

Oil in Southern Tamaulipas, Mexico

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THE great activity with which the oil resources of the northern Cantons of the State of Veracruz have been developed has largely resulted from the great success obtained by the important explorations carried out since 1902 in the Ebano district in the North, and several years later near Tuxpam, in the South. It must not be thought that these successes were quickly obtained, since the preliminary studies by good experts, the acquisition of what were thought to be the most promising coast lands, the extensive clearing thereof, and finally the number of unsuccessful drillings at great depth, signified an original outlay of some tens of millions of dollars before finding commercial oil.

The discovery of oil in industrial quantities at Cerro de la Pez, Ebano district, and the famous Dos Bocas gusher some years later, which was burned, once and for all made famous the Veracruz coast, where today is concentrated the Mexican output of mineral oil. In 1917, this production was nearly 61,000,000 bbl. It is well known that this output represents only a fraction of what the wells in actual production can furnish, because with adequate means of transportation and storage, the present extraction could be somewhat over 300,000,000 bbl. a year.

These enormous potential oil resources of the Veracruz coast proceed from a relatively small number of wells, scattered over a few oil fields, separated from each other by large unexplored areas, wherein may be found other favorable fields which, in time, will undoubtedly become just as great centers of oil production.

Experts who know our Gulf Coast believe that lands with commercial oil resources lie not only between the Pánuco and Tuxpan Rivers, but that indications are that the oil zone of Mexico, with more or less interruption, takes in the coast zone from Northern Tamaulipas to the foot of the Sierra Madre of Chiapas, and the banks of the Usumacinta River. This generalization is not merely the outcome of optimism, but is the result of the persistency with which one finds, throughout this Gulf Coast, the most usual characteristics upon which we depend for recognizing oil-bearing lands.

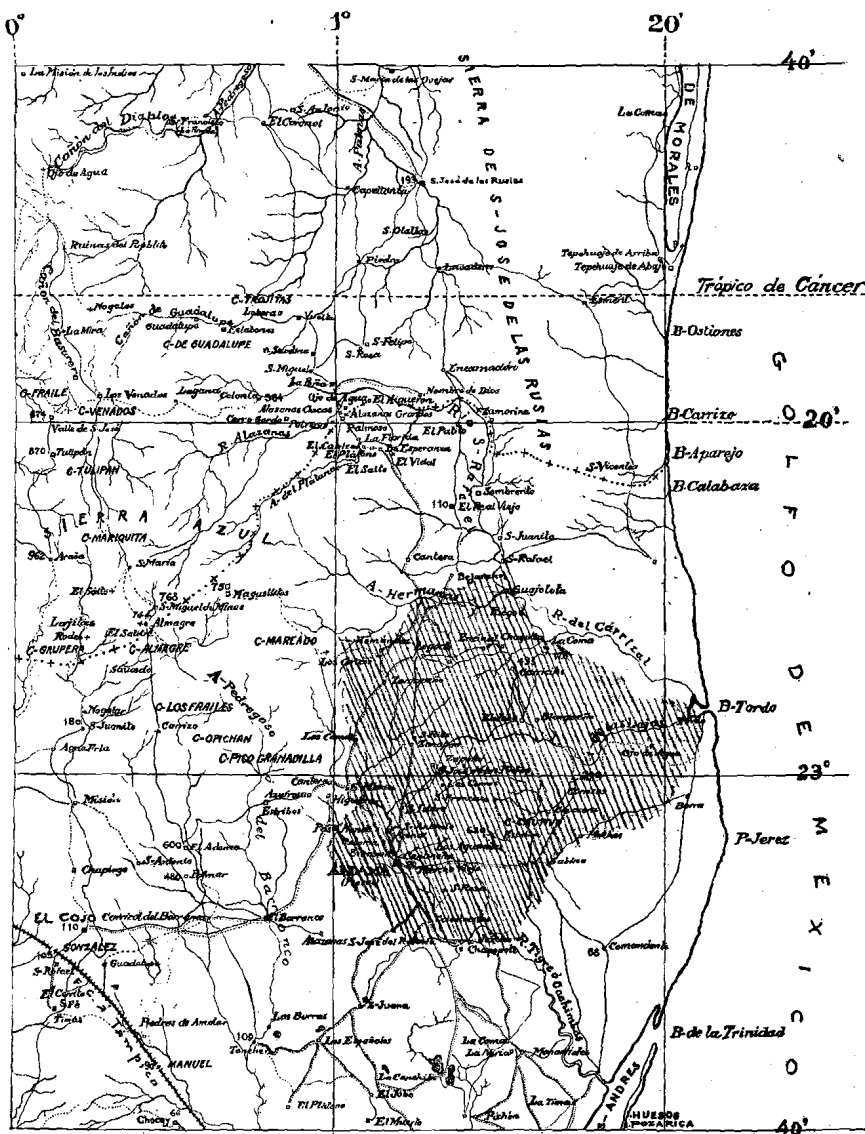


FIG. 1.—MAP OF SOUTHERN TAMAULIPAS, MEX. SHADED AREA REPRESENTS BASALT

In this short paper, we can discuss only the oil possibilities which, in our opinion, exist in that part of the State of Tamaulipas extending southward from the Soto la Marina River and its tributaries, that is to say, south of the San José de las Rusias property, which everyone is watching at present, because the Corona company is making certain very important explorations there.

The wide coastal belt and littoral of Tamaulipas, in the district near Tampico, to the north of the Tamesi River, with its low lands, lagoons and belt of sandstone hills reaching almost to the San Andres lagoon, sheltered on the sea side by sandy dunes, greatly resembles the sea shore and coast of the Canton of Ozuluama to the South of Tampico, in the State of Veracruz. The Pánuco and Tamesi Rivers, at their joint outlet to the sea at Tampico bar, have cut through a chain of hills which is merely an extensive strip of Neozoic formation which has largely disappeared over a great part of the interior. Before the Pánuco opening existed, from the outskirts of Tampico to the sea, the waters of the Pánuco undoubtedly emptied into the Gulf through various channels, representing the overflow from a very extensive lagoon stretching for many kilometers inland, which is now drained. This explains the estuary material covering the entire coast for 50 km. (31 mi.) inland, including oyster banks and other sea shells as far as Topila, and those estuary deposits and aluvions which have adhered to the first high undulations to the west and at a considerable distance from Tampico.

In the southern part of the State of Tamaulipas, there is a vast area of low-lying gently undulating coast, measuring over 150 km. from east to west, and about the same from north to south, with an elevation of from 100 to 200 m. (328 to 656 ft.) above sea level. This low-lying coast continues toward the northwest by a wide valley which, rising gently, is used by the railway between Tampico and Ciudad Victoria. This flat southern coast of Tamaulipas is bounded on the west by the Sierra del Abra, or Tanchipa. To the north, the Buena Vista and Sierra Azul ranges, forming part of the Sierra de Tamaulipas, form higher valleys. Important units of the Sierra Azul are joined by hills to a coast range, not very high, called San José de las Rusias. The flat coast, mentioned above, extends south to Veracruz territory beyond the Pánuco and Tamesi Rivers. On this coast, in Tamaulipas, there are only two important breaks which are of importance from the point of view of oil possibilities; these are: (1) The beautiful peak known as Bernal de Horcasitas, which resembles a sharp and narrow crest supported by a cone with a very wide base, the top of the rocky crest being over 1000 m. above sea level. (2) The group of mountains situated near the village of Presas Aldama, dominated by the Cerro Cautivo, the top of which is some 650 m. above sea level. The slopes of this mountainous mass approach the sea shore between Tordo bar and the sandy Point of Jerez.

Both the Bernal and Cautivo mountains, separated by a distance of 70 km., are volcanic and their bases are formed by extensive flows of basaltic lava; both mountains are very recent. Bernal has a relatively short formation history, implying lava flows in close succession from one or few craters, after which eruptions a lava cap formed over the principal crater and filled it; the crater has disappeared by erosion and the lava neck has a graceful appearance as seen from the distance. The Cautivo mountain mass is very different. Here we find a group of volcanoes having a much longer period of activity, during which numerous lava flows overlapped one another, building the whole mass higher and higher. On the summits can be identified various craters, some of considerable dimensions. Among the most recent ones we may mention one of explosive type situated on the southern slopes of the Zapotal crest. This crater has a diameter of about 1.5 km. and is about 100 m. deep at its lowest edge, with an extensive flat surface in the bottom. The walls of the crater are of basalt, basaltic breccia and tufa, with limestone, sandstone and marl coming from the adjoining formation underlying the eruptive rock.

The importance of the eruptive center of the Cerro Cautivo, in the neighborhood of the village of Presas Aldama, is not to be measured by the number and height of the summits and craters which compose it, but rather by the area which the lava from these volcanoes has covered in the form of a thin and uniform mesa. The lava from the large and small volcanoes, spreading to the north and northwest of Presas Aldama, cover an area of not less than 2500 sq. km. (965 sq. mi.). Several overlapping flows sustain the crests and craters of Cautivo, but the greatest spread of the lava field stretches in the form of a slightly elevated and uniform plateau, abruptly cut at its edges by erosion. To the northwest and west the lava crust almost reaches the southern slopes of the Sierra Azul, and to the north the San Rafael River washed away part of it, thus forming a wide valley whence this river reaches the sea bordering the southern end of the San Jose de las Rusias range.

As regards the secondary hills and small volcanoes, subordinate in origin to the eruptive center of Cautivo, they usually occur at the edge of the lava crust, but are also to be found on top of it. Among the small hills scattered throughout this vast low plateau, only a few may be mentioned, such as the cone with an open crater, known as Cerrito del Maiz, to the south near Presas Aldama; the three consecutive hills, Los Tres Hermanos, to the west of the Lagarto ranch; the cones with craters or dome-shaped hills at the edges of the lava at the foot of the Sierra Azul; and lastly, the remarkable little cones on the ranches of Bejarano, Real Viejo, El Sombrerito, La Muralla, etc., etc. The majority of these basaltic cones are important as suggesting the possibility of encountering oil near them, as usually occurs in the Veracruz oil districts.

It may be of interest to state briefly some data furnished us by the study of these basaltic cones in relation to the Tertiary land formation underlying them.

The geological formation of the southern Tamaulipas coast is very uniform, both in physical constitution and in structure. The entire formation is Tertiary (Eocene). The top layers are of limestone alternating with phosphatic lime, sandstone, and thin beds of shale. This formation may be studied very well near Rancho del Cojo, on the flanks of the hills cut by erosion, forming that broad and low depression which extends between the heights of Cojo and those of Barranco ranch east of Gonzalez station of the Tampico-Monterey R. R. In various other parts of that area the formation of El Cojo is found with good exposures. The strata, as is everywhere the case on the southern Tamaulipas plain, are almost horizontal or in successive undulations and domes, invariably having a monoclinical structure slightly dipping to the east. Below the limestone strata of the top of the formation, thin limestone beds, with shales, are found overlying the very thick shale formation, known as the Mendez shales, which has a thickness sometimes exceeding 3000 ft. (914 m.) and rests upon the San Felipe formation or upon Cretaceous limestone.

From the village of Presas Aldama to the north the country is flat over the basaltic lava or malpais for nearly 40 km. passing the ranches of Zanapa, Lagarto, and others, to near Rancho Bejarano, where the basaltic plateau ends and Eocene rocks are again exposed by the wide erosion valley of the San Rafael River.

A well-aligned series of almost isolated high mountains, with peaks broken into fantastic forms, arises from the eastern foot of Tamaulipas range, forming an advanced ridge the base of which is touched by the malpais. This row of high peaks limits the Coastal plain on the west. Prominent among these mountains are Jerez, Platano, Plateros, and Cerro Gordo or Alazanes, all having elevations exceeding 1500 ft. (460 m.) above sea level. A little further on from the Bejarano ranch, toward the Real Viejo farmstead, the river flows between hills at the foot of the high mountains to the west and the coast range of San José de las Rusias to the east. At the junction of the eastern hills with the low ramifications of Las Rusias range, at Lomas de la Encarnación, a broad gap divides the waters of the San Rafael river from those of the important Soto la Marina river.

Leaving the northern edge of the basaltic plateau between La Coma, Guajolote, and vicinity of the Bejarano ranches, the Tertiary shales appear throughout the valley of the San Rafael river with here and there small basaltic cones. Near certain of these cones there are some oil seepages, which suggest that in this San Rafael river valley there is a wide area of great prospective value. Even more, it is probable that

the malpais of Presas Aldama, in its eastern and southern portions, covers a large area of excellent oil ground, a prolongation of that of the San Rafael valley.

Toward the bank bordering the San Rafael river bed, or at the edge of the basaltic plateau which also bounds the valley of this river, there are excellent cuts where not only the Tertiary rocks may be observed, but also the basaltic necks in their relation to those sedimentary rocks. Among the most instructive cuts carved by the river, I would mention a low hill near Real Viejo ranch, 10 km. to the north of Bejarano ranch, and on the right bank of the San Rafael river. A wall has here been cut 20 m. high in the Tertiary shales, at the same time cutting the basaltic hill rising from the river bed to a height of 50 m. This wall plainly shows the contact between the lava and the shales, clearly marking the line of separation between these rocks. The Mendez beds, made of yellow and red shales intercalated with fine-grained reddish sandstone, in slight undulations, show a gentle uplift at the junction with the basaltic rock. Near

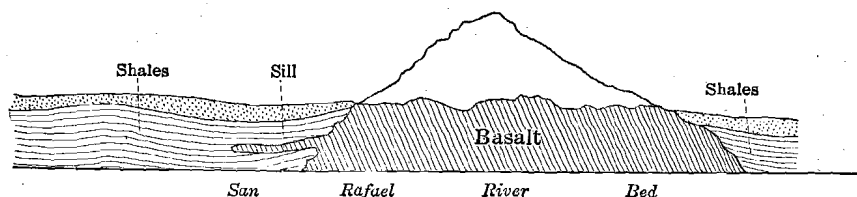


FIG. 2.—REAL VIEJO LAVA PLUG AND SURROUNDING SHALES SHOWING SLIGHT MOVEMENT OF THE SHALES UPWARD AT THE CONTACT WITH THE LAVA, AND SOME METAMORPHISM. A SMALL SILL IS NOTICED IN THE ILLUSTRATION.

this lava are some layers of shale metamorphosed into a hard schistose rock resembling flint. This metamorphism, produced by heat upon contact with the lava, is commonly found in the Veracruz oil fields where there are basaltic cones. We have seen this at Juan Casiano, La Pez, Cerro Azul and at many other places on that coast. A sill about 4 ft. (1.2 m.) thick of lava from the Real Viejo hill enters into the shales, and though this sill is not very long in the cut, it must extend much farther in places which are not visible. These lava intrusions in the form of sills in the shale formation of our oil lands are more frequent than is generally believed, and many drillers are familiar with the appearance of these lava strata in certain oil districts, even at considerable depths and at great distances from basaltic plugs.

This cut of the San Rafael river in the Real Viejo ranch illustrates various important facts to which I would draw attention. First, the sedimentary strata, upon contact with a basaltic neck, are slightly moved upward with the lava plug. Second, a slight metamorphism of the sedimentary rock occurs at its contact with the lava, due to heat. Third, the lava intrudes as sills in sedimentary rocks.

On various occasions, I have already stated that plugs of lava traversing the Tertiary strata of the Gulf Coast oil fields do not perceptibly move those strata, and we take as our reason for this belief the observation of what happens in the explosive craters or *xalapascos* to which type many of the diminutive volcanoes of our eastern coast belong. Our observation is opposed to the statements of Garfias and Hawley in a recent article¹ in which the authors, on the strength of observations by Geikie and other writers on certain volcanic districts, maintain that a synclinal movement of the sedimentary rocks takes place around the necks in our oil lands, and that this synclinal curve, together with other phenomena which they try to explain, facilitates accumulations of petroleum in the vicinity of the necks. This phenomenon might occur, but it is not fully proved in our oil fields. Whereas we continue to assert the almost immovable position or a gentle uplift of sedimentary rocks around the neck; the formation of broken zones at the contact of the lava and the sedimentary rocks, greater at some places than at others; and lastly, the absorption of sedimentary material by the lavas and hot waters, gases, and vapors, all determining the formation of extensive hollow or porous spaces very recently filled with liquid hydrocarbons. The roots of the plugs of lava, ramified like those of a plant, have served as channels to bring the mineral oil to the hollow or porous spaces prepared during the appearance of the lava plugs. It also frequently happens that large accumulations of mineral oil, when they come in limestone subjacent to the Mendez shales and San Felipe formation, fill cavities in these limestones which have been caused exclusively by circulating waters without the help of any volcanic phenomena. In the Pánuco district it has happened that, while drilling a hard limestone, suddenly the drill has been lost in a big cave.

If oil has sometimes accumulated in old hollow spaces made by water circulation in the limestone, there is room for the belief that the slight upheaval and breaking caused in limestone by the effect of explosions, or by the sudden passage of lava, has produced fractures which, even at a great distance, may facilitate the communication between the drill holes and an oil seam, so the connection between oil and volcanic phenomenon is purely mechanical.

In front of the Real Viejo ranch, the San Rafael river bed passes at the foot of a low hill, called Sombrerito, formed at its base of shales and sandstones, a continuation of the Real Viejo Eocene shales. Higher up, shales with a greater number of thin limestone layers are seen, then the cavernous limestone of the Cojo formation. Erosion has respected there these top formations, due to a thick lava capping with a ruined crater which forms a small indent. Between the basaltic lava and the

¹ Funnel and Anticlinal Ring Structure Associated with Igneous Intrusions in the Mexican Oil Fields. *Trans.* (1917) 57, 1071.

limestone, on the northwest slope of this hill, there is a small oil seepage which is carried away by waters of the arroyo during the rainy season.

I have already said that the ample valley of the San Rafael east of Real Viejo and Bejarano is a most promising field for the occurrence of mineral oil. The existence of oil seepages at various points in the wide lava field of Presas Aldama indicates that this oil region is very extensive, and that undoubtedly the malpais conceals good ground which, but for the lava crust, would show oil seepages.

At Jobo ranch in the eastern part of the malpais, at no great distance from the main mass of Cautivo Mountain, a *chapopote* seepage appears through thick lava. To the southeast of Jobo, toward the edge of the lava field, are other seepages at Sabino ranch.

Undoubtedly, even the good Mexican oil lands, far from the centers of actual exploitation, to become productive require assiduous and detailed geological studies, drilling and exploration, implying considerable investments.

DISCUSSION

V. R. GARFÍAS,* Palo Alto, Cal. (written discussion†).—Regarding the statement of Mr. Ordoñez, on page 538, concerning the synclinal curving of sedimentary beds caused by the extrusion of volcanic necks, that "this phenomenon might occur, but it is not fully proved in our fields," I beg to reply that the funnel and anticlinal-ring structure is *actually associated* with igneous intrusions in the Mexican oil fields, as we were able to ascertain by plotting an underground contour map and making a structural model of the oil-bearing beds of the Ebano field.

E. DE GOLYER, New York, N. Y. (written discussion‡).—The paper under discussion is not only of interest in connection with its subject but it is a contribution of considerable importance to our knowledge of the possible effect of igneous rocks upon the accumulation of petroleum in the Mexican fields.

Señor Ordoñez¹ has long held that the intrusion of igneous rocks in the Mexican fields has had no important structural effect in the accumulation of petroleum and does not seem to have found it necessary to change his opinion because of his studies in Tamaulipas.

Clapp,² as a result of his most recent consideration of the Mexican fields, has concluded that:

* Geologist and Civil Engineer.

† Received Aug. 19, 1918.

‡ Received Sept. 6, 1918.

¹ Sobre Algunos Ejemplos Probables de Tubos de Erupcion. *Memorias Sociedad Científica "Antonio Alzate"* (1904-05) **22**, 141-150. The Oil Fields of Mexico. *Trans.* (1914) **50**, 859-863.

² Revision of the Structural Classification of Petroleum and Natural Gas Fields. *Bulletin, Geological Society of America* (1917) **28**, 586.

At the base of the upheavals (around the plugs) and surrounding them in close proximity the Tamasopo limestone and overlying formations form pockets or places of catchment where large deposits of oil have accumulated. In the Tamasopo limestone and the San Felipe beds these oil deposits were presumably concentrated from surrounding portions of the same strata, owing to the upheavals mentioned; possibly with the assistance of heat.

The presence of the oil accumulations surrounding the plugs is sometimes, although not always, evinced by large seepages of oil. Some cases are known where the lower beds actually reach the surface and a true quaquaversal structure exists. Whether this is common has been doubted, but it is certain that definite doming does exist surrounding some of the plugs. At any rate, it is a fact that where the plugs exist pockets of oil have accumulated, and the conical plugs themselves may be considered as quaquaversal structures.

Garfias and Hawley,³ following and developing the theory advanced by Garfias⁴ in 1912, apparently largely as a result of his observation of wells in northern Alazan and a consideration of the analogy suggested by driving a nail through a book, have tried to find in the action of the intrusion a reason for the common occurrence of oil in the vicinity of igneous plugs in Mexico. They propose a theory of a circular anticlinal ring and funnel structure surrounding igneous necks and argue by analogy, citing numerous sections and examples of such structure, though they fail to cite any Mexican occurrences, merely concluding that there is no "question of the existence of these conditions in the Mexican fields."

I have long held with Ordoñez that important occurrences of petroleum in the Mexican fields, under the conditions described by Garfias and Hawley, and by Clapp, have not yet been proved to exist and, although I am not yet prepared to accept wholly the Ordoñez theory that the "roofs of the plugs of lava, ramified like those of a plant, have served as channels to bring the mineral oil to the hollow or porous spaces prepared during the appearance of the lava plugs," I agree that one important effect of the intrusions has been the formation of pore space by brecciation and metamorphism. I have further suggested that the greatest importance of the porous zones thus formed is that they cut across the sedimentary strata and so provide for transverse migration of petroleum.

The accompanying sketch of the Tepetate-Casiano pool, showing the surface relation of the outcrop of igneous rock⁵ to producing wells and dry holes, is instructive in this connection, since the region is one of considerable igneous activity. No evidence of doming similar to that suggested by Clapp, nor of anticlinal ring and funnel structure similar to that suggested by Garfias and Hawley, has yet been seen in this field. In the sketch, only those wells which have been completed to the Tama-

³ *Trans.* (1917) **57**, 1071-1082.

⁴ The Effect of Igneous Intrusions on the Accumulation of Oil in Northeastern Mexico. *Journal of Geology* (1912) **20**, 666-672.

⁵ Igneous rocks mapped by C. W. Hamilton.

sopo limestone are shown. The occurrence of the deeper dry holes or salt-water wells on both flanks, and of shallower producing wells along a narrow, unbroken, N.-S. striking zone are the distinctive features of this field as thus far developed by exploration. The surface geology does not show a marked fold corresponding to the ridge in the Tamasopo limestone that is shown by drilling operations. The structure has been ten-



SKETCH MAP OF TEPETATE-CASIANO OIL FIELD.

tatively explained as being the result of folding which started in the Tamasopo before the deposition of younger rocks. The strike of the field parallel to that of the dyke to the west and parallel to the line of weakness shown by the three domes or dyke outcroppings to the east of the field indicate that faults, the existence of which cannot be determined at the surface because of the lack of good rock exposures, may have been the controlling factor in determining the structure of this field, one of the most important in Mexico.

A few kilometers to the south is another important field, the Los Naranjos, in which the discovery well was located by the writer. This field is a broad dome; the producing wells are located on its crest, and

the only known igneous rocks consist of a dyke on the south flank and another on the eastern flank.

The oil industry is to be congratulated in having a clear recognition, by so distinguished a Mexican as Señor Ordoñez, of the preliminary preparation and the risks incident to exploratory drilling. Attention was early attracted to the petroleum seepages of Tamaulipas, and particularly to those of the San José de las Rusias region. In 1864, permission to exploit petroliferous substances at San José de las Rusias and at Chapopote, near Aldama, were granted to a certain Ildefonse Lopez, and similar permission was granted in 1865, to one Parades to exploit *chapopote* at Carancitos.

In 1873, Alajandro Prieto in his book, "Historia, Geografia, y Estadística del Estado de Tamaulipas," describes the profusion of *chapopote* seepages in southern Tamaulipas and concludes (p. 264): "This class of product, which is encountered in such abundance in Tamaulipas, should form some day, by itself alone, a branch of industry which will doubtless offer greatly to the prosperity of these communities."

In 1889, a well was drilled to a depth 40 m. near San José de las Rusias by a certain Manuel Flores and is said to have gushed oil.

The oil field department of S. Pearson & Son, in 1907, commenced drilling near Los Esteros in southern Tamaulipas and completed four wells before abandoning the enterprise as unproductive. Subsequently the American International Fuel and Petroleum Co. drilled 8 wells in the same region. In 1909-1911, the Tamesi Asphalt and Petroleum Co. drilled two wells near the same place. All of these wells were unsuccessful. In 1913, Tampico Oil, S. A., drilled a dry hole near Jopoy, on the Tampico River.

In 1910, the Texas Mexican Asphalt and Petroleum Co. moved a small drilling machine to the San José de las Rusias property and drilled a number of shallow wells, none of which was successful. Finally, a standard rig was brought in and a shallow well was drilled at a seepage rising along a dyke near Encarnacion. The rig was moved a short distance and a well was drilled to a depth of 2274 ft. (690 m.) and abandoned. The Corona Petroleum Co. (Royal Dutch-Shell group) then became interested, took over the lease and, after careful surveys by competent geologists, commenced drilling in 1914. To date, they have completed and abandoned as dry holes five wells having depths of 3450, 4000, 3496, 3030 and 3370 ft. (1052, 1219, 1066, 924, 1027 m.) respectively, and are now drilling two other wells.

During the past year, the Mexican Gulf Oil Co. completed and abandoned as a dry hole, at a depth of 3280 ft. (999 m.), a well on the Sabino Gordo property near Chapopote, just south of Aldama. This well was drilled near a seepage at a small hill of rock metamorphosed by igneous intrusions, and resulted in a salt-water well.

It is quite probable that in the purchase of leasehold, drilling of unproductive wells, and for various incidentals in an unsuccessful attempt to develop a productive oil field in the State of Tamaulipas, as much as a million dollars has already been expended, most of it under competent technical direction. The region has been recognized as probable oil territory since the earliest time and yet not a single commercially productive well has been encountered. Nor has it been proved that the state will not be an important oil producer at some future date. The conclusion reached in the paper under discussion that "even the good Mexican oil lands, far from the centers of actual exploitation, to become productive require assiduous and detailed geological studies, drilling and exploration, implying a considerable investment" would seem to be irresistible.