RECONNAISSANCE OF THE BARSTOW-KRAMER REGION, CALIFORNIA.

By R. W. Pack.

INTRODUCTION.

PURPOSE OF THE REPORT.

From time to time since 1900 the region between Mohave and Barstow in the Mohave Desert, Cal., has attracted attention as a possible oil field, and a report that valuable light-gravity oil occurs there has been widely circulated. Great stretches of land in the northern part of the desert have been located as oil claims, a considerable number of derricks have been erected, and wells have been drilled at four rather widely separated localities. Indications of oil have been reported in at least two of these wells. In the early part of December, 1912, the writer spent a few days in a reconnaissance of the eastern part of this region in order to obtain a general understanding of its broader geologic features and to determine if possible from such a study whether or not oil might reasonably be expected to occur there in sufficient amounts to be commercially valuable.

CONCLUSIONS.

The main conclusion arrived at as a result of this examination is entirely adverse to the idea that oil occurs in this region. Traces of oil and gas are present in different parts of the world in fine-grained sedimentary beds, and it is possible that similar traces of oil may exist in the fine-grained detrital beds of this region, but the writer believes it highly improbable that oil and gas occur here in greater amounts. The reasons for this conclusion are given in detail at the end of the report.

GEOLOGIC MAPPING.

The geology and structure of this region are far from simple, and although the work was detailed enough to fully warrant the preceding statement regarding the occurrence of oil, it was not sufficient to furnish data for more than a superficial description of the areal geology. On the sketch map (Pl. VII) the areal extent of the several groups of rocks has been shown. The boundaries of these areas have

been located by rough compass triangulation and by pacing from section corners wherever such corners could be discovered. In parts of the region, notably along the eastern edge and in the north-central portion, the land lines have recently been resurveyed, and a considerable number of corners were found, but in much of it the geologic boundaries shown are only sketched. This is particularly true of the area between Barstow and the Chicago Oil Co.'s well, where very little effort was made to place accurately the line of contact between the complex of pre-Tertiary rocks and the Tertiary rhyolitic flows and tuffs.

ACKNOWLEDGMENTS.

Mr. R. G. Davies assisted in the examination, and the mapping of the northwestern portion of the region here discussed is largely the result of his work. Messrs. S. L. Gillan and Frank Farmer, mineral inspectors for the General Land Office, made a reconnaissance of this area in May, 1911, and the results of their work have been found most useful in the preparation of the present report.

The writer takes pleasure in acknowledging his indebtedness also to Mr. L. J. Pepperberg, of San Francisco; Messrs. C. E. Kendrick and G. D. Hutchinson, of Barstow; and Messrs. William F. Forsyth and J. P. Jacobs, of the Kramer Consolidated Oil Co., for information and assistance of various kinds.

GENERAL GEOGRAPHIC AND TOPOGRAPHIC FEATURES.

The area here described lies in the central part of the Mohave Desert in San Bernardino County, Cal. Its location is shown in the index map on Plate VII. Two railroads pass through it—the Atchison, Topeka & Santa Fe Railway, with two lines which join at Barstow, one to San Francisco and the other to Los Angeles, and the San Pedro, Los Angeles & Salt Lake Railroad, which, through most of this region runs over the Los Angeles branch of the Santa Fe. The only settlement of any considerable size is Barstow, which has about 800 or 900 inhabitants. It lies approximately 140 miles by rail east of Los Angeles.

The topography is typical of that existing throughout the Great Basin. Much of the region is occupied by broad, practically level stretches of desert sand and gravel, from which irregular barren ridges and hill groups rise rather abruptly to elevations of several hundred feet above the plain. These barren hills rising in the midst of a broad expanse of sand look not unlike islands rising out of the sea. The abruptness with which many of the hills rise from the desert gives the impression that the alluvial basins are deep. This idea is strengthened by the fact that one of the wells drilled here has, as nearly as can be judged from the imperfect record kept, penetrated many

hundred feet of loosely consolidated sand and gravel. In the main, however, the thickness of the alluvium and the contour of the basins in which it was deposited can only be left to the imagination.

The granitic and older crystalline rocks weather to rounded somber-colored hills. The younger volcanic and clastic beds, however, are highly colored and present a wonderful array of reds, greens, browns, and blues, which, combined with the peculiar rugged topography characteristic of them, form a striking and in places fantastic landscape.

The region is very poorly watered, the annual rainfall being rarely over 5 inches and commonly less than 3 inches. Wells along the course of Mohave River and near the center of some of the inclosed drainage basins afford a small quantity of water, in places sufficient to irrigate a few acres. Small farms are tilled along the river and at a few places near the dry lakes where water can be obtained in shallow wells, but for the most part the land in this portion of the desert has at present little use other than as a rather poor range. Except for scattered ranches along the river and between Hinkley and Black's ranch the region outside of Barstow and Daggett is practically uninhabited. The vegetation is limited to the common desert types, mainly small shrubs, cacti, bunch grass, and yucca. A group of mesquite near Black's ranch are the only trees outside of the river valley.

The main drainage line is Mohave River, which flows to its sink in the east end of the desert, some 50 miles to the northeast. Much of the region, however, drains into inclosed basins whose centers are occupied in the wet season by shallow lakes, the largest of which, known as Harper Lake, is shown on the map. These lakes or playas are dry during the greater part of the year and their beds form hard pavement-like surfaces swept bare of all dust by the heavy winds that are characteristic of the region, but with a slight rain the playas become impassable bogs.

PREVIOUS KNOWLEDGE OF THE GEOLOGY.

But little has been published about the geology of this region. Most of the written accounts are either descriptions of brief reconnaissance trips, such as that on which the present paper is based, or else detailed descriptions of some very local mineral deposit, mainly the borax near Daggett. The only published account that attempts to give a comprehensive idea of the geology of the area here discussed is that by C. L. Baker entitled "Notes on the later Cenozoic history of the Mohave Desert region in southeastern California."[1] This paper gives also a bibliography of other papers describing the general region.

[1] Univ. California Dept. Geology Bull., vol. 6, No. 15, pp. 34–43, 1911.

GEOLOGY.

MAIN GROUPS OF ROCKS.

The rocks in this part of the Mohave Desert may conveniently be described as belonging to four main groups—(1) a complex association of rocks of pre-Tertiary age composed of more or less altered sedimentary and igneous rocks, (2) volcanic flows and tuffs with interstratified detrital beds, mainly fine sand and clay, of Tertiary age, (3) a basaltic flow of Quaternary age, and (4) Recent deposits of unconsolidated gravel, sand, and clay. The rocks included in the first three groups have been tilted from their original position, closely folded, and faulted, and their present structure is complex. They form the numerous hill groups which rise out of the level sandy plain and evidently also continue under the plain as the floor upon which the flat-lying sand beds were laid down. The Recent unconsolidated materials, which constitute the fourth group, have now practically the same attitude as they had when they were deposited. They not only occupy the centers of the topographic basins but in places extend for considerable distances up the flanks of the rocky hills, where they cap the interarroyo ridges. Besides these practically flat-lying beds of gravel and sand, thick masses of similar materials, having a slightly greater though still a low dip, occur south of the Chicago well and also south of Mohave River between Barstow and Daggett.

PRE-TERTIARY ROCKS.

The pre-Tertiary rocks in this part of the Mohave Desert comprise schist, gneiss, crystalline limestone, and some less altered sedimentary and volcanic rocks, together with granitoid rocks of various kinds, some of which are intrusive into the metamorphic rocks. This complex forms a large number of the rocky hill groups which rise above the desert in this and adjacent regions, and with little question was the basement upon which the Tertiary and Quaternary beds were deposited.

Metamorphic and granitic rocks of this general type are distributed widely over southeastern California and the neighboring parts of Nevada and Arizona. Only a small amount of geologic work has been done on them in the central part of the Mohave Desert, and in consequence little can be said definitely concerning their age. The nearest point to the Barstow-Kramer region at which the age of rocks of this type has been accurately determined is between 60 and 80 miles to the north, in the Funeral and Kingston ranges, where various altered early Paleozoic sedimentary formations rest upon nonfossiliferous rocks that are believed to be pre-Cambrian. The geology of these ranges is described by Gilbert,[1] Campbell,[2] and

[1] Gilbert, G. K., Report on the geology of portions of Nevada, Utah, California, and Arizona: U. S. Geol. and Geog. Surveys W. 100th Mer., vol. 3, pp. 33, 179, 181, 1875.

[2] Campbell, M. R., Reconnaissance of the borax deposits of Death Valley and Mohave Desert: U. S. Geol. Survey Bull. 200, p. 14, 1902.

Spurr.[1] The Randsburg district, which lies 15 or 20 miles northwest of the area shown on the accompanying map (Pl. VII), is described by Hess.[2] The oldest rocks there are granite and schist, the schist probably being the younger of the two, although the relationship is not entirely distinct. The quadrangle also contains a younger series of altered sedimentary rocks which on the evidence of a few poorly preserved fossils is regarded as not younger than Carboniferous. The granite, which according to Hess is probably the oldest rock in the Randsburg region, continues southeastward, forming Fremont Peak and the low hills in the northwest corner of the area shown on Plate VII. The San Bernardino Mountains, which lie 40 or 50 miles south of Barstow, are, according to Mendenhall,[3] formed largely of granitic and dioritic rocks. These rocks are intrusive into metamorphosed sedimentary rocks of unknown age. Hershey[4] briefly describes the complex of gneiss, schist, and old igneous rocks near Barstow, correlating them with the pre-Cambrian rocks of Inyo County, to the north. He also describes limestone and quartzite in the Granite Mountains, 15 or 20 miles south of Barstow, and correlates them with Lower Cambrian rocks in the White Mountains of Inyo County. These correlations by Hershey are based wholly upon the general lithologic similarity and degree of metamorphism of the rocks in the two places and can not be regarded as established.

Granitoid rocks form the greatest part of the surface in the areas shown on the accompanying map as occupied by the pre-Tertiary complex. Some of the granite is younger than the metamorphosed sedimentary rocks and may belong to the same general period of intrusion as the granite in the Sierra Nevada. Part of it, however, particularly that in the northwest corner of the area, which forms the continuation of the granitic rocks in the Randsburg district, may be much older.

TERTIARY ROCKS.

GENERAL CHARACTER AND CORRELATION.

Resting with marked unconformity upon the complex just described are rocks of Tertiary age, which comprise a variety of volcanic flows and tuffs interstratified with sedimentary beds of diverse kinds, from chemically deposited limestone to bowlder beds containing fragments several feet in diameter. Tertiary rocks of this general type are found in many parts of the Mohave Desert, from

[1] Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U. S. Geol. Survey Bull. 208, pp. 187-200, 1903.

[2] Hess, F. L., Gold mining in the Randsburg quadrangle, California: U. S. Geol. Survey Bull. 430, pp. 23-47, 1910.

[3] Mendenhall, W. C., unpublished notes.

[4] Hershey, O. H., Some crystalline rocks of southern California: Am. Geologist, vol. 29, p. 286, 1902.

its western edge eastward far beyond the area described in the present report. About Barstow they form many of the rocky hills which rise above the desert and evidently extend over considerable areas beneath the Recent sand and gravel that constitute the surface of the desert.

The Tertiary rocks in this part of the Mohave Desert have been briefly described by Hershey,[1] who correlates all of them except some beds of reddish sandstone, conglomerate, and tuff exposed near Mohave River between Barstow and Daggett with the "Rosamond series," which he describes as typically exposed in the western part of the desert. The reddish beds mentioned above he believes to be younger than the "Rosamond" and the same as rocks which he terms the "Escondido series," also typically exposed in the western part of the desert. In a later paper the same author published a map[2] on which the distribution of the "Rosamond" and "Escondido" about Barstow are shown.

The name "Mohave beds" was applied by Merriam[3] to the Tertiary rocks which contain mammalian remains in the Barstow syncline. He says:

> According to a sketch map published by Hershey the point at which the collection was made would fall within the limits of what is designated by Hershey as the Rosamond series. This series has not, however, been characterized in any way, so that the nature of the formation is unknown. As geographic location is one of the important factors concerned, the horizon at which this collection was obtained may be referred to under a geographic designation as the Mohave beds.

Baker[4] in describing the Tertiary rocks about Barstow restricted the term "Rosamond" to the part of the section that is composed predominantly of sedimentary rocks, offering evidence that these rocks rest unconformably upon older volcanic rocks which Hershey included in the "Rosamond."

Tertiary rocks like those in the Barstow-Kramer region occur in Red Rock Canyon, about 60 miles northwest of Barstow. These rocks were described by Fairbanks,[5] who found in them a few fossil leaves that Knowlton determined as of Tertiary and probably of Eocene age. These beds were described as the "Mojave formation" and correlated with the Eocene by Smith,[6] who based his correlation entirely on Fairbanks's description. The Tertiary rocks in and

[1] Hershey, O. H., Some Tertiary formations of southern California: Am. Geologist, vol. 29, pp. 367, 368, 1902.

[2] Hershey, O. H., The Quaternary of southern California: Univ. California Dept. Geology Bull., vol. 3, No. 1, Pl. I, 1902.

[3] Merriam, J. C., A collection of mammalian remains from Tertiary beds in the Mohave Desert: Univ. California Dept. Geology Bull., vol. 6, pp. 167, 168, 1911.

[4] Baker, C. L., Notes on the later Cenozoic history of the Mohave Desert region in southeastern California: Univ. California Dept. Geology Bull., vol. 6, pp. 333–383, 1911.

[5] Fairbanks, H. W., Notes on the geology of eastern California: Am. Geologist, vol. 17, pp. 67, 68, 1896.

[6] Smith, J. H., The Eocene of North America west of the 100th meridian: Jour. Geology, vol. 8, p. 455, 456, 1900.

about Red Rock Canyon were later described by Baker,[1] who correlated them as a whole with the "Rosamond series," on the evidence of mammalian remains which he collected and which Merriam determined as of upper Miocene age.

The field work that forms the basis of the present report was too meager to admit of any definite correlation of the rocks about Barstow with the "Rosamond series," and it was impossible to work out the sequence of the various effusive rocks and their relation to the sedimentary rocks. The Tertiary rocks have in consequence been shown as a unit on the map. An attempt will be made, however, to indicate the general character of the rocks in the different areas and to describe the lithology of the sedimentary beds.

LITHOLOGY.

The sedimentary beds are best exposed in the Barstow syncline, where they have a thickness of not less than 3,000 feet and probably considerably more, but on account of the numerous faults which have in part duplicated the section it is impossible to give an accurate estimate of the thickness. The beds vary greatly in character, both vertically and along the strike, and it is difficult to group them into any definite formations which may be followed consistently. They may, however, be divided roughly into three parts. The lowest of these divisions has a thickness of not less than 1,200 feet and is composed largely of coarse to fine grained tuff, volcanic ash, various thin lava flows, and especially, near the base, a few beds of coarse granitic bowlders and brownish sandstone. This division weathers to ragged, irregular hills and shows a remarkable variety of bright colors ranging from green, blue, or almost purple to various shades of yellow, brown, and red.

The middle division is composed mainly of slightly greenish gray clay, with thin beds of brownish arkose sandstone, numerous layers of white calcareous clay and somewhat impure limestone, beds of white ash, and, toward the base, beds of coarse granitic fragments. It has a thickness of not less than 1,500 feet. The greenish clay which forms the bulk of the division is in places thin bedded, but in other places it forms masses 20 or 30 feet thick without trace of stratification and the intermittent streams have intrenched themselves in it, leaving almost vertical cliffs 50 or 60 feet high. The coarse beds near the base are formed almost wholly of unsorted granitic fragments, the largest 3 or 4 feet in diameter. They are embedded in an arkose matrix, in places firmly cemented, and to casual observation look like granite in place. The calcareous beds

[1] Baker, C. L., Notes on the later Cenozoic history of the Mohave Desert region in southeastern California: Univ. California Dept. Geology Bull., vol. 6, pp. 354-357, 1911; Physiography and structure of the western El Paso Range and the southern Sierra Nevada: Idem, vol. 7, pp. 123-134, 1912.

are of two types. The most numerous are layers of calcareous clay whose composition is in general like that of the greenish clay with which they are stratified, but owing to their lime content they weather almost pure white. They are more resistant than the clay, and the consequent unequal erosion results in the formation of fantastic badlands. Besides the calcareous clay there are numerous beds of yellowish to dark brown limestone which vary in thickness, the maximum being about 10 feet. Many of the calcareous beds emit a peculiar fetid odor when struck. This odor, which is not unlike that of petroleum, has been considered by many persons as an indication of oil. A sample of the fetid limestone was examined by D. T. Day, of the United States Geological Survey, who reported that no trace of liquid hydrocarbons could be extracted from it by various solvents. After treatment with sulphuric acid he detected a trace of resin, but this was too small in amount to account for the odor. The limestone contains a considerable amount of sulphur and the odor is probably due largely to hydrogen sulphide.

Locally the remains of fresh-water mollusks and somewhat more rarely fossil bones similar to those occurring in the overlying division were found in the beds in the upper part of this division. In contrast to both the overlying and underlying divisions this division is well bedded, and the writer believes that it was deposited in water.

The uppermost division is formed of poorly consolidated beds of coarse angular rock fragments, fine gray ashy sand, and clay. The materials are much more poorly stratified than those of the preceding division and resemble slightly the Recent flat-lying gravel and sand. The beds in this division form rounded buff-colored hills, in marked contrast to the badland of the middle division and the multicolored hills of the lower division. Fossil bones occur abundantly in this division, especially in the finer-grained beds.

Baker[1] has grouped the Tertiary rocks exposed in the Barstow syncline into five members. Although these members may be recognized in the central part of the syncline, the writer found that they could not be followed consistently and rather doubts the advisability of attempting to divide the section so minutely. The divisions are, beginning with the base, "(1) basal breccia, (2) tuff-breccia, (3) fine ashy and shaly tuff, (4) resistant breccia, (5) fossiliferous tuff." The first two of these members correspond roughly with what is described in the present paper as the lowest division, the third and fourth members with the middle division, and the fossiliferous tuff with the uppermost division.

West of Black Mountain the oldest Tertiary rocks appearing along the axis of the small anticline are clay shale, fine sand, and ash

[1] Baker, C. L., Notes on the later Cenozoic history of the Mohave Desert region in southeastern California: Univ. California Dept. Geology Bull., vol. 6, pp. 342-347, 1911.

similar to those forming the middle division in the Barstow syncline. Layers of fetid limestone are abundant and on that account this part of the region has been considered as the most favorable locality for prospecting for oil. Several thin beds of basic lava, usually less than 6 feet thick, are bedded with the clay, and a somewhat thicker though lenticular bed occurs near the contact with the overlying buff-colored gravel. This bed of basalt forms the hill immediately north of the Giroux well. Overlying the clay and occupying most of the area mapped as Tertiary to the northwest are buff-colored gravel and ashy sand much like the upper division in the Barstow syncline.

A belt of outcrop from a quarter to half a mile in width, formed mainly of friable sandstone and clay, trends east and west along the south flank of the Calico Mountains, passing approximately through the old town of Calico. These beds rest upon the rhyolitic tuffs and lava flows which form the main mass of the Calico Mountains on the north and are separated from the desert on the south by volcanic rocks which Lindgren [1] believed to be younger. Isolated patches of sandstone and limestone occur also high on the slope of the Calico Mountains, in the south half of T. 11 N., R. 1 E.

The central part of the area of Tertiary rocks on the north side of Mohave River between Barstow and Daggett is formed of fine-grained clayey sand, calcareous clay, and limestone interstratified with numerous thin beds of volcanic rock. Fetid limestones are exceptionally abundant. The northwestern edge of this area is composed of tuffs and solid lavas, which weather out prominently and form rugged hills in sec. 25, T. 10 N., R. 1 W. A dark rocky ridge trending approximately north and south and meeting the river a mile or two west of Daggett is also composed predominantly of tuff and volcanic flows.

The Tertiary rocks near the old Alpha and Omega mines, about 4 miles north of Barstow, and also those between that place and Black's ranch consist almost wholly of tuff and lava, although with these are intercalated beds of coarse detrital material 10 or 12 feet thick.

The Tertiary rocks on both the north and the south sides of Mohave River at Barstow are wholly rhyolitic flows, but calcareous clay and limestone form two small hills about three-quarters of a mile to the north.

AGE.

Remains of several extinct species of horses, camels, and other mammals occur abundantly in the Barstow syncline in the uppermost division of the Tertiary beds. These fossils have been studied

[1] Lindgren, Waldemar, The silver mines of Calico, Cal.: Am. Inst. Min. Eng. Trans., vol. 15, p. 719, 1887.

by Merriam,[1] who believes them to be of upper Miocene age and similar to mammalian remains found in other parts of the Great Basin.

QUATERNARY ROCKS.

BASALT.

The blanket of basalt which covers Black Mountain rests with marked unconformity upon the uptilted Tertiary rocks and is probably of Quaternary age. The flow is not thick, averaging over much of the hill less than 50 feet, but the numerous faults traversing it in places exaggerate the thickness. The diagrammatic section given by Baker[2] is rather misleading, for the surface of the south flank of the mountain is not formed by an unbroken tilted sheet of basalt. Numerous normal faults traverse the basalt and the south flank of the mountain is really a succession of small fault blocks. The basalt varies from a massive fine-grained porphyritic black rock to vesicular or even scoriaceous material. Massive fine-grained material is probably the most abundant.

RECENT SAND AND GRAVEL.

All the topographic basins in this region are filled with masses of gravel, sand, and clay which have been laid down since the uptilting of the Miocene rocks and largely, perhaps wholly, since the outpouring of the lava that now caps Black Mountain. These materials were probably deposited under much the same condition as those now existing in the desert, the coarser material being carried in by running water, the finer material, perhaps largely wind carried, forming drifts in sheltered places or settling in the shallow lakes that intermittently occupy the playas. The thickness of these masses of material is not known. The well of the Chicago Oil Co. and also that of the Kramer Consolidated Oil Co. were drilled in the center of broad alluvial flats. Both these wells penetrated several hundred feet of material, which, as nearly as may be judged from the record kept, is probably part of the Recent alluvial desert filling. Besides the flat-lying gravel in the topographic basins, a thin veneer of similar material caps the interarroyo ridges in the low foothills. This material evidently records an epoch when the country was lower and the hill groups even smaller than at present.

Thick masses of sand and gravel like that in the present desert flats form low rolling hills south of Barstow and a mile or so south of the Chicago well. These beds have about the same degree of indura-

[1] Merriam, J. C., A collection of mammalian remains from Tertiary beds on the Mohave Desert: Univ. California Dept. Geology Bull., vol. 6, pp. 167–169, 1911.

[2] Baker, C. L., Notes on the later Cenozoic history of the Mohave Desert region in southeastern California: Univ. California Dept. Geology Bull., vol. 6, p. 348, 1911.

tion as the Recent alluvium, but unlike it they dip at slight angles, their attitude probably being due to tilting and not to inclined deposition.

STRUCTURE.

The structure about Barstow is irregular and complicated. For the most part the rocks are broken by innumerable faults and the stratified Tertiary rocks are tilted at irregular angles. In places the beds are bent into folds, the largest of which is the Barstow syncline, but most of these folds are small, irregular, and discontinuous and are a minor feature of the structure.

WELLS DRILLED FOR OIL.

Although this region has attracted considerable attention for the last 12 years, only four wells have been drilled to any considerable depth. These are the Kramer Consolidated Oil Co.'s well, in the NW. ¼ sec. 11, T. 10 N., R. 5 W.; the Chicago Oil Co.'s well, in the SW. ¼ sec. 35, T. 11 N., R. 1 W.; the Giroux well, in the SE. ¼ sec. 17, T. 32 S., R. 44 E.; and the Mojave Oil Co.'s well, in the SE. ¼ sec. 14, T. 11 N., R. 12 W.

The well of the Kramer Consolidated Oil Co. is located about 3 miles north of Hawes, a station on the Santa Fe Railway, in the midst of a broad expanse of desert, the nearest outcrops of rock in place being the granite in the hills some 5 miles to the northwest. Drilling has been carried on here at irregular intervals for the last 12 years, and the well is said to have been drilled to a depth of almost 3,000 feet. It is asserted that a little oil was obtained in the well, and small samples of light-gravity oil and of paraffin wax were seen at the Los Angeles office of the company. At the time of the writer's visit to the well the lower part of the hole had been lost and no evidence corroborating the reported discovery of oil was obtained.

The abandoned Giroux well is located about a mile west of Black Canyon, at the foot and on the south side of a small hill determined by a bed of basalt which is interstratified with the fine-grained Tertiary clay. According to Mr. C. E. Kendrick, this well was started in 1902 and drilled to a depth of 440 feet. It is said that a trace of oil was obtained in the well at a depth between 300 and 400 feet. The basalt forming the hill on the north dips 70°–80° S., and the well was probably drilled into it.

The well of the Chicago Oil Co. is located in the desert on the west side of the Calico Mountains, about a mile from the nearest hills in which the Tertiary or older rocks are exposed. In December, 1912, it had reached a depth of more than 2,000 feet and drilling was still being carried on. "Showings" of oil are reported in the well.

The well of the Mojave Oil Co. is located about 2½ miles southeast of Mohave. It was started in 1907 and has been drilled to a depth of a little more than 1,100 feet. "Showings" of oil are reported, but no greater quantity was found and the well is now abandoned.

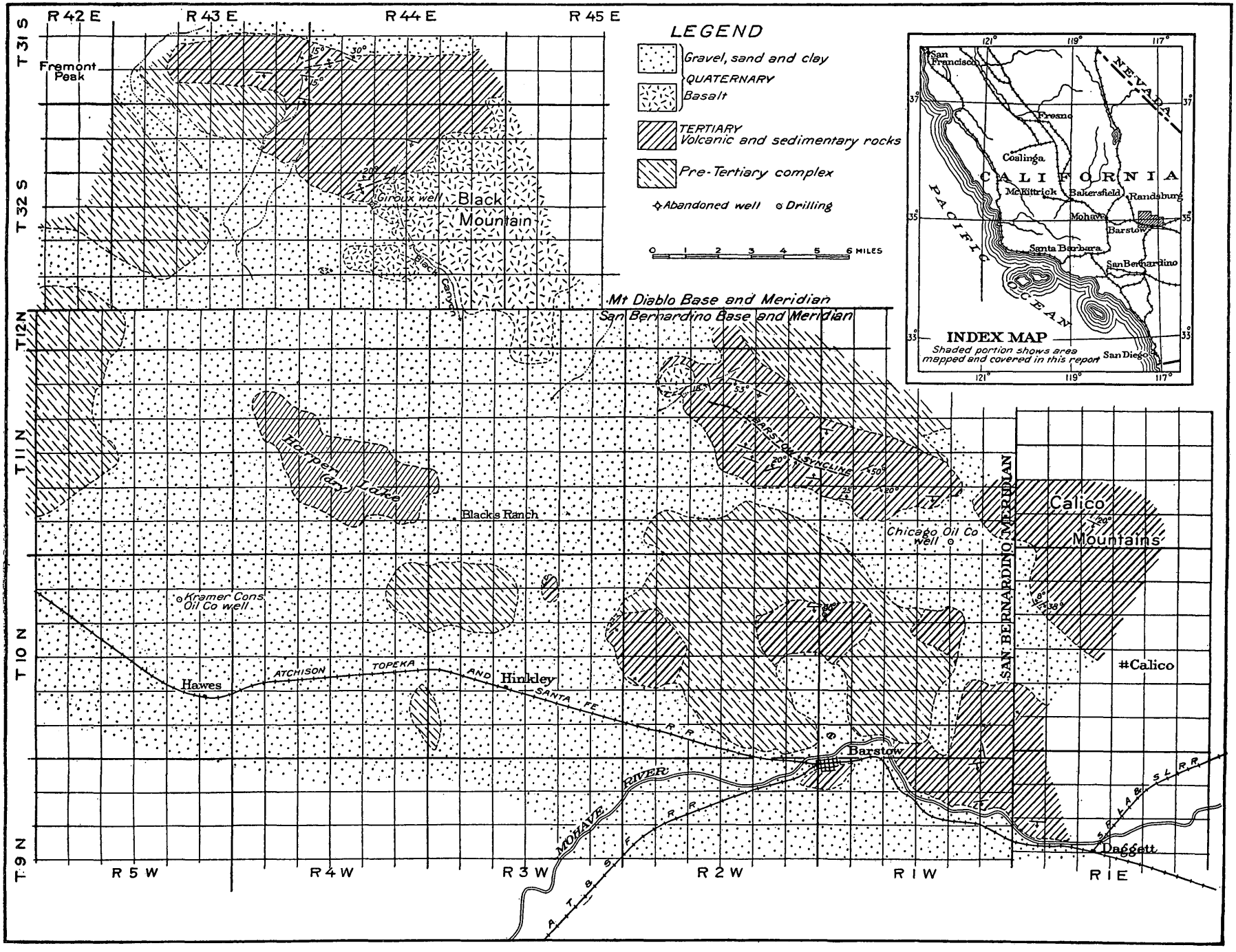
CONCLUSIONS AS TO THE PRESENCE OF PETROLEUM.

The writer believes that the northern part of the Mohave Desert between Barstow and the town of Mohave offers practically no promise of becoming a productive oil field, and that further drilling will prove but a waste of money. The principal reasons for believing that this land will not prove productive are (1) the lack of strata from which it would seem reasonable to believe that oil might have been formed, especially the lack of thick masses of organic material (diatomaceous and foraminiferal shale) such as those which occur in or near all the oil fields in the southern half of California and in which the oil is believed to have originated; (2) the lack of structural features favorable for the collection of petroleum even if it existed disseminated through the strata.

The pre-Tertiary rocks can not reasonably be regarded as a source of petroleum. Only a small portion of these rocks are of sedimentary origin, and they are so metamorphosed that even had oil once existed in them it is hardly conceivable that they should still contain it. The granitic rocks in the complex are if possible an even less likely source of petroleum, as their texture is so dense that they would offer practically no reservoir in which oil might collect if it existed in the near-by rocks. Oil has been found in rocks lithologically similar to some of the pre-Tertiary rocks of the Mohave Desert at only a single locality in California. This occurrence, at Placerita Canyon, about 20 miles north of Los Angeles, has been described by Eldridge.[1] The oil at this place occurs in fractured schists which rest upon the granite of the San Gabriel Mountains. The most logical explanation for the presence of the oil here is that it has migrated from early Tertiary organic shales which may have at one time rested upon the metamorphic rocks and which may now occur in the vicinity beneath the unconformably overlying late Tertiary beds. In the Santa Clara River valley, a few miles west of Placerita Canyon, the early Tertiary strata and the beds in contact with them are filled with oil. As organic materials similar to those in the Santa Clara River valley are unknown in the Barstow-Kramer region, it can not be expected that a similar accumulation of oil will be found in the metamorphic rocks in this region.

The Recent coarse gravel, sand, and clay which form the filling in the topographic basins and which in places extend as a veneer over

[1] Eldridge, G. H., and Arnold, Ralph, The Santa Clara Valley, Puente Hills, and Los Angeles oil districts, southern California: U. S. Geol. Survey Bull. 309, pp. 100–101, 1907.



RECONNAISSANCE MAP OF THE BARSTOW-KRAMER REGION, SAN BERNARDINO COUNTY, CAL.

By R. W. Pack.

the lower hills are equally as unlikely a source of petroleum as the pre-Tertiary complex. They are composed almost or quite completely of fragments derived from the older rocks in this or in adjacent regions, and it is not reasonable to believe that these masses of rock fragments would be more likely to produce petroleum than the same rocks in place. The Tertiary volcanic rocks are likewise not to be considered as a source of petroleum, for much the same reasons as apply to the granitic rocks in the pre-Tertiary complex.

It remains then but to consider the Tertiary sedimentary rocks. The coarse-grained Tertiary beds are formed of fragments of various types of granitic, volcanic, and metamorphic rocks and are evidently no more probable a source of petroleum than are the Recent beds of sand and gravel. On the other hand, to casual observation the fine-grained Tertiary rocks of the Barstow-Kramer region appear to be similar to the Tertiary rocks in many of the oil fields of this State, and it is not so very surprising that in this region they have been regarded as a possible source of oil. A careful examination of them shows, however, that they are really very different from the Tertiary shales in the productive oil fields, and in place of being composed very largely of the remains of organisms they are formed almost wholly either of fine volcanic ash or of detrital material derived from rocks of various types. They thus resemble the coarse-grained beds in the same region, differing from those beds mainly in the size of the particles they contain, and are not to be compared with the masses of organic material in the large productive oil fields of California. The only indications of organic matter seen in these beds were small particles of carbonized terrestrial vegetation scattered through some of the clayey and finer sandy beds, but the total amount of organic matter is entirely too small to be considered as a possible source of more than the merest traces of oil.

It is, of course, possible that in the broad, level desert areas rocks of different types from any exposed in the hills may lie buried beneath the desert gravel. It is also possible that such rocks, if they occur, are like those in the Tertiary formations in the San Joaquin Valley on the opposite side of the Tehachapi Mountains. There is, however, nothing in the geology of this region, or, so far as known, in that of the desert as a whole, to support such a hypothesis.

No surface indication of petroleum was seen anywhere in the region. It is commonly rumored that a seep occurs in the Tertiary rocks northwest of Black Mountain, but a careful search failed to reveal it nor did persistent questioning discover anyone who could describe its location. The structure of the Tertiary rocks is complex. In many places they are tilted to high angles and intricately faulted, and if oil occurs in them it is surprising that it does not at some place show at the surface.

Even if oil was originally distributed in minute quantities through the rocks, the structure is not such that it would have tended to collect or trap the oil. Irregular and faulted folds occur in at least three places northwest of Barstow—the Barstow syncline in T. 11 N., R. 2 W., a small anticline just north of the Giroux well in T. 32 S., R. 44 E., and an irregular fold or folds in T. 31 S., R. 44 E. It is generally reported that a well-marked anticline passes through the hills north of Barstow. Indeed, it is believed by some that such a fold extends along the north side of the desert from Tehachapi Pass nearly to Barstow. This idea is erroneous, for the only folds here are small, discontinuous, and much faulted. Faults, not folds, dominate the structure. Thus the structure is much more favorable for the escape of any oil that might possibly have been found here than it is for its concentration in appreciable quantities.