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OCCURRENCE OF OIL IN METAMORPHIC ROCKS OF SAN GABRIEL MOUNTAINS, LOS ANGELES COUNTY, CALIFORNIA[1]

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ABSTRACT

An occurrence of nearly water-white light-gravity oil obtained from wells drilled into metamorphic rocks on the north side of the San Gabriel Mountains, Los Angeles County, California, has been of interest to geologists for many years. The metamorphic rocks are in fault contact with sedimentary rocks, those at the surface being of late Pliocene and Pleistocene age. From a detailed study of the geology of this region the conclusion is reached that the oil has migrated in Eocene strata underlying the Pliocene and migrated along faults to its present position in the crystalline rocks. Filtration taking place during this migration is thought to have been competent to produce this light oil having a high percentage of aromatic hydrocarbons.

Six wells drilled between 1899 and 1901 in Placerita Canyon, near Newhall, Los Angeles County, California (SE. corner of NE. ¼ of Sec. 4, T. 3 N., R. 15 W., S. B. B. and M.) are of particular interest to those studying the occurrence of oil, due to the fact that they are located, for the most part, in the metamorphic rocks of the San Gabriel Mountains. They formerly produced small quantities of light-gravity, almost water-white oil from this formation. Neither of the two wells now capable of yielding oil is commercially productive. One is shut in and the other is open and flowing a small amount of gas with about a gallon per day of fluid of which not more than about 15 per cent is oil. In addition, several unsuccessful tests have been drilled in this vicinity at various times.[3] All the wells were drilled with cable tools, and logs which might have any geologic value are not available. The most northerly of this group of six wells was drilled practically on the fault contact between the metamorphic rocks of the San Gabriel Mountains on the south, and

[1]Published by permission of G. C. Gester, chief geologist, Standard Oil Company of California. Manuscript received, June 23, 1931.

[2]Standard Oil Company of California.

[3]G. H. Eldridge and Ralph Arnold, "The Santa Clara Valley, Puente Hills, and Los Angeles Basin Oil Districts, Southern California," *U. S. Geol. Survey Bull. 309* (1907), p. 100.
W. S. W. Kew, "Geology and Oil Resources of a Part of Los Angeles and Ventura Counties, California," *U. S. Geol. Survey Bull. 753* (1924), pp. 155-56.

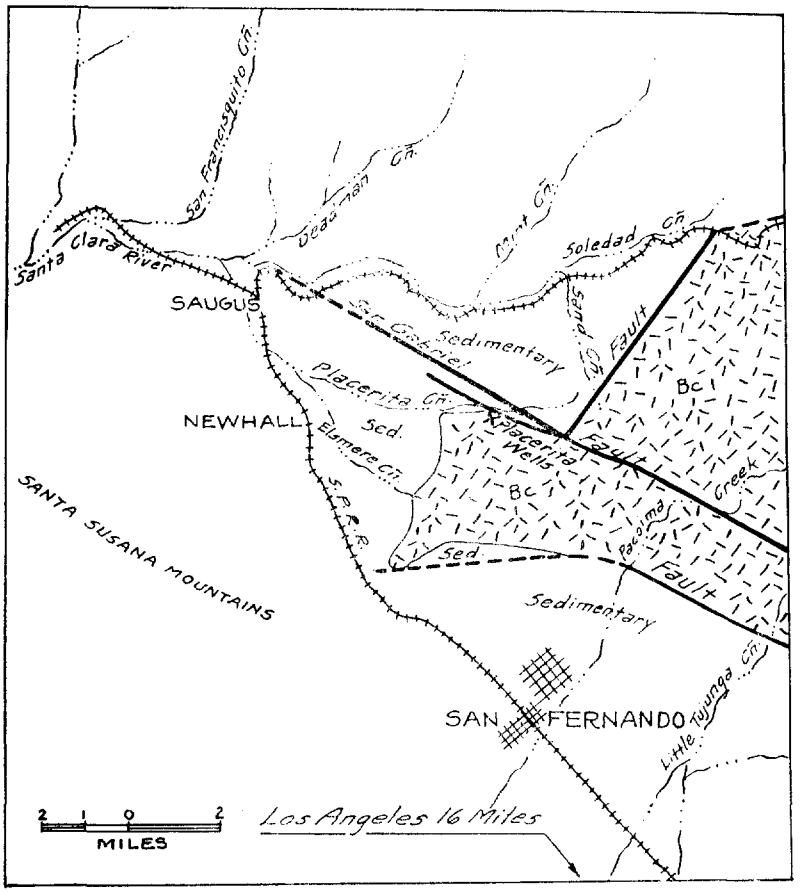


FIG. 1.—Generalized map showing location of Placerita Canyon wells with respect to Basement complex and sedimentary rocks.

the Saugus formation (Pleistocene) on the north. The other five wells were located within the area of metamorphic rocks.

The "Basement complex" of the San Gabriel Mountains consists of schists, gneisses, and various types of igneous rocks. In the immediate vicinity of the Placerita wells schists predominate, but no attempt has been made to classify the various rock types.

The oldest post-crystalline rocks known in the district are Eocene shales, sandstones, and conglomerates correlated with the Domengine formation, which crop out near by in Elsmere Canyon.[1] The closest

[1]W. S. W. Kew. Paper read before Geology and Paleontology Club, California Institute of Technology, March 31, 1931.

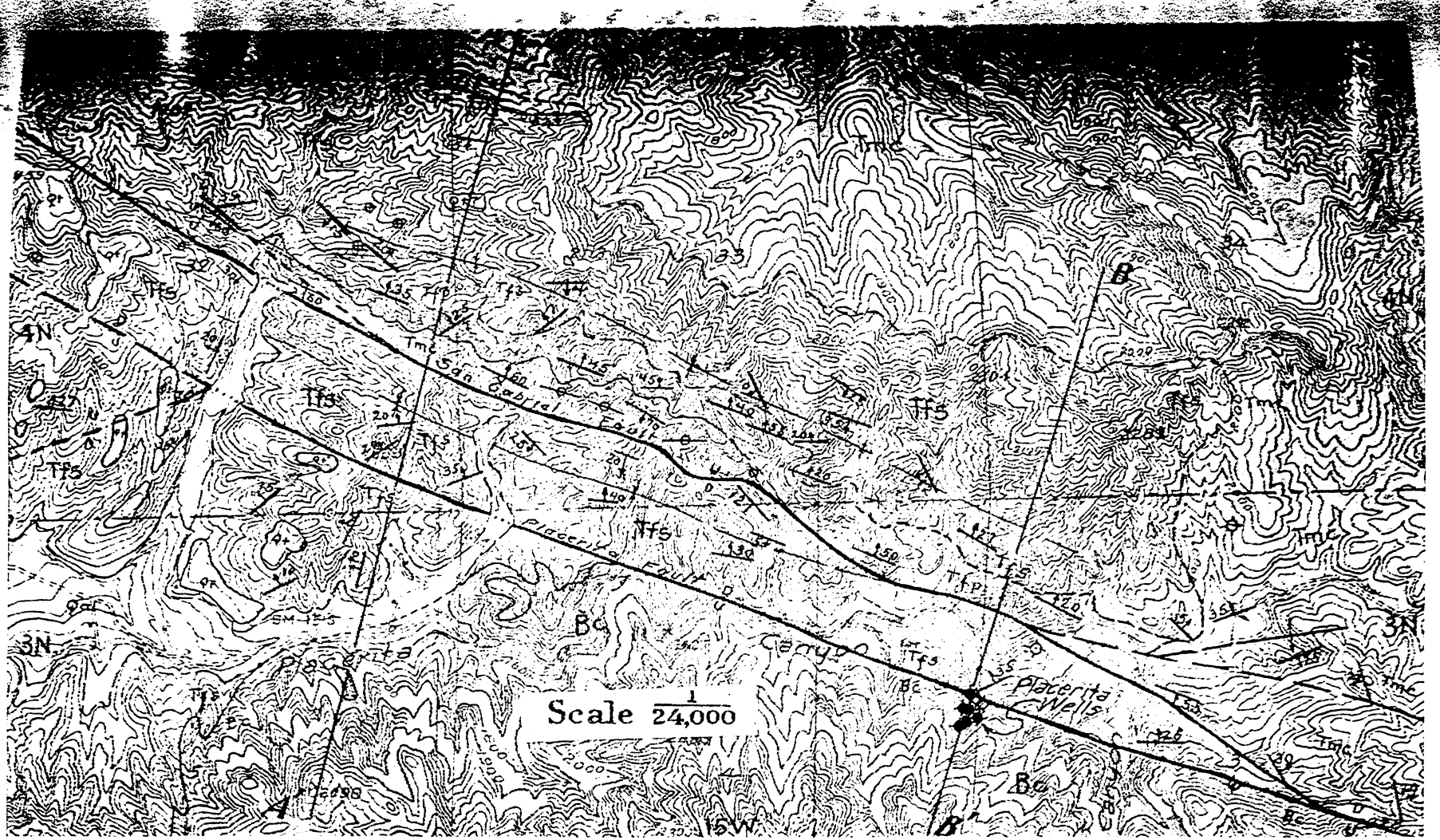


FIG. 2.—Geologic map of Placerita Canyon in vicinity of wells. *Bc*, Basement complex; *Tmc*, Mint Canyon formation (upper Miocene); *Tfp*, Pico formation (upper Pliocene); *Tfs*, Saugus formation (Pleistocene); *Qt*, Quaternary terrace deposits; *Qal*, Quaternary alluvium.

known occurrence to the Placerita wells is in Sec. 31, T. 4 N., R. 15 W., where a well recently drilled cored hard sand and conglomerate of probable Eocene age. As the Eocene is known to have a wide distribution in this general region it is considered very probable that these rocks underlie the later sedimentary rocks on the north side of the San Gabriel Mountains. Eocene rocks yield oil in natural seepages and in small quantities from wells in the Newhall district. For this reason their presence in the Placerita region is important.

The Mint Canyon is the oldest sedimentary formation exposed in the area shown on the map. It consists of non-marine sands, gravels, and clays of upper Miocene age.[1] It is known to lie beneath beds containing fossils of Santa Margarita age (upper Miocene) and has yielded a vertebrate fauna, the age of which is considered to indicate the middle part of the upper Miocene.[2] It contains no beds considered to be a source of oil, nor has any oil ever been found in it.

The Mint Canyon formation is unconformably overlain by beds consisting principally of coarse sandstone, conglomerate, and silty sand of marine origin, which are correlated with the Pico formation (upper Pliocene) as exposed in Elsmere Canyon.[3] The only fossils found in the Pico of the Placerita Canyon area occur in a lenticular outcrop in the northwest corner of Section 33, where it consists of massive, light gray, fine, silty sand, locally containing scattered boulders some of which are several inches in diameter. This outcrop is on the north limb of a syncline, whereas the corresponding position on the south limb is occupied by coarse sandstone and conglomerate. At localities beyond the limits of this map, similar beds directly overlie the fine silty sand. On this basis as well as that of lithologic similarity the beds cropping out along the southern limb of the syncline are classed as Pico, although fossils are lacking. The dissimilarity of the Pico on the opposite limbs of the syncline may be explained by the unconformable contacts both with the Mint Canyon below and the Saugus above (Fig. 3, Section AA'). The relatively thin series of silty, gray sands was probably never deposited in the area now occupied by the southern limb of the syncline, whereas on the northern side, the overlying sandstones and conglomerates

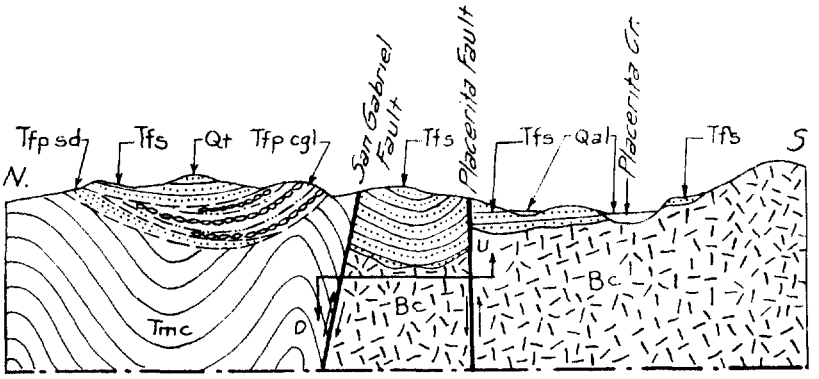
[1]W. S. W. Kew, "Geology and Oil Resources of a Part of Los Angeles Basin and Ventura Counties, California," *U. S. Geol. Survey Bull. 753* (1924), pp. 52-55.

[2]J. H. Maxson, "A Tertiary Mammalian Fauna from the Mint Canyon Formation of Southern California," *Carnegie Institution of Washington Pub. 404* (August, 1930), pp. 77-112.

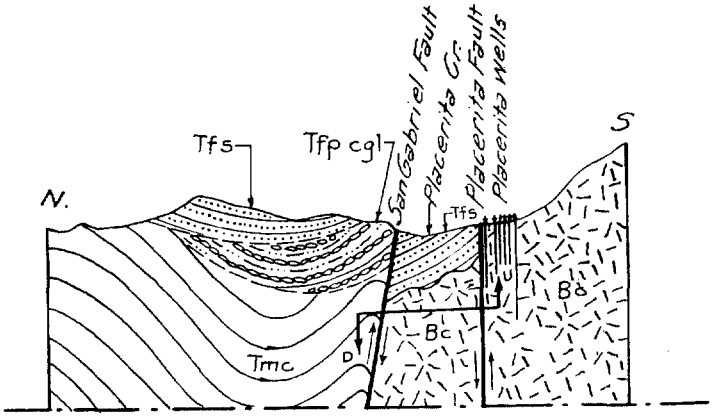
[3]W. S. W. Kew, *op. cit.*, p. 70. Recent work shows all the lower Pliocene to be absent.

were eroded before the deposition of the Saugus. The unconformity between the Pico and Mint Canyon is well exposed in the western half of the area mapped, where nearly vertical beds of Mint Canyon crop out between the cliffs formed by the Pico conglomerates, and the San Gabriel fault.

The Pico formation is unconformably overlain by the non-marine clays, sands, and gravels of the Saugus formation (Pleistocene).[1] Cer-



SECTION A-A'



SECTION B-B'

SCALE:-1"= 2000'

FIG. 3.—Structure sections *AA'* and *BB'* across Placerita Canyon.

[1]W. S. W. Kew, *op. cit.*, p. 81. Recent work has shown that the Saugus is entirely of Pleistocene age.

tain clay beds of the Saugus are similar to those of the Mint Canyon, and there are conglomerate beds closely resembling the Pico but differing chiefly in a less degree of induration. Where the unconformable relationship is not distinct it may be difficult or impossible to map the contacts accurately. The lower part of the Saugus is characterized by the presence of dark greenish brown and olive-green beds of sand and gravel, in contrast to the lighter tan, white, or bluish sands, clays, and conglomerates above. The general absence of the lower "green" series on the north side of the San Gabriel fault suggests that this area may have been somewhat higher than that immediately south of the fault, at the time the Saugus was laid down. The Saugus is locally overlain by nearly flat terrace deposits, which are extensive a short distance west of the area mapped.

The dominant structural feature of the area is the San Gabriel fault, which strikes approximately N. 65° W., and, at least locally, dips steeply north. About ¼ mile farther south, and approximately parallel with it, is another fault, called for convenience the Placerita fault, which marks the contact of the Saugus with the Basement complex in the eastern half of the area. It can be followed for some distance west where it brings the lower "green" beds of the Saugus formation into contact with the upper, lighter beds. Several smaller faults have been mapped but are of little importance. The Placerita fault, the plane of which dips nearly vertically, is well exposed in cuts on the old road leading from Placerita Canyon to the three southerly wells of the group drilled into the metamorphic rocks. The fault passes practically through the location of the most northerly well in the group.

The north side of the Placerita fault is downthrown with respect to the south side; the movement probably does not exceed a few hundred feet, and occurred in post-Saugus time. This is shown by the fact that the Saugus formation was affected by the movement, and also by the absence of older sedimentary formations between the Saugus and the Basement complex. Unless older formations are present and completely overlapped by the Saugus, which is not considered probable, the block between the San Gabriel and Placerita faults must either have been entirely above the limit of deposition during Miocene and early Pliocene time, or at least have stood sufficiently high to allow these formations to be removed by erosion before the deposition of the Saugus. The presence of the Mint Canyon and Pico formations north of, and ter-

minating along, the San Gabriel fault, on the other hand, shows that this area was downthrown at least as early as Miocene time, and although Eocene rocks do not crop out, it is probable that rocks of that age underlie this area as they do the area farther south.

In post-Saugus time, however, and probably during the time that the Placerita fault was active, the movement on the San Gabriel fault was reversed. It is possible that the block between the San Gabriel and Placerita faults moved down as a unit, forming a graben, and that little or no relative movement occurred between the block north of the San Gabriel fault and that south of the Placerita fault; or even that the north block moved downward with respect to the south block, though upward with respect to the intervening "graben block."

The sedimentary rocks on the north side of the San Gabriel fault are folded into a syncline. It is evident that folding was in progress during Miocene and lower Pliocene time, as well as in late Pliocene and Pleistocene, for the beds of the Mint Canyon are much more sharply folded near the San Gabriel fault than those of the Pico, and the Pico, in turn, more sharply than the overlying Saugus.

The Saugus beds between the San Gabriel and Placerita faults are folded into a gentle syncline in the western part of the area. This structure does not continue throughout the eastern part of the area, apparently striking into the San Gabriel fault.

It is evident from the foregoing brief description of the contiguous formations, that neither the non-marine Mint Canyon and Saugus formations, nor the coarse sandstones and conglomerates of the Pico formation, could be a source of petroleum. Formations of Eocene age are considered to be the source of oil in several California fields, including Simi (Tapo Canyon), Bardsdale, Goleta, Sespe Canyon, Shields Canyon, South Mountain, and Torrey Canyon. At Elsmere Canyon live oil seepages occur in outcrops of the Eocene, and this formation undoubtedly is the source of oil obtained from the Pliocene in this vicinity. As previously noted, it is probable that the Eocene underlies a considerable area on the north side of the San Gabriel fault, as well as areas west and south of that mapped, and it seems logical to consider that this series might be the source rock for any oil found in the vicinity.

Although it is beyond the scope of this paper to disprove the possibility that oil originated through some process such as that proposed

by White[1] or Rich[2] from sedimentary rocks now incorporated in the schist, this mode of origin is not thought to be probable, due to the highly metamorphosed condition of the rocks in the vicinity, which here consist of "hornblende schist intruded by aplite dikes."[3]

Oil originating in the Eocene may have migrated along the San Gabriel fault into the Saugus beds on the graben block and thence up the dip (Fig. 3, Section *BB'*) to the Placerita fault. It is possible that such migration occurred before the movement on the Placerita fault was complete, and took place chiefly near the contact of the Saugus and the underlying crystalline rocks. Filtration through fine sand and clay beds of the Saugus as well as through gouge developed along the Placerita fault may account for the peculiar character of the oil, for, according to Prutzman,[4] filtration through such material is competent to produce this type of oil. It is even conceivable that heat generated by movement along the Placerita fault may have resulted in increased pressures and thus have produced somewhat the effect of filtering under pressure.

A sample of oil from the most northerly well was recently analyzed. This sample was kindly furnished by F. E. Walker, the present owner of the property, and was typical of oil from this group of wells, excepting that it had remained in open storage for some time, giving an opportunity for evaporation of some of the lighter fractions. The data tabulated on the following page were obtained.

The high percentage of aromatics, the low percentage of unsaturated hydrocarbons as shown by absorption in H_2SO_4, low sulphur content, and absence of heavy ends are the outstanding chemical characteristics of the oil. However, G. J. Ziser, who made the analysis, does not believe that the character of the oil in itself furnishes sufficient evidence on which to base an opinion as to its origin, inasmuch as any process that would result in a concentration of lighter fractions might be responsible for the formation of an oil of such character. The recently published work of Brooks[5] is of particular interest in this regard. He concludes

[1]David White, "Late Theories Regarding Origin of Oil," *Bull. Geol. Soc. Amer.*, Vol. 28 (1917), pp. 723-34.

[2]John L. Rich, "Generation of Oil by Geologic Distillation During Mountain Building," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11, No. 11 (November, 1927), pp. 1139-49.

[3]W. S. W. Kew, *op. cit.*, p. 156.

[4]P. W. Prutzman, "Petroleum in Southern California," *California State Min. Bur. Bull. 63* (1913), p. 177.

[5]Benjamin T. Brooks, "Chemical Considerations Regarding the Origin of Petroleum," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 15, No. 6 (June, 1931), pp. 611-27.

that "The presence of benzene hydrocarbons in petroleum can be accounted for by disproportionation reactions at low temperatures," and mentions recent unpublished work in which he has shown that fuller's earth is capable of causing such reactions. He further cites experiments performed on various minerals and sedimentary rocks showing that many of these have properties generally supposed to be characteristics of fuller's earth, particularly that of causing polymerization.

A. P. I. gravity	37.7
Flash (closed Tag.)	73
Color Saybolt	+5
Sulphur	0.10
Aromatics	52.5 by weight
Refractive index at 20° C.	1.4096
Absorption in sulphuric acid	3 per cent

A. S. T. M. Distillation

Start	245 degrees
5 per cent	272
10	283
20	298
30	317
40	337
50	361
60	391
70	428
80	464
90	513
End point	594
Per cent recovered	98

If, on a basis of chemical analysis, however, the possibilities of formation by filtration and of formation by natural distillation from organic material in sediments now lithified are both admitted; from the facts that (1) neighboring areas are underlain by Eocene sediments, the source of petroleum at localities within a few miles, as well as elsewhere in California, (2) that so far as known production was limited to an area closely adjacent to a fault forming the contact between sedimentary and metamorphic rocks, and (3) that the crystalline rocks are intruded by igneous dikes and are highly metamorphosed, the conclusion is reached that the theory of filtration offers the more plausible explanation.