerly direction about three hundred and fifty feet into the hill, exposing a bed of very clean coal five and one half feet thick, with only a single soft streak of dirt, about one inch thick, in the middle of the bed, which facilitates mining. Immediately over the coal there is about two and one half feet of mixed clay and sand rock, above which lies another stratum of from two to two and one half feet of coal, which, however, is not so pure as that in the lower bed. The strike at this locality is about N. 70° W., magnetic, and the dip about 5° to the southwest.

About five or six hundred feet northwest of here, a second tunnel starts in a direction about due east, magnetic, and runs three or four hundred feet into the hill, curving gradually around towards the northeast, and at last strikes a large fault which consists of a downthrow of some thirty or forty feet towards the northeast. The mouth of this tunnel appears to be outside of the edge of the coal basin; for, though the strata are continuous and undisturbed until the above mentioned fault is reached, yet no carbonaceous matter whatever is visible in the shales at the mouth of the tunnel. But as we advance into the hill it soon begins to show itself and thence gradually increases in quantity until, at a point between two and three hundred feet from the mouth of the tunnel, the shale is completely replaced by the same bed of clean coal which is exposed in the other tunnel. About half a mile north of here there is another opening which I did not visit, but in which, I am told, that the bed shows the same characteristics as in the two tunnels just described. It ranges from four to eight feet in thickness, but will average fully five and a half feet. The overlying rock here is rather a coarse-grained sandstone, not very hard, but nevertheless strong enough to make a moderately good roof.

The hills are not very high, and the covering above the coal is probably nowhere more than one hundred to one hundred and fifty feet deep. The formation is either very recent Tertiary or perhaps Post-Tertiary in age, and the coal basin is probably a local deposit covering no very great extent of country. What its actual area may be can only be determined by further explorations under ground. But there is in any case enough of it here to last for many years. The coal itself at this locality looks very clean, is bright black in color, and when first taken out of the mine is quite handsome, though rather soft. It, however, contains considerable water, and on exposure to the air it rapidly cracks and crumbles so badly that it cannot be burned to advantage except upon grates specially adapted to its use. It kindles easily, burns freely with a long smoky flame, does not coke nor clinker, and leaves a fine pulverulent and very white ash. It can be used for domestic purposes as well as for steam, and will be of much value in this portion of the State where fuel is scarce and high.

An analysis of the bituminous shale from Dolbeer & Hoff's Mine made by Mr. Thomas Price, May 13, 1887, gave the following result:

Water	2.65 per cent.
Volatile bituminous matter	44.25 per cent.
Fixed carbon	7.40 per cent.
Ash	45.70 per cent.
	100.00
Sulphur	3.43 per cent.

An analysis of the coal from the same mine, also made by Mr. Price in March, 1887, gave the following:

Water	17.50 per cent.
Volatile bituminous matter	41.00 per cent.
Fixed carbon	28.65 per cent.
Ash	12.85 per cent.
	100.00
Sulphur	5.6 per cent.

An analysis of the coal from the Cheney Mine, made by Dr. W. D. Johnston, Chemist of the Bureau, in June, 1887, gave:

Water	19.00 per cent.
Volatile matters	46.50 per cent.
Fixed carbon	21.90 per cent.
Ash	12.60 per cent.
	100.00

I think the sample of coal from Dolbeer & Hoff's Mine, of which the analysis by Mr. Price is given above, must have been a picked specimen, for the analysis shows larger percentages, both of fixed and volatile carbonaceous matters, together with a considerably smaller percentage of ash, than I should judge the average product to contain.

About three hundred feet south of the mouth of the first tunnel above described on the Cheney property, in Section 22, there is exposed a bank of very pure clay of considerable thickness. At the time of my visit they were manufacturing brick here, and were laying plans for a large establishment for the manufacture of various kinds of pottery, terra cotta, etc.

There is said to be rich gold quartz in the southeast part of the Temescal Range of mountains, some five or six miles north of Elsinore, and some of the specimens which I saw in Mr. Hoff's store at Elsinore were literally wired through and through with gold.

Mr. Hoff also has an asbestus mine some seven miles southeasterly from Elsinore, where he says there is a vein of it three feet thick, out of which he is now making fire-proof paint, as well as coverings for steam pipes, steam boilers, etc.

On the peninsula between San Diego Bay and the ocean a well has been sunk four hundred and thirty-five feet deep without success in finding artesian water. The strata passed through are said to have been almost exclusively loose sand, with only occasional thin layers of sandstone and clay shale.

In the bluffs at Ocean Beach, near San Diego, recent strata lie nearly horizontal. At this locality, also, a hole dug five or six feet deep in the sands of the beach, not more than three hundred or four hundred feet back from the edge of the surf and only about five feet above tide, gives an abundance of good, fresh water, while a quarter of a mile further back a well sunk seventy-five feet deep in the hill yields only brackish alkaline water. The fresh water in the beach sands probably finds its way there from a distance of some miles back in the country by percolation through the sands underlying the dry bed of the San Diego River, whose mouth is close at hand.

The following analyses were recently made by Dr. W. D. Johnston, Chemist of the Bureau, of Southern California coals collected by Mr. Goodyear during the past summer.

Coal mine, Section 14, T. 22 S., R. 13 E., Mount Diablo meridian:

Water	4.10 per cent.
Volatile carbonaceous matter	43.40 per cent.
Fixed carbon	40.25 per cent.
Ash	12.25 per cent.
	100.00
Coke, firm and compact	52½ per cent.

Robinson & Rawlins:

Water	15.50 per cent.
Volatile carbonaceous matter	40.00 per cent.
Fixed carbon	29.50 per cent.
Ash	15.00 per cent.
	100.00

Does not coke.

Dolbeer & Hoff, near Elsinore. Poorest coal:

Water	9.00 per cent.
Volatile carbonaceous matter	38.50 per cent.
Fixed carbon	19.25 per cent.
Ash	34.25 per cent.
	100.00

Best piece:

Water	15.4 per cent.
Volatile carbonaceous matter	43.6 per cent.
Fixed carbon	27.9 per cent.
Ash	13.1 per cent.
	100.0

Does not coke.

Face of gangway:

Water	16.25 per cent.
Volatile carbonaceous matter	43.75 per cent.
Fixed carbon	28.15 per cent.
Ash	11.85 per cent.
	100.00

NATURAL GAS.

To the State Mineralogist, WILLIAM IRELAN, JR.:

DEAR SIR: Herewith please find my report on the geological field-work carried out by me under your instructions in the sections where I was especially delegated.

Very respectfully,

ADOLPH H. WEBER.

NATURAL GAS.

Owing to the almost entire absence of good coal in this State within easy reach of the markets, and the high price of the imported article, the discovery of natural gas within the limits of our State has been very welcome. The discoveries have become quite numerous, particularly since the successful application of natural gas as a fuel in Pittsburg and other places.

Most prominent among the localities investigated are the ones in the neighborhood of Stockton, the gas, however, being under a low pressure and accompanied by a copious flow of water.

In the following the various localities are given according to the counties:

Nevada County.

Near Boca, when the snow is crusted and an inverted funnel thrust into the snow, gas enough can be collected in certain localities to give a flame. In the ice company's reservoir at Prosser Creek, near Boca, gas bubbles are rising continually.

Santa Cruz County.

The disastrous explosions which took place in the tunnels of the South Pacific Coast Railroad at Highland some years ago were due to natura gas.

Sonoma County.

As early as the end of the fifties, the occurrence of natural gas was known at Geyserville, for it interfered seriously with the digging of wells. The gas came into the wells in such quantity as to compel the men to quit work. Many a well was abandoned on this account and filled up again. In the marsh lands, on Sonoma Creek, gas has been found in the artesian wells. At one or more wells the gas is collected and used for domestic purposes.

San Joaquin County.

In the vicinity of Stockton a large number of artesian wells have been sunk.

The first of these, the celebrated Court House Well, was bored during the years 1854–58, reaching a depth of one thousand or one thousand and two feet.

At five hundred and sixty feet a stream of water was struck, but lacked five feet of reaching the surface; at nine hundred and thirteen feet the water rose seven feet above the surface, and at one thousand feet depth, the water rose nine feet above the city grade. The water coming from the bottom of the well brought up with it considerable gas, exciting great curiosity, particularly as the gas would burn. The flow of the well is still very large (one hundred and fifty thousand gallons in twenty-four hours); but the piping has rusted and become leaky. The waters from this well now supply the swimming baths, having a temperature of 80° F.—warm enough for a delightful bath.

In 1879, Charles D. Gibbs read a paper before the California Academy of Sciences, giving a history of this well and the results obtained.

The following is a list of the artesian wells bored in the immediate neighborhood of Stockton:

Name of Well.	Distance and Direction from Stockton.	Depth, in Feet.	Flow, in Gallons, in 24 Hours.
Old Court House	In Stockton	1,003	150,000
Paper Mill, No. 1	¼ mile west	597	100,000
Paper Mill, No. 2	¼ mile west	365	
Old Waterworks	In the city	1,076	225,000
Geo. Ladd	2 miles southeast	976	450,000
Zignego & Podesto	⅛ mile northeast	1,045	225,000
Dr. Grattan	4 miles northeast	1,010	450,000
S. Sanguinetti	2¼ miles northeast	1,100	225,000
New Waterworks, No. 1	In the city	1,013	300,000
New Waterworks, No. 2	In the city	1,005	300,000
New Waterworks, No. 3	In the city	1,011	300,000
McDougald	2 miles south	976	600,000
Cutler Salmon	7 miles southeast	1,000 / 1,250	375,000
Gen. Williams	14 miles west	1,435	150,000
S. Strait	3 miles southeast	1,080	300,000
State Insane Asylum	In the city	1,091	225,000
Pope Salmon	9 miles southeast	1,404	
Crown Mills	In the city	1,220	350,000
Haas	In the city	*3,000	
Standard, No. 1	½ mile south	*2,000	
Standard, No. 2	1,300 feet west of No. 1	*1,100	

The well on Cutler Salmon's place, in Castoria Township, was bored in 1883, during the months of July and August, to a total depth of one thousand two hundred and fifty feet. Seven-inch piping was put down to eight hundred and forty-two feet, and four-inch to a depth of one thousand one hundred and forty feet; the latter pipe reaches the surface.

The water from the larger pipe is excellent, while that issuing from the smaller is brackish. However, the latter carries a large amount of gas, while the former contains but little. The gas is collected in a tank and used for lighting, heating, and cooking in the house. The supply of gas is ample, not one half of it being caught, and that is more than sufficient for the purposes mentioned.

At the Old Waterworks the water carried enough gas to cushion the pumps, and consequently had to be thrown into a pond to allow the gas to escape, before the water could be forced into the city mains. The water is good. This well has a nine-inch casing nine hundred and sixty or nine hundred and seventy feet deep.

At the New Waterworks all three wells carry gas—No. 1 most, and No. 3 least. The gas from Well No. 1 is passed over gasoline to enrich it in carbon, and is used to light the engine-room. Altogether eleven ordinary burners are in use, with no reserve, the gas being used directly as it comes from the well. The gas from Wells No.'s 2 and 3 is not used at present; these wells are seven inches in diameter, while No. 1 is eight inches. The water from all three is good.

The McDougald Well, bored in 1883, two miles south of Stockton, has a seven-inch casing, nine hundred and seventy-six feet deep, the well itself having been carried about fifty feet further. This well produces a large

*Approximate. Accurate figures for these wells cannot be given; the reasons will be given later on.

amount of gas. By actual measurement it registered between seven thousand and eight thousand cubic feet of gas per twenty-four hours, under the average meter pressure. The gas is used in Mr. McDougald's house, but only a small part of the flow is actually used; the rest escapes into the air. The water is poor.

About fourteen miles west of Stockton, on Roberts Island, General Williams had a well sunk in 1883 to a total depth of one thousand four hundred and thirty-five feet. The seven-inch pipe reached one thousand feet; the six-inch, one thousand two hundred and fifty feet, and the five-inch pipe to the bottom. Quite a copious flow of gas was struck; it was sufficient to supply either the house or the boilers of the engine, but not enough for both. The water was very poor, in fact got worse the greater the depth, and the well had to be closed to keep the water off the land, to prevent the latter from being ruined.

In 1884 Pope Salmon put down a well to a depth of one thousand four hundred and four feet (seven-inch pipe to seven hundred feet, and five-inch to bottom), from which he obtains gas sufficient for domestic purposes. The water is fair and plentiful.

Other wells, with the exception of the Crown Mills, the Haas, and the Standard, furnish little or no gas, though their water supply is ample. Strange to say, these are often bored to the same depth, and are situated in close proximity to others that do produce gas. A further and more complete investigation will doubtless throw some light on the subject.

The occurrence of the natural gas in some quantity finally began to attract the attention of capitalists. The great success in the use of natural gas in the East spurred them up to develop the deposits of gas in California. In December, 1885, the Standard Gaslight and Fuel Company was incorporated at Merced, with the object of developing natural gas in the San Joaquin Valley, beginning operations in the spring of 1886 at Stockton.

In the summer of the same year the California Well Company was organized at Stockton for a similar purpose, and began operations immediately (August, 1886), by sinking the Haas well, named after Jerome Haas, the Superintendent.

The Crown Mills well has been bored during the past summer with an initial diameter of nine inches. At the end of October a depth of one thousand two hundred and twenty feet had been reached. A large flow of gas was struck at this depth, the flames reaching a height of eight or nine feet. Careful measurements of the gas and water flow made by Mayor Welsh, show that the gas flow from the well is eighteen thousand cubic feet in twenty-four hours, while the water flow is two hundred and fifty-five gallons per minute, or about three hundred and fifty thousand gallons per twenty-four hours. Mr. Welsh says the mill requires six thousand cubic feet of gas each week for lighting, and he expects to light the mill with the natural gas and use the surplus as fuel. The well will be bored deeper, as it is thought a better flow of gas can be had two or three hundred feet deeper.

The gas is not being used as yet (December, 1887), as its introduction either as a fuel or as light requires many a change to be made in the plant on hand, or a new one to be set up.

The Haas well, bored by Jerome Haas for the California Well Company, is situated on the northern bank of Mormon Slough, nearly opposite the paper mill. The gas flow from this well was very large many months ago. However, the boring has been continued to a greater depth, but just how deep no one knows except those connected with the company. The well was started with a diameter of twelve inches and continued to one thousand and twenty-three feet, of which nine hundred and eighty-two feet were piped; then a ten-inch pipe was inserted and carried to a depth of over one thousand three hundred feet. As was indicated by other wells sunk in and near Stockton, a strong flow of good water, with some gas, was tapped by the twelve-inch pipe. The ten-inch pipe pierced a stream of brackish water with considerable gas. This was also expected from previous experience. Both pipes reached to the surface, and the space between was cemented at the top. Then the ten-inch pipe was perforated a few feet down, thus uniting the flow of both pipes. The gas was collected in a box and amply sufficed to keep up steam in the boiler running the drills and pumps.

Inside of the ten-inch pipe there is one of eight and a half inches, also reaching to the surface, but how deep it penetrates the earth is unknown. This much, however, is true; that the diameter of the well was again reduced to seven and one fourth inches, and it was being sunk in May, 1887, with that diameter, with further reductions to six-inch, five-inch, and four-inch still in view. The temperature of the water flowing from this well, 92° F., gives currency to the belief that a depth of fully three thousand feet has been reached.

The company has furnished the following statement of measurements of the flow: "Most of the water-bearing strata pierced beyond a depth of one thousand feet, carry more or less gas. A total of eighty-one thousand to eighty-two thousand cubic feet of gas per twenty-four hours has been measured by means of a twelve-foot receiver; a large amount of gas, however, escapes in the water, of which the measured flow is one thousand five hundred gallons per minute."

The right to lay pipes throughout the city has been granted to the company, and encouraged by the large flow of gas from their well they intend to compete with the local gas company for the contract to light the City of Stockton for the next ten years. It is the purpose of the company to enrich the natural gas with some vapor rich in carbon so as to give the flame a greater candle power.

The well (No. 1) of the Standard Gaslight and Fuel Company is situated on the north side of the French Camp road, just south of the city limits of Stockton. Their other well, No. 2, is about one thousand three hundred feet to the west of No. 1, on the levee, and is claimed to be about one thousand feet deep. The company assert that their principal well (No. 1) is a good deal over two thousand feet deep, but decline to give accurate figures.

The well was started with a diameter of ten inches; this was subsequently reduced to eight inches, and in May, 1887, six-inch pipe was in use. But at what depths these reductions were found necessary is unknown. Similarly the quantity of gas and the depth at which it was struck is unknown.

Marin County.

It is said that Cornelius Murray has discovered natural gas on his ranch at Nicasio, and has already bonded the right to San Francisco capitalists.

Contra Costa County.

Natural gas bubbles up in the mineral springs at Byron.

Lake County.

Gas is found near Kelseyville, and has been used to make steam.

Solano County.

Natural gas is found back of Davisville in the foothills.

Sacramento County.

On the Norris Ranch, the property of Messrs. Haggin & Tevis, on the American River, a few miles from Sacramento, some gas has been found.

Tehama County.

Eight miles east of Red Bluff are found the Tuscan Springs. The waters are medicinal, but with the water quite an amount of gas escapes. It is the intention of the owner to collect the gas and light the house with it, but he hesitates to sink a well for fear he might tap several of his springs and thus mix them.

Mendocino County.

Some gas has been found at Caspar Creek. Hiram Willits, at Willits, bored a well for water seventy-five feet deep, but instead of obtaining water he struck a small flow of gas.

Humboldt County.

The fact that natural gas occurs at Petrolia and neighborhood, in this county, has been mentioned under the subject of "Petroleum."

The wells on Oil Creek, sunk in 1866, have since then given off gas together with brackish water, continuously.

The Davis Well, on Bear River, struck quite a strong flow of gas at a depth of about nine hundred feet. The flow of gas continues to the present day. When once ignited it will burn with a flame a few feet high, all through the summer, until the first of the winter storms extinguishes it. In the spring and early summer, it is a regular thing for travelers to stop and light it. No use is made of it.

In the well on Mr. Gear's place, on Bear River, some gas occurred; however, the well has caved in now.

Along the Upper Mattole the presence of gas is very pronounced. All three wells sunk there struck gas. It also rises from the bottom of the Mattole River for several hundred yards. On Roscoe Creek a shaft had to be abandoned on account of the gas.

In the middle section of the oil district natural gas was found in several of the wells, but mostly in small amounts.

On James Gough's place in Sec. 8, of T. 2 S., R. 2 W., a strong flow of gas issues from a well sunk there in 1866–67. The flow continues unabated to the present day, producing, when ignited, a flame three or four feet high. Unluckily the well is close to the barn and consequently a source of anxiety to the owner. At a slight expense the gas could be piped to the house and used for fuel and light.

On the Union Claim on the Lower North Fork of the Mattole, the wells pierced a bed of sandstone, four to five feet thick, at a depth of thirty-five feet, carrying some petroleum and plenty of gas.

Near Petrolia, in the Jeffrey Well, since caved in, gas was found nearly all the time while sinking.

A natural gas spring is found on the left bank of Bear River between the Davis Well and the road.

When cutting the tunnel (one thousand nine hundred and forty feet long), on the Eel River and Eureka Railroad, in Secs. 8 and 17, T. 3 N., R. 1 W., great difficulty was experienced on account of the inflammable gas flowing from the strata pierced.

At Freshwater, a ten-inch well was drilled for water to a depth of two hundred feet. At eighty feet, gas enough for a jet was struck. This is on the edge of Humboldt Bay, in marshy ground.

In the low swampy grounds to the west and southwest of Eureka, along the edge of the bay, gas bubbles up through the water in a number of places.

In August, 1886, a six-inch well was started for the Ricks Waterworks, in Eureka, on the south side of Fourth Street, between G and H Streets. At the end of July, 1887, after one hundred working days, a depth of six hundred and seventy-seven feet had been reached. At a depth of six hundred and fifty to six hundred and sixty-five feet gas was struck sufficient for two lights.

Humboldt County.

Coal has been known to exist at various localities in Humboldt County for over twenty years. The abundance of wood throughout the county has, however, prevented any development of the coal veins. The magnificent redwood forests have as yet been scarcely touched, and outside of the redwood belt there is no lack of oak and other trees, furnishing the best firewood. With refuse wood from the mills at about $1 a cord at Eureka, and given away or burnt elsewhere to dispose of it, and cordwood at $3, coal is used by very few. As return freights for the lumber vessels are always in demand, the amount of coal actually needed at Eureka and the immediate neighborhood is readily supplied at cheap rates.

Nevertheless, the time will come when Humboldt's stately forests will be leveled and the available wood burnt. It is then that the more concentrated mineral fuel will be in demand; and the coal deposits will receive due attention.

The blacksmiths at various interior points have taken out coal sufficient for their purposes, at the cost of considerable time and labor, rather than pay the enormons freight charges on the imported coal.

The advent of a railroad, either from the Sacramento Valley or from Ukiah into Humboldt County, will necessarily add a great stimulus to the development of the coal veins.

The finds of coal in the county have been quite numerous, particularly in the southern half. Among the localities in which mineral fuel has been found in Humboldt County may be mentioned:

*1. Eureka.
*2. On Maple Creek, three miles from Mad River.
*3. Two miles north of Arcata; half mile from the Jolly Giant Mill.
*4. On the Upper Mattole, on Mr. Thomas Rudolph's place, T. 3 S., R. 1 W., Sections 11, 12, 13, and 14.
5. On the Main Eel River, two miles below Alder Point, on Wm. Wood's place.
*6. On Jacoby Creek.
*7. On Larribee Creek, T. 1 S., R. 4 E., Section 26; also Sections 2, 3, 10, and 11.
8. Across the Eel River from Eagle Prairie, in the bluff.
9. On the Van Dusen, three or four miles above Bridgeville.
10. On the Van Dusen, opposite the Cooper place.
*11. On the South Fork of Eel River, one mile north of Garberville.
*12. On Bear Creek, one mile east of Garberville.
*13. On Panther Gulch. } Tributaries of the East Branch of the South Fork of
*14. On Buckmountain Gulch. } Eel River.
*15. On the East Branch of the South Fork of Eel River, on the Ray Ranch, T. 4 S., R. 4 E., Sections 32, 33, 34, and 27.
16. On the Hoopa Indian Reservation.

* The localities marked thus were visited in July, 1887, by the writer.

The mineral fuel found in Eureka occurs within the city limits, near Twelfth and L streets. The succession of the strata from the surface down is as follows:

1. Sand, 16 feet.
2. Lignite, 18 to 24 inches, average 22 inches.
3. Clay, 4 feet.
4. Lignite, 1 foot.
5. Clay, 3 feet.
6. Clay with shells, 1 foot.
7. Clay, 11 feet and deeper.

The clay is an excellent material for brick-making, particularly when mixed with some sand. The sand from the top layer is used for this purpose. It was the establishment of a brickyard that caused the opening of these beds. The lignite was thrown away for a long time as useless, waste material, before it was recognized.

The lignite is a very poor, soft material, soaked with water, in reality being only a somewhat consolidated peat. It must be dried like peat before it can be used. The only use that has been made of it has been to help burn the bricks made of the clay and sand found above and below the lignite. The strata are very nearly horizontal.

2. The first United States patent taken out for coal lands in the county, or, in fact, in the Humboldt Land District, was issued May 5, 1887, to John C. Preston for the following land: S.W. ¼ of S.W. ¼ of S. 20, and S.W. ¼ of N.W. ¼ of S. 29, T. 5 N., R. 3 E., H. M., together eighty acres.

The lignite, for such is the material occurring on the land, is of a brown color, woody texture, and devoid of luster. Locally it was pronounced petrified wood, experienced woodmen claiming to recognize madrona, redwood, and other trees still growing in the neighborhood. Be that as it may, a woody texture is easily discernible in the lignite.

The lignite has a strike of N. 45° W., and a dip of 45° to the N.E., magnetic. There are two beds, separated by three to three and a half feet of rock; the upper being one foot and the lower two feet thick. Both the roof and floor are sandstone. The two beds could easily be mined together, and the material between them used to fill up the old workings. A shaft was sunk and a tunnel driven on this bed of lignite, but both have caved in.

There are evidences of another bed of lignite further up Maple Creek, as proved by drift, etc., but it was not examined. The lignite described above crosses Maple Creek about three miles from Mad River. The Arcata and North Fork Railroad is only six or eight miles from the mouth of Maple Creek. The composition of the lignite is—

Water	11.75 per cent.
Volatile carbonaceous matter	46.80 per cent.
Fixed carbon (does not coke)	29.60 per cent.
Ash	11.85 per cent.
	100.00

The ash is a yellowish gray powder.

3. It is claimed that lignite occurs about two miles north of Arcata, and a half mile from the Jolly Giant Mill. A tunnel was driven on the bed years ago; the tunnel has now caved, and, as the bed is nowhere exposed, nothing definite can be said about this locality.

4. On the Upper Mattole, on Mr. Thomas Rudolph's place, T. 3 S., R. 1 W., Section 12, several small beds of coal have been noticed six and eight inches thick. One was found in digging a well, others in the im-

mediate neighborhood, on Sections 11, 12, 13, 14. Nothing has been done to prospect this locality. The strata have a small dip to the north.

5. On the Main Eel River, two miles below Alder Point, on William Wood's ranch, the existence of an eight-inch bed of coal has been known for some years. Beyond taking out a few sacks of the coal for blacksmith work, nothing has been done.

6. On Jacoby Creek, about a half mile from the end of the lumber railroad, and four miles from Humboldt Bay, a half-inch seam of coal occurs in the sandstone, mentioned under the head of Building Stones. Several beds of black shale were taken to be coal by the workmen. This section can be easily and thoroughly prospected, as the strata are nearly vertical and the exposures quite numerous.

7. On Larribee Creek, T. 1 S., R. 4 E., Section 26, H. M., on the ranch of B. Curless, small pieces of coal were found; but on closer examination the rock proved to be breccia made up of small fragments of shale, sandstone, etc. Amongst these were the specimens of coal found, showing the former existence of some small beds, but now crushed and mixed with fragments of the other rocks. In Sections 2, 3, 10, 11, of the same township, coal is also reported; also in Section 21.

8. The occurrence of lignite in the bluff on Eel River, opposite Eagle Prairie, has been known some time, but it has not been developed.

9. The existence of coal in the Van Duzen Creek, three or four miles above Bridgeville, has been noted.

10. Also on the Van Duzen, opposite the Cooper place, coal has been reported. Also on Yager Creek, one mile above Hydesville.

11. On the South Fork of Eel River, one mile north of Garberville, seams of coal, a few inches thick, are found in heavy beds of sandstone and conglomerate. Practically, only traces found here.

12. On Bear Creek, emptying into the South Fork, near Garberville, about one mile east of the town, a few inches of coal have been found with slate in the sandstone.

13. On Panther Gulch, one of the tributaries of the East Branch of the South Fork of Eel River, traces of coal have been found.

14. On Buckmountain Gulch, another of the tributaries of the East Branch, a bed of coal crops a couple of feet thick. Several sackfuls have been taken from here and used in the forge, and pronounced excellent. It is possibly a continuation of the next.

15. On the Ray Ranch, T. 4 S., R. 4 E., six or seven miles south of Garberville, on the East Branch of the South Fork of Eel River, a bed of coal has been found of good quality, three or four feet thick. The strike is a little west of south, and the dip is 50° to 60° W., magnetic.

This coal cokes well; its composition is:

Water	10.75 per cent.
Volatile carbonaceous matter	48.50 per cent.
Fixed carbon (firm coke)	38.30 per cent.
Ash	2.45 per cent.
	100.00

The ash is a light yellow powder.

The coal has good luster, and, as far as examined, is nearly free from pyrites. Some work has been done in this locality. Possibly this is the same bed that crops out in Buckmountain Gulch, to the north of the Ray Ranch.

16. Lignite has been found on the Hoopa Valley Indian Reservation.

Trinity County.

1. At Poison Camp, not far from the western county line in T. 3 S., R. 6 E., H. M., Section 33, a fair sized bed of lignite is found. It is from four to four and a half feet thick. The strike is N. 20° W., and the dip 20° N.E., magnetic. The roof is clay, while the floor is a hard sandstone.

The composition of the lignite is:

Water	16.50 per cent.
Volatile carbonaceous matter	44.15 per cent.
Fixed carbon (does not coke)	34.10 per cent.
Ash	5.25 per cent.
	100.00

The ash is a light gray powder.

The lignite is a true, typical one, brown color, no luster, and even showing some woody structure.

2. About three hundred yards further down the creek (Sandstone Gulch) another bed of three feet thickness is found. It is overlaid with two feet of pipe clay, and underlaid by sandstone. This bed is exposed for some distance along the creek and thins out to twenty inches at one point. The strike and dip were not recorded. There is a possibility that this is a section of the bed described above, having been carried down into the creek by a slide. But the distance, and the bedding of the other rocks, speak rather in favor of its being an independent bed.

3. On Bluff Creek, five or six miles beyond Poison Camp (eastward), some coal has been found, but mixed with slate.

4. Near the middle of Hettenchon Valley, near Mr. D. Wilburn's place, coal is reported, but mixed with shale.

5. Near the head of Hay Fork, a branch of the South Fork of the Trinity River, and on several places along the course of Hay Fork, beds of coal are exposed, but seem to be broken up considerably. They are alleged to be a continuation of the beds occurring on the Trinity River, near Cox's Bar.

6. At Cox's Bar, on Trinity River, the placer miners have uncovered several beds of coal. It seems the auriferous gravels lay directly upon the coal in a number of places. This locality has furnished the coal for all the blacksmiths in that part of the county for a number of years.

Messrs. Newton, Bankhead & Co. have filed seven or eight claims on a coal vein on Trinity Mountain, to the north of the South Fork of Trinity River. On the divide between the Little and Big French Creeks several beds of coal are said to be exposed.

Tehama County.

On Elder Creek, about thirty miles west and south of Red Bluff, the existence of coal has been noted. On the North Fork seams a few inches thick imbedded in sandstone show themselves in two places, really mere traces. On the South Fork an eight-inch bed is said to occur.

Mendocino County.

1. Coal has been found on the Albion River, about eight miles from the coast, in cutting a lumber road. The bed is two feet thick; it has not disappeared under a slide.

2. In Russian Gulch, two and a half miles from Mendocino City, coal

has been noticed; it is only a small vein. It is in T. 17 N., R. 17 W., M. D. M., either in S.W. ¼ of S. 18 or in N.W. ¼ of S. 19.

3. Traces of coal occur near Ferguson's Cove, five miles south of Point Arena, T. 12 N., R. 16 W.

4. Near the head of the Garcia River, about twelve miles from Point Arena and near the east line of T. 12 N., R. 13 W., coal has been seen.

5. A five-foot bed of coal is reported as cropping out about ten or eleven miles up the South Fork of Ten-Mile River, in T. 19 N., R. 16 W.

6. Coal in traces has been noticed at the mouth of Salmon Creek.

7. On the stage road from Cahto to Westport, about three miles from Cahto, coal has for some time been known to exist.

8. In the Doolan Cañon, three miles west of Ukiah, coal was reported. It turns out to be shale, with fine, very thin seams of coal.

9. The coal found on Ackerman Creek, about three miles northwest of Ukiah, proves to be a small, irregular vein, in sandstone, an inch or so in thickness.

10. Four miles south of Little Lake a very small, irregular seam of coal has been found in conglomerate. The seams are pockety.

The coal occurring on the Middle Fork of Eel River has been described by Mr. W. A. Goodyear, in his report. However, the following additional facts were noted:

The metamorphism and silicification extend to the coal itself, as is proven by the occurrence of highly silicified petrifactions, in the shape of tree stumps, etc., in the coal itself. Moreover, the bed of coal extends across the river to the north side, and not further, being cut by a fault running northeast and southwest.

About two hundred yards east, up the river, the strata, consisting of shales and sandstones, have a strike of N. 15° W., and a dip of 48° E., magnetic, indicating the existence of another fault.

To the south of the river the shales can be traced to the top of the ridge, about a mile distant from the river. Here the coal again crops out, and seems to have separated into two beds. The shales accompanying the coal can be traced a mile further south.

At the top of the ridge, a few hundred feet west of the point mentioned where the coal is found, a bed of limestone, six to eight feet thick, crops out on a spur, with a dip of 20° to 30° to the northeast.

It is said that the coal crops out on the North Fork of Eel River, but this statement has not been verified.

Sonoma County.

Indications of coal were found in the Santa Rosa Valley, on Mark West Creek, a few miles from Santa Rosa. A shaft was sunk to prospect the locality, and several beds, of varying thickness, were cut, but they all proved of such poor quality and carried such a high percentage of ash that the work was abandoned.

Colusa County.

Several small beds of coal are known to exist on Sulphur Creek, in the southwestern part of the county.

Shasta County.

In the east central part of Shasta County there is found a belt of sedimentary rocks, fifteen to twenty miles in width, and over thirty miles in length, north and south. These sedimentary rocks consist in the main of sandstones, shales, and limestones; they lie in a nearly horizontal position, having a slight dip in different directions in various localities. Several faults, accompanied by some metamorphic rocks, traverse this belt. Among these strata a number of coal beds have been discovered, cropping out in the gulches and watercourses. The occurrence of the coal in the N.W. ¼ of Section 20, T. 33 N., R. 1 W., has been fully described by Mr. W. A. Goodyear in his report.

In the S.W. ¼ of S. 28, T. 33 N., R. 1 W., a small bed of coal about eighteen inches thick has been discovered inclosed in two layers of clay. The coal, as far as can be seen, is nearly free from slate; it has a slight dip to the west.

A small vein of coal was noticed in the creek bed in the S.E. ¼ of Section 29 of the same township. It is over a foot thick but full of slate.

In Section 7 there is an outcrop of slate, with very little coal close to the road.

In the northern tier of Sections 1, 2, 3, 4, and 5 of T. 33 N., R. 1 W., a bed of coal six or seven feet thick crops out at many points. The upper section of this bed is only a manifold repetition of thin layers of coal and slate, while the lower two feet are coal not wholly free from slate. The roof is sandstone; the floor is pipe clay nearly thirty feet thick.

This same bed crops in one or two of the gulches in Sections 32, 33, and 34 of T. 34 N., R. 1 W.

An eight-foot bed of coal has been developed to some extent by a tunnel on Section 12 of T. 33 N., R. 2 W. The tunnel was driven into the hill a distance of fifty or sixty feet in 1876. The separate layers making up the bed are as follows:

	Ft.	In.
Slate and coal in alternate thin seams	3	6
Coal with some slate	1	0
Slate	0	9
Coal with gypsum on the surface	0	9
Clayey slate	1	3
Coal	1	0
Total	8	3

Recently the tunnel was cleaned out and a sample of the coal taken to Redding to be tried at the gas works.

Messrs. S. Hull, W. Beamis, Clay Taylor, and William C. Whiten, made an application for coal land on the following land: E. ½ of S. 11, and N. ½ of S. 14, T. 35 N., R. 1 W. No proof has yet been offered, though the application was made years ago. The coal found on the place indicated is mixed with slate, and dips at a rather high angle (for the neighborhood) showing that the beds have been displaced and disrupted by faults.

Another filing on the S.E. ¼ of S.E. ¼ of S. 29, S. ½ of S.W. ¼ of S. 28, N.E. ¼ of N.E. ¼ of S. 32, and N.W. ¼ of S. 33, T. 33 N., R. 1 W., though of long standing, was never proved upon. The only patented coal land in the district is the N. ½ of S. 20, T. 33 N., R. 1 W.

On Nelson Creek, T. 37 N., R. 1 E., there are several small beds of coal exposed in slides along the creek.

On Kosk Creek, T. 37 N., R. 1 W., S. 24, a heavy bed of coal is said to exist, though in October, 1887, its outcrop was covered by a slide, and could not be examined. Coal is also reported from near the head of Kosk Creek.

PETROLEUM AND ASPHALTUM.

NORTHERN CALIFORNIA.

PETROLEUM AND ASPHALTUM.

NORTHERN CALIFORNIA.

Humboldt County.

The oil region of Humboldt County is the most northerly in the State, in fact, the only one north of the bay of San Francisco that has ever produced any oil. The existence of petroleum here was known to the Indians and to the white settlers—to the latter certainly as early as 1860. Small quantities of the crude petroleum were collected from time to time and used for medicinal purposes. The district is not producing any oil at present, so that the following sketch is more of a history than a description of an industry now in successful operation. Nevertheless, the district is the principal one of Northern California, and was among the earliest discovered and prospected; so that a short review of the doings of twenty years ago may not be amiss.

The region is found in the southwestern part of the county, to the west of Eel River, extending from the coast about twenty miles inland, covering parts of T. 1 N., R. 1, 2, and 3 W.; T. 1 S., R. 1, 2, and 3 W.; T. 2 S., R. 1, 2, and 3 W.; T. 3 S., R. 1 W.; also T. 1 S., R. 1 E., and T. 2 S., R. 2 E., all reckoned from the Humboldt meridian.

The district can be naturally divided into three sections: The first and northern is that along Bear River and Oil Creek, extending some ten miles inland from the coast. The second is four or five miles south of the first, and comprises the drainage areas of Davis and McNutt Creeks, Lower North Fork of the Mattole, and adjacent tributaries of the Mattole River. The third section lies to the southeast of the second, along the Upper Mattole, the Upper North Fork, and the South Fork of the Mattole. The first comprises an area of twelve to fifteen square miles, the second covers about thirty square miles, and the third nearly twenty square miles.

In the fall of 1864 J. W. Henderson procured samples and took them to San Francisco. Here he interested several capitalists in the oil field.

The oil industry in the East had recovered from the collapse in 1861 and 1862, due to reckless speculation and over-production, and capitalists were again investing. This renewed confidence in the future of the oil industry extended to the people of this coast. They began to hope that oil fields similar to those of Pennsylvania might be discovered in our State.

People flocked to the oil district in question from all parts of the country and coast. One discovery followed another; oil springs were found on Oil Creek, on Davis Creek, on the Lower North Fork of the Mattole, etc. A town was started at the junction of the Lower North Fork with the Mattole River and appropriately called "Petrolia."

The scenes of Pennsylvania were repeated over and over again. The district had, however, one great difficulty to contend with, and that was its transportation facilities. There were in general but two ways of reaching "Petrolia;" one by sea to Eureka and thence overland, and the other directly overland from the bay.

In the northern section of the district the surface indications were quite pronounced. A group of four or five wells were sunk on the right bank of

Oil Creek. One of them was started with four inches, reaching a depth of one hundred and twenty feet, and was then continued at three inches and carried to a depth of one hundred and seventy-six feet; a small amount of oil was obtained at this depth and plenty of gas. A second well of six-inch diameter was put down two hundred feet and then had to be abandoned on account of the gravel in which it stood. No oil was found in this well and but little gas. The others did not reach any considerable depth. These wells were not dry, but alkaline water flowed from them all with the gas bubbling through it. The flow of water and gas continues to this day.

On the left shore of Bear River, about three miles from the coast, Mr. Irwin Davis put down a well six inches in diameter over nine hundred feet. The well proved to be dry; however, a copious flow of natural gas was tapped, as will be mentioned further on.

The Fortuna Well is situated on the Webster place—T. 1 N., R. 1 W., S. 18, S.E. ¼ of S.W. ¼. It was six inches in diameter and was put down full six hundred feet, but was dry, a small amount of gas only being found.

On the Johnson farm, N.E. ¼ of N.E. ¼ S. 19, T. 1 N., R. 2 W., a well was sunk two hundred feet, but struck neither oil, gas, nor water.

A well was bored in 1865 on the Hawley farm, now Mr. Gear's place, on N.W. ¼ of S. 21, T. 1 N., R. 2 W. It reached a depth of two hundred feet, though only four inches in diameter. Nothing but gas was found.

Oil springs were found along the courses of the various tributaries of Bear River as far as ten miles inland from the coast. Also one or two miles south of the mouth of Bear River, near the coast. Thus in T. 1 N., R. 1 W., S. 17; N.W. ¼ N.E. ¼ S. 8, T. 1 N., R. 2 W.; also N.W. ¼ S. 9; T. 1 N., R. 2 W.; N.W. ¼ of S.E. ¼ S. 15, T. 1 N., R. 2 W.; S. 5, T. 1 N., R. 2 W., Humboldt meridian.

These springs were developed by means of trenches and shallow pits, allowing the oil to collect on the surface of the water and gathering it by means of skimming or absorption in blankets.

The total amount of oil produced by this section was very insignificant.

On the Upper Mattole, in that part of the district described above as the third section, but three wells were sunk.

The Fonner Well was put down by Mr. J. C. Fonner in 1866, on the south side of the river, in the N.W. ¼ of N.E. ¼ S. 33, T. 2 S., R. 1 W. It reached a depth of nearly three hundred feet, striking some gas, but no oil.

2. The Upper Mattole Oil Company in 1867 bored a five-inch well to a depth of over two hundred and fifty feet in the S.W. ¼ of S.W. ¼ S. 28, T. 2 S., R. 1 W., and struck a small flow of gas.

3. The third well was sunk in the same year under the superintendency of Dr. Pugh, on the S.E. ¼ of S.E. ¼ S. 28, T. 2 S., R. 1 W., three hundred feet deep, five inches in diameter, with same results.

There is an oil spring a little over two miles up the Upper North Fork of the Mattole. Another is on the South Fork, a mile and a half from the main river. On Roscoe Creek, about a mile from the Mattole, there is still another, on which a shaft was sunk thirty feet but abandoned on account of the gas. Traces of oil may also be discovered on the main river itself just below the mouth of the South Fork. This section has produced no oil at all.

In the central section of the district quite a large number of wells were sunk during the years 1865, 1866, 1867:

1. The Jeffrey Well was sunk on the right bank of the Lower North

Fork, about half a mile west of "Petrolia." It reached a depth of nine hundred feet. At four hundred feet a twenty-foot bed of sandstone was passed; above and below this the material was shale and blue clay. There was no oil found and but little gas. The first three hundred feet were cased with six-inch pipe. It took from June, 1865, to May, 1866, to sink the well.

2. The Davis Well was located half a mile north of the Jeffrey claim, and about one mile from town. It was started with seven inches; at fifty feet it was found necessary to reduce to six inches; this was carried to two hundred feet, when a five-inch pipe had to be substituted; this was carried down another hundred feet, when it was found that the well would stand without casing. The total depth reached by this well was between one thousand four hundred and one thousand five hundred feet. It was dry, only a small amount of gas being found; no water. This was the deepest well in the entire district. John Hunter, now of Grass Valley, was the Superintendent.

3. The Knowlton well was situated on the left bank of the Lower North Fork, in the N.E. ¼ of S. 26 of T. 1 S., R. 1 W., opposite the mouth of the North Fork of the Lower North Fork. It was shallow and dry.

4. To the north of the last, on the right bank and to the west of the North Fork of the North Fork, was the Brown & Knowles' Well. It was four and one half inches in diameter and three hundred feet deep, but neither oil, water, nor gas were struck.

5. About one mile up the North Fork of the North Fork, a San Francisco company went down two hundred and twenty feet unsuccessfully.

6. Across the creek, to the eastward of the Brown & Knowles' Well about half a mile, is the North Fork Well. It is a four-inch well and was put down one hundred and eighty feet. Its present depth is in the neighborhood of thirty feet. This was one of the productive wells, the total product being about thirty barrels. At the present time, although nearly filled up, one or two gallons can be collected every month.

7. In Section 30, T. 1 S., R. 1 W., on the left bank of the Lower North Fork of the Mattole, is the Union Claim, about one and one half miles further up the gulch than the last named. On this claim several wells were drilled, ranging in depth from thirty feet to one thousand feet. They passed through the following strata:

Shale and sandstone, 30 feet; depth, 30 feet.
Sandstone, 4–5 feet; depth 35 feet, carrying little oil, but plenty of gas.
Shale, 25 feet; depth, 60 feet.
Sandstone, 4 feet; depth, 64 feet; oil bearing.
Shale and blue clay, 26 feet; depth, 90 feet.
Sandstone, 5–6 feet; depth, 95 feet; oil bearing.
Shale and blue clay, 905 feet; depth, 1,000 feet; some gas.
Gravel, ? feet; depth, 1,003 feet; stopped here in the deep well.

The deep well was cased all the way, carrying three hundred feet of eight-inch pipe, four hundred feet of six-inch, and six hundred feet of five-inch pipe.

This claim produced considerable oil. About one hundred barrels were taken out and sent to San Francisco for trial. The wells had to be pumped, yielding at the rate of one barrel a day. All the oil was obtained either from sixty feet or ninety feet depth. The claim belonged to the Mattole Petroleum Company, in which Hon. L. Stanford was the principal owner. The wells were never tested to their full productive capacity, on account of the lack of storage facilities; quite an amount of oil was used on the spot for fuel and light. One of the wells is open to the present day, and oil may be obtained in small quantities most any time, provided it rises above some tools left in the well; if it does not, a few buckets of water soon remedy the defect.

8. On the opposite bank, and about half a mile above the Union Claim, the Paragon Well was sunk, unsuccessfully, in 1865–66, under Thomas Duff as Superintendent.

9. Between the Union Claim and the North Fork Well, was the Kellogg Well—another dry hole.

10. Three miles to the northeast of "Petrolia," on Joel's Flat, the "Joel Flat" Well was located on John Walker's land, T. 1 S., R. 2 W., Sec. 23. This well was put down in 1867 to a depth of two hundred and thirty feet, with five-inch casing. At this depth the casing stuck, and the hole was continued without it; but only thirty feet more could be added on account of the sides caving in. The water was then pumped out, and on nearly reaching the bottom, oil issued from the pipe instead of water. All the available vessels in camp were soon filled and pumping discontinued. After a few days a tank had been put up, and the well was again opened; but it was found that the bottom of the well had caved. After several unsuccessful attempts to reach the oil-bearing zone again, the well was abandoned. The total amount of oil this well produced was about five barrels. The claim belonged to Scott & Parsons. Financial and other difficulties prevented a renewal of the enterprise.

In the neighborhood of the well small quantities of oil were obtained from pockets in the shale by sinking small holes and pits. About two hundred yards from the well there is a spring yielding a little oil. Messrs. George Noble and J. W. Henderson were Superintendents.

11. A company, with Mr. Muldrow at the head, bored several wells on McNutt Gulch. One of them, a six-inch, reached a depth of two hundred and fifty feet; two others, each four and a half inches only, reached one hundred feet. From the deepest one a few barrels of oil were obtained, but it was exhausted on pumping.

12. A well was drilled on the left bank of the Mattole River, directly south of "Petrolia." The venture was not successful.

13. In S. 8 of T. 2 S., R. 2 W., on James Gough's place, the drills penetrated the earth several hundred feet and quite a flow of gas was struck.

14. On Langdon Creek, one mile east of Petrolia, Minor K. Langdon located the Comet. No results obtained.

15. The Buckeye was on Conklin Creek, about two miles from the Mattole River. No oil.

16. About six miles from "Petrolia," up the Mattole, a party of Sacramento gentlemen bored a well and searched in vain for oil.

17. At Dudley's Mill, about a mile above the last named, another unlucky venture in the shape of a well left the owners poorer than they started out.

Several other wells were sunk in the district, but all record of them is lost; in fact, of quite a number of the wells enumerated above nothing remains to mark their spot save a few decaying timbers and an odd length or two of rusted pipe.

The existence of oil springs on Davis Creek and on McNutt Creek has already been noticed.

Having recounted at length the work done to develop the district, it now becomes necessary to review briefly the causes which led to its final abandonment.

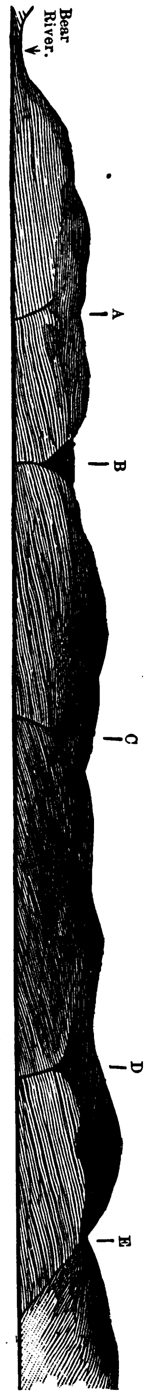
Among these, the expensive transportation already alluded to above, was a great drawback from the very start and made itself specially felt during the first year. The heavy machinery absolutely necessary for drilling was hauled in at an enormous cost, often crippling an enterprise at its beginning. Another reason was the drop in the price of crude petroleum, due to rich discoveries in Pennsylvania. During the year 1867 the price reached a second minimum, so that it was impossible for this coast (with the price of labor and machinery at a maximum) to compete with the East. Then, again, the failure to strike any flowing wells. But even if flowing wells had been tapped it would have cost more to bring the oil to market than it was worth, the transportation being expensive and tedious.

The chief reason was the following: The people interested in the oil lands had located them by the usual methods, as homesteads, or preëmptions, or by means of school warrants, soldiers' warrants, college scrip, etc. The land agent at Eureka had received these applications, made as they were, in good faith. When the oil was discovered in some quantity, the land agent reported the fact to the Commissioner at Washington, holding the title in abeyance pending the answer. Months passed ere the answer came, but work had been progressing steadily and considerable money was spent. The Union Wells had produced a quantity of oil and everything seemed prosperous. The answer came at last. It was an order to withdraw all the oil lands from sale and hold them as mineral land subject to entry as such. This order proved the death knell to the oil boom in Humboldt County. Special messengers were sent by the owners from San Francisco by way of the Sacramento Valley and Weaverville, with the order to stop work. This was a natural consequence. The investors, finding that they had no title, and were at the mercy of any person ready to jump their claim, rather chose to close down at once. Others, though they discontinued work, procured titles to their claims. Messrs. Scott, Parsons & Co. in this way obtained, it is said, over eighty thousand acres which they subsequently sold, reserving, however, the right to bore for oil. If the information received is correct, the Joel Flat Well was the first, of those in operation, to close down, the others following in a few days. The wells were plugged, and the machinery removed and sold.

The oil obtained in the Humboldt District is of a light brown color, quite limpid, with a slight green fluorescence.

During the course of the examination of the district in July, 1887, oil was obtained from a spring near Bear River, from the North Fork Well, and from the Union Well.

The oil-bearing rock is in all cases a fine-grained, porous sandstone, of a gray color. It is usually interbedded with thick strata of blue clayey shale. The following sketch gives a view of the bluffs on the coast south of Bear River, showing strata.

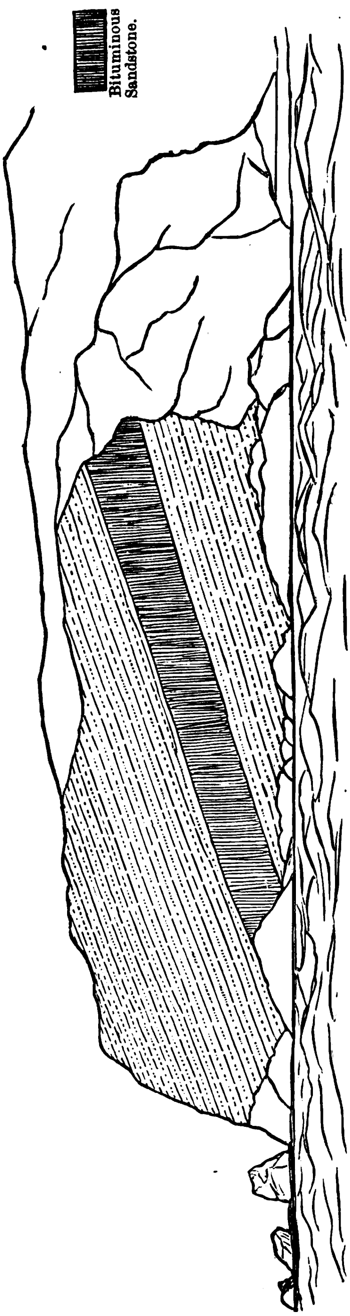


SKETCH OF THE BLUFFS ON THE COAST, SOUTH OF BEAR RIVER (THREE MILES).

A, B, C, D, E are faults. [EXPLANATION—By *faults* is meant a break in the continuance of the strata, and not an error in the sketch.]

In the interior, that is five to ten miles from the coast, the strata lie even more horizontal than shown in the sketch; especially along the Upper Mattole.

Mendocino County.



BLUFF ON THE NORTH SIDE OF POINT ARENA HARBOR (FROM THE WHARF). SHOWING THE BITUMINOUS SANDSTONE.

The Point Arena Petroleum Oil and Coal Mining Company was organized in January, 1864, and on February first had seven claims, each three hundred feet square, recorded at Ukiah.

Messrs. S. B. Campbell, David Beebe, T. S. Benoist, J. G. Campbell, F. H. Graves, Charles Koble, and H. K. Petygrove, were the original locators of these claims. Porter Oneal also took up a claim.

Several wells were sunk at Point Arena, but they struck no oil to amount to anything. At various places, however, beds of bituminous sandstone were developed. After failing to find any oil, the company next turned its attention to the production of oil from the bituminous sandstone by means of distillation. The preliminary experiments were very successful. A quantity of the material was sent to San Francisco and distilled. Although the oil produced was very good, its cost of production, and particularly the freightage from Point Arena, was too high to make the enterprise a profitable one, compelling the company to give up the project. The idea of utilizing the beds of bituminous sandstone lay dormant for a number of years. Only during the last few years the use of bituminous rock as a pavement for streets and sidewalks came into vogue.

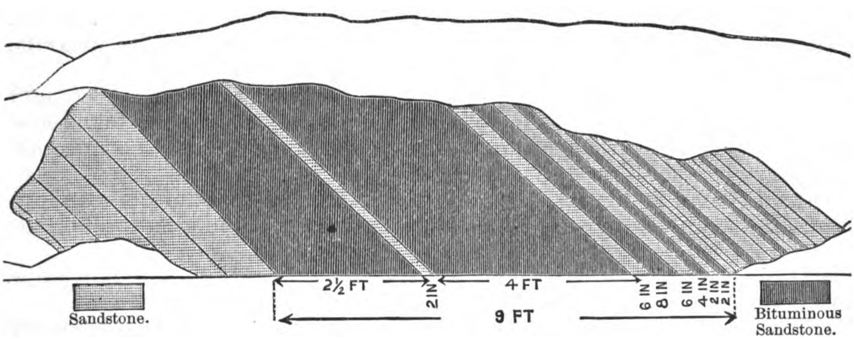
It was then recalled that enormous quantities of the material lay close at hand at Point Arena. The California Bituminous Paving Company was formed by Senator A. J. Meany, of Merced, Legrand Morse, Louis Morse, of Point Arena, and others. They bought up the rights to the asphalt rock in the neighborhood, and are now at work opening the quarries and getting ready for large shipments.

The largest bed is exposed in the Point Arena harbor. It is fully twenty feet thick, with a dip of 35° to the north, the strike being N. 10° to 20° W.

The foregoing is a sketch of the locality.

About a mile and a half north of the harbor is the other place where bituminous rock has been exposed by quarries. It is on the land of Mr. Porter Oneal, a short half mile from shore. There are two beds, called respectively the Upper and Lower Bed; the Lower Bed being to the eastward of the other.

The following is a sketch of the Lower Bed as exposed in August, 1887:



VIEW OF QUARRY ON LOWER LEDGE ONEAL CLAIM, POINT ARENA (LOOKING SOUTH).

The Lower Ledge has a total thickness of nine feet, of which, however, a foot and a half must be subtracted as the total of several thin beds of sandstone. The material from this Lower Ledge is of a brownish-black color, crumbles between the fingers quite easily, and on ignition leaves a residue of 93.2 per cent, showing but 6.8 per cent of volatile matter. The residue consists of a rather coarse quartz sand.

The section in the quarry exposing the Upper Ledge, about one hundred yards west of the one just described, is very similar to that of the Lower Ledge. The thickness is only eight feet, but there is scarcely any barren sandstone included. The two ledges differ somewhat in their dip and strike; the Upper has a dip of 48° or 50° to the southwest, and strike of N. 45° W.; while the Lower Ledge dips 38° S. and strikes N. 70° W.

The material from the Upper Ledge differs considerably from that of the Lower Ledge. It is a black, sticky, pliable mass, coarse-grained, but reunites under pressure. On ignition it leaves a residue of 88.8 per cent, showing 11.2 per cent volatile matter. The residue consists of quartz grains colored by oxide of iron.

The ledge in the harbor furnishes an article very similar to that of the Upper Ledge. The volatile matter amounts to 10.4 per cent, leaving 89.6 per cent residue of fine quartz grains. The mass has a brownish-black color, is soft and sticky, but crumbles under pressure.

Picked specimens have yielded as high as 15 per cent volatile matter.

The ledge at the harbor has been exposed, as can be readily seen from the sketch, to wind and weather, for many a year, so that its lack of cohesiveness and its low percentage of bituminous matter are readily explained. As soon as the surface material is removed, and the ledge developed, these properties will gradually improve.

The same may be true of the Lower Ledge, particularly when opened deeper below the surface than at present. The Upper Ledge furnishes a good material; its difference from that of the Lower Ledge is in part, at least, due to the fact that the former is inclosed in hard, dense sandstone, not very pervious to water and air.

At several other points in the neighborhood of Point Arena, bituminous rock has been found, but apparently lacking not only in quality but also in quantity, as they have not been developed.

A slight indication of petroleum has been found on Caspar Creek when logging roads were being cut.

Oil springs were found and located in the hills east of Potter Valley, on May 22, 1865. The piece of land on which these springs occurred was to the east of a ranch owned by a Mr. Christopher, and only two hundred yards wide, but extending to the summit of the hills. G. W. Smith, P. W. Vann, and J. M. Cainer took up claims in this locality. (County Records, Ukiah.)

During the oil excitement on this coast in the years 1865, 1866, and 1867, the whole country was prospected for oil, and indications found and followed up in localities that are nowadays never mentioned in connection with oil.

Oil was found at Bolinas Bay, and the Bolinas Petroleum Company organized. Their works were located in the Arroya Honda, on the Bolinas Grant.

In Colusa County oil was found in various sections. In 1867 eight wells had been sunk, but with what result is not known.

Oil is also said to occur on "Sulphur Creek," not far from the county line. In 1865 Messrs. Rowe and Fleeson sank a well one mile below Simmons Spring, "Sulphur Creek." During the same year the Antelope Valley and the Pioneer Oil Company were operating in Colusa County.

In an article in "Mining and Scientific Press," April 15, 1865, it is stated that the "Colusa oil is light and sufficiently pure to burn just as it is taken up from the springs."

San Joaquin County.

According to newspaper accounts petroleum has been struck in two deep wells bored at Stockton during the present year.

Alameda County.

The Livermore Oil Company exhibited a sample of dark greenish-brown heavy petroleum from their well, seven miles southeast of Livermore, at the Mechanics' Fair, September, 1887.

BUILDING STONES.

BUILDING STONES.

We had hoped that the following communication from Hon. W. W. Morrow would have created sufficient enthusiasm to have induced the citizens of our State to at least have sent us a showing approaching a respectability. The within incorporated circular was scattered throughout the State, but with the exception of that which is incorporated in the article by Professor A. Wendell Jackson, the response has been immaterial, although promises have been plentiful:

"San Francisco, April 4, 1887.

"*Hon.* Wm. Irelan, Jr., *State Mineralogist, San Francisco, California:*

"Dear Sir: I have heard it frequently stated that no discovery has yet been made on this coast of any good building stone other than that of the granite formation.

"I cannot believe this to be true, and I have always met such statements with the assertion that beds of good quality of sandstones were known, while quarries of basalt, and even rhyolite, have been developed.

"But it is claimed that our sandstones are not desirable, either in color or structure, and that the other stones are not convenient to market.

"In view of the fact that large, substantial buildings are about being erected in San Francisco and elsewhere on the coast, with every prospect that a season of building enterprise is upon us, I would recommend that your Bureau should give special attention just now to an investigation of building-stone quarries, or deposits, in this State. Full and reliable information upon this subject would, I think, aid very materially in securing the opening of such quarries and the erection of substantial buildings of stone for private as well as business purposes.

"The material for the new Post Office building will soon be a question of importance to the General Government, as well as the people of this community, and it would be of great advantage in securing liberal appropriations for the construction of the building, if we were able to show that we have a good variety of building stone of a durable quality and of sufficient quantity near enough to San Francisco to warrant us in saying that the erection of a substantial and imposing structure may be undertaken upon a moderate estimate for such building materials. This question has already been raised, and I think we should be prepared to meet it fully with all the information that can be obtained.

"I therefore commend this subject to your careful attention, in the hope that an examination be made in the direction indicated.

"Yours very truly,

"WM. W. MORROW."

CIRCULAR FROM THE STATE MINING BUREAU.

To Quarrymen, Architects, and Builders:

Wm. Irelan, Jr., State Mineralogist, with the coöperation of A. Wendell Jackson, Professor of Mineralogy, Petrography, and Economic Geology, in the State University, proposes to make an exhaustive investigation of the building stones of the State, and to that end invites your active assistance in procuring the necessary material. The report will cover Mineralogical Description, based on Microscopical Examination of thin Sections; Chemical Composition, where necessary; Density; Tests of Strength; Permanence of Color; Absorptive Properties for Moisture and Water; Weathering Properties; Resistance to Heat; and General Adaptability to Structural Purposes.

For the purpose of this series of investigations, the following material will be required for each stone examined:

Ten (10) cubes of one and one half inches, roughly dressed.

Two (2) cubes of two inches, roughly chipped.

Two (2) cubes, cut out conformably with the bedding of the rock, of two and one half inches, if rock is soft, and of one and one half inches, if rock is hard.

Ten (10) hand specimens, roughly chipped to the size of four and one half inches by three and one half inches by one and one half inches.

Six (6) hand specimens, polished on one side and roughly dressed otherwise, of the size of four and one half inches by three and one half inches by one and one half inches.

Twenty (20) thin chips or flakes, approximately one and one half inches square.

In the preparation of the cubes, it is important to mark which is the edge and which the bedding side, unless this is sufficiently obvious from the texture or grain of the rock.

All of the foregoing specimens should be carefully selected from a sufficient depth to insure fresh material, and as complete freedom as possible from weathered surfaces. In addition, one or two specimens, particularly illustrating the natural weathered surfaces, should be sent.

Each specimen must be carefully wrapped, and all packed firmly in a wooden box, and addressed, with inclosed label, to the "Mining Bureau, Pioneer Building, San Francisco," *freight or express charges prepaid.*

A letter should likewise be addressed to the State Mineralogist, giving detailed information as to the exact locality and extent of deposit, present means of transportation to nearest market, buildings in which the stone may already have been used, and the name of the owner of the quarry.

William Irelan, Jr., *State Mineralogist:*

Dear Sir: I take pleasure in sending to you the results obtained in the testing of a few California building stones. The work was undertaken so late in the year that comparatively little could be accomplished in time for publication in this year's report, and even this can be presented with but little critical comment. The main interest attaching to this kind of work must lie in the thorough examination of all the available building stones of the State, and their comparison, not only with one another, in order that the strong and weak points of each may be well brought out to the end that the appropriate selection of material may be made for any given work, but also with the most celebrated building stones of the East and of Europe, the good and bad qualities of which have been determined by the actual test of use for decades or centuries. It is the belief of the writer that a very large variety of ornamental and useful stones will be furnished by the mountains of this State. The number already discovered is large, and a proper appreciation of their beauty and value is sure to follow the systematic investigation into and publication of their merits. The difficulty of access to places distant from the railways has been a great obstacle to fruitful returns for the labor of prospecting and opening quarries; but difficulties of this kind are diminishing each year, and the natural result is already evident in the increasing interest taken by quarrymen, architects, and capitalists in our building stone resources. In no country now inhabited by the more highly cultivated races of mankind are the natural conditions for the durability of constructions in stone more kindly than here. Still it behooves us to move carefully now in the very beginning of the development of our quarry resources, in order to avoid such costly mistakes as have been made both in the East and in Europe in the selection of stone for elaborate private and national structures. The construction of the new Post Office building in San Francisco will soon make it a matter of great practical importance, as well as of general interest, to know what building stones the State can furnish that shall meet all the requirements of durability, strength, and beauty. The following results as a mere beginning in this direction are formulated as a contribution from the Mineralogical Department of the State University towards a better knowledge of our resources in this direction.

Before proceeding to the description of results, a few words concerning the methods of examination may be in place.* For purposes of an exact mineralogical determination, a thin chip of the stone is ground to an even surface with emery and water, on a rotating iron lathe, then ground fine with flour of emery and water. The side thus prepared is then cemented, by means of Canada balsam, to a small square of thick plate glass, which furnishes the means for holding it steadily while the rough side is gradually ground away, first with coarse then with fine emery, until the section of rock is perfectly transparent, not exceeding 0.025 to 0.05 mm. in thickness. The section is then transferred to a microscope slide, covered with a thin glass cover, and is then ready for study and for permanent record. Three sections of each stone are prepared, one parallel to the bedding, and one in each of two directions at right angles to each other and to the bedding.

The determination of the specific gravity was made in the usual way with an analytical balance. Roughly cubical specimens of about 75 grammes weight were dried at 100° C. to a constant weight (six days), weighed in air, and then weighed suspended in water by a horsehair, after prolonged immersion. The weight of the dried cube divided by the loss of weight on suspension in water, was taken as the specific gravity. The weight of one cubic foot was then calculated from the weight of a cubic foot of water equal to sixty-five and one half pounds.

The crushing strength was determined by the Riehl testing machine of the Mechanical Department of the University, through the courtesy of Professor Hesse, and the kindly coöperation of Mr. Sladky. The maximum capacity of the machine is fifty thousand pounds, so that the size of the cubes used was necessarily limited to less than the usual two-inch cube. The tests were made at the last moment before the transmission of this report, on but two specimens of each rock, one on the bed and one on the edge, and consequently must be considered only approximate. During the coming year they will be carefully repeated with a large number of cubes of each rock.

The absorption of moisture was determined by exposing carefully dried, roughly cubical fragments, of about seventy-five grammes weight, in a saturated atmosphere of water-vapor for seven weeks. The specimens were placed on a glass shelf under a bell jar over standing water. The absorption of water was determined by exposing still another set of stones

*See Geol. of Minnesota, vol. I, p. 185.

of about seventy grammes weight, in a vessel of water for — days. They were carefully dried and weighed first, and the increase of weight after immersion represented the amount of water taken up.

The action of carbonic acid was determined by immersing carefully dried and weighed rough cubes of the same size as the preceding, in water kept saturated by carbonic acid. The loss of weight was inconsiderable unless the stone contained an appreciable amount of carbonate of lime.

The exposure of weighed fragments to strong corroding acid and chlorine fumes, was made to determine the weathering and staining effect that could be produced within the short period of exposure (seven weeks), as indicative of what might be expected from the long continued exposure to the natural weathering agencies in buildings. The effect of dry heat was obtained by exposing cubes of stone in a muffle furnace raised to a red heat. The cubes were gradually heated up to a full redness and then changes of color, cracking, or softening noted. The cubes were then removed, and after cooling below red heat, plunged into cold water and further changes noted.

The tests thus noted by no means furnish all the information it is desirable to obtain concerning the rocks examined. It is hoped that the final report may include the results of the examination of the quarries to determine the extent of the supply, appearance, and behavior of the stone on weathered surfaces, and facilities for quarrying and transportation; further, an enumeration and examination of the structures in which the stone has been used, and the cost of delivery in the San Francisco market.

Five sets of stones have been received; two kinds of Santa Susanna sandstone from the Gilbert Stone Company, of Los Angeles; one sandstone from Robert Rangeley, of Henley, Siskiyou County; Colton marble from the Colton Marble and Lime Company, of Colton; and a volcanic tufa from the Campo Seco Stone Agency, San Francisco. I give below the results thus far obtained from an examination of these stones.

SANTA SUSANNA SANDSTONE.

Two varieties of this stone were sent by the Gilbert Stone Company, one very coarse-grained and the other very fine-grained.

I. Coarse-Grained Sandstone.

Macroscopic.—To the unaided eye the rock appears as a very coarse-grained, light grayish-yellow sandstone, consisting of subangular, smoky gray quartz granules, from 5 mm. in diameter downwards, averaging perhaps about 1.5 mm., dull yellowish-white, soft granules, apparently of kaolinized feldspar, numerous small, black, and a few white, mica scales; the whole cemented together by a very slight yellowish argillaceous cement.* An occasional bluish-black slate fragment is observable. The stone can be made to crumble somewhat in the hand on the edges and angles, but in larger fragments it holds well together.

Microscopic.—Thin sections could be prepared only after saturating the fragments to be ground with boiling Canada balsam, and allowing them to cool and harden. Sections were thus obtained thin enough, but they

* The term "cement" is technically used in geology, with reference to the finely divided or fine-grained material which holds together the larger grains of quartz or other mineral entering into the composition of the sandstone. This cementing material, or "cement," is ordinarily clay, carbonate of lime, oxide of iron, or silica, more or less mixed with finely comminuted particles derived by attrition from the larger grains, whence the four chief classes of sandstones: the *argillaceous*, the *calcareous*, the *ferruginous*, and the *silicious*.

went to pieces during the final mounting. The above mentioned constituents are all readily recognizable. The quartz is greatly in excess in sharply angular granules from the largest size (5 mm.) down to minute grains. The quartz substance is quite clear, or with bands or clouds of tiny liquid cavities, with movable bubbles, minute yellowish patches of hydrated ferric oxide, now and then a few colorless cylindrical microlites (perhaps apatite), or thickly interpenetrated in every direction with long, exceedingly delicate hair-like forms (possibly asbestos).

The feldspar is present both as potash and as soda-lime feldspar; its granules rarely exceed 1 mm. or 1.5 mm. in diameter, and diminish from this down to the minute particles which make up the cement. It presents every stage of decomposition, and consequent softening, from comparatively fresh substance, showing the brilliant bands of plagioclas between crossed nicols in polarized light, down to the more or less completely kaolinized mass that has become dull white, soft, and opaque. Roughly estimated the quartz makes up perhaps three quarters of the granular constituents, and the feldspars and mica scales the remainder. The mica scales (the black largely in excess) are abundant and closely wedged in between the quartz and feldspar granules, with their cleavage surfaces mainly in the plane of the rock-bedding. The white scales are still fresh, and from their toughness add to the strength of the stone. The black mica has, however, lost its elasticity and toughness, and by its partial decomposition has furnished much of the yellow oxide of iron, to which the color of the stone is due.

Cement.—The small proportion of cement present is easily seen in the thin sections. The above described granules are either in actual contact or separated by a thin film of yellowish argillaceous material, derived from the decomposition of the feldspars. In an uncovered section one can likewise discern delicate patches and films of snowy white substance, which is evidently the carbonate of lime that effervesces at numerous detached spots when the surface of the stone is moistened with chlorhydric acid. Like the kaolin of the cement, it also was probably derived from the decomposition of the feldspars.

The specific gravity of the stone is 2.62, whence the weight of one cubic foot equals 163.7 pounds. The amount of moisture absorbed in seven weeks equals 1.51 per cent of the weight of the stone, and the amount of water to 5.33 per cent. The effect of strong corroding acid fumes was very marked. The stone became somewhat discolored with yellow iron oxide stains, and crumbled considerably, losing 3.7 per cent of its weight standing untouched on the glass shelf upon which it was exposed, and 3.6 per cent more upon being brushed with a moderately stiff brush. The stone was entirely unaffected by heat, except that it changed color to a beautiful brownish-red, and subsequent exposure to water, while still hot, failed to crack or scale it in the least.

The crushing strength, determined from a single cube for edge and another single cube for bed, amounts to five thousand eight hundred and twelve pounds per square inch for *bed*, six thousand eight hundred and twenty-eight pounds per square inch for *edge*. The dimensions of the bed-cube were 1.395 inch by 1.416 inch by 1.183 inch, and of the edge-cube 1.380 inch by 1.394 inch by 1.350 inch. In each case the last dimension was the height of the cube.

Occurrence.—According to the sender, an official of the Gilbert Stone Company, Los Angeles, the stone occurs in bowlders, of which the company has an inexhaustible supply in the Santa Susanna Mountains, about eight miles southwesterly from San Fernando Station, on the Southern Pacific

Railroad, in Los Angeles County, and about twenty-eight miles from Los Angeles City. Great difficulty is at present experienced in getting the stone hauled from the quarries to the railroad. The cost of hauling is $1 50 per ton, and the cost from San Fernando to Los Angeles is $1 per ton. The sandstone beds cover an area of two and one half miles in length by one mile in width, and the beds of the finer grained stone are said to be one half mile in thickness. Both the Southern Pacific and the Atchison, Topeka, and Santa Fe Railroads are expected to run through the immediate vicinity of these beds, and thus furnish a ready means of transportation to market.

II. Fine-Grained Sandstone.

Macroscopic.—This variety differs in appearance from the former in the size of the grain. It is a beautiful evenly fine-grained stone, of nearly uniform light, grayish-yellow, minutely specked with black and silver-white mica scales. Under the microscope, all of the characteristics of the preceding rock reappear here. While a thin layer of the stone occurs now and then in which granules 1½ mm. diameter occur, in general the average grain does not exceed 0.15 mm. to 0.20 mm. Hardly a trace of effervescence is noticeable when the rock is moistened with chlorhydric acid, nor even when the rock powder is heated with acid.

The specific gravity is 2.52; weight of one cubic foot is 157.5 pounds; absorption of moisture, 1.19 per cent; absorption of water, 6.19 per cent; loss on exposure to carbonic acid gas solution, 0.27 per cent. Exposed to acid fumes, the stone was stained brownish-yellow in spots, became loosely coherent on the surface, lost 7.77 per cent through quiet disintegration, and an additional 9.13 per cent by brushing. In the muffle furnace its color changed to a deep brownish-red, but no crack nor flaw developed in the stone up to full red heat, nor on subsequent immersion, while hot, in water. The crushing strength determined on cubes 1.425 in. × 1.465 in. × 1.359 in. (ht.) for *bed*, and 1.291 in. × 1.258 in. × 1.147 in. (ht.) for *edge*, resulted in 9,752 pounds per square inch for *bed*, and 7,380 pounds per square inch for *edge*. The specimens examined came from six to twelve inches from the face of the sandstone bed.

For occurrence, see above under the coarse-grained sandstone.

Henley Sandstone.

Macroscopic.—The Henley sandstone is a moderately fine-grained, light bluish-gray stone, showing to the unaided eye, dark gray and whitish quartz granules, with numerous black and few white mica scales, held together by a slight argillaceous and calcareous cement. A somewhat free effervescence follows the moistening of the surface with acid. The stone will work easily, and in specimens appears quite free from flaws.

Microscopic.—The quartz granules are most numerous. They are subangular in shape, varying in diameter from 2 mm. downwards, averaging 0.33 mm. The quartz substance is, in the main, quite clear, except for the fluid cavities that are thickly crowded in many of the granules. These cavities vary in size from 0.02 mm. down to the minutest dimensions. While mostly oval, they occur also in the most curiously irregular branching forms, and now and then in the familiar shape of the quartz crystal; the cavity repeating in negative the external dihexahedral form of quartz. Some are completely filled with fluid; others contain liquid with a little bubble in constant motion; others have a stationary bubble; others again are filled with a liquid that does not wet the sides of the cavity, so that it appears in the form of a bubble so large as to fill all except the outer irregularities of the cavity. Finally, some of the cavities appear to contain *two* bubbles, one within the other. We have in such cases two liquids that will not mix. In one such that was measured, the cavity was .008 mm. in diameter; the outer fluid .007 mm., and the inner one .004 mm.; the latter was in constant motion within the limits of the outer fluid.

Feldspar granules are also present, constituting more than one third the mass of the rock. The feldspar is usually so decomposed that its granules are whitish opaque in thin sections; the fresher granules still show, however, the banded structure of plagioclase in polarized light between crossed nicols.

The numerous black mica scales are much decomposed, the different laminæ often forced asunder by opaque white calcitic decomposition products. The white mica scales are much fewer and, as usual, quite fresh. An occasional magnetic oxide of iron granule, not exceeding 0.1 mm. in diameter, is observable.

Cement.—The cement consists of a mixture of argillaceous and calcareous material mixed with the finest granules of quartz and feldspar, and colored throughout slightly yellowish by the oxide of iron. The specific gravity is 2.63; weight of one cubic foot 164.5 pounds. The absorption of moisture equals 1.78 per cent, the absorption of water 4.07 per cent, and the loss by exposure to carbonic acid equals 0.35 per cent. Exposure to corroding acid fumes changed the color from gray to bright yellow, and rendered the stone crumbly on the surface. The loss by quiet disintegration was 3.27 per cent, and the further loss by brushing was 2.28 per cent, making the total loss 5.55 per cent.

In the muffle this sandstone cracked and scaled somewhat below a red heat, and changed its color, on full red heat, to a brownish-yellow. No further cracking was noticeable upon immersion of the hot cube in water.

The crushing strength was determined on a bed-cube 1.418 in. × 1.354 in. × 1.271 in. (ht.) yielding 12,601 pounds per square inch; and on an edge-cube 1.309 in. × 1.404 in. × 1.476 in. (ht.), yielding 8,722 pounds per square inch.

Occurrence.—The owner of the quarry, Mr. Robert Rangeley, of Henley, Siskiyou County, states that the sandstone beds are behind the town of Henley, and within one mile of Hornbroke Station on the California and Oregon Railroad; that the supply is inexhaustible, and that the stone was used in the construction of the abutments for the railroad bridge over the Klamath River.

Campo Seco Tufa.

Macroscopic.—The Campo Seco tufa is a dull, grayish-white, earthy-looking stone, that to the casual glance seems to be fairly homogeneous in color and compact in texture, except for the occurrence of irregularly-shaped, soft, snowy-white fragments, with delicate, silky luster, immediately suggestive of pumice fragments. They are from 30 mm. in length downwards, and are much softer than the surrounding rock. More closely observed, one sees, in the apparently compact mass, whitish fragments with glassy luster, whose good cleavage betrays their feldspathic character; brownish, angular fragments, otherwise similar to the surrounding stone, and a few minute hexagonal scales of black mica. All of these fragments lie imbedded in a whitish, earthy, but coherent mass, showing in hand specimen an apparently massive texture, no appearance of lamination being visible. On the cubes polished for the crushing tests, and on thin sections cut in the right direction, a very marked, banded texture is developed, due to alternating broader bands (3 mm.) colored delicately brownish-red and narrower bands of the whitish colored material; the bands are seen but faintly on a ground surface, and distinctly only on a polished surface.

The stone is quite soft, easily admitting sawing into blocks and slabs, and yet is remarkably coherent, as the comparative high crushing strength testifies. Mr. Morton A. Edwards, of San Francisco, the sender of the specimens tested, states that two years' experience has proved that the tufa hardens somewhat on exposure to the weather.

Microscopic.—Under the microscope the stone is seen to consist mainly of clear, colorless, sharply angular, and exceedingly irregularly shaped glass fragments, from 0.75 mm. in diameter to the minutest dimensions, in a cement of excessively finely comminuted isotropic material, which the highest objectives ($\times$ 1,000) resolve into colorless or slightly brownish oblong or rounded transparent granules.

Through this mass are scattered fragments of fibrous and cellular pumice, filled with the characteristic elongated or rounded gas cavities, fragments of fresh samidin feldspar characterized by cleavage and Carlsbad twinning, plagioclase feldspar, recognizable by the bands in polarized light, and fragments of a brownish tufa, identical in general appearance and constitution with the mass of the stone, but with its cement colored brown and rendered opaque by iron oxide. All these fragments are of decidedly secondary importance in the composition of the stone.

The specific gravity is 2.322; the weight of one cubic foot is 145.12 pounds. The amount of moisture absorbed in seven weeks is 2.02 per cent of weight of the stone, and the amount of water absorbed is 10.92 per cent; 9.62 per cent of water is absorbed within four days after immersion, so that the subsequent absorption is not considerable. The effect of exposure to strong acid fumes was inappreciable; the stone was not stained in the least, and was just as firm and coherent as when first exposed. The loss by exposure to carbonic acid solution equals 0.48 per cent. The effect of heat upon the stone is very marked. A comparatively low heat develops a clouded dark color and numerous superficial cracks. A full red heat fused the surface of the cube in contact with the muffle, shrunk the rock perceptibly, and subsequent immersion in water cracked the stone throughout, so that large fragments fell off in handling. The delicately shaded bands before described in the natural rock, became deep brownish-red in color, and very prominent.

The crushing strength determined on a *bed*-cube 1.356 in. $\times$ 1.406 in. $\times$ 1.433 in. (ht.), gave 7,469 pounds per square inch; and on an *edge*-cube 1.325 in. $\times$ 1.402 in. $\times$ 1.461 in. (ht.) gave 7,262 pounds per square inch.

Occurrence.—Mr. Edwards states that there is an inexhaustible supply of the quarries near Campo Seco, in Calaveras County. The stone has not yet been used in San Francisco.

Colton Marble.

From the Colton Marble and Lime Company, of Colton, Los Angeles County, specimens were received illustrating three varieties of marble: a nearly pure white, a white clouded with gray, and a grayish-black finely mottled with white. Most of the specimens were of the clouded white variety, and the examinations made have special reference to this stone.

Microscopic.—The clouded Colton marble is a medium-grained, granular limestone, homogeneous in texture, and so far as can be judged from hand specimens, quite sound and strong. It takes a good polish, but closely observed on a polished surface, unless the polishing has been very carefully done, a thick sprinkling of duller granules in the more perfectly polished ground can be seen. Two different kinds of granules are evidently present, with different degrees of hardness. Chemical examination showed the presence of about 6 per cent of carbonate of magnesia, and the subsequent microscopic examination proved that the stone was made up of granules, each showing the characteristic polysynthetic structure of calcite, due to repeated twinning parallel to $-\frac{1}{2}$ R., and other granules without this twinning structure. This observation, taken together with the fact that a residue remains from digestion with cold dilute chlorhydric acid which is in part readily soluble in hot dilute chlorhydric, proves that the limestone is dolomitic and consists of a mechanical mixture of calcite granules (carbonate of lime), and dolomite granules (double carbonate of lime and magnesia). The former have the hardness of 3 in the Mohs scale, and the latter of 4. On the imperfectly polished surface, therefore, the polishing process has continued long enough to polish the softer calcite granules, but not long enough for the harder dolomite granules.

The mechanical mixture of the two kinds of granules can easily be shown by etching a polished surface with cold dilute chlorhydric acid. The calcite readily dissolves, and the dolomitic granules are left in relief. A further residue insoluble in hot dilute chlorhydric acid exists. This consists of granules, which in thin sections of the marble may readily be distinguished, singly or in groups, lying between the carbonate granules now and then inclosed in them. They are colorless, about 0.25 mm. in diameter, polarize in brilliant colors, and have cleavage in one direction, with oblique extinction at a high angle. I reserve their determination for further study. The clouding of the marble is due to small scales and patches of graphite. The more numerous and more closely aggregated the scales the darker the clouding. The grayish-black marble contains the scales *very* thickly disseminated, and even the purest white variety is not entirely free from them. They mar the purity of the color by their appearance here and there in isolated scales or groups of scales.

The specific gravity is 2.75; the weight of one cubic foot is 172.06 pounds. The absorption of water amounts to 0.021 per cent of the weight of the stone and of water to 0.13 per cent. The loss in the carbonic acid solution, after seven weeks' exposure, amounted to 0.97 per cent. No change was observed at first when heated in the muffle, except, perhaps, an increased whiteness. At a full red heat it becomes mottled dull-white on a polished surface, loses its strength and coherence on the edges, and develops minute cracks all over the surface that do not penetrate far inward. Its general strength is fairly well preserved. Exposure, while still hot, to water, causes considerable disintegration on the edges.

The crushing strength was determined on a bed-cube, 1.422 in. × 1.414 in. × 1.434 in. (ht.), giving 17,783 pounds per square inch, and on an edge-cube 1.469 in. × 1.429 in. × 1.519 in. (ht.), giving 17,095 pounds per square inch.

Mr. O. T. Dyer, President of the Colton Marble and Lime Company, states that the company owns an inexhaustible supply of the marble in all shades and colors, and that the quarries are located at Colton, Los Angeles County, within one half mile of the junction of the Southern Pacific Railroad and the California Central Railroad. Both roads have built switches and side-tracks to the quarries. The stone can be quarried in large blocks without seams, suitable for large pillars, shafts, etc.

A further study of this stone will be made for next year's report.

A. WENDELL JACKSON,
Professor of Mineralogy, Petrography, and Economic Geology, University of California.

STATISTICS

OF

WELLS, FARGO & CO.

REPORT OF WELLS, FARGO & CO.

PRECIOUS METALS PRODUCT, UNITED STATES OF AMERICA AND MEXICO.

SAN FRANCISCO, December 31, 1887.

DEAR SIR: The following is a copy of our annual statement of precious metals produced in the States and Territories west of the Missouri River (including British Columbia, and receipts by express from the west coast States of Mexico) during 1887, which shows aggregate products as follows: Gold, $33,074,022; silver, $51,578,118; copper, $10,362,746; lead, $9,631,073. Total gross result, $104,645,959.

As stated repeatedly, the facilities afforded for the transportation of bullion, ores, and base metals, by the extension of railroads into mining districts, increase the difficulty of verifying the reports of the products from several important localities; especially is this the case in the reports from Colorado and Montana; and the general tendency is to exaggeration when the actual values are not obtainable from authentic sources; but the aggregate result as shown herein, we think may be relied on with reasonable confidence as approximately correct.

STATES AND TERRITORIES.	Gold Dust and Bullion by Express.	Gold Dust and Bullion by other Conveyances.	Silver Bullion by Express.	Ores and Base Bullion by Freight.	Total.
California	$10,760,052	$1,076,905	$972,707	$853,259	$13,662,923
Nevada	2,590,962		5,355,647	2,285,844	10,232,453
Oregon	650,000	300,000			950,000
Washington	130,000	30,000			160,000
Alaska	559,000	50,000			609,000
Idaho	1,940,000	200,000	2,800,000	3,300,000	8,240,000
Montana	4,400,000	200,000	10,783,275	10,100,000	25,483,275
Utah	13,910		2,049,090	5,574,730	7,637,730
Colorado	4,900,000		6,480,000	11,913,000	23,293,000
New Mexico	147,800	50,000	279,434	3,752,000	4,229,234
Arizona	680,545	200,000	1,073,985	3,817,020	5,771,550
Dakota	2,385,320	200,000	473,285		3,058,605
Mexico (West Coast States)	17,801		744,234		762,035
British Columbia	556,154				556,154
Totals	$29,731,544	$2,306,905	$31,011,657	$41,595,853	$104,645,959

The gross yield for 1887, shown above, segregated, is approximately as follows:

Gold	$31\frac{61}{100}$	$33,074,022
Silver	$49\frac{28}{100}$	51,578,118
Copper	$9\frac{90}{100}$	10,362,746
Lead	$9\frac{20}{100}$	9,631,073
Total		$104,645,959

ANNUAL PRODUCTS OF LEAD, COPPER, SILVER, AND GOLD IN THE STATES AND TERRITORIES WEST OF THE MISSOURI RIVER, 1870–1887.

YEAR.	Production, as per W. F. & Co.'s statements, including Amounts from British Columbia and West Coast of Mexico.	Product after deducting Amounts from British Columbia and West Coast of Mexico.	The Net Products of the States and Territories West of the Missouri River, exclusive of British Columbia and West Coast of Mexico, divided, is as follows:			
			Lead.	Copper.	Silver.	Gold.
1870..	$54,000,000	$52,150,000	$1,080,000	....	$17,320,000	$33,750,000
1871..	58,284,000	55,784,000	2,100,000	....	19,286,000	34,398,000
1872..	62,236,959	60,351,824	2,250,000	....	19,924,429	38,177,395
1873..	72,258,693	70,139,860	3,450,000	....	27,483,302	39,206,558
1874..	74,401,045	71,965,610	3,800,000	....	29,699,122	38,466,488
1875..	80,889,057	76,703,433	5,100,000	....	31,635,239	39,968,194
1876..	90,875,173	87,219,859	5,040,000	....	39,292,924	42,886,935
1877..	98,421,754	95,811,582	5,085,250	....	45,846,109	44,880,223
1878..	81,154,622	78,276,167	3,452,000	....	37,248,137	37,576,030
1879..	75,349,501	72,688,888	4,185,769	....	37,032,857	31,470,262
1880..	80,167,936	77,232,512	5,742,390	$898,000	38,033,055	32,559,067
1881..	84,504,417	81,198,474	6,361,902	1,195,000	42,987,613	30,653,959
1882..	92,411,835	89,207,549	8,008,155	4,055,037	48,133,039	29,011,318
1883..	90,313,612	84,639,212	8,163,550	5,683,921	42,975,101	27,816,640
1884..	84,975,954	81,633,835	6,834,091	6,086,252	43,529,925	25,183,567
1885..	90,181,260	87,311,382	8,562,991	7,838,036	44,516,599	26,393,756
1886..	103,011,761	100,160,222	9,185,192	9,276,755	52,136,851	29,561,424
1887..	104,645,959	103,327,770	9,631,073	10,362,746	50,833,884	32,500,067

The exports of silver during the past year to Japan, China, the Straits, etc., have been as follows: From London, $23,861,805; from Marseilles, $4,699,906; from Venice, $———; from San Francisco, $14,444,907. Total, $43,006,618, as against $44,034,590 last year. (Pounds sterling estimated at $4 84.)

UNITED STATES OF MEXICO.

STATEMENT OF THE PRODUCT OF GOLD AND SILVER IN THE REPUBLIC OF MEXICO, REVISED AND CORRECTED, FROM 1877 TO 1887.

YEARS.	Gold.	Silver.	Total.
1877–1878	$747,000	$24,837,000	$25,584,000
1878–1879	881,000	25,125,000	26,006,000
1879–1880	942,000	26,800,000	27,742,000
1880–1881	1,013,000	29,234,000	30,247,000
1881–1882	937,000	29,329,000	30,266,000
1882–1883	956,000	29,569,000	30,525,000
1883–1884	1,055,000	31,695,000	32,750,000
1884–1885	914,000	33,226,000	34,140,000
1885–1886	1,026,000	34,112,000	35,138,000
1886–1887	1,047,000	34,600,000	35,647,000
Totals	$9,518,000	$298,527,000	$308,045,000

EXHIBIT OF COINAGE OF GOLD, SILVER, AND COPPER, IN THE REPUBLIC OF MEXICO, FROM THE FIRST OF JULY, 1873, TO THE THIRTIETH OF JUNE, 1887.

YEARS.	Gold.	Silver.	Copper.
1873–1874	$866,743	$18,846,067	$15,966
1874–1875	862,619	19,386,958	21,712
1875–1876	809,401	19,454,054	30,654
1876–1877	695,750	21,415,128	9,035
1877–1878	691,998	22,084,203	41,364
1878–1879	658,206	22,162,987	16,300
1879–1880	521,826	24,018,528	14,035
1880–1881	492,068	24,617,395	42,258
1881–1882	452,590	25,146,260	11,972
1882–1883	407,600	24,083,921	----------
1883–1884	328,698	25,377,379	----------
1884–1885	423,250	25,840,728	----------
1885–1886	425,000	25,850,000	----------
1886–1887	410,000	25,600,000	----------
Totals	$8,045,749	$323,883,608	$203,296

SUMMARY—TOTALS.

Gold	$8,045,749
Silver	323,883,608
Copper	203,296
Grand total	$332,132,653

EXHIBIT OF THE COINAGE OF MEXICO FROM THE ESTABLISHMENT OF THE MINTS IN 1537 TO THE END OF THE FISCAL YEAR OF 1887.

DATES OF COINAGE.	Gold.	Silver.	Copper.	Total.
Colonial Epoch.				
Unmilled coin from 1537 to 1731	$8,497,950	$752,067,456	$200,000	$760,765,406
Pillar coin, 1732 to 1771	19,889,014	441,629,211	----------	461,518,225
Bust coin, 1772 to 1821	40,391,447	888,563,989	342,893	929,298 329
Totals	$68,778,411	$2,082,260,656	$542,893	$2,151,581,960
Independence.				
Iturbide's imp'l bust, 1822 to 1823	$557,392	$18,575,569	----------	$19,132,961
Republic eagle, 1824 to June 30, 1873	45,040,628	740,246,485	$5,235,177	790,522,290
Totals	$45,598,020	$758,822,054	$5,235,177	$809,655,251
Republic.				
Eagle coin, from July 1, 1873, to June 30, 1887	$8,045,749	$323,883,608	$203,296	$332,132,653

SUMMARY.

Colonial Epoch, from 1537 to 1821	$2,151,581,960
Independence, from 1822 to 1873	809,655,251
Republic, from 1873 to 1887	332,132,653
Total	$3,293,369,864

The exhibits of production and mintage indicate a steady development of the mining interests of the United States of America, and also of Mexico, and with the increasing facilities of railway communication fostering every department of industry, the outlook for a continued growth in the product of precious metals is flattering.

JOHN J. VALENTINE,
Vice-President and General Manager Wells, Fargo & Co.

CATALOGUE

OF

CALIFORNIAN FOSSILS.

CATALOGUE OF CALIFORNIAN FOSSILS.

Compiled by J. G. Cooper, M.D.

The latest published catalogue of fossils (including many from other portions of the Pacific Slope between Alaska and Mexico), was that given in Vol. II Palæontology of California, issued in 1869. Between that time and the final suspension of the State Geological Survey under Professor J. D. Whitney, in 1874, considerable additions to the collections were made by members of the survey, and important contributions presented by assistants in the United States Coast Survey under Professor Davidson, Dr. L. G. Yates, of Santa Barbara, and others, mentioned in Professor Whitney's works on the "Auriferous Gravels of the Sierra Nevada," the "Climatic Changes of Recent Geological Times," and Professor Lesquereux's descriptions of "Fossil Plants of California, Oregon," etc. We are also indebted to Rev. S. Bowers, of San Buenaventura, for additions to the known fossils of the Quaternary beds near Santa Barbara, and to Dr. L. G. Yates for later additions to the list of localities of Mesozoic and Tertiary fossils. The United States Geological Surveys have also added very much to our previous knowledge of their distribution, especially in relation to the fresh-water quaternary deposits of the Great Basin east of the Sierra Nevada, which extend over much of the northeastern and southeastern counties of California, with a few additions to the marine fossils from more western counties, described by Dr. C. A. White. The publications relating to the geology of the other western States and Territories, as well as those of the Canadian surveys, have extended our knowledge of the distribution of Californian fossils, showing more clearly their relations to geological changes in the earth's surface, together with those in climate and productions. The connection between fossils and mineral products is another important reason for recording the localities in which similar deposits are proved by their fossils to exist, and therefore great care has been taken to include all such facts.

Much assistance has been rendered in preparing and revising this catalogue by Professor Whitney, now of Harvard University, Professor Leidy and Professor Cope, of Philadelphia, Professor St. John, of Kansas, Professor Dall, of Washington, D. C., and other specialists.

A number of species have also been added to the lists of the latter formations about San Diego, from the collections of Mr. H. Hemphill, as determined by Professor W. H. Dall, of the United States National Museum. The following table shows the advance made in our knowledge of the fossils since 1869.

Localities along the coast are usually in counties of the same names, and well known. Those inland, and all little known, have the county name added. Numerous new localities and many additional species have been added to those given in the reports of the Geological Survey of California, 1860 to 1874. Much is also added from the Canadian and United States Geological Surveys up to the present date. It must be remarked that the exact geological position of many fossils in the Tertiary and Cretaceous strata is still unsettled, there not being such distinct divisions between them in California as in some countries. The mollusca, etc., found in the strata called Upper Cretaceous (Div. B) by the former survey, are now generally admitted to represent the Eocene Tertiary, but its exact limits have not been determined.

A few changes have been made in names before published, to correspond with recent advances in science.

The divisions of the fresh water deposits of the auriferous gravels and coast ranges are also unsettled.

L.—Living, the present geographical range being given.

T.—Terrestrial (land shells).

F.—Fresh-water shells (all others marine).

Eoc.—Eocene.

Mioc.—Miocene tertiary.

Pl.—Pliocene.

Quat.—Quaternary (post-pliocene).

(*Not ident.*)—Not identified among the fossils found by the State Geological Survey under Whitney, but where much resembling a described species its name is given.

TERTIARY AND QUATERNARY MAMMALIA.

The human remains found in the Sierra Nevada are apparently as old as those of some of the extinct animals here mentioned, with which they are imbedded, thus carrying back their age to the beginning of the Quaternary Epoch. Professor Whitney thinks they even belong to the Pliocene, and as that is a still unsettled question, the reader is referred to his "Auriferous Gravels," and other works, for information.

It is suggested that these fossils, being only fragments, have been washed down during the Quaternary Epoch, from older tertiary strata into the more recent, and thus represent only that and later deposits. (See list of fossil plants.)

Aphelops hesperius Leidy.

(*Related to the Rhinoceros.*)

Mioc.—Douglas Flat and Chili Gulch, Calaveras County. Bones found beneath the lava only. Also believed to be found in Eastern Oregon, together with remains of two other species of rhinoceros, distinct from any now living.

Arctotherium simum Cope.

Extinct Bear.

Quat.—Found in a cave in limestone of Shasta County by describer. Teeth differ from those of living bears, but other similar species have been found in South America fossil; size of the grizzly bear.

Bison latifrons Harlan.

The extinct American Buffalo.

Pl.?—Kincaid Flat, Tuolumne County, above the lava.

Quat.—Near Millerton, Fresno County; Pilarcitos Valley, San Mateo County; near Centerville, Alameda County; Texas, and Mississippi Valley.

Canis indianensis Leidy.

An extinct Wolf.

Pl.—Livermore Valley, Alameda County. (Living? C. occidentalis var.?) Larger than the living form.

Canis latrans Say.

The Coyote or Prairie Wolf.

Living.—Western United States and Mexico.
Pl.—Auriferous gravels, Sierra Nevada (Murphy's? Calaveras County).

Delphinus occiduus Leidy.

Like a living kind of Porpoise.

Mioc.—Half-moon Bay, San Mateo County.

Desmostylus hesperus Marsh.

Related to the Dugong and Manatee.

Pl.—South of Livermore, Alameda County; Salinas Valley, Monterey County, near lat. 36°.

Elephas americanus DeKay.

(*American Elephant*) *E. Columbi* Falconer.

Pl.?—Auriferous gravels, Sierra Nevada, above the lava.
Quat.—Later strata, Sierra Nevada; whole skeleton twenty miles northwest of Millerton, Fresno County; bones, Coast Range, in later strata; Santa Rosa Island, Santa Barbara County; remains also found in most parts of North America, south of lat. 50°.
E. primigenius in Alaska and on eastern continent.

Elotherium imperator Leidy.

(*Related to the Hog.*)

Mioc.?—Douglas Flat, Calaveras County, under the lava.

Equus excelsus Leidy.

Quat.?—Near Buena Vista Lake, Kern County; Columbia, Tuolumne County; Nebraska. Size of the living horse, but enamel of teeth simpler in upper jaw, like those of the ass.

Equus occidentalis Leidy.

Pl.—Murphy's, Calaveras County, above the lava; Martinez, Contra Costa County; Solano County, foothills; near Centerville, Alameda County; Texas. Larger than any living horses.

Eschrichtius davidsoni Cope.

Fossil Finback Whale.

Pl.?—Same size as the "California Gray Whale." Bones sent from near Santa Barbara by Professor G. Davidson, United States Coast Survey.

Felis imperialis Leidy.

A large species of Lion.

Pl.?—Livermore Valley, Alameda County.

Holomeniscus californicus Leidy.

A Llama, a third larger than the living Camels.

Pl.—Foothills, Merced County.

Holomeniscus hesternus Leidy.

A Llama, smaller than H. californicus.

Pl.—Foothills, Alameda County.

Mastodon americanus Cuvier.

American Mastodon.

Mioc.?—Auriferous gravels, lower beds; some under the lava. From three thousand feet elevation downward, Sierra Nevada. Especially Gold Spring, Tuolumne County, and Horseshoe Bend, Merced County.

Pl.—Above the lava beds, Coast Ranges.

Quat.—Bottle Hill, Mare Island, Solano County. Also, eastward throughout the United States, from near surface to over one hundred feet depth.

Mastodon shephardi. Leidy.

Western Mastodon.

Pl.?—Dry Creek, Stanislaus County; Kincaid Flat, Tuolumne County; Oak Spring, Contra Costa County; New Mexico (and southeast coast from Maryland to Georgia? perhaps *M. obscurus* only).

Megalomeryx niobrarensis Leidy.

Pl.?—A large animal of the camel family, first found in Nebraska, but only teeth are yet known. Found beneath the lava, Tuolumne County. Also, in the pliocene of Nebraska.

Protohippus insignis Leidy.

Pl.?—Soulsbyville and Table Mountain, Tuolumne County, beneath the lava, two hundred and ten feet deep. Size of the ass, with grinders like those of the ox, etc.

Found in the pliocene of Texas and Nebraska. Southern California, sixty feet deep (may be another species).

Mylodon? sodalis Cope.

An extinct Sloth.

Quat.—From auriferous gravel of the Klamath River at Yreka, California.

Tapirus americanus? Linnæus.

South American Tapir.

Quat.—Auriferous gravels, Sierra Nevada, above the lava, near Sonora, Tuolumne County; Eastern States. Like a living species found in tropical America, but may be distinct.

TERTIARY FISHES.

Carcharodon rectus Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

Echinorhinus blakei Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

Galeocerdo productus Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

Hemipristis heteropleurus Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

Lamna elevata Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

Lamna ornata Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

Oxyrhina plana Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

Oxyrhina tumula Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

Prionodon antiquus Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

Scymnus occidentalis Agassiz.

Pl.—Ocoya, or Posa Creek, Kern County.

The above all represent species of sharks, described from the teeth (the only parts preserved as fossils), and similar remains are found in many other localities, especially near the coast.

TERTIARY CRUSTACEA.

Cancer brewerii Gabb.

Pl. or *Mioc.*—Calleguas Ranch, Ventura County.

TERTIARY AND QUATERNARY MOLLUSCA.

Acila castrensis Hinds.

(*A. lyalli* Baird.)

L.—Sitka to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—San Fernando, Los Angeles County; San Diego well.
Mioc.—Oregon; Martinez, Contra Costa County; Griswold's, San Benito County.

Acmæa insessa Hinds.

L.—Baulines Bay to San Diego.
Quat.—San Diego.

Acmæa mitra Escholtz.

L.—Sitka to San Diego.
Quat.—Santa Barbara to San Diego.

Acmæa pelta Escholtz.

L.—Sitka to San Diego.
Quat.—Santa Barbara.

Acmæa persona Escholtz.

L.—Sitka to San Diego; Mazatlan.
Quat.—Santa Barbara to San Nicolas Island.

Acmæa rudis Gabb.

Pl.—San Fernando, Los Angeles County.

Acmæa scabra Nuttall.

L.—Baulines Bay to San Diego; Mazatlan.
Quat.—Santa Barbara.

Acmæa spectrum Nuttall.

L.—Cape Mendocino to San Diego.
Quat.—Santa Barbara; San Pedro.

Acmæa testudinalis Müller.

(*A. patina* Esch.)

L.—Circumpolar to San Diego.
Quat.—Santa Barbara.

Agasoma gravida Gabb.

Mioc.—Martinez, Contra Costa County; Ocoya (Posa) Creek, Kern County.

Agasoma sinuata Gabb.

Mioc.—Walnut Creek, Contra Costa County.

Amphissa corrugata Reeve.

(*A. versicolor* Dall.)

L.—Alaska to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Amnicola longinqua Gould.

L., *F.*—Lake Point, Utah.
Quat.—Lahontan basin (Lassen County), and Nevada; Colorado Desert, San Diego County.

Amusium caurinum Gould.

L.—Straits of Fuca to Santa Barbara; Japan.
Quat.—Santa Barbara; San Pedro.
Pl.—Eagle Prairie, Humboldt County; San Fernando, Los Angeles County.
(*Mioc.*—See *Pecten propatulus.*)

Amycla gausapata Gould.

L.—Alaska to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—Kirker's Pass, Contra Costa County.

Amycla tuberosa Carpenter.

L.—Neah Bay to San Diego.
Quat.—Santa Barbara to San Pedro.
Pl.—San Diego well.

Amycla undata Cpr.

L.—Catalina Island.
Quat.—Santa Barbara.

Ancillaria fishii Gabb.

Mioc.—Martinez; Griswold's; San Benito County.

Ancylus newberryi Lea.

L., *F.*—Klamath Lake, Oregon, and northern rivers of California.
Quat.—Lahontan Basin, Lassen County, and Nevada.

Anodonta nuttalliana Lea.

L., *F.*—British Columbia to Arizona.
Quat.—Lake basins east of Sierra Nevada; Colorado Desert, San Diego County. (Includes varieties *californiensis* Lea, *oregonensis* Lea, and *wahlamatensis* Lea.)

Anomia lampe Gray.

L.—"Monterey 60 fms." San Pedro to Mexico.
Quat.—San Pedro.

Anomia limatula Dall.

Quat.—San Pedro.

Anomia subcostata Conrad.

Pl.—West of Colorado Desert, San Diego County.

Arca congesta Conrad. (Not ident.)

"*Mioc.*—Santa Barbara." (Probably variety of *A. microdonta.*)

Arca microdonta Conrad.

Pl.—Santa Rosa, Sonoma County; San Francisco, seven miles beach; Twelve-Mile House, San Mateo County; Half-moon Bay, San Mateo County; Sargents, Santa Clara County; San Diego well.
Mioc.—Martinez, Contra Costa County; Griswold's, San Benito County; Soquel, Santa Cruz County; El Toro Ranch, Monterey County; Foxins, Santa Barbara County; Santa Barbara.

Arca obispoana Conrad. (Not ident.)

"*Mioc.*—San Luis Obispo County." (Probably var. of *A. microdonta.*)

Arca sulcicosta Gabb.

Pl.—Mark West Creek, Sonoma County.

Arcopagia unda Conrad. (Not ident.)

Mioc.—Estrella, San Luis Obispo County; Santa Barbara.
Pl.—San Benito County. (Like *Lutricola alta* Conrad. Living.)

Axinæa intermedia Broderip.

L.—Monterey to San Diego; South America.
Quat.—San Pedro.

Axinæa patula Conrad.

Mioc.—Oregon; Martinez; San Pablo; Walnut Creek, Contra Costa County.
Pl.—Santa Rosa, Sonoma County.

Axinæa profunda Dall.

Quat.—San Diego.

Bittium armillatum Carpenter.

L.—Farallone Islands to San Diego.
Quat.—Santa Barbara.
Pl.—San Diego well.

Bittium asperum Gabb.

L.—Santa Barbara to Catalina Island.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Bittium filosum Gould.

L.—Sitka to Monterey.
Quat.—Santa Barbara.

Bittium quadrifilatum Carpenter.

L.—Monterey to San Diego.
Quat.—Santa Barbara.

Bulla adamsii Menke.

L.—San Pedro to Panama.
Quat.—San Pedro.
Pl.—San Fernando, Los Angeles County.

Bulla jugularis Conrad. (Not ident.)

"*Mioc.*—Ocoya Creek (Posa Creek), Kern County."

Bulla nebulosa Gould.

L.—Santa Barbara to Lower California; Gulf of California.
Quat.—San Diego.
Pl.—San Fernando, Los Angeles County; San Diego well.

Bythinella binneyi Tryon.

L., F.—Marin County to San Diego County, east to Alameda County.
Quat.—Walnut Creek, Contra Costa County. Nevada?

Cadulus fusiformis Phillippi.

L.—West coast of Mexico.
Pl.—San Diego well.

Calliostoma annulatum Martyn.

L.—Straits of Fuca to San Diego.
Quat.—San Pedro to San Diego.
Pl.—San Diego well.

Calliostoma canaliculatum Martyn.

L.—Straits of Fuca to San Diego.
Quat.—San Pedro to San Diego.

Calliostoma costatum Martyn.

L.—Sitka to San Diego.
Quat.—San Pedro to San Diego.
Pl.—San Fernando, Los Angeles County.

Calliostoma gemmulatum Carpenter.

L.—San Pedro to San Diego.
Quat.—San Pedro to San Diego.

Calliostoma tricolor Gabb.

L.—New Year Point to San Diego.
Quat.—San Pedro to San Diego.

Callista voyi Gabb.

Pl.—Eagle Prairie, Humboldt County; Kirker's Pass, Contra Costa County; Lobitos, San Mateo County; Sargents, Santa Clara County; Soquel, Santa Cruz County. (Probably same as *Venus pajaroensis* Conrad, a prior species.)

Callista newcombiana Gabb.

L.—Monterey to Catalina Island.
Quat.—San Diego.
Pl.—San Diego well.

Cancellaria altispira Gabb.

Pl.—San Fernando, Los Angeles County.

Cancellaria gracilior Carpenter.

Quat.—Santa Barbara.

Cancellaria tritonidea Gabb.

Quat.—Coyote Creek, Ventura County; San Pedro.

Cancellaria vetusta Gabb.

Mioc.—Martinez, Contra Costa County; Coyote Creek, Ventura County.

Capulus tumens Carpenter.

L.—Monterey to San Diego and Islands.
Quat.—San Pedro.

Cardium blandum Gould.

L.—Sitka to Monterey. Asia?
Quat.—San Pedro.
Pl.—Eagle Prairie, Humboldt County.
Mioc.—Walnut creek, Contra Costa County; El Toro Ranch, Monterey County.

Cardium centifilosum Carpenter.

L.—Monterey to Catalina Island.
Quat.—San Pedro.
Pl.—San Diego well.
Mioc.—Sunol, Alameda County.

Cardium corbis Martyn.

L.—Kodiak to Santa Barbara; Kamtschatka.
Quat.—San Francisco; Monterey; San Pedro.

Cardium graniferum Sowerby.

L.—West coast of Mexico to South America.
Quat.—Santa Barbara (also *Pl.?*).

Cardium meekianum Gabb.

Pl.—Eagle Prairie, Humboldt County; Santa Rosa, Sonoma County; Green Valley, Contra Costa County; Santa Cruz.

Cardium modestum Conrad. (Not ident.)

"*Mioc.*—San Diego Mission."
(Like *Hemicardium biangulatum*, Sowerby.
L.—Catalina Island; Mexico; Panama.)

Cardium panamense Sowerby.

L.—West tropical America.
Quat.—San Pedro; San Diego.

Cardium procerum Sowerby.

L.—West tropical America.
Pl.—San Diego well.

Cardium quadragenarium Conrad.

L.—Monterey to San Diego.
Quat.—San Diego.
Pl.—Calleguas Ranch, Ventura County.

Carinifex newberryi Lea.

L., *F.*—Klamath Lake, Oregon, to Clear Lake, Lake County, and Owens Lake, Inyo County; Utah.
Quat.—Lahontan Basin, Lassen County, and Nevada.
Pl.—Mission San José, Santa Clara County; Gelcichs coal mine, Santa Cruz County.

Caryatis barbarensis Gabb.

Pl.—Santa Barbara.

Cellepora californiensis Gabb & Horn.

L.? and Quat.—Santa Barbara.

Cemoria crucibuliformis Conrad. (Not ident.)

"*Quat.*—Santa Barbara." (Like *Puncturella cooperi* Carpenter.)

Cerithidea californica Haldemann.

L.—Baulines Bay to San Diego; Mazatlan.
Quat.—San Pedro to San Diego.
Pl.—San Fernando, Los Angeles County.
Mioc.—Santa Monica.

Cerithiopsis assimilata C. B. Adams.

L.—Monterey to Panama.
Quat.—San Diego.

Cerostoma nuttalli Conrad.

L.—Baulines Bay to San Diego.
Quat.—San Diego.

Chama exogyra Conrad.

L.—Bodega Bay to San Diego; Mexico.
Quat.—Santa Barbara to San Pedro.

Chemnitzia chocolata Carpenter.

L.—Monterey to San Diego.
Quat.—San Diego.

Chemnitzia papillosa Trask. (Not ident.)

"*Quat.*—Santa Barbara." (Like *Bittium asperum* Gabb.)

Chemnitzia stylina Carpenter.

L.—Monterey to Santa Barbara.
Quat.—San Diego.
Pl.—San Diego well.

Chemnitzia tenuicula Gould.

Quat.—Santa Barbara.

Chemnitzia torquata Gould.

L.—Straits of Fuca to San Diego.
Pl.—Wheeler's Cañon, Ventura County; San Diego well.

Chione fluctifraga Sowerby.

L.—San Pedro to San Diego; Gulf of California.
Quat.—Santa Barbara; San Diego.
(Is *Amiantis callosa* of Gabb's list, not of Conrad.)

Chione mathewsonii Gabb.

Mioc.—Martinez, Contra Costa County.

Chione pertenuis Gabb.

Mioc.—Martinez, Contra Costa County; Griswold's, San Benito County; Santa Inez, Santa Monica, Santa Barbara County.

Chione simillima Sowerby.

L.—Monterey to San Diego.
Quat.—Santa Barbara to San Diego.

Chione succincta Valenciennes.

L.—Santa Barbara to San Diego; Mexico; South America.
Quat.—Santa Barbara to San Diego.
Pl.—Seven-Mile Beach, San Mateo County; San Fernando, Los Angeles County.
Mioc.—Oregon; Martinez; San Pablo, Contra Costa County; Griswold's, San Benito County; Foxins, Santa Barbara County; Santa Monica, Los Angeles County.

Chione whitneyi Gabb.

Mioc.—Martinez, Contra Costa County; El Toro Ranch, Monterey County.

Chlorostoma aureotinctum Forbes.

L.—Monterey? Santa Barbara to Lower California.
Quat.—Santa Barbara.

Chlorostoma brunneum Philippi.

L.—Cape Mendocino to San Diego.
Quat.—Santa Barbara Island.

Chlorostoma funebrale A. Adams.

L.—Sitka to San Diego.
Quat.—Santa Barbara to San Diego.

Chlorostoma pfeifferi Philippi.

L.—Baulines Bay to San Diego.
Quat.—Santa Barbara to San Diego.

Chorus belcheri Hinds.

L.—Catalina Island to San Diego; Lower California.
Quat.—San Pedro.
Pl.—San Diego well.

Chrysodomus carinatus Dunker.

L.—Sitka, Alaska; Asia.
Pl.—Santa Barbara.

Chrysodomus diegoensis Dall.

Pl.—San Diego well.

Chrysodomus dirus Reeve.

L.—Sitka to Monterey.
Quat.—Santa Barbara.

Chrysodomus liratus Martyn.

L.—Kodiak to Straits of Fuca.
Quat.—Santa Barbara.

Chrysodomus tabulatus Baird.

L.—Straits of Fuca to Catalina Island.
Pl.—Eagle Prairie, Humboldt County; Twelve-Mile House, San Mateo County; San Fernando, Los Angeles County; Santa Barbara; San Pedro.

Clathurella conradiana Gabb.

Pl.—San Diego well.
Quat.—Santa Barbara.

Clementia subdiaphana Carpenter.

L.—Straits of Fuca to San Diego.
Quat.—San Pedro to San Diego.
Pl.—San Diego well.

Clidiophora punctata Conrad.

L.—Straits of Fuca to San Diego.
Pl.—San Benito County.
Mioc.—Ventura County.

Clypidella bimaculata Dall.

L.—Farallone Islands to Santa Barbara Island.
Quat.—Santa Barbara; San Pedro.

Clypidella callomarginata Carpenter.

L.—Lobitos to San Diego.
Quat.—San Pedro to San Diego.

Cochliopa rowellii Tryon.

L., *F.*—Panama?
Quat.—Walnut Creek, Contra Costa County.

Cœcum californicum Dall.

(*Cœcum cooperi* Carpenter, not of Smith.)

L.—San Diego Bay and Islands.
Quat.—San Diego.

Columbella richthofeni Gabb.

Pl.—Russian River, Sonoma County; Seven-Mile Beach, San Mateo County; San Fernando, Los Angeles County.

Colus dupetithouarsi Kiener.

L.—West Mexican Coast.
Quat.—Santa Barbara.
Pl.—Santa Barbara; San Diego well.

Conchocele disjuncta Gabb.

Quat.—Dead Man's Island, San Pedro Bay.

Conus californicus Hinds.

L.—Farallone Islands to San Diego; Lower California.
Quat.—Santa Barbara to San Diego.
Pl.—San Fernando, Los Angeles County.

Corbula diegoana Conrad. (Not ident.)

" *Quat.*—San Diego."

Corbula luteola Carpenter.

L.—San Pedro to San Diego.
Quat.—San Diego.

Crassatella collina Conrad.

Pl.?—Sargents?, Santa Clara County.
Mioc.—Santa Inez, Santa Barbara County; Ojai Valley, Ventura County.

Crepidula aculeata Gmelin.

L.—Monterey south; Asia; Atlantic Ocean.
Quat.—San Pedro to San Diego.
Pl.—San Fernando, Los Angeles County.

Crepidula adunca Sowerby.

L.—Straits of Fuca to Santa Barbara; Mexico.
Quat.—Santa Barbara; San Diego.

Crepidula dorsata Broderip.

(*C.—var. lingulata* Gould.)

L.—Straits of Fuca to Mazatlan; Peru, South America.
Quat.—Santa Barbara.
Pl.—San Fernando, Los Angeles County.

Crepidula excavata Broderip.

L.—Sitka to Santa Barbara; Mexico to Peru.
Quat.—Santa Barbara to San Pedro.

Crepidula grandis Middendorf.

Quat.—Santa Barbara; San Pedro.
Pl.—Russian River and Santa Rosa, Sonoma County; Seven-Mile Beach, San Mateo County; Kirker's Pass, Contra Costa County; Santa Cruz; Santa Barbara; San Fernando, Los Angeles County; San Diego well.
Mioc.—Oregon; Tomales, Marin County; Walnut Creek, Contra Costa County; Foxins and Santa Rosa Island, Santa Barbara County.

Crepidula navicelloides Nuttall.

L.—Alaska to San Diego.
Quat.—Santa Barbara.
Pl.—San Diego well.

Crepidula rugosa Nuttall.

L.—Santa Barbara to San Diego; Mexico to Peru?
Quat.—San Pedro to San Diego.

Crucibulum spinosum Sowerby.

L.—San Pedro, south, to Peru, South America.
Quat.—Santa Barbara.
Pl.—San Diego well.

Cryptochiton stelleri Middendorf.

L.—Straits of Fuca to Monterey; Kamtschatka.
Quat.—San Diego.

Cryptodon flexuosus Montagu.

L.—Catalina Island, seven hundred and twenty feet depth; England; Asia?
Quat.—Santa Barbara.
Pl.—Santa Barbara; San Diego well.

Cryptomya californica Conrad.

L.—Straits of Fuca to San Diego.
Quat.—San Diego well.
Pl.—Santa Rosa, Sonoma County; Twelve-Mile House, San Mateo County; Soquel, Santa Cruz County; San Fernando, Los Angeles County; San Diego well.
Mioc.—Siebeck's, Santa Clara County; Griswold's, San Benito County; Foxins, Santa Barbara County.

Cuma biplicata Gabb.

Mioc.—Martinez, Contra Costa County.

Cumingia californica Conrad.

L.—Monterey to San Diego; Mazatlan.
Quat.—Santa Barbara; San Diego.

Cylichna cylindracea Linnæus.

(*C. alba?* Brown.)

L.—Monterey to San Diego; Europe.
Quat.—Santa Barbara; San Diego.
Pl.—San Diego well.

Cyrena californica Gabb.

Pl.—Kirker's Pass, and Green Valley, Contra Costa County; Soquel, Santa Cruz County. (Prime's living species of same name (prior) from Gulf of California seems distinct.)

Daphnella clathrata Gabb.

L.—Catalina Island, three hundred and sixty feet depth.
Pl.—San Diego well.

Dentalium hexagonum Sowerby.

L.—Santa Barbara to Mexico; East Indies; China.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Dentalium indianorum Carpenter.

L.—Straits of Fuca to Santa Barbara.
Quat.—Santa Barbara.

Dentalium semipolitum Broderip and Sowerby.

L.—San Diego to Gulf of California.
Pl.—San Diego well.

Diala acuta Carpenter.

L.—Monterey to Catalina Island.
Quat.—Santa Barbara.

Diplodonta orbella Gould.

L.—Straits of Fuca to San Diego.
Quat.—San Pedro to San Diego.
Pl.—San Diego well.

Donax californicus Conrad.

L.—Monterey?; San Luis Obispo to San Diego.
Quat.—San Pedro to San Diego.

Donax flexuosus Gould.

L.—Santa Barbara to San Pedro.
Pl.—San Diego well.

Dosinia conradi Gabb.

Mioc.—Monterey; San Emidio Cañon, Kern County.

Dosinia longula Conrad. (Not ident.)

"*Mioc.*—Salinas Valley, Monterey County."

Dosinia mathewsonii Gabb.

Mioc.—Martinez, Contra Costa County; Suñol, Alameda County; Griswold's, San Benito County; El Toro Ranch, Monterey County.

Dosinia montana Conrad. (Not ident.)

"*Mioc.*—Salinas Valley, Monterey County."

Dosinia ponderosa Gray.

L.—West Mexico to Panama.
Quat.—Santa Barbara to San Diego.
Pl.—Kirker's Pass, Contra Costa County; San Fernando, Los Angeles County.

Dosinia subobliqua Conrad. (Not ident.)

"*Mioc.*—Salinas Valley, Monterey County."

Drillia hemphilli Stearns.

L.—Lower California.
Quat.—San Diego.

Drillia incisa Carpenter.

L.—Straits of Fuca, Washington Territory, to Santa Cruz, California.
Quat.—Santa Barbara to San Pedro.

Drillia inermis Hinds.

L.—Santa Barbara to San Diego, Lower California.
Quat.—Santa Barbara.

Drillia mœsta Carpenter.

L.—Santa Barbara to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Drillia penicillata Carpenter.

L.—San Pedro, south; Cerros Island, Lower California.
Quat.—Santa Barbara to San Diego.

Drillia torosa Carpenter.

L.—Santa Cruz to Santa Barbara.
Quat.—Santa Barbara.

Drillia voyi Gabb.

Pl.—Eagle Prairie, Bear River, Humboldt County.

Entalophora punctulata Gabb & Horn.

L.? and Quat.—Santa Barbara.

Erato columbella Menke.

L.—Monterey to San Diego; Mazatlan.
Quat.—Santa Barbara.

Eulima micans Carpenter.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara to San Diego.

Eulima rutila Carpenter.

L.—Monterey to San Diego.
Quat.—San Diego.
Pl.—San Diego well.

Ficula nodifera Gabb.

Mioc.—Griswold's, San Benito County.

Ficula ocoyana Conrad. (Not ident.)

"*Mioc.*—Ocoya Creek (Posa Creek), Kern County."

Ficula pyriformis Gabb.

Mioc.—Martinez, Contra Costa County.

Fissurella volcano Reeve.

L.—Santa Cruz to San Diego.
Quat.—Santa Barbara to San Diego.

Fluminicola fusca Haldemann.

L. F.—Oregon to Idaho; Northern California to Utah.
Quat.—Lahontan basin (Lassen County), and Nevada.

Fusus arctatus Conrad. (Not ident.)

Mioc.—Ocoya creek (Posa creek), Kern County.

Fusus barbarensis Trask. (Not ident.)

Quat.—Santa Barbara.

Fusus harfordi Stearns.

L.—Cape Mendocino.
Quat.—San Diego.

Fusus kobelti Dall.

L.—Santa Barbara to San Diego.
Quat.—Santa Barbara to San Pedro.
Pl.—San Diego well.

Fusus robustus Trask.

(*F. kobelti?* Dall.)
Quat.—Santa Barbara.

Fusus rugosus Trask. (Not ident.)

Quat.—Santa Barbara.

Galerus contortus Carpenter.

L.—Santa Barbara to San Diego.
Quat.—Santa Barbara to San Diego.

Galerus costellatus Conrad. (Trochita.)

Mioc.—Santa Inez Mountains, Santa Barbara County; Santa Monica, Los Angeles County.

Galerus diegoanus Conrad. (Trochita.)

Mioc.—San Diego.

Galerus inornatus Gabb.

Mioc.—Halfmoon Bay, San Mateo County.

Galerus fastigiatus Gould.

L.—Puget Sound to Monterey; Vancouver Island.
Pl.—San Diego well.

Galerus filosus Gabb.

Pl.—Twelve-Mile Creek, San Mateo County; Kirker's Pass, Contra Costa County; San Diego well.
Mioc.—Walnut Creek, Contra Costa County; Suñol, Alameda County; Griswold's, San Benito County.

Gari alata Gabb.

Pl.—Kirker's Pass, Contra Costa County.

Glycimeris generosa Gould.

L.—Puget Sound to San Pedro; Kamschatka.
Quat.—Santa Barbara to San Pedro.
Pl.—Santa Barbara; San Fernando, Los Angeles County.
Mioc.—Oregon; Martinez, Walnut Creek, Contra Costa County; Estrella, San Luis Obispo County; Foxin's, Santa Barbara County.

Glyphis aspera Escholtz.

L.—Sitka to San Diego.
Quat.—Santa Barbara to San Pedro.

Glyptostoma-yana Binney.

L., *T.*—Temecula, San Diego County, to Lower California.
Quat.—San Pedro.

Gnathodon mendicus Gould.

L.—Colorado estuary to Mazatlan, Mexico.
Quat.—Colorado desert.

Gonostoma (Ammonitella) yatesii J. G. Cooper.

L., *T.*—Cave City, Calaveras County.
Mioc.—John Day Valley, Oregon.

Gyraulus parvus Say.

L., *F.*—Montana to Nevada; Eastern States.
Quat.—Lahontan Basin (Lassen County), and Nevada.

Gyraulus vermicularis Gould.

L., *F.*—Walla Walla, Washington Territory, to Santa Cruz and Merced County.
Quat.—Walnut Creek, Contra Costa County; Nevada?; Oregon?
Pl.—Gelcich's coal mine, Santa Cruz County.

Haliotis cracherodii Leach.

L.—Farallone Islands to San Diego; Lower California.
Quat.—San Pedro.

Haliotis rufescens Swainson.

L.—Farallone Islands to San Nicolas Island. Galapagos?
Quat.—San Pedro to San Nicolas Island.

Helisoma ammon Gould.

L., *F.*—Klamath Lake, Oregon, to Clear Lake, Lake County, and Colorado River; Honey Lake, Lassen County; Nevada. Semi-fossil in Lahontan Basin.
Quat.—Colorado Desert.

Helisoma trivolvis Say.

L., *F.*—Eastern States; Cuba; across northern United States, north of latitude 40°, only.
Quat.—Lahontan Basin, Lassen County, and east to Bonneville Basin, Utah.

Helix (californiensis) bridgesii Newcomb.

L., *T.*—Contra Costa County to Santa Clara County.
Quat.—Walnut Creek, Contra Costa County.

Helix (californiensis) ramentosa Gould.

L., *T.*—Napa County to Santa Clara County.
Quat.—Sargent's, Santa Clara County; Walnut Creek, Contra Costa County. (Some intermediate.)

Helix exarata Pfeiffer.

L., *T.*—Santa Cruz County to Santa Clara County.
Quat.—Alameda County to Santa Clara County.

Helix (rufocincta?) facta Newcomb.

L., T.—Barbara and Nicolas Islands, California.
Quat.—Barbara Island (larger than living).

Helix fidelis Gray.

L., T.—Vancouver Island to Humboldt Bay, California.
Mioc.—John Day Valley, Oregon.

Helix (rufocincta) gabbi Newcomb.

L., T.—Catalina Island to Clemente Island.
Quat.—Catalina Island (intermediate).

Helix mormonum Pfeiffer.

L., T.—Shasta County to Tulare County.
Quat.—Mariposa and Fresno Counties.
Pl.—Calaveras County.

Helix (mormonum) hillebrandi Newcomb.

L. T.—Tuolumne and Mariposa Counties, California.
Quat.—Near Mariposa (some intermediate).

Helix traskii Newcomb.

(*H. carpenteri*, Newcomb, and *H. remondi*, Tryon.)
L., T.—Mariposa County to Guadalupe Island, Lower California.
Quat.—Santa Paula, Ventura County.

Helix tryoni Newcomb.

L., T.—Barbara and Nicolas Islands, California.
Quat.—Barbara and Nicolas Islands, California (sometimes angled).

Helix tudiculata Binney.

L., T.—Shasta to San Diego.
Quat.—San Pedro.

Hemimactra lenticularis Gabb.

Mioc.—Martinez, Contra Costa County; Griswold's, San Benito County.

Hemimactra occidentalis Gabb.

Mioc.—Martinez, Contra Costa County.

Hinnites giganteus Gray.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—Santa Rosa Island, Santa Barbara County; Ventura County; Los Angeles County.
Mioc.—Siebeck's, Santa Clara County.

Hipponyx antiquatus Linnæus.

L.—Bodega and south; South America; Atlantic.
Quat.—San Pedro.

Hipponyx cranioides Carpenter.

L.—Straits of Fuca to Santa Barbara.
Quat.—Santa Barbara.

Idmonea californica Conrad.

L.? *Quat.*—Santa Barbara.

Ischnochiton magdalensis Hinds.

L.—Monterey to San Diego; Lower California.
Quat.—Santa Barbara.

Janira bella Conrad.

Pl.—Santa Barbara.

Janira dentata Sowerby.

L.—West tropical America.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Janira florida Hinds.

L.—Monterey to Lower California.
Pl.—San Diego well.

Lacuna solidula Loven.

L.—Alaska to San Diego; Norway; circumpolar?
Quat.—Santa Barbara to San Diego.

Lacuna vincta Montagu.

L.—Straits of Fuca; Washington Territory; North Atlantic; circum polar?
Quat.—San Diego.

Laqueus californicus Koch.

L.—Catalina Island; Kamtschatka.
Quat.—Santa Barbara to San Diego.

Lasea rubra Montagu.

L.—Straits of Fuca to San Pedro; circumpolar.
Quat.—Santa Barbara.

Lazaria subquadrata Carpenter.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara.

Leda cælata Hinds.

L.—Bodega Bay to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—San Fernando, Los Angeles County; San Diego well.
Mioc.—Walnut Creek, Contra Costa County; Griswold's, San Benito County; San Juan Capistrano, San Diego County.

Leda cuneata Sowerby.

L.—Monterey to San Diego; Peru.
Quat.—Santa Barbara.

Leptothyra bacula Carpenter.

L.—Monterey to Catalina Island.
Quat.—Santa Barbara to San Pedro.

Leptothyra paucicostata Dall.

L.—Santa Cruz to Monterey.
Quat.—Santa Barbara.

Leptothyra sanguinea Carpenter.

L.—Straits of Fuca to San Diego; Japan; Europe?
Quat.—Santa Barbara.

Lichenopora californica Conrad.

L.? Quat.—Santa Barbara.

Lima dehiscens Conrad.

(*L.* orientalis *Adams?* China.)
L.—Monterey to San Diego.
Pl.—Santa Barbara.

Limnophysa bulimoides Lea.

L., *F.*—Washington Territory to San Diego, California; Idaho to Nevada.
Quat.—Lahontan Basin, Lassen County, to Nevada; Oregon.

Limnophysa desidiosa Say.

L., *F.*—Northern United States.
Quat.—Walnut Creek, Contra Costa County.

Limnophysa humilis Say.

(*L. ferruginea* Haldemann.)

L., *F.*—Eastern States to California.
Quat.—Walnut Creek, Contra Costa County; Lahontan Basin (Lassen County) to Nevada.

Limnophysa palustris.

(*L. proxima* Lea.)

L., *F.*—Oregon to Alameda County, California.
Quat.—Walnut Creek, Contra Costa County; Lahontan Basin (Lassen County) to Utah (var. *sumassi*, etc.).

Lingula albida Hinds.

L.—Santa Barbara to San Diego; Lower California.
Pl.—San Diego well.

Liocardium elatum Sowerby.

L.—San Pedro to San Diego; Mazatlan.
Quat.—San Pedro.

Liocardium substriatum Conrad.

L.—Monterey to San Diego; South America.
Quat.—Santa Barbara; San Pedro; San Diego.

Liropecten crassicardo Conrad.

Pl.—Kirker's Pass, Contra Costa County; Santa Barbara; Ojai Valley, Ventura County.
Mioc.—Estrella, San Luis Obispo County.

Liropecten estrellanus Conrad.

Mioc.—Estrella, San Luis Obispo County; Santa Rosa Island.

Liropecten veatchii Gabb.

Quat.—Cerros Island, Lower California.
Pl.—Ojai Valley, Ventura County.

Liropecten volæformis Conrad.

L.—West Coast of Mexico. (*L. subnodosus?*)
Pl.—Mountains of San Benito County.
Mioc.—Alameda County; Santa Clara County; Estrella, San Luis Obispo County.

Litorina planaxis Nuttall.

L.—Sitka; San Diego.
Quat.—San Nicolas Island; San Diego.

Litorina remondii Gabb.

Pl.—Kirker's Pass, Contra Costa County.

Litorina scutulata Gould.

(*L. plena* Gould.)

L.—Monterey to San Diego.
Quat.—San Pedro to San Diego.

Lucina borealis Linnæus.

(*L. acutilineata* Conrad.)

L.—Catalina Island, North Atlantic; Asia.
Quat.—Santa Barbara to San Diego.
Pl.—Santa Rosa, Sonoma County; Santa Cruz; Sargent's, Santa Clara County; Santa Barbara; San Fernando; Los Angeles County; San Diego well.
Mioc.—Oregon; Martinez, Contra Costa County; Griswold's, San Benito County; Orestimba Cañon, Stanislaus County; Foxin's; Santa Barbara County.

Lucina californica Conrad.

L.—Santa Cruz to San Diego.
Quat.—Santa Barbara; San Pedro.

Lucina estrellana Conrad. (Not ident.)

"*Mioc.*—Estrella, San Luis Obispo County."

Lucina nuttalli Conrad.

L.—Monterey to San Diego.
Quat.—Santa Barbara; San Pedro.

Lucina permacra Conrad. (Not ident.)

"*Mioc.*—Santa Monica, Los Angeles County."

Lucina richthofeni Gabb.

Pl.—San Fernando, Los Angeles County.

Lucina tenuisculpta Carpenter.

L.—Straits of Fuca to Catalina Island; Mazatlan.
Pl.—San Diego well.

Lunatia lewisii Gould.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara; San Pedro and San Nicolas Islands.
Pl.—Kirker's Pass; Contra Costa County; Santa Barbara; San Fernando, Los Angeles County.

Lunatia pallida Broderip and Sowerby.

L.—Alaska to Catalina Island; circumpolar.
Pl.—Eagle Prairie, Humboldt County; Santa Cruz.

Luponia spadicea Swainson.

L.—Santa Barbara to San Diego, and Lower California.
Quat.—Santa Barbara Island.

Lutricola alta Conrad.

L.—Santa Barbara to San Diego.
Quat.—San Pedro.
Pl.—Santa Barbara; San Fernando, Los Angeles County.
Mioc.—Monterey; El Toro Ranch, Monterey County.

Lutricola viridotincta Carpenter.

L.—Cape St. Lucas, Lower California.
Quat.—Santa Barbara; San Diego.

Lutraria transmontana Conrad. (Not ident.)

"*Pl.*—Los Angeles County." (Like *Reata undulata* Gould.)
L.—San Pedro, Cal.; La Paz, Gulf of California.

Machæra patula Dixon.

L.—Alaska to San Diego; Kamtschatka; Japan.
Pl.—Eagle Prairie, Humboldt County; Santa Rosa, Sonoma County; Twelve-Mile House, San Mateo County; Soquel, Santa Cruz County.
Mioc.—Oregon; Tomales, Marin County; Martinez; Walnut Creek, Contra Costa County; Foxin's, Santa Barbara County; San Emidio Cañon, Kern County.

Macoma calcarea Chemnitz.

L.—Alaska to Santa Barbara; Arctic Ocean.
Quat.—Santa Barbara; San Pedro. *Pliocene?*

Macoma edulis Nuttall.

(*M. secta*, var. Conrad?)

L.—Straits of Fuca to Bolinas Bay; Japan.
Quat.—Santa Barbara; San Pedro.
Pl.—Eagle Prairie, Humboldt County; Santa Rosa, Sonoma County; Twelve-mile House, San Mateo County.
Mioc.—Walnut Creek, Contra Costa County.

Macoma expansa Carpenter.

L.—Straits of Fuca.
Quat.—Santa Barbara; San Pedro.
Pl.—Eagle Prairie, Humboldt County; San Fernando, Los Angeles County; San Diego well.
Mioc.—El Toro Ranch, Monterey County.

Macoma indentata Carpenter.

L.—Monterey to San Diego.
Quat.—San Diego.
Mioc.—El Toro Ranch, Monterey County; Griswold's, San Benito County.

Macoma inquinata Deshayes.

L.—Alaska to San Diego.
Quat.—Monterey to San Diego.
Pl.—Twelve-mile House, San Mateo County; San Fernando, Los Angeles County.

Macoma nasuta Conrad.

L.—Alaska to San Diego; Kamtschatka.
Quat.—Santa Barbara to San Diego.
Pl.—Eagle Prairie and Danger Creek, Humboldt County; Santa Rosa, Sonoma County; San Fernando, Los Angeles County.
Mioc.—Suñol, Alameda County; Foxin's, Santa Barbara County.

Macoma ocoyana Conrad. (Not ident.)

"*Mioc.*—Ocoya Creek" (Posa Creek), Kern County.

Macoma pedroana Conrad. (Not ident.)

"*Quat.*—San Pedro." (Like *M. gemma* Gould, of Mexico.)

Macoma secta Conrad.

L.—Bodega Bay to San Diego; Japan.
Quat.—Santa Barbara to San Diego.
Pl.—Santa Barbara; San Fernando, Los Angeles County.

Macoma yoldiformis Carpenter.

L.—Straits of Fuca to San Pedro.
Quat.—Santa Barbara.

Mactra gabiotensis Conrad. (Not ident.)

"*Mioc.*—Gabiota Pass, Santa Barbara County." (Like *Mulinia angulata*, Gray, of west tropical America.)

Mamma nana Müller.

L.—Alaska; circumpolar.
Quat. and *Pl.*—San Diego; Japan.

Mangelia tabulata Carpenter.

L.—Neah Bay, Washington Territory.
Quat.—Santa Barbara.
Pl.—San Diego well.

Mangelia variegata Carpenter.

L.—Monterey to San Diego.
Quat.—Santa Barbara.

Margarita acuticostata Carpenter.

L.—Bodega Bay to Santa Barbara.
Quat.—Santa Barbara; San Pedro.

Margarita cidaris A. Adams.

L.—Neah Bay, Washington Territory; Japan?
"*Quat.*—San Marcial" (Santa Barbara County?), Carpenter.

Margarita pupilla Gould.
(*M. salmonea* Carpenter.)

L.—Alaska to Catalina Island.
Quat.—Santa Barbara.

Margaritana margaritifera Linnæus.
(*M. falcata* Gould.)

L., *F.*—Circumpolar, south to Santa Cruz and Merced Counties; Arizona.
Quat.—Lahontan Basin (Lassen County), and Walker River Cañon, Nevada.

Marginella jewettii Carpenter.

L.—Monterey to Santa Barbara.
Quat.—San Pedro.

Martesia intercalata Carpenter.

L.—Farallone Islands to Mazatlan.
Quat.—Santa Barbara.

Melampus olivaceus Carpenter.

L.—Salinas River, Cal., to Mazatlan.
Quat.—San Diego.
Pl.—San Diego well.

Membranipora californica Gabb and Horn.

L.? Quat. Santa Barbara.

Membranipora barbarensis Gabb and Horn.

L.? Quat.—Santa Barbara.

Mera gouldii Hanley.

L.—San Diego; Cerros Islands, Lower California.
Quat.—San Diego.

Mera modesta Carpenter.

L.—Straits of Fuca, Washington Territory.
Quat.—San Diego.
Pl.—San Diego well.

Mera obtusa Carpenter.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara.

Mercenaria perlaminosa Conrad.
(=*M. kennerleyi?* Carpenter.)

L.—Straits of Fuca to Monterey.
Quat.—Santa Barbara.

Meretrix decisa Conrad. (Not ident.)

"*Mioc.*—Ocoya Creek" (Posa Creek), Kern County.

Meretrix traskii Conrad.

Mioc.—Martinez, Contra Costa County; Monterey.

Meretrix tularana Conrad. (Not ident.)

"*Mioc.*—San Emidio Cañon, Kern County."

Meretrix uniomeris Conrad. (Not ident.)

"*Mioc.*—Tres Pinos," San Benito County.

Metula remondii Gabb.

Mioc.—Tomales Bay, Marin County.

Mitra maura Swainson.

L.—Farallone Islands to San Diego; South America.
Quat.—Santa Barbara to San Diego; San Nicolas Island.

Mitromorpha aspera Carpenter.

L.—Monterey, California.
Quat.—Santa Barbara.

Menetus opercularis Gould.

L., *F.*—Straits of Fuca, Washington Territory, to Carmel River, Monterey County; Nevada; Utah.
Quat.—Lahontan Basin (Lassen County); Nevada; Walnut Creek, Contra Costa County.

Modiola capax Conrad.

L.—Santa Barbara to San Diego; Lower California and Mexico.
Quat.—Santa Barbara.
Pl.—Santa Barbara.

Modiola contracta Conrad. (Not ident.)

Like *M. multiradiata* Gabb.
"*Mioc.*—Sixteen miles south of Tres Pinos, San Benito County."

Modiola multiradiata Gabb.

Pl.—Eagle Prairie, Humboldt County; Kirker's Pass, Contra Costa County.
Mioc.—Martinez, Walnut Creek, Contra Costa County; El Toro Ranch, Monterey County; San Emidio Cañon, Kern County.

Modiola recta Conrad.

L.—Santa Cruz to San Diego.
Quat.—San Pedro.
Pl.—Santa Rosa, Sonoma County; Twelve-Mile House, San Mateo County; Soquel, Santa Cruz County; San Fernando, Los Angeles County; San Diego well.
Mioc.—El Toro Ranch, Monterey County; Foxin's, Santa Barbara County.

Monoceros engonatum Conrad.

L.—Baulines Bay to San Diego.
Quat.—San Pedro; San Diego.

Monoceros lugubris Sowerby.

L.—West Mexico to South America.
Quat.—Santa Barbara Island.

Morrisia hornii Gabb.

Quat.—Santa Barbara.

Mulinia densata Conrad.

Mioc.—Martinez, San Pablo, Walnut Creek, Contra Costa County; and mountains south to San Emidio Cañon, Kern County.

Muricidea foveolata Hinds.

L.—Baulines Bay to Lower California.
Quat.—Santa Barbara; San Pedro.

Muricidea paucivaricata Gabb.

Quat.—Santa Barbara; San Diego.

Muricidea perita Hinds.

L.—Santa Barbara to Lower California.
Quat.—Santa Barbara.

Mya montereyana Conrad. (Not ident.)

"*Mioc.*—Monterey."
(Like *Periploma argentaria* Conrad, *L.*—San Pedro to San Diego.)

Mya subsinuata Conrad. (Not ident.)

"*Mioc.*—Monterey."
(Like *Macoma inquinata* Deshayes.)

Mytilimeria nuttalii Conrad.

L.—Straits of Fuca to San Diego.
Quat.—San Pedro.
Mioc.—Tomales, Marin County.

Mytilus californianus Conrad.

L.—Straits of Fuca to San Diego; Queen Charlotte's Island.
Quat.—Santa Barbara.
Pl.—San Fernando, Los Angeles County.

Mytilus edulis Linnæus.

L.—Monterey, north; Japan; circumpolar.
Quat.—Benicia, Solano County.

Mytilus inezensis Conrad (Not ident.)

"*Mioc.*—Santa Inez Mountains, Santa Barbara County."

Mytilus mathewsonii Gabb.

Mioc.—Martinez, Contra Costa County; Monterey; San Luis Obispo; San Emidio Cañon, Kern County; Santa Monica, Los Angeles County.

Mytilus pedroanus Conrad. (Not ident.)

"*Quat.*—San Pedro."
(Probably a variety of *M. californianus* Conrad.)

Myurella simplex Carpenter.

L.—Santa Barbara to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Myurella specillata Hinds

L.—San Pedro to Lower California.
Quat.—San Diego.
Pl.—San Diego well.

Nassa fossata Gould.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—Danger Creek, Humboldt County; Russian River, Santa Rosa, Sonoma County; Twelve-Mile House, and Seven-Mile Beach, San Mateo County; west of San José, Santa Clara County; Soquel, Santa Cruz County; San Diego well.
Mioc.—Martinez, Walnut Creek, Contra Costa County; Griswold's, San Benito County; Foxin's, Santa Barbara County.

Nassa insculpta Carpenter.

L.—Catalina Island, California.
Quat.—Santa Barbara.

Nassa mendica Gould.
(*N. cooperi* Forbes.)

L.—Sitka to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—Kirker's Pass, Contra Costa County; Twelve-Mile House, San Mateo County; San Diego well.

Nassa perpinguis Hinds.

L.—San Francisco Bay to San Diego; Margarita Bay, Lower California.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.
Mioc.—Santa Monica and Alisos Creek, Los Angeles County.

Nassa tegula Reeve.

L.—Santa Barbara to San Diego, Lower California.
Quat.—Santa Barbara to San Diego.

Natica clausa Broderip and Sowerby.

L.—Alaska; Kamtschatka, North Atlantic.
Quat.—Santa Barbara to San Diego.

Natica geniculata Conrad. (Not ident.)

"*Mioc.*—Ocoya Creek" (Posa Creek), Kern County. (Like *Agasoma gravida*, Gabb.)

Neptunea altispira Gabb.

Pl.—Eagle Prairie, Humboldt County; Santa Barbara.

Neptunea humerosa Gabb.

Pl.—San Fernando, Los Angeles County.

Neptunea recurva Gabb.

Mioc.—Tomales, Marin County; Griswold's, San Benito County; El Toro Ranch, Monterey County; Foxin's, Santa Barbara County.

Neverita callosa Gabb.

Mioc.—Walnut Creek, Contra Costa County; Griswold's, San Benito County; Santa Rosa Island.

Neverita recluziana Petit.

L.—Monterey to Lower California.
Quat.—Santa Barbara to San Diego.
Pl.—Santa Barbara; San Fernando, Los Angeles County; San Diego well.
Mioc.—Martinez; Walnut Creek, Contra Costa County; Santa Inez, Santa Barbara County; Santa Monica, Los Angeles County; Posa Creek, Kern County; Death Valley, Inyo County.

Nitidella gouldii Carpenter.

L.—Straits of Fuca to San Diego.
Quat.—San Pedro to San Diego.

Nitidella chrysalloidea Carpenter.

L.—San Pedro and San Diego.
Quat.—Santa Barbara.

Nucula exigua Sowerby.

L.—Catalina Island to South America.
Pl.—San Diego well.

Ocinebra interfossa Carpenter. (And varieties.)

L.—Sitka to San Diego.
Quat.—Santa Barbara.

Ocinebra lurida Middendorf.
(*O. var. aspera* Baird.)

L.—Sitka to Santa Barbara.
Quat.—Santa Barbara; San Pedro.
Pl.—San Diego well.

Odostomia gravida Gould.

L.—Bodega Bay to San Diego.
Quat.—San Pedro; San Diego.

Odostomia straminea Carpenter.

L.—Monterey to Lower California.
Quat.—San Diego.
Pl.—San Diego well.

Olivella biplicata Sowerby.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—Seven-Mile Beach, and Twelve-Mile House, San Mateo County; Kirker's Pass, Contra Costa County; San Diego well.

Olivella boetica Carpenter.

L.—Sitka to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—Danger Creek, Humboldt County; San Diego well.

Olivella intorta Carpenter.

L.—Bodega Bay to Monterey; Gulf of California.
Quat.—San Pedro; San Diego.
Pl.—San Diego well.

Omphalius fuscescens Philippi.

L.—Catalina Island to San Diego.
Quat.—San Pedro.

Opalia anomala Stearns.

Quat.—San Diego.
Pl.—San Diego well.

Opalia borealis Gould.

L.—Straits of Fuca to San Diego; Kamtschatka.
Quat.—Santa Barbara.

Opalia crenatoides var. (?) insculpta Carpenter.

L.—Santa Cruz to Santa Barbara.
Quat.—Santa Barbara.

Opalia varicostata Stearns.

Quat.—San Diego.
Pl.—San Diego well.

Ostrea attwoodii Gabb.

Pl.?—San Benito County.

Ostrea bourgeoisii Remond.

Pl.—Kirker's Pass, Contra Costa County; Santa Anna Mountains, Los Angeles County.

Ostrea conchaphila Carpenter.

L.—Catalina Island to Panama.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Ostrea heermanni Conrad.

Pl.—West of Colorado Desert, San Diego County?

Ostrea lurida Carpenter.

L.—Straits of Fuca to San Diego.
Quat.—Benicia, Solano County; San Diego.

Ostrea panzana Conrad. (Not ident.)

"*Mioc.*—Panza Valley, Santa Inez Mountains," Santa Barbara County; "Estrella," San Luis Obispo County.

Ostrea subjecta Conrad. (Not ident.)

"*Mioc.*—Santa Monica Mountains." (Like *O. titan* Conrad, young.)

Ostrea titan Conrad.

(*O. virginica* var. *californica* Marcose, fragments.)

Mioc.—Kirker's Pass, Contra Costa County, and throughout Upper Miocene of the Coast Ranges to Lower California.

Ostrea tayloriana Gabb.

(*O. titan* Conrad, young?)

Mioc.—San Marcos Pass, Santa Barbara County; San Juan Capistrano, Los Angeles County.

Ostrea veatchii Gabb.

Pl.—Santa Rosa Island; Lower California; San Diego well.

Ostrea vespertina Conrad.

Pl.—Santa Barbara, San Fernando, Los Angeles County; west of Colorado Desert, San Diego County.

Pachydesma crassatelloides Conrad.

L.—Santa Cruz to San Diego.
Quat.—Santa Barbara to San Diego.

Pachydesma inezana Conrad.

Mioc.—Santa Inez Mountains, Santa Barbara County.

Pachypoma biangulata Gabb.

Mioc.—Martinez, Contra Costa County.

Pachypoma gibberosum Chemnitz.

L.—Straits of Fuca to Catalina Island; New Zealand?
Quat.—Santa Barbara; San Pedro.

Pandora bilirata Conrad. (Not ident.)

Quat.—Santa Barbara. (Like *Kennerlia bicarinata* Carpenter, Catalina Island.)

Pandora scapha Gabb.

Mioc.—Martinez, Contra Costa County.

Parapholas californica Conrad.

L.—Baulines Bay to San Diego.
Quat.—Santa Barbara.

Pecten æquisulcatus Carpenter.

(*P. ventricosus*, var.?)
L.—Monterey to San Diego.
Quat.—San Diego.

Pecten catilliformis Conrad.

Mioc.—Oregon; Walnut Creek, Contra Costa County; Ocoya (Posa) Creek, Kern County; Alisos Creek, Los Angeles County.

Pecten deserti Conrad. (Not ident.)

"*Pl.*—West of Colorado Desert; San Diego County;" near San Diego?

Pecten discus Conrad. (Not ident.)

"*Mioc.*—Santa Inez Mountains, Santa Barbara County."

Pecten hastatus Sowerby.

(*P. altiplicatus* Conrad.)

L.—Sitka to Santa Barbara.
Quat.—Santa Barbara to San Diego.
Pl.—Santa Barbara; San Fernando, Los Angeles County; San Diego well.
Mioc.—Estrella, San Luis Obispo County; San Rafael hills, Santa Barbara County.

Pecten hemphilli Dall.

Pl.—San Diego.

Pecten islandicus Müller.

L.—Arctic Seas; circumpolar.
Quat.—Santa Barbara; San Diego.
Pl.—San Diego.

Pecten latiauritus Conrad.

(*P. monotimeris* Conrad.)

Quat.—Santa Barbara; San Pedro.

Pecten magnolia Conrad. (Not ident.)

"*Mioc.*—Santa Inez Mountains, Santa Barbara County."

Pecten meekii Conrad. (Not ident.)

"*Mioc.*—San Rafael hills, Santa Barbara County."

Pecten nevadanus Conrad. (Not ident.)

Mioc.—Ocoya (Posa) Creek, Kern County; San Juan Capistrano, Los Angeles County?

Pecten pabloensis Conrad.

Pl.—Lobitas, San Mateo County; Alisos Creek, Kern County.
Mioc.—Martinez, San Pablo, Contra Costa County; Suñol, Alameda County; El Toro Ranch, Monterey County; Foxins, Santa Barbara County; Point Mogu, Ventura County; San Juan Capistrano, Los Angeles County.

Pecten paucicostatus Carpenter.

L.—Santa Barbara to San Diego.
Quat.—San Diego.

Pecten peckhami Gabb.

Mioc.—San Pablo, Contra Costa County; Monterey County; Ojai Valley, Ventura County.

Pecten pedroanus Trask.

Mioc.—San Pedro (May be an Aucella and cretaceous).

Pecten propatulus Conrad.
(*P. caurinus* Gould; see *Amusium.*)

Mioc.—Oregon; Eel River, Humboldt County; Tomales, Marin County; Walnut Creek, Contra Costa County; Sunol, Alameda County; Griswolds, San Benito County.

Pecten stearnsii Dall.

Pl.—San Diego.

Pecten ventricosus Sowerby.

L.—West tropical America.
Quat.—San Pedro; San Diego.
Pl.—San Diego well.

Periploma argentaria Conrad.

L.—San Pedro to San Diego.
Quat.—San Diego.

Perna montana Conrad. (Not ident.)

"*Mioc.*—San Buenaventura," Ventura County.

Petricola carditoides Conrad.

L.—Sitka to San Diego.
Quat.—San Pedro to San Diego.

Phasianella compta Gould.

L.—San Pedro to Mazatlan.
Quat.—San Pedro; San Diego.

Phidolopora labiata Gabb & Horn.

L.? Quat.—Santa Barbara.

Pholadidea ovoidea Gould.

L.—Baulines Bay to San Diego.
Quat.—Santa Barbara to San Diego.

Pholadidea penita Conrad.

L.—Straits of Fuca to Santa Barbara.
Quat.—Santa Barbara.

Phorcus pulligo Martyn.

L.—Sitka to San Pedro.
Quat.—San Diego.

Physa ampullacea Gould.

L., F.—Lake Osoyoos, latitude 49°, Washington Territory, to Owens River, California.
Quat.—Mono Basin, Mono County.

Physa diaphana Tryon.

L., F.—Northern California.
Quat.—Walnut Creek, Contra Costa County.

Physa humerosa Gould.

L., F.—Pyramid Lake, Nevada; Colorado River, California; Pecos River, Texas.
Quat.?—Near Carson, Nevada, to Colorado Desert.

Pinna alamadensis Yates.*

Mioc.—Alameda County.

Pinna venturensis Yates.†

Pl.—Casitas Pass, Ventura County.

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* **Pinna alamadensis** Yates. This species has nine concentric inequidistant rounded wrinkles emanating from the open side, and turning toward the hinge at nearly right angles, the entire shell marked by small longitudinal narrow ribs (about forty), which, radiating from the apex, extend to the basal margin, becoming more indistinct as they approach the lower margin. These ribs at their intersections with the lines of growth are ornamented by slight elevations forming zigzag markings along the lines of growth. The hinge side is straight the entire length, the opposite side running parallel for about one half the distance from base to apex, where it makes a sharp curve, thence at an angle of about forty-five degrees to the apex. Length nine, width five, and thickness about two inches. Locality, Alameda Creek, Alameda County. Only one specimen found, and that a very fine one, in the center of a round sandstone bowlder. Miocene.

† **Pinna venturensis** Yates. From the hinge side about two thirds of the width of this shell is marked by nine well developed, narrow ribs, radiating from the apex to the basal margin; the other portion shows rounded, concentric inequidistant ribs extending only to the line of the radiating ribs, so that about two thirds of the surface is covered by the radiating smaller ribs, and one third by the curved, concentric, rounded ribs or wrinkles, very like Pinna pectinata, figured in "Brown's Recent Conchology." Pinna venturense is short and thick compared with its length. The largest specimen found was about five and one half inches long, three and one half in width, and one and three fourths in thickness, the hinge side considerably shorter than the other. Locality, several specimens collected by the writer in Casitas Pass, Ventura County. Pliocene.—*L. G. Yates.*

Pisania fortis Carpenter.

Quat.—Santa Barbara.

Pisidium compressum Prime.

L., *F.*—California; North Atlantic States; Utah; Nevada.
Quat.—Lahontan Basin, Lassen County (?), California, to Walker River Cañon, Nevada.

Pisidium occidentale Newcomb.

L., *F.*—Brooks and ponds, sea level to 7,200 feet altitude, California.
Quat.—Walnut Creek, Contra Costa County.

Pisidium ultramontanum Prime.

L., *F.*—Canoe Creek, Pit River, Shasta County (to Clear Lake, Lake County?; near *P. compressum*), Oregon.
Quat.—Lahontan Basin, Lassen County, California (?), to Truckee Valley, Nevada.

Placunanomia macroschisma Deshayes.

L.—Unalaska to San Diego; Japan.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Planorbis subcrenatus Carpenter.

L., *F.*—Vancouver Island, and Washington Territory; Oregon to Northern California; Honey Lake, Lassen County.
Quat.—Walnut Creek, Contra Costa County.

Platyodon cancellatus Conrad.

L.—Baulines Bay to San Diego.
Quat.?—Santa Cruz.

Pleurotoma perversa Gabb.

L.—Vancouver Island to Catalina Island.
Quat.—Santa Barbara to San Pedro.

Pleurotoma transmontana Conrad. (Not ident.)

" *Mioc.*—Ocoya (Posa) Creek, Kern County."

Pomaulax undosus Wood.

L.—Santa Barbara to Cape Saint Lucas; Monterey?
Quat.—Santa Barbara to San Diego.

Pompholyx effusa Lea.

L., *F.*—Dalles, Oregon, to Tehama, California; Carson River to White Pine, Nevada.
Quat.—Lahontan Basin, Lassen County, and Nevada.

Priene oregonensis Redfield.

L.—Straits of Fuca to Monterey; Japan.
Quat.—Santa Barbara; San Pedro.

Psephis lordi Baird.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara.

Psephis salmonea Carpenter.

L.—Catalina Island.
Quat.—Santa Barbara.

Psephis tantilla Gould.

L.—Straits of Fuca to Catalina Island.
Quat.—Santa Barbara.

Pseudocardium gabbii Remond.

Pl.—Kirker's Pass, Contra Costa County.
Mioc.—Martinez, Contra Costa County; Cerro Bonito, Monterey County.

Pteronotus festivus Hinds.

L.—San Pedro and San Diego; Lower California.
Quat.—Santa Barbara; San Diego.

Puncturella cucullata Gould.

L.—Straits of Fuca to Monterey.
Quat.—Santa Barbara; San Pedro.

Pupilla muscorum Linnæus.

L., *T.*—Circumpolar; Truckee Valley, Nevada.
Quat.—Lahontan Basin, Lassen County (?), California; Rye Patch, Nevada.

Purpura canaliculata Duclos.

L.—Alaska to Monterey.
Quat.—Santa Barbara.
Pl.—Danger Creek, Humboldt County; Kirker's Pass, Contra Costa County; Twelve-Mile House, San Mateo County.

Purpura crispata Chemnitz.

(Var. *septentrionalis* Reeve.)

L.—Sitka to Santa Barbara.
Quat.—Santa Barbara to San Diego.
Pl.—Seven-Mile Beach, San Mateo County.

Purpura (Stramonita) petrosa Conrad. (Not ident.)

"*Mioc.*—Tulare County" (Siebeck's, Santa Clara County?). Like *Monoceros lugubre* Sowerby.

Purpura saxicola Valenciennes.
(*Var. ostrina* Gould.)

L.—Alaska to San Diego; Lower California.
Pl.—Santa Rosa, Sonoma County; Kirker's Pass, Contra Costa County; San Fernando, Los Angeles County.

Ranella mathewsonii Gabb.

Quat.?—Santa Barbara.
Pl.—Santa Barbara; San Diego well.
Mioc.—Martinez, Contra Costa County.

Ranella muriciformis Broderip.

L.—West coast of Mexico, and south.
Quat.—San Diego.

Ranella triquetra Carpenter.

L.—West coast of Mexico.
Quat.—San Diego.

Reptescharella heermanni Gabb & Horn.

L.? and Quat.—Santa Barbara.

Reptescharella plana Gabb & Horn.

L.? and Quat.—Santa Barbara.

Reptescharellina cornuta Gabb & Horn.

L.? and Quat.—Santa Barbara.

Reptescharellina disparilis Gabb & Horn.

L.? and Quat.—Santa Barbara.

Reptescharellina heermanni Gabb & Horn.

L.? and Quat.—Santa Barbara.

Reptoporina eustomata Gabb & Horn.

L., *Quat.*—Santa Barbara.

Rissoina woodwardi Carpenter.

L.—West coast of Mexico; Gulf of California.
Quat.—San Diego.

Rupellaria lamellifera Conrad.

L.—Farallone Islands to San Diego.
Quat.—Santa Barbara.
Pl.?—Monterey.

Saxicava abrupta Conrad. (Not ident.)

"*Quat.*—San Pedro." (Like *Petricola carditoides* Conrad, living.)

Saxicava pholadis Linnæus.

L.—Alaska to Santa Barbara. Universal?
Quat.—Santa Barbara.

Saxidomus gibbosus Gabb.

Pl.—Eagle Prairie, Humboldt County.

Saxidomus gracilis Gould.

(*S. aratus* Gould.)

L.—Baulines Bay to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—Kirker's Pass, Contra Costa County; Twelve-Mile House, San Mateo County; Santa Barbara; San Fernando, Los Angeles County.
Mioc.—Martinez; Walnut Creek, Contra Costa County; Santa Cruz; Santa Inez, Santa Barbara County; Santa Monica, Los Angeles County.

Saxidomus nuttalli Conrad.

L.—Sitka to San Diego; Japan?
Quat.—Santa Barbara; San Pedro.
Pl.—Santa Barbara.

Scalaria bellastriata Carpenter.

L.—San Pedro to San Diego.
Quat.—Santa Barbara.

Scalaria crebricostata Carpenter.

L.—Monterey to San Diego.
Quat.—Santa Barbara; San Pedro.

Scalaria hemphilli Dall.

Quat.—San Diego.
Pl.—San Diego well.

Scalaria indianorum Carpenter.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara; San Diego.

Scalaria subcoronata Carpenter.

L.—Bodega Bay to San Diego.
Quat.—Santa Barbara; San Pedro.
Pl.—San Diego well.

Scalaria tincta Carpenter.

L.—Santa Cruz to San Diego.
Quat.—San Diego.
Pl.—San Diego.

Schizodesma abscissa Gabb.

Mioc.—Martinez, San Pablo, Walnut Creek, Contra Costa County.

Schizothoerus nuttalli Conrad.

L.—Alaska to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—Santa Barbara.

Semele decisa Conrad.

L.—Santa Barbara to San Diego.
Quat.—San Pedro.

Semele pulchra Sowerby.

L.—Santa Barbara to San Diego; Acapulco to South America.
Quat.—San Pedro; San Diego.

Semitubigera tuba Gabb & Horn.

L.? Quat.—Santa Barbara.

Septifer bifurcatus Reeve.

L.—Farallone Islands to San Diego.
Quat.—Santa Barbara; San Diego.

Serpulorbis squamigerus Carpenter.

L.—Monterey to San Diego.
Quat.—Santa Barbara to San Diego.

Sigaretus debilis Gould.

L.—Monterey to Lower California; South America.
Pl.—San Diego well.

Sigaretus planicostum Gabb.

Pl.—San Fernando, Los Angeles County.

Siliquaria edentula Gabb.

Pl.—San Fernando, Los Angeles County.

Siphonalia kelletii Forbes.

L.—Santa Barbara to San Diego; Japan.
Quat.—San Pedro to San Diego.

Siphonella multipora Gabb & Horn.

L.? and Quat.—Santa Barbara.

Siphonodentalium lofotense Sars.

L.—Islands of California Coast; Norway.
Pl.—San Diego well.

Siphonodentalium pusillum Gabb.

Pl.—San Diego well.
(*Cret.* or *Eocene?*)—Martinez, Contra Costa County; Tejon, Kern County. (See Cret. list.)

Solarellia peramabilis Carpenter.

L.—Catalina Island, 40 to 120 fathoms deep. (240 to 720 feet.)
Quat.—Dead Man's Island; San Pedro.

Solecurtus californianus Conrad.

(*S. subteres?* Conrad.)

L.—Santa Barbara to San Diego.
Quat.—Santa Barbara; San Pedro; San Diego.
Pl.—San Diego well.

Solen rosaceus Carpenter.

L.—Santa Barbara to San Diego.
Quat.—Santa Barbara.
Pl.—Santa Rosa, Sonoma County; San Ramon, Kirker's Pass, Contra Costa County; San Fernando, Los Angeles County; San Diego well.
Mioc.—Tomales, Marin County; Martinez, Contra Costa County.

Solen sicarius Gould.

L.—Straits of Fuca to San Pedro; Japan.
Pl.—Twelve-Mile Creek, San Mateo County; San Fernando, Los Angeles County.
Mioc.—Walnut Creek, Contra Costa County.

Sphærium dentatum Haldemann.

L., *F.*—Oregon to Idaho; Humboldt River, Nevada, to Utah Lake.
Quat.—Lahontan Basin (Lassen County), to Utah.

Sphærium patella Gould.

(S. *nobile* Gould.)

L., *F.*—Oregon to Southern California (Kern County); Colorado River (?).
Quat.—Near Martinez, Contra Costa County.

Sphærium striatinum Lamarck.

L., *F.*—Hell Gate River, Montana, to Humboldt River, Nevada; Missouri River east to Canada.
Quat.—Lahontan Basin (Lassen County?); Rye Patch, Nevada.

Standella californica Conrad.

(*S. planulata* Conrad.)

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—Kirker's Pass, Contra Costa County; Twelve-Mile House, San Mateo County; Santa Barbara.
Mioc.—Oregon; Martinez, Contra Costa County; Griswold's, San Benito County; Foxins, Santa Barbara County.

Standella falcata Gould.

(*S. nasuta* Gould.)

L.—Kodiak, Alaska, to San Diego.
Quat.—San Diego.
Pl.—Eagle Prairie, Humboldt County; Kirker's Pass, Contra Costa County; Seven-Mile Beach, San Mateo County.
Mioc.—Martinez, Contra Costa County; Half-moon Bay, San Mateo County; Suñol, Alameda County; Siebeck's, Santa Clara County; Griswold's, San Benito County; Foxins, Santa Barbara County; Santiago, Los Angeles County.

Succinea stretchiana Bland.

(*S. gabbii* Tryon.)

L., *T.*—Northeast California, and southeast Oregon.
Quat.—Lahontan Basin, Lassen County (?); Rye Patch, Nevada.

Surcula carpenteriana Gabb.

L.—Monterey to San Diego.
Quat.—Santa Barbara; San Pedro.
Pl.—Santa Rosa, Sonoma County; San Fernando, Los Angeles County; San Diego well.

Surcula tryoniana Gabb.

L.—San Diego.
Pl.—Santa Barbara; San Pedro.

Tamiosoma gregaria Conrad.

Mioc.—Tulare Valley; Estrella; Santa Margarita, San Luis Obispo County; San Juan Capistrano, Los Angeles County.

Tapes inezensis Conrad. (Not ident.)

"*Mioc.*—Santa Inez Mountains, Santa Barbara County." (Like *Saxidomus gracilis* Gould.)

Tapes montana Conrad. (Not ident.)

"*Mioc.*—San Buenaventura." (Like *Amiantis callosa* Conrad.
L.—Santa Barbara to San Diego; Cape St. Lucas.)

Tapes staleyi Gabb.

Pl.—Eagle Prairie, Humboldt County; Santa Rosa, Sonoma County; Kirker's Pass, Contra Costa County; Santa Cruz.

Tapes staminea Conrad. (And varieties.)

L.—Straits of Fuca to San Diego; Margarita Bay; Lower California.
Quat.—Santa Barbara to San Diego.
Pl.—Santa Rosa, Sonoma County; Twelve-Mile House, San Mateo County; Kirker's Pass, Contra Costa County; Monterey; San Fernando, Los Angeles County.
Mioc.—West of San José, Santa Clara County; Foxins, Santa Barbara County. Varieties *diversa* Sowerby, *orbella* Carpenter, and *petitii* Deshayes, the last northward.

Tapes tenerrima Carpenter.

L.—Straits of Fuca to San Diego.
Quat.—Santa Barbara.
Pl.—Santa Barbara.

Tapes truncata Gabb.

Pl.—San Fernando, Los Angeles County.
Mioc.—Suñol, Alameda County; near Black Mountain, Santa Clara County; Griswold's, San Benito County.

Tellina bodegensis Hinds.

L.—Straits of Fuca to San Diego; Japan.
Quat.—San Pedro to San Diego.
Mioc.—Oregon; Walnut Creek, Contra Costa County.

Tellina congesta Conrad.

Mioc.—San Pablo, Contra Costa County; Monterey to San Diego.

Tellina diegoana Conrad. (Not ident.)

"*Mioc.*—San Diego?"

Thalotia caffea. Gabb. (*Ptychostylis.*)

L.—Monterey.
Quat.—Santa Barbara and San Pedro.

Thracia mactropsis Conrad. (Not ident.)

"*Mioc.?*—Monterey County."

Thracia trapezoides Conrad.

Pl.—Eagle Prairie, Humboldt County.
Mioc.—Oregon.

Tornatella elliptica Trask. (Not ident.)

"*Quat.*—Santa Barbara."

Tornatella punctocælata Carpenter.

L.—Santa Cruz to San Diego.
Quat.—Santa Barbara to San Diego.

Tornatina carinata Carpenter.

L.—Santa Barbara to San Diego; Panama.
Quat.—San Diego.
Pl.—San Diego well.

Tornatina cerealis Gould.

L.—Monterey to San Diego.
Quat.—Santa Barbara; San Diego.

Tornatina culcitella Gould.

L.—Monterey to San Diego.
Quat.—Santa Barbara.

Tornatina eximia Baird.

L.—Vancouver Island to San Diego.
Quat.—San Diego.
Pl.—San Diego well.

Triptera clavata Gabb.

Mioc.—Griswold's, San Benito County.

Trochiscus norrisii Sowerby.

L.—Santa Barbara to San Diego; Monterey?
Quat.—Santa Barbara.

Trophon multicostatus Escholtz.

L.—Sitka to Monterey; Greenland.
Quat.—Santa Barbara.

Trophon orpheus Gould.
(*Murex fragilis* Trask ?)

L.—Sitka to Straits of Fuca; Washington Territory.
Quat.—San Pedro; San Diego.
Pl.—San Diego well.

Trophon ponderosus Gabb.

Mioc.—Walnut Creek, Contra Costa County; Griswold's, San Benito County.

Trophon tenuisculptus Carpenter.

Quat.—Santa Barbara.

Trophon triangulatus Carpenter.

L.—Santa Cruz Island to Catalina Island; Lower California?
Quat.—Santa Barbara.

Tryonia clathrata Stimpson.

F., *Quat.*—Colorado Desert, California. (Fossil only?)

Tryonia exigua Conrad.
(*T. protea* Gould.)

L., *F.*—Southern Utah.
Quat.—Colorado Desert, California.

Turbinella cæstus Broderip.

L.—Lower California to Panama.
Pl.?—Santa Rosa Island.

Turritella cooperi Carpenter.

L.—Santa Barbara to San Diego.
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Turritella hoffmani Gabb.

Mioc.—Siebeck's, Santa Cruz Mountains; Sespi Cañon, Ventura County.

Turritella inezana Conrad.

Mioc.—Santa Inez Mountains, Santa Rosa Island, Santa Barbara County; Santa Monica, Los Angeles County.

Turritella jewetti Carpenter.

L.—Santa Barbara; (Jewett, fossil only?)
Quat.—Santa Barbara to San Diego.
Pl.—San Diego well.

Turritella ocoyana Conrad.

Mioc.—Ocoya Creek (Posa Creek), Kern County; Santa Rosa Island, Santa Barbara County; Santa Monica, Los Angeles County.

Turritella variata Conrad.

Mioc.—Santa Monica, Los Angeles County; Najohui Ranch.

Vallonia pulchella Müller.

L., *T.*—Circumpolar, south to latitude 38°, on mountains.
Quat.—Lahontan Basin, Lassen County?; Rye Patch, Nevada.

Valvata virens Tryon.

L., *F.*—Mendocino County to Alameda County; Grant's Lake, Eastern Oregon.
Quat.—Lahontan Basin, Lassen County, to Nevada.
Pl.?—Gelcich's coal mines, Santa Cruz County.

Vanikoro diegoana Conrad. (Not ident.)

"*Mioc.*—San Diego."

Velutina lævigata Linnæus.

L.—Straits of Fuca to Monterey; North Atlantic.
Quat.—Santa Barbara.

Venericardia borealis Conrad.
(Var.? *ventricosa* Gould.)

L.—Alaska to Catalina Island; North Atlantic.
Quat.—Santa Barbara to San Diego.
Pl.—San Fernando, Los Angeles County; Santa Barbara to San Diego.
Mioc.—Oregon; Foxins, Santa Barbara County; Santa Monica, Los Angeles County.

Venus pajoroensis Conrad. (Not ident.)

"*Pl.*—Pajaro River, Gavilan Mountains, Monterey County." (Like *Callista voyi* Gabb.)

Volvula cylindrica Carpenter.

L.—Santa Barbara to San Diego.
Quat.—San Diego.

Volutilithes indurata Conrad.

Pl.—Half-moon Bay, San Mateo County.
Mioc.—Oregon; Tomales Bay, Marin County.

Yoldia impressa Conrad.
(*Y. cooperi* Gabb.)

L.—Santa Cruz to San Diego.
Quat.—San Pedro.
Pl.—San Fernando, Los Angeles County.
Mioc.—Oregon; Martinez; Walnut Creek, Contra Costa County.

Yoldia nasuta Gabb.

Pl.?—Los Angeles.

Yoldia amygdala Valenciennes.

L.—Straits of Fuca to Monterey.
Quat.—Dead Man's Island, San Pedro.

Zirphœa dentata Gabb.

Quat.—Santa Barbara; San Pedro.
Pl.—Kirker's Pass, Contra Costa County.

Zirphœa gabbi Tryon.
(*Z. crispata* Linnæus?)

Quat.—Santa Barbara; San Pedro.
Mioc.?—Alameda County.

TERTIARY RADIATA.

Asterias remondi Gabb.

Mioc.—Star Fish Point, Martinez, Contra Costa County.

Astrodapsis antiselli Conrad.

Mioc.—Near Buena Vista Lake, Kern County.

Astrodapsis tumidus Remond.

Pl.—Kirker's Pass.
Mioc.—Walnut Creek, Contra Costa County.

Astrodapsis whitneyi Remond.

Pl.—Kirker's Pass, Contra Costa County.

Clypeaster gabbi Remond.

Mioc.—Martinez; San Pablo; Walnut Creek, Contra Costa County.

Echinarachnius brewerianus Remond.

Mioc.—San Pablo; Walnut Creek; Mt. Diablo, Contra Costa County.

Echinarachnius excentricus Escholtz.
(*Scutella striatula* Conrad.)

L.—Alaska to San Pedro.
Quat.—San Pedro.
Pl.—Seven-Mile Beach, San Mateo County; San Fernando, Los Angeles County; San Diego.

Scutella interlineata Stimpson.

Pl.—Seven-Mile Beach, San Mateo County.

Scutella gibbsi Remond.

Mioc.—Near Buena Vista Lake, Kern County.

CRETACEOUS (AND EOCENE?)* CRUSTACEA.

Callianassa stinpsoni Gabb.

Cret.—Chico, Butte County; Clayton, Contra Costa County.
B.?—Tejon, Kern County; very probably includes more than one species.

CRETACEOUS (AND EOCENE) MOLLUSCA.

Acmæa tejonensis Gabb.

Cret. B.—Tejon, Kern County.

Actæon impressus Gabb.

Cret.—Cottonwood Creek, Shasta County.

Actæonella oviformis Gabb.

Cret.—Cottonwood Creek, Shasta County; Santa Ana Mountains, Los Angeles County.

*Note—The Cretaceous strata of Gabb, are now considered to include the Eocene, though the line of division between them cannot be determined in most parts of California. The name Cretac-eocene has been suggested for the combined series, but to indicate the localities where the Eocene is best defined, the term *Cret. B.* is used as equivalent to Gabb's "Divis on B."

Actæonina californica Gabb.

Cret.—Near Yreka, Oregon; Benicia, Solano County; Martinez, Contra Costa County.

Actæonina pupoides Gabb.

Cret.—Cottonwood Creek, Shasta County.

Amauropsis oviformis Gabb.

Cret.—Tuscan Springs, Tehama County.

Ammonites (Lytoceras) batesi Trask.

Cret.—Cottonwood Creek, Shasta County; Benicia, Solano County; Mt. Diablo, Contra Costa County.

Ammonites (Haploceras) breweri Gabb.

Cret.—Queen Charlotte's Island, B. C.; Cottonwood Creek, Shasta County; Arroyo Valley, Alameda County.

Ammonites chicoensis Trask.

Cret.—Siskiyou Mountains; Cottonwood Creek, Shasta County; Chico Creek, Kelly's, Pentz's, Butte County; Pacheco's Pass, Merced County; Santa Ana Mountains, Los Angeles County.

Ammonites (Heteroceras) cooperi Gabb.

Cret.—Comox, Vancouver Island; San Diego (old coal mine near Point Loma, from below sea level).

Ammonites fraternus Gabb.

Cret.—Benicia, Solano County; Arroyo Valley, Alameda County.

Ammonites hoffmanni Gabb.

Cret.—Horsetown, Shasta County; Arroya Valley, Alameda County.

Ammonites jugalis Gabb.

Cret.—Benicia, Solano County; Martinez, Mt. Diablo, Contra Costa County.

Ammonites peruvianus Von Buch.

Cret.—Tuscan Springs, Tehama County.

Ammonites ramosus Meek.

Cret.—Cottonwood Creek, Shasta County; Arroyo Valley, Alameda County.

Ammonites remondi Gabb.

Cret.—Cottonwood Creek, Shasta County; Pentz's, Butte County.

Ammonites (Hoplites) stoliczkanus Gabb.

Cret.—Cottonwood Creek, Shasta County.

Ammonites complexus suciensis Meek.

Cret.—Vancouver Island, and Sucia Island, B. C.; Folsom, Sacramento County, and Mt. Diablo.

Ammonites tehamaensis Gabb.

Cret.—Battle Creek, Tehama County.

Ammonites traski Gabb.

Cret.—Cottonwood Creek, Shasta County; Arroya Valley, Alameda County.

Ammonites whitneyi Gabb.

Cret.—Cottonwood Creek, Shasta County.

Ampullina striata Gabb.

Cret.—Martinez, Contra Costa County.

Anatina inæquilateralis Gabb.

Cret.—Siskiyou Mountains.

Anatina lata Gabb.

Cret.—Pentz's Ranch, Butte County.

Anatina tryoniana Gabb.

Cret.—Gabriola Island, B. C.; Martinez, Contra Costa County.

Anchura angulata Gabb.

Cret.—Huling Creek, Shasta County; Martinez, Contra Costa County.

Anchura californica Gabb.

Cret.—Siskiyou Mountains; Chico, Butte County; Martinez; Puerto Cañon, and Orestimba Cañon, Stanislaus County.

Anchura carinifera Gabb.

Cret.—Martinez, Contra Costa County.

Anchura exilis Gabb.

Cret.—Sucia Island, B. C.; Martinez, Contra Costa County.

Anchura falciformis Gabb.

Cret.—Tuscan Springs, Tehama County; Chico, Butte County; Texas Flat, Placer County.

Anchura monilifera Gabb.

Cret.—Santa Ana Mountains, Los Angeles County; Arivechi, Mexico.

Anchura transversa Gabb.

Cret.—Martinez, Contra Costa County.

Ancillaria elongata Gabb.

Cret. B.—Near Mt. Diablo; San Diego.

Ancyloceras lineatus Gabb.

Cret.—Cottonwood Creek, Shasta County; Folsom, Sacramento County.

Ancyloceras percostatus Gabb.

Cret.—Cottonwood Creek, and Arbuckles, Shasta County; Martinez, Contra Costa County.

Ancyloceras quadratus Gabb.

Cret.—Pentz's, Butte County.

Ancyloceras remondi Gabb.

Cret.—Queen Charlotte's Island, B. C.; Cottonwood Creek, and Arbuckles, Shasta County.

Angaria ornatissima Gabb.

Cret.—Hornby and Sucia Islands, B. C.; Tuscan Springs, Tehama County; Texas Flat, Placer County.

Anisomyon meeki Gabb.

Cret.—Vancouver Island, B. C.; Cottonwood Creek, Shasta County.

Anomia lineata Gabb.

Cret.—Chico Creek; Pentz's, Butte County; Texas Flat, Placer County.

Anthonya cultriformis Gabb.

Cret.—Martinez, Contra Costa County.

Arca breweriana Gabb.
(*A. vancouverensis* Meek.)

Cret.—Cottonwood Creek, Shasta County; Tuscan Springs, Tehama County.

Arca decurtata Gabb.

Cret.—Millville, Shasta County; Rag Cañon, Napa County; Alameda County.

Arca gravida Gabb.

Cret.—Rag Cañon, Napa County; Pacheco's Pass, San Benito County.

Arca horni Gabb.

Cret. B.—Tejon, Kern County

Architectonica cognata Gabb.

Cret. B.—Martinez, Clayton, Contra Costa County; Tejon, Kern County.

Architectonica horni Gabb.

Cret. B.—Tejon, Kern County.

Architectonica inornata Gabb.

Cret.—Tuscan Springs, Tehama County; Martinez, Contra Costa County.

Architectonica veatchi Gabb.

Cret.—Tuscan Springs, Tehama County.

Arcomya undulata Gabb.

Cret.—Indian Creek, Butte County.

Asaphis undulata Gabb.

Cret.—Texas Flat, Placer County.

Astarte conradiana Gabb.

Cret.—Sucia Island, British Columbia; Texas Flat, Placer County.

Astarte mathewsoni Gabb.

Cret.—Martinez, Contra Costa County.

Astarte tuscana Gabb.

Cret.—Vancouver and Sucia Islands, B. C.; Tuscan Springs, Tehama County; Pentz's, Butte County; Santa Ana Mountains, Los Angeles County.

Astrocœnia petrosa Gabb.

Cret.—Martinez, Contra Costa County.

Ataphrus crassus Gabb.

Cret.—Martinez, Contra Costa County.

Ataphrus compactus Gabb.

Cret.—Denman Island, B. C.; Texas Flat, Placer County.

Atresius liratus Gabb.

Cret.—Near Hot Sulphur Springs, Colusa County.

Aturia mathewsonii Gabb.

Cret. B.?—Martinez, Clayton, Contra Costa County; Tejon, Kern County.

Aucella piochi Gabb.

Cret.—Queen Charlotte's Island, B. C.; Washington Territory; Colusa County; Knoxville, Lake County; Putah Creek, Solano County; north side of Mount Diablo; south of New Almaden, Santa Clara County. (N. B.—It is believed by Dr. C. A. White, Professor Becker, and others, that at least part of these specimens are identical with *A. erringtoni* Gabb, one of the Jurassic fossils of the Sierra Nevada, and both may be varieties of *A. mosquensis* (Von Buch) of Russia, etc.)

Avicula pellucida Gabb.

Cret.—Siskiyou Mountains; Lower Lake, Lake County; Martinez; Griswold's, San Benito County; Pacheco's Pass, Merced County; Tejon, Kern County. (Perhaps two species of Divisions A and B.)

Axinæa cor Gabb.

Cret. B.—Tejon Pass, Kern County.

Axinæa sagittata Gabb.

Cret. B.—Martinez; Griswold's, San Benito County; Tejon, Kern County.

Axinæa veatchi Gabb.

Cret.—Vancouver Island, British Columbia; Cow Creek, Shasta County; Pentz's Ranch, Butte County; Tuscan Springs, Tehama County; Texas Flat, Placer County; Lower Lake, Lake County; Martinez; Orestimba Cañon, Stanislaus County; Santa Ana Mountains, Los Angeles County; San Diego. (Perhaps two species in Divisions A and B.)

Baculites chicoensis Trask.

Cret.—Vancouver and Sucia Islands, B. C.; Cottonwood Creek, Shasta County; Chico Creek, and Pentz's, Butte County; Martinez; Orestimba Cañon, Stanislaus County; Alameda County; San Diego County.

Baculites occidentalis Meek.

Cret.—Sucia Island, B. C.; Shasta County to Alameda County.

Barbatia morsei Gabb.

Cret. B.—Near San Luis Rey to San Diego.

Bela clathrata Gabb.

Cret. B.—Martinez, Contra Costa County.

Belemnites impressus Gabb.

Cret.—Cottonwood Creek, Shasta County; Colusa County; Mount Diablo, Contra Costa County; Napa County; San Benito County.

Brachysphingus liratus Gabb.

Cret. B.—Martinez, Clayton, Marsh's, Contra Costa County.

Brachysphingus sinuatus Gabb.

Cret. B.—Martinez, Contra Costa County.

Bulla horni Gabb.

Cret. B.—Tejon, Kern County.

Bullia (Molopophorus) striata Gabb.

Cret. B.—Vancouver and other islands, B. C.; Tejon, Kern County.

Calliostoma radiatum Gabb.

Cret.—Texas Flat, Placer County.

Cardita planicosta Lamarck.

(*C. horni* Gabb.)

Cret. B.—Albany, Oregon; Martinez, Clayton, Contra Costa County; Griswold's, New Idria, San Benito County; Tejon, Kern County; San Diego; Eastern States and Europe in eocene strata.

Cardita veneriformis Gabb.

Cret.—Martinez, Contra Costa County.

Cardium (Lævicardium) annulatum Gabb.

Cret.—Martinez, Mount Diablo, Contra Costa County; Orestimba Cañon, Stanislaus County.

Cardium breweri Gabb.

Cret. B.—Martinez, Clayton, Contra Costa County; Griswold's, San Benito County; Tejon, Kern County.

Cardium cooperi Gabb.

Cret. B.—Martinez, Mount Diablo, Contra Costa County; Tejon, Kern County; San Diego.

Cardium (Lævicardium) linteum Conrad.

Cret. B—Tejon, Kern County.

Cardium (Protocardium) placerense Gabb.

Cret.—Texas Flat, Placer County.

Cardium remondianum Gabb.

Cret.—Wright's Gulch, Shasta County.

Cardium (Protocardium) translucidum Gabb.

Cret.—Martinez, Contra Costa County.

Caryatis nitida Gabb.

(*C. plana* Sowerby.)

Cret.—Vancouver and other islands, B. C.; Cow Creek, Tehama County; Chico, Butte County; Martinez, Contra Costa County; Orestimba Cañon, Stanislaus County; Europe; India.

Cerithiopsis alternata Gabb.

Cret. B.—Martinez and east of Mt. Diablo, Contra Costa County.

Chemnitzia planulata Gabb.

Cret.—Pentz's, Butte County.

Chione angulata Gabb.

Cret.—Martinez, Contra Costa County.

Chione varians Gabb.

Cret.—Jacksonville, Oregon; Siskiyou Mountains and Cow Creek, Shasta County; Chico Creek and Pentz, Butte County; Tuscan Springs, Tehama County; Texas Flat, Placer County; Folsom, Sacramento County; Benicia, Martinez, and Mount Diablo, Contra Costa County; Orestimba Cañon, Stanislaus County. (Probably includes more than one species.)

Cinulia mathewsoni Gabb.

Cret.—Martinez, Contra Costa County; Orestimba Cañon, Stanislaus County.

Cinulia obliqua Gabb.

Cret.—Vancouver and other islands, B. C.; Cottonwood Creek, Siskiyou County; Cottonwood Creek, Shasta County; Tuscan Springs, Tehama County; Chico Creek and Pentz, Butte County; Texas Flat, Placer County.

Cinulia rectilabrum Gabb.

Cret.—Millville, Shasta County; Alameda County; Arivechi, Mexico.

Clisoclus dubius Gabb.

(*C. cordatus* Meek and Hayden?)

Cret.—Vancouver and Sucia Islands, B. C.; Tuscan Springs, Tehama County; Chico Creek, Butte County; Texas Flat, Placer County.

Conus horni Gabb.

Cret. B.—Tejon, Kern County.

Conus remondi Gabb.

Cret. B.—Martinez; Mt. Diablo, Contra Costa County; Tejon, Kern County; San Diego.

Coralliochama orcutti White.

Cret.—Wallala, Mendocino County; Todos Santos Bay, Lower California.

Corbula alæormis Gabb.

Cret. B.—Lower Lake, Lake County.

Corbula cultriformis Gabb.

Cret.—Martinez, Contra Costa County.

Corbula horni Gabb.

Cret. B.—Tejon, Kern County.

Corbula parilis Gabb.

Cret. B.—Martinez; Mt. Diablo, Contra Costa County; Griswold's, San Benito County; San Diego.

Corbula primorsa Gabb.

Cret. B.—Corral Hollow, Alameda County.

Corbula traski Gabb.

Cret.—Hornby Island, B. C.?; Tuscan Springs, Tehama County; Pentz's Ranch, Butte County; Texas Flat, Placer County.

Cordiera microptygma Gabb.

Cret. B.—Tejon, Kern County.

Cordiera mitræformis Gabb.

Cret.—Near Sulphur Springs, Colusa County.

Crassatella compacta Gabb.

Cret.—Martinez, Contra Costa County.

Crassatella grandis Gabb.

Cret. B.—Placer County; Lower Lake, Lake County; Clayton, Contra Costa County; Tejon, Kern County.

Crassatella uvasana Conrad.

Cret. B.—Tejon and Uvas Passes, Kern County; San Diego.

Crioceras latus Gabb.

Cret.—Near Weaverville, Trinity County.

Cucullæa inermis Gabb.

Cret.—Millville, Shasta County; Santa Ana Mountains; Arivechi, Mexico.

Cucullæa mathewsoni Gabb.

Cret.—Lower Lake, Lake County; Martinez, Contra Costa County.

Cucullæa truncata Gabb.

(*C. glabra* Parkinson?)

Cret.—Vancouver Island, B. C.; Jacksonville, Oregon; Siskiyou Mountains; Tuscan Springs, Tehama County; Texas Flat, Placer County; Benicia, Solano County; Martinez, Mt. Diablo, Contra Costa County; Orestimba Cañon, Stanislaus County; Pacheco's Pass, Merced County; Europe?

Cylichna costata Gabb.

Cret.—Pentz's, Butte County; Texas Flat, Placer County; Martinez, Mt. Diablo, Contra Costa County; Tejon, Kern County; San Diego (perhaps two species, in Divisions A and B).

Cylindrites brevis Gabb.

Cret.—Martinez, Contra Costa County.

Cymbophora ashburneri Gabb.

Cret.—Vancouver and other islands, B. C.; Millville, Shasta County; Tuscan Springs, Tehama County; Chico and Pentz's, Butte County; Texas Flat, Placer County; Benicia, Solano County; Martinez, Contra Costa County; Orestimba Cañon, Stanislaus County; Pacheco's Pass, Merced County; Alisos Creek, Kern County.

Cypraea (Luponia) bayerquei Gabb.

Cret. B.—Martinez, Clayton, Contra Costa County; Tejon, Kern County.

Cypraea (Epona) mathewsoni Gabb.

Cret. B.—Martinez, Contra Costa County.

Dentalium cooperi Gabb.

Cret. B.—Vancouver and Hornby Islands, B. C.; Martinez, Mt. Diablo, Contra Costa County; Tejon, Kern County; San Diego.

Dentalium stramineum Gabb.

Cret. B.—Martinez, Mt. Diablo, Contra Costa County; Tejon, Kern County; San Diego.

Diodus tenuis Gabb.

Cret. B.—Corral Hollow, Alameda County.

Diptychoceras lævis Gabb.

Cret.—Cottonwood Creek, Shasta County.

Discohelix leana Gabb.

Cret.—Texas Flat, Placer County.

Donax latus Gabb.

Cret. B.—Ten miles west of Griswold's, San Benito County.

Dosinia elevata Gabb.

Cret. B.—Tejon, Kern County; San Diego.

Dosinia gyrata Gabb.

Cret. B.—Sucia Island, B. C.; Martinez, Mount Diablo, Contra Costa County; Griswold's, San Benito County; Tejon, Kern County; San Diego.

Dosinia inflata Gabb.

Cret.—Chico Creek, Butte County.

Dosinia pertenuis Gabb.

Cret.—Siskiyou Mountains; Santa Ana Mountains, Los Angeles County?

Emarginula radiata Gabb.

Cret.—Texas Flat, Placer County.

Eripachya hoffmanni Gabb.

Cret.—Cottonwood Creek, Shasta County.

Eripachya perforata Gabb.

Cret.—Cottonwood Creek, Shasta County.

Eripachya ponderosa Gabb.

Cret.—Tuscan Springs, Tehama County; Pentz's, Butte County.

Eriphyla umbonata Gabb.

Cret.—Vancouver and Sucia Islands, B. C.; Cow Creek, Shasta County; south of Mount Diablo.

Euspira alveata Conrad.

Cret. B.—Lower Lake, Lake County; Martinez, Mount Diablo, Contra Costa County; Griswold's, San Benito County; Tejon, Kern County; San Diego.

Euspira tabulata Gabb.

Cret.—Santa Ana Mountains, Los Angeles County; Arivechi, Mexico.

Exogyra parasitica Gabb.

Cret.—Cottonwood Creek, Shasta County; Texas Flat, Placer County; Folsom, Sacramento County.

Fasciolaria io Gabb.

Cret. B.—Tejon, Kern County.

Fasciolaria læviuscula Gabb.

Cret. B.—Lower Lake, Lake County; Clayton, Contra Costa County.

Fasciolaria sinuata Gabb.

Cret. B.—Tejon, Kern County; San Diego.

Ficopsis cooperi Gabb.

Cret. B.—Clayton, Contra Costa County; San Diego.

Ficopsis horni Gabb.

Cret. B.—Tejon, Kern County.

Ficopsis remondi Gabb.

Cret. B.—Martinez and Clayton, Contra Costa County; Griswolds, San Benito County; San Diego.

Fusus aratus Gabb.

Cret.—Millville, Shasta County; Martinez, Contra Costa County.

Fusus averilli Gabb.

Cret.—Tuscan Springs, Tehama County.

Fusus californicus Conrad.

Cret. B.—Lower Lake, Lake County; Clayton, Contra Costa County; Tejon, Kern County.

Fusus diaboli Gabb.

Cret. B.—Near Mt. Diablo, Contra Costa County; Tejon, Kern County.

Fusus flexuosus Gabb.

Cret.—Martinez, Contra Costa County.

Fusus kingi Gabb.

Cret.—Sucia Island, B. C.; Cottonwood Creek, Siskiyou County.

Fusus martinez Gabb.

Cret. B.—Martinez, Contra Costa County; Tejon, Kern County; San Diego.

Fusus occidentalis Gabb.

Cret.—Martinez, Contra Costa County.

Fusus tumidus Gabb.

Cret.—Martinez, Contra Costa County.

Gari? texta Gabb.

Cret.—Martinez, Contra Costa County.

Globiconcha remondi Gabb.

Cret.—Benicia, Solano County.

Gryphæa vesicularis Lamarck.

Cret.—San Luis Rey to San Diego; Eastern States and Europe.

Gyrodes expansa Gabb.

Cret.—Jacksonville, Oregon; Siskiyou Mountains, Cottonwood Creek, Shasta County; Tuscan Springs, Tehama County; Pentz, Butte County; Texas Flat, Placer County; Lower Lake, Lake County; Martinez, Contra Costa County.

Haydenia impressa Gabb.

Cret.—Tuscan Springs, Tehama County; Pentz's, Butte County.

Helcion circularis Gabb.

Cret.—Martinez, Contra Costa County.

Helcion dichotoma Gabb.

Cret.—Texas Flat, Placer County.

Helicancylus æquicostatus Gabb.

Cret.—Cottonwood Creek, Alderson's Gulch, and Eagle Creek, Shasta County.

Helicaulax bicarinata Gabb.

Cret.—Cottonwood Creek, Shasta County.

Helicaulax costata Gabb.

Cret.—Martinez, Contra Costa County.

Helicoceras breweri Gabb.

Cret.—Pentz's, Butte County.

Helicoceras declive Gabb.

Cret.—Pentz's, Butte County.

Helicoceras vermicularis Gabb.

Cret.—Martinez, Contra Costa County.

Heteroterma trochoidea Gabb.

Cret.—Martinez, Contra Costa County.

Homomya concentrica Gabb.

Cret.—Sucia Island, B. C.; Cottonwood Creek, Shasta County; Tuscan Springs, Tehama County; Martinez, Contra Costa County.

Inoceramus elliotti Gabb.

Cret.—Alcatraz Island, San Francisco County; Alameda County.

Inoceramus whitneyi Gabb.

Cret.—Millville, Shasta County; Folsom, Sacramento County.

Leda gabbi Conrad.

Cret. B.—Martinez, Clayton, Contra Costa County; Griswold's, San Benito County; Tejon, San Emidio Cañon, Kern County.

Leda translucida Gabb.

Cret.—Cow Creek, Shasta County.

Lima appressa Gabb.

Cret.—Pacheco Pass, Merced County.

Lima microtis Gabb.

Cret.—Cottonwood Creek, Shasta County; Texas Flat?, Placer County.

Lima multiradiata Gabb.

Cret. B.—Departure Bay, B. C.?; Lower Lake, Lake County; Santiago Cañon, Santa Anna Mountains, Los Angeles County.

Lima shastaensis Gabb.

Cret.—Cottonwood Creek, Shasta County.

Limopsis transversa Gabb.

Cret.—Texas Flat, Placer County.

Liocium punctatum Gabb.

Cret.—Colusa County.

Lithophagus oviformis Gabb.

Cret.—Cow Creek, Shasta County.

Loxotrema turrita Gabb.

Cret. B.—Griswolds, San Benito County; San Diego.

Lucina? cretacea Gabb.

Cret. B.—Clayton to Marsh's Creek, Contra Costa County.

Lucina cumulata Gabb.

Cret.?—Tejon, Kern County.

Lucina nasuta Gabb.

Cret.—Sucia Island, B. C.; Martinez, Contra Costa County.

Lucina postradiata Gabb.

Cret.—Texas Flat, Placer County.

Lucina subcircularis Gabb.

Cret.—Sucia Island, B. C.; Texas Flat, Placer County.

Lunatia avellana Gabb.

Cret.—Cottonwood Creek, Shasta County.

Lunatia horni Gabb.

Cret. B.—Tejon Pass, Kern County; San Diego.

Lunatia nuciformis Gabb.

Cret. B.—Clayton, Contra Costa County; Tejon Pass, Kern County; San Diego?

Lunatia shumardiana Gabb.

Cret. B.—Lower Lake, Lake County; Martinez, Contra Costa County.

Lutraria truncata Gabb.

Cret.—Chico Creek, Pentz's, Butte County.

Lysis duplicosta Gabb.

Cret.—Texas Flat, Placer County.

Mactra tenuissima Gabb.

Cret.—Martinez, Contra Costa County.

Margaritella angulata Gabb.

Cret.—Martinez, Contra Costa County.

Margaritella crenulata Gabb.

Cret. B.—San Diego.

Margaritella globosa Gabb.

Cret.—Benicia, Solano County.

Martesia clausa Gabb.

Cret.—Vancouver Island, B. C.; Pentz's, Butte County; Tuscan Springs, Tehama County; Texas Flat, Placer County.

Meekia navis Gabb.

Cret.—Chico Creek, Pentz's, Butte County; Martinez, Contra Costa County.

Meekia radiata Gabb.

Cret.—Jacksonville, Oregon; Siskiyou Mountains; Tuscan Springs, Tehama County; Chico Creek, Butte County; Orestimba Cañon, Stanislaus County; Pacheco's Pass, Merced County.

Meekia sella Gabb.

Cret.—Siskiyou Mountains; Tuscan Springs, Tehama County; Martinez, Contra Costa County.

Megistostoma striatum Gabb.

Cret. B.—Martinez; San Diego.

Meretrix arata Gabb.

Cret.—Siskiyou Mountains; Cottonwood Creek, Shasta County; Orestimba Cañon, Stanislaus County.

Meretrix californica Conrad.

Cret. B.—Tejon, Kern County.

Meretrix fragilis Gabb.

Cret.—Martinez, Contra Costa County.

Meretrix horni Gabb.

Cret. B.—Tejon Pass, Kern County; San Diego.

Meretrix lens Gabb.

Cret.—Hornby and Sucia Islands, B. C.; Chico Creek, Butte County; Santa Ana Mountains, Los Angeles County.

Meretrix longa Gabb.

Cret.—Texas Flat?; Placer County.

Meretrix ovalis Gabb.

Cret. B.—Tejon, Kern County.

Meretrix uvasana Conrad.

Cret. B.—Martinez, Mount Diablo, Contra Costa County; Griswold's, New Idria, San Benito County; Tejon, Kern County; San Diego.

Mitra cretacea Gabb.

Cret. B.—Martinez, Contra Costa County.

Modiola cylindrica Gabb.

Cret.—Tuscan Springs, Tehama County; Pentz's, Butte County.

Modiola major Gabb.

Cret.—Lake and Colusa Counties.

Modiola ornata Gabb.

Cret. B.—Hornby and Sucia Islands, B. C.; Martinez, Mount Diablo, Contra Costa County; Griswold's, New Idria, San Benito County; Tejon, Kern County.

Modiola siskiyouensis Gabb.

Cret.—Jacksonville, Oregon; Siskiyou Mountains.

Morio (Sconsia) tuberculatus Gabb.

Cret. B.—Millville, Shasta County; Martinez, Clayton, Contra Costa County; Griswold's, San Benito County; Tejon, Kern County; San Diego.

Mysia ? polita Gabb.

Cret. B.—Martinez, Clayton, Contra Costa County; New Idria, San Benito County; Tejon, Kern County.

Mytilus ascia Gabb.

Cret. B.—Tejon, Kern County.

Mytilus humerus Conrad.

Cret. B.—Tejon, Kern County.

Mytilus pauperculus Gabb.

Cret.—Sucia Island, B. C.; Martinez, Contra Costa County.

Mytilus quadratus Gabb.

Cret.—Tuscan Springs, Tehama County; Martinez, Contra Costa County.

Nassa antiquata Gabb.

Cret. B.—Martinez, Contra Costa County.

Nassa cretacea Gabb.

Cret. B.—Martinez, Contra Costa County; ten miles west of Griswold's, San Benito County; Tejon, Kern County.

Natica uvasana Gabb.

Cret. B.—Tejon, Kern County.

Naticina obliqua Gabb.

Cret. B.—Martinez, Contra Costa County; Tejon, Kern County; San Diego.

Nautilus texanus Shumard.

Cret.—Cottonwood Creek, Alderson Gulch, Shasta County; Mt. Diablo, Contra Costa County; Texas.

Neæra dolabræformis Gabb.

Cret.—Martinez, Contra Costa County.

Netihea grandicosta Gabb.

Cret.—Cottonwood Creek, Shasta County.

Neptunea (Tritonofusus) cretacea Gabb.

Cret. B.—Martinez, Contra Costa County.

Neptunea curvirostris Gabb.

Cret.—Cow Creek, Shasta County.

Neptunea? gracilis Gabb.

Cret. B.—Martinez, Contra Costa County.

Neptunea mucronata Gabb.

Cret.—Martinez, Contra Costa County.

Neptunea? supraplicata Gabb.

Cret. B.—Clayton, Contra Costa County; San Diego.

Nerinæa dispar Gabb.

Cret.—Cottonwood Creek, Shasta County.

Nerita cuneata Gabb.

Cret.—Tuscan Springs, Tehama County.

Nerita deformis Gabb.

Cret.—Cottonwood Creek, Shasta County.

Nerita (Theliostyla) triangulata Gabb.

Cret. B.—New Idria, San Benito County; near San Luis Rey to San Diego.

Neverita globosa Gabb.

Cret. B.—Millville, Shasta County; Griswold's; New Idria, San Benito County.

Neverita secta Gabb.

Cret. B.—Tejon, Kern County.

Nucula solitaria Gabb.

Cret.—Queen Charlotte's Island, B. C.; Texas Flat, Placer County.

Nucula traskana Meek.

Cret.—Vancouver Island, B. C.; Mount Diablo, Contra Costa County.

Nucula (Acila) truncata Gabb.

Cret.—Vancouver and other islands, B. C.; Tuscan Springs, Tehama County; Chico Creek; Pentz's, Butte County; Texas Flat, Placer County; Martinez, Contra Costa County; Pacheco's Pass, Merced County; Tejon, Kern County.

Olivella mathewsoni Gabb.

Cret. B.—Martinez; Clayton, Contra Costa County; Griswold's, San Benito County; Tejon, Kern County; San Diego.

Ostrea appressa Gabb.

Cret. B.—Mendocino County.

Ostrea breweri Gabb.

Cret.—Cow Creek, Shasta County; Santa Ana Mountains, Los Angeles County.

Ostrea idriaensis Gabb.

Cret. B.—New Idria, San Benito County; San Diego.

Ostrea malleiformis Gabb.

Cret.—Jacksonville, Oregon; Cottonwood Creek, Siskiyou County.

Palæatractus crassus Gabb.

Cret.—Near Sulphur Springs, Colusa County.

Patella traski Gabb.

Cret.—Texas Flat, Placer County.

Pecten californicus Gabb.

Cret.—Cottonwood Creek, Shasta County.

Pecten complexicosta Gabb.

Cret.—Morgan Valley, Lake County.

Pecten interradiatus Gabb.

Cret. B.—New Idria, San Benito County.

Pecten martinezensis Gabb.

Cret.—Martinez, Contra Costa County.

Pecten operculiformis Gabb.

Cret.—Cottonwood Creek, Shasta County; south of Mount Diablo.

Pecten traski Gabb.

Cret.—Vancouver Island, B. C.; Texas Flat, Placer County.

Perissolax blakei Conrad.

Cret. B.—Martinez, Mount Diablo, Contra Costa County; Tejon, Kern County; San Diego.

Perissolax brevirostirs Gabb.

Cret.—Sucia Island, B. C.; Tuscan Springs, Tehama County; Pentz's Ranch, Butte County; Lower Lake, Lake County; Martinez, Contra Costa County.

Pharella alta Gabb.

Cret.—Martinez, Contra Costa County.

Pholadomya breweri Gabb.

(*P. royano* D'Orbigny?)

Cret.—Vancouver and other islands, B. C.; Pentz's Ranch, Butte County; France?

Pholadomya nasuta Gabb.

Cret.—Martinez, Contra Costa County.

Pholadomya oregonensis Gabb.

Cret.—Siskiyou Mountains.

Pinna breweri Gabb.

Cret.—Cottonwood Creek, Siskiyou County; Cottonwood Creek, Shasta County; Martinez, Mt. Diablo, Contra Costa County; Santa Ana Mountains, Los Angeles County.

Pleuromya papyracea Gabb.

Cret.—Cottonwood Creek, Shasta County.

Plicatula variata Gabb.

Cret.—Battle Creek, Shasta County.

Potamides diadema Gabb.

Cret.—Cottonwood Creek, Shasta County.

Potamides tenuis Gabb.

Cret.—Denman and Sucia Islands, B. C.; Pentz's Ranch, Butte County.

Ptiloteuthis foliatus Gabb.

Cret.—Cottonwood Creek, Shasta County.

Pugnellus hamulus Gabb.

Cret.—Martinez, Contra Costa County.

Pugnellus manubriatus Gabb.

Cret.—Cottonwood Creek, Siskiyou County.

Rhynchonella whitneyi Gabb.

Cret. B.—Lake and Colusa Counties.

Rimella canalifera Gabb.

Cret. B.—Martinez, Contra Costa County; Tejon, Kern County.

Rimella simplex Gabb.

Cret. B.—Clayton, Contra Costa County; San Diego.

Ringicula varia Gabb.

Cret.—Cow Creek, Shasta County.

Ringinella pinguis Gabb.

Cret.—Martinez, Contra Costa County.

Ringinella polita Gabb.

Cret.—Colusa County.

Scalaria (Opalia) mathewsoni Gabb.

Cret. B.—Sucia Island, B. C.; Martinez, Contra Costa County.

Septifer dichotomus Gabb.

Cret. B.—Tejon, Kern County.

Siliqua oregonensis Gabb.

Cret.—Siskiyou Mountains.

Siphonodentalium pusillum Gabb.
(*Gadus pusillus* Gabb.)

Cret. B.—Martinez, Contra Costa County; Tejon, Kern County.

Solarium wallalense White.

Cret.—Wallala, Mendocino County.

Solen (Hypogella) cuneatus Gabb.

Cret.—Martinez, Contra Costa County.

Solen (Hypogella) diegoensis Gabb.

Cret. B.—San Diego.

Solen parallelus Gabb.

Cret.—Martinez and Marsh's, Contra Costa County; Tejon, Kern County.

Spirocrypta pileum Gabb.

Cret. B.—New Idria, San Benito County; Tejon, Kern County.

Stalagmium concentricum Gabb.

Cret. B.—Martinez, Contra Costa County.

Straparollus lens Gabb.

Cret.—Texas Flat, Placer County.

Straparollus paucivolvis Gabb.

Cret.—Texas Flat, Placer County.

Surcula claytonensis Gabb.

Cret. B.—Clayton, Contra Costa County; Tejon, Kern County.

Surcula inconspicua Gabb.

Cret.—Martinez, Contra Costa County.

Surcula mathewsoni Gabb.

Cret.—Martinez, Mount Diablo, Contra Costa County.

Surcula præattenuata Gabb.

Cret. B.—San Diego.

Surcula raricostata Gabb.

Cret. B.—Vancouver Island, B. C.; Clayton, Contra Costa County.

Surcula sinuata Gabb.

Cret. B.—Tejon, Kern County.

Sycodes cypræoides Gabb.
(*S. glaber* Shumard?)

Cret.—Vancouver and Sucia Islands, B. C.; Tuscan Springs, Tehama County; Texas Flat, Placer County.

Tapes conradiana Gabb.

Cret. B.—Lower Lake, Lake County; Martinez, Clayton, Contra Costa County; Griswold's, San Benito County; Tejon, Kern County.

Tapes? cretacea Gabb.

Cret. B.—Corral Hollow, Alameda County.

Tapes? quadrata Gabb.

Cret. B.—Martinez; Clayton, Contra Costa County; Tejon, Kern County.

Tellina æqualis Gabb.

Cret.—Martinez, Contra Costa County.

Tellina ashburneri Gabb.

Cret.—Millville, Shasta County; Pentz's, Butte County.

Tellina californica Gabb.

Cret. B.—Marsh's, Contra Costa County; Tejon, Kern County.

Tellina decurtata Gabb.

Cret.—Pentz's, Butte County.

Tellina hoffmanniana Gabb.

Cret.—Pentz's, Butte County; Martinez, Contra Costa County; Griswold's, San Benito County.

Tellina horni Gabb.

Cret. B.—Clayton, Contra Costa County; Tejon, Kern County.

Tellina longa Gabb.

Cret. B.—Martinez, Clayton, Marsh's, Contra Costa County; Tejon, Kern County.

Tellina mathewsoni Gabb.

Cret.—Vancouver Island, B. C.; Millville, Shasta County; Martinez, Contra Costa County.

Tellina monilifera Gabb.

Cret.—Texas Flat, Placer County.

Tellina ooides Gabb.

Cret.—Pentz's, Butte County; Martinez, Contra Costa County.

Tellina parilis Gabb.

Cret.—Martinez, Contra Costa County.

Tellina quadrata Gabb.

Cret.—Hornby Island, B. C.; Tuscan Springs, Tehama County.

Tellina remondi Gabb.

Cret. B.—Martinez, Mt. Diablo, Contra Costa County; Tejon, Kern County.

Tellina? undulifera Gabb.

Cret.—Martinez, Contra Costa County.

Tellina (Sanguinolaria) whitneyi Gabb.

Cret.—Jacksonville, Oregon.

Terebra californica Gabb.

Cret. B.—Martinez, Contra Costa County.

Terebratella obesa Gabb.

Cret.—Queen Charlotte's Island, B. C.; Texas Flat, Placer County.

Tessarolax distorta Gabb.

Cret.—Vancouver Island, B. C.; Tuscan Springs, Tehama County.

Thetis elongata Gabb.

Cret.—Cottonwood Creek, Shasta County.

Trapezium carinatum Gabb.

Cret.—Texas Flat, Placer County.

Trigonia æquicostata Gabb.

Cret.—Oregon; Cottonwood Creek, Shasta County; Martinez and south of Mount Diablo, Contra Costa County; Orestimba Cañon, Stanislaus County.

Trigonia evansana Meek.

Cret.—Vancouver Island, B. C.; Oregon; Siskiyou Mountains; Cottonwood Creek, Shasta County; Tuscan Springs, Tehama County; Chico Creek and Pentz, Butte County; Texas Flat, Placer County; Rag Cañon, Lake County; Benicia, Solano County; Martinez, Contra Costa County; Orestimba Cañon, Stanislaus County; Pacheco Pass, Merced County; Santa Ana Mountains, Los Angeles County.

Trigonia leana Gabb.

Cret.—Jacksonville, Oregon; Martinez, Contra Costa County; South America?

Trigonia tryoniana Gabb.

Cret.—Vancouver Island, B. C.; Tuscan Springs, Tehama County.

Tritonium californicum Gabb.

Cret. B.—Tejon, Kern County; San Diego.

Tritonium (Trachytriton) diegoense Gabb.

Cret. B.—San Diego.

Tritonium (Trachytriton) fusiforme Gabb.

Cret. B.—Tejon, Kern County.

Tritonium horni Gabb.

Cret. B.—Near Mt. Diablo, Contra Costa County; Tejon, Kern County.

Tritonium paucivaricatum Gabb.

Cret. B.—Tejon, Kern County.

Tritonium (Trachytriton) tejonensis Gabb.

Cret. B.—Tejon, Kern County.

Tritonium whitneyi Gabb.

Cret. B.—Tejon, Kern County; San Diego.

Turbinella crassitesta Gabb.

Cret.—Martinez, Contra Costa County.

Turnus plenus Gabb.

Cret.—Cottonwood Creek, Shasta County; Pacheco's Pass, Merced County.

Turritella chicoensis Gabb.

Cret.—Chico Creek, Butte County.

Turritella infragranulata Gabb.

Cret.—Martinez, Contra Costa County.

Turritella infralineata Gabb.

Cret.—Cottonwood Creek, Shasta County; Orestimba Cañon, Stanislaus County.

Turritella martinezensis Gabb.

Cret. B.—Martinez, Contra Costa County.

Turritella robusta Gabb.

Cret.—Tuscan Springs, Tehama County.

Turritella saffordi Gabb.

Cret.—Lower Lake, Lake County; near Suisun, Solano County; Martinez, Contra Costa County; Tennessee; New Jersey.

Turritella seriatim-granulata Rœmer.

Cret.—Cottonwood Creek, Siskiyou County; Cottonwood Creek, Shasta County; Tuscan Springs, Tehama County; Santa Ana Mountains, Los Angeles County; Arivechi, Mexico; Texas.

Turritella uvasana Conrad.

Cret.—Martinez, Contra Costa County; Griswolds, San Benito County; Tejon, Kern County; San Diego.

Unio penultimus Gabb.

Cret. B.—Coal mines near Clayton, Contra Costa County.

Urosyca caudata Gabb.

Cret.—Martinez, Contra Costa County.

Venus æquilateralis Gabb.

Cret. B.—Near San Luis Rey to San Diego.

Venus lenticularis Gabb.

Cret.—Benicia, Solano County; Mount Diablo, Contra Costa County.

Venus tetrahedra Gabb.

Cret.—Tuscan Springs, Tehama County.

Volutilithes navarroensis Shumard.
(Fulguraria elongata? D'Orbigny.)

Cret.—Jacksonville, Oregon; Siskiyou Mountains; Cow Creek, Shasta County; Tuscan Springs, Tehama County; Chico Creek, Butte County; Texas; France? India?

CRETACEOUS AND EOCENE RADIATA.

Astrocœnia? petrosa Gabb.

Cret.—Martinez, Contra Costa County.

Flabellum remondianum Gabb.

Cret.—Clayton, Contra Costa County.

Smilotrochus curtus Gabb.

Cret.—Martinez, Contra Costa County.

Trochosmilia (Acrosmilia) striata Gabb.

Cret. B.—Clayton, Contra Costa County.

Trochosmilia (Ellipsosmilia) granulifera Gabb.

Cret.—Chico Creek, Butte County.

JURASSIC MOLLUSCA.

Ammonites colfaxii Gabb.

Jur.—Colfax, Placer County; Robinson's Ferry, Stanislaus County.

Astarte ventricosa Meek.

Jur.—Genesee Valley, Plumas County.

Amussium aurarium Meek.

Jur.—Mariposa.

Aucella erringtoni Gabb.

Jur.—Mariposa to Coulterville, Mariposa County.

Belemnites pacificus Gabb.

Jur.—Mariposa to Coulterville, Mariposa County; Spanish Flat, El Dorado County.

Inoceramus obliquus Meek.

Jur.—Genesee Valley, Plumas County.

Inoceramus rectangulus Meek.

Jur.—Genesee Valley, Plumas County.

Lima ? cuneata Meek.

Jur.—Genesee Valley, Plumas County.

Lima recticostata Meek.

Jur.—Genesee Valley, Plumas County.

Lima sinuata Meek.

Jur.—Genesee Valley, Plumas County.

Myacites depressus Meek.

Jur.—Genesee Valley, Plumas County; Volcano, Nevada.

Mytilus multistriatus Meek.

Jur.—Genesee Valley, Plumas County.

Pecten acutiplicatus Meek.

Jur.—Genesee Valley, Plumas County.

Pholadomya orbiculata Gabb.

Jur.—Mariposa.

Rhynchonella gnathophora Meek.

Jur.—Genesee Valley, Plumas County.

Trigonia pandicosta Meek.

Jur.—Genesee Valley, Plumas County.

Unicardium gibbosum Meek.

Jur.—Genesee Valley, Plumas County.

TRIASSIC MOLLUSCA.

Arcestes gabbi Meek.

Tri.—Humboldt County, Nevada; Plumas County, California ?

Ammonites billingsianus Gabb.

Tri.—Humboldt County, Nevada; Plumas County, California.

Ammonites homfrayi Gabb.

Tri.—Humboldt County, Nevada; Plumas County, California.

Ammonites ramsaueri Quenstedt.

Tri.—Gifford's, Plumas County; Humboldt, Nevada.

Avicula homfrayi Gabb.

Tri.—Star City, Humboldt County, Nevada; Plumas County, California.

Avicula mucronata Gabb.

Tri.—Gifford's, Plumas County.

Ceratites haidingeri Hauer.

Tri.—Humboldt County, Nevada; Plumas County, California?

Clydonites lævidorsatus Hauer.

Tri. ?—Spanish Flat, El Dorado County?; Coloma, Amador County; White Mountains, Inyo County, California; near Dayton, Nevada.

Corbula blakei Gabb.

Tri.—Humboldt County, Nevada; Plumas County, California.

Gymnotoceras blakei Gabb.

Tri.—Near Star City, Humboldt County, Nevada; Plumas County, California?

Halobia dubia Gabb.

Tri.—Gifford's, Plumas County, California; Star City, Humboldt County, Nevada.

Monotis subcircularis Gabb.

Tri.—Gifford's, Plumas County, California; Star City, Humboldt County, Nevada; Vancouver Island and Peace River, British Columbia.

Myacites (Panopœa) humboldtensis Gabb.

Tri.—Gifford's, Plumas County, California; Humboldt County, Nevada.

Myophoria alta Gabb.

Tri.—Dun Glen, Humboldt County, Nevada; Plumas County, California?

Mytilus homfrayi Gabb.

Tri.—Dun Glen, Humboldt County, Nevada; Plumas County, California?

Nautilus multicameratus Gabb.

Tri.—Dun Glen, Humboldt County, Nevada; Plumas County, California?

Nautilus whitneyi Gabb.

Tri.—Buena Vista, Humboldt County, Nevada; Plumas County, California?

Orthoceratites blakei Gabb.

Tri.—Buena Vista, Humboldt County, Nevada; Volcano, Nevada; Plumas County, California.

Pecten deformis Gabb.

Tri.—Giffords, Genesee Valley, Plumas County, California.

Posidonomya daytonensis Gabb.

Tri.—Near Dayton, Nevada; Plumas County, California?

Posidonomya stella Gabb.

Tri.—Star City, Humboldt County, Nevada; Plumas County, California?

Rhynchonella æquiplicata Gabb.

Tri.—Cinnabar, Humboldt County, Nevada; Plumas County, California?

Rhynchonella lingulata Gabb.

Tri.—Star City, Humboldt County, Nevada; Plumas County, California.

Rhynchopterus obesus Gabb.

Tri.—Near Humboldt City, Nevada.

Spirifer homfrayi Gabb.

Tri.—Star City, Humboldt County, Nevada; Plumas County, California?

Terebratula humboldtensis Gabb.

Tri.—Star City, Humboldt County, Nevada; Plumas County, California?

Trachyceras whitneyi Gabb.

Tri.—Humboldt County, Nevada; Plumas County, California?

CARBONIFEROUS MOLLUSCA.

Euomphalus (Omphalotrochus) whitneyi Meek.

Carb.—Shasta County.

Productus giganteus Martin.

Carb.—McCloud River, Shasta County; Europe.

Productus semireticulatus Martin.

Carb.—Flathead Valley (latitude 49°), British Columbia; Shasta County, California; Missouri?; South America; England; Ireland.

Retzia compressa Meek.

Carb.—Shasta County.

Spirifer lineatus? Martin.

Carb.—Shasta County; Iowa; England; Ireland.

CARBONIFEROUS RADIATA.

Clisiophyllum gabbi Meek.

Carb.—Shasta County.

Lithostrotion californiensis Meek.

Carb.—Shasta County.

Lithostrotion mamillare? Castelnau.

Carb.—Shasta County; Mississippi Valley.

CARBONIFEROUS PROTOZOA.

Fusulina cylindrica Fischer.

Carb.—Bass Ranch, Shasta County; British Columbia; Russia.

Fusulina gracilis Meek.

Carb.—Bass Ranch, Shasta County.

Fusulina robusta Meek.

Carb.—Bass Ranch, Shasta County.

ADDITION TO MAMMALIA (page 224).

Morotherium giganteum Marsh.

Pl.—"Central California." An extinct sloth, which may have made the tracks like gigantic human footprints found in the Carson quarry.

TERTIARY PLANTS.*

ACER—Maple.

Acer æquidentatum Lesquereux.

Pl.—Chalk Bluffs, Nevada County; Colorado; Greenland.

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*Note.—The uncertainty of evidence as to the age of formations, is greater when derived from plants, than from animal remains. Several species are here added from the United States government reports, now in preparation. Professor Lesquereux has revised this catalogue.

Acer arcticum Heer.

Pl. and Mioc.—Chalk Bluffs, Nevada County; Forest City, Sierra County; Bad Lands, Nebraska; Alaska; Arctic Zone.

Acer bendirei Lesquereux.

Mioc.—Monte Cristo Tunnel, Spanish Peak, Plumas County.

Acer bolanderi Lesquereux.

Pl.—Table Mountain, Tuolumne County.

Acer sextianum Saporta.

Pl.?, Mioc., and Eocene.—Chalk Bluffs, Nevada County; France.

ALNUS—Alder.

Alnus corralina Lesquereux.

Pl. and Mioc.—Corral Hollow, Alameda County; John Day Valley, Oregon.

Alnus kefersteini Gœppert.

Mioc.—Shasta County, California; Wyoming; Arctic Zone; Europe.

ARALIA—Spikenard.

Aralia acerifolia Lesquereux.

l. and Mioc.—Chalk Bluffs, Nevada County; Bad Lands, Nebraska.

Aralia angustiloba Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Aralia lasseniana Lesquereux.

Mioc.—Lassen County.

Aralia whitneyi Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Aralia zaddachi Heer.

Pl. and Mioc.—Chalk Bluffs, Nevada County; Europe.

BETULA—Birch.

Betula æqualis Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

CARYA—Hickory.

Carya bilinica Unger.

Mioc.—Monte Cristo Tunnel, Spanish Peak, Plumas County, California.

CASTANEA—Chestnut.

Castanea ungeri Heer.

Mioc.—Rock Corral, Placer County; Corral Hollow, San Joaquin County; British Columbia; Alaska; Greenland; Europe.

Castanopsis chrysophylloides Lesquereux.

Pl.—Chalk Bluffs, Nevada County. Like the Chinquapins.

Cercocarpus antiquus Lesquereux.

Pl.—Table Mountain, Tuolumne County. Like "Mountain Mahogany."

CINNAMOMUM—Cinnamon.

Cinnamomum affine Lesquereux.

Mioc.—Corral Hollow, San Joaquin County; Colorado; Carbon, Wyoming Territory; Europe.

Cinnamomum scheuchzeri Heer.

Mioc.—Lassen County, California; Wyoming; Europe.

COLUTEA—Bladder-senna.

Colutea boweniana Lesquereux.

("*C. oregonensis*" in Catalogue Hayden's Survey, p. 272.)

Mioc.—"Bowen's Claim, Oregon." (Professor Whitney and C. D. Voy state that this claim is in Nevada County, California.)

CORNUS—Dogwood.

Cornus hyperborea Heer.

Mioc.—Lassen County, California; Arctic Zone.

Cornus kelloggii Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Cornus ovalis Lesquereux.

Pl.—Table Mountain, Tuolumne County.

Diospyros virginiana Linnæus.

(var. *turneri* Lesquereux.)

Mioc.—Contra Costa County. Apparently a variety of the eastern persimmon.

FAGUS—Beech.

Fagus antipofi Heer.

Pl. and Mioc.—Table Mountain, Tuolumne County; British Columbia; Alaska; Europe.

Fagus pseudo-ferruginea Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

FICUS—Fig.

Ficus asiminæfolia Lesquereux.

Mioc.—Rock Corral, Placer County.

Ficus appendiculata Heer.

Mioc.—Lassen County.

Ficus microphylla Lesquereux.

Pl.—Table Mountain, Toulumne County.

Ficus sordida Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Ficus tiliæfolia Al. Brogniart.

Pl.?, *Mioc.*, *and Eocene*—Forest City, Sierra County; Chalk Bluffs, Nevada County; Carbon, Wyoming; Colorado; Bad Lands, Dakota; Europe.

Geonomites schimperi Lesquereux.

Mioc. and Eocene—Contra Costa County, California; Yellowstone Lake, Wyoming. An extinct palm tree.

ILEX—Holly.

Ilex prunifolia Lesquereux.

Pl.—Table Mountain, Tuolumne County.

JUGLANS—Walnut.

Juglans californica Lesquereux.

Pl.—Chalk Bluffs, Nevada County. (Not the living species of same name; but the fossil has priority.)

Juglans egregia Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Juglans aurinea Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Juglans oregoniana Lesquereux.

Pl. and Mioc.?—Oregon; Chalk Bluffs, Nevada County.

Juglans rugosa Lesquereux.

Mioc.—Lassen County; Wyoming; Montana.

LAURUS—Laurel.

Laurus californica Lesquereux.

Mioc.—Corral Hollow, San Joaquin County; Monte Cristo Tunnel, Spanish Peak, Plumas County. (Not the living "California Laurel," *Oreodaphne.*)

Laurus furstenbergi Al. Brogniart.

Mioc.—Corral Hollow, San Joaquin County.

Laurus grandis Lesquereux.

Mioc.—Corral Hollow, San Joaquin County.

Laurus princeps Heer.

Mioc.—Corral Hollow, San Joaquin County; Europe.

Laurus resurgens ? Saporta.

Mioc.—Corral Hollow, San Joaquin County; Montana.

Laurus salicifolia Lesquereux.

Mioc.—Corral Hollow, San Joaquin County.

Laurus socialis Lesquereux.

Mioc.—Lassen County; Wyoming.

LIQUIDAMBAR—Sweet Gum.

Liquidambar californicum Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

MAGNOLIA.

Magnolia californica Lesquereux.

Pl. and Mioc.—Chalk Bluffs, Nevada County; Lassen County; Contra Costa County.

Magnolia inglefieldi Heer.

Mioc.—Lassen County; Wyoming.

Magnolia lanceolata Lesquereux.

Pl.—Chalk Bluffs, Nevada County; Forest City, Sierra County.

MYRICA—Wax Myrtle.

Myrica ungeri Heer.

Mioc.—Monte Cristo Tunnel, Spanish Peak, Plumas County.

MYRTUS—Myrtle.

Myrtus oregonensis Lesquereux.

Mioc.—Corral Hollow, San Joaquin County; Oregon?

OREODAPHNE—Mountain Laurel.

Oreodaphne heeri Gaudichaud.

Mioc.—Lassen County.

Oreodaphne litseæformis Lesquereux.

Mioc.—Lassen County.

PERSEA—Alligator Pear.

Persea dolleri Lesquereux.

Mioc.—Shasta County, California.

Persea pseudo-carolinensis Lesquereux.

Mioc.—Corral Hollow, Alameda County.

Persea punctulata Lesquereux.

Mioc.—Corral Hollow, Alameda County.

Phragmites œningensis Al. Brogniart.

Mioc.—Lassen County; Colorado; New Mexico; Arctic Zone; Europe. A species of cane.

PLATANUS—Sycamore.

Platanus appendiculata Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Platanus dissecta Lesquereux.

Pl.—Chalk Bluffs, Nevada County; Table Mountain, Tuolumne County.
Mioc.—Monte Cristo Tunnel, Plumas County.

POPULUS—Poplar.

Populus balsamoides Goeppert.

Pl.? and Mioc.—Corral Hollow, San Joaquin County; Alaska; Wyoming; Bad Lands, Dakota; Europe.

Populus zaddachi Heer.

Pl.?, Mioc., and Eocene—Chalk Bluffs, Nevada County; Bad Lands, Dakota; Colorado; Alaska; Greenland; Spitzbergen; Europe.

Pterospermites spectabilis Heer.

Mioc.—Monte Cristo Tunnel, summit of Spanish Peak, Plumas County.

QUERCUS—Oak.

Quercus boweniana Lesquereux.

Pl.—Bowen's Claim, Nevada County.

Quercus convexa Lesquereux.

Pl.—Table Mountain, Tuolumne County.

Quercus distincta Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Quercus elænoides Lesquereux.

Pl.—Table Mountain, Tuolumne County.

Quercus furcinervis Rossmassler.

Mioc. and Eoc.—Plumas County, California; Bridge Creek and Cascade Mountains, Oregon; Greenland; Europe.

Quercus goepperti Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Quercus moorii Lesquereux.

Mioc.—Lassen County, California; Mississippi.

Quercus nevadensis Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Quercus olafseni Heer.

Pl. and Mioc.—Table Mountain, Tuolumne County, and Lassen County, California; Bad Lands, Dakota; Utah; Greenland.

Quercus pseudo-chrysophylla Lesquereux.

Pl.?—Forest City, Sierra County. Living? (*Q. densiflora ?* living.)

Quercus pseudo-lyrata Lesquereux.

Pl.—Chalk Bluffs ?, Nevada County.

Quercus steenstrupiana ? Heer.

Pl. and Mioc.—Forest City, Sierra County; Arctic; Greenland.

Quercus transgressa Lesquereux.

Pl.?—Forest City, Sierra County. Living? (=*Q. chrysolepis?* living.)

Quercus voyana Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

RHUS—Sumach.

Rhus boweniana Lesquereux.

Pl.—Table Mountain, Tuolumne County.

Rhus dispersa Lesquereux.

Pl.—Table Mountain, Tuolumne County.

Rhus heufleri Heer.

Mioc.—Corral Hollow, Alameda County.

Rhus metopioides Lesquereux.

Pl.—Table Mountain, Tuolumne County.

Rhus mixta Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Rhus myricæfolia Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Rhus typhinoides Lesquereux.

Pl.—Table Mountain, Tuolumne County.

Sabalites californicus Lesquereux.

Pl.—Chalk Bluffs, Nevada County. An extinct kind of Palmetto.

SALIX—Willow.

Salix californica Lesquereux.

Pl. ?—Table Mountain, Tuolumne County.

Salix elliptica Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Salix integra Goeppert.

Mioc.—Corral Hollow, San Joaquin County; Europe.

Salix varians Goeppert.

Pl., *Mioc.*, *and Eoc.*—Table Mountain, Tuolumne County; Corral Hollow, San Joaquin County; Alaska; Greenland; Europe.

Sequoia angustifolia Lesquereux.

Mioc.—Corral Hollow, San Joaquin County. A kind of Redwood.

Taxites olriki Heer.

Mioc.—Corral Hollow, San Joaquin County; Alaska; Greenland; Spitzbergen. Resembling the yew trees.

ULMUS—Elm.

Ulmus californica Lesquereux.

Pl.—Chalk Bluffs, Nevada County; Table Mountain, Tuolumne County.

Ulmus affinis Lesquereux.

Pl.—Table Mountain, Tuolumne County.

Ulmus pseudo-fulva Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Viburnum whymperi? Heer.

Mioc.—Shasta County; Wyoming; Alaska? Related to the Laurestinus.

Zanthoxylon diversifolium Lesquereux.

Pl.—"Bowens claim," Oregon; Nevada County, California. Like the eastern "Toothache Tree."

ZIZYPHUS—Lotus Tree.

Zizyphus microphyllus Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

Zizyphus piperoides Lesquereux.

Pl.—Chalk Bluffs, Nevada County.

CRETACEOUS PLANT.

Juglans debeyana Heer.

Cret. (possibly Eocene).—Rock Corral, Placer County; "100 feet deep in cretaceous rocks;" Dakota; Colorado. Leaflets only known, not unlike those of *J. regia.*

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