THE JURASSIC AS A SOURCE OF OIL IN WESTERN CUBA

The occurrence of asphalt deposits in the western part of Cuba, notably at Mariel and Bejucal, is evidence that at one time oil accumulations were present below the surface. At Mariel it has been estimated that twenty to thirty million barrels of oil must have been oxidized to leave this residue. An igneous intrusion through the Cretaceous and younger sediments was the cause of the migration of the oil to the surface. At Bejucal the asphalt occurs in connection with fault fissures, but with no evidence of igneous intrusion.

Most of the wells which have been drilled in Cuba have been located in or at the contact of serpentine in regions of extreme distortion. Some produced high-grade oil for short periods, and the writers are informed that at present some twenty barrels of oil are produced daily from Bacuranao and Motembo in western Cuba. The oil at Bacuranao is of high gasoline content, while that at Motembo is almost naphtha.

Live oil seepages have been reported from various localities, but the writers have observed only one, about 2 miles northeast of the town of Madruga in Havana province.

Little has been published as to the origin of this oil. Some refer the probable source to the Jurassic, others to the Cretaceous, but few have made any effort definitely to connect the oil with a certain stratum or formation. As the oil-generating strata are of great importance in determining whether or not any future development may be expected in western Cuba, the writers have endeavored to connect the oil produced and evidenced with either the Jurassic or Cretaceous sediments.

A thorough examination of the literature and available private reports and a field study of Havana and Pinar del Rio provinces were made with this end in view. This investigation has led to the conclusion that the Jurassic limestones and shales are the most likely source of the oil, and that there should be valuable deposits yet to be found under favorable structural conditions in western Cuba. The reasons for this conclusion are: (1) The highly petroliferous character of these Jurassic sediments makes them stand out among the other sediments of Cuba as likely source beds. The non-oil-forming beds resting uncomformably on the Jurassic are impregnated with asphalt to a very great extent in Pinar del Rio province. In Havana province the oil seeps and asphalt deposits 3,000 or more feet above the Jurassic are found in connection with post-Jurassic faulting or igneous intrusions. (2) At Bacuranao and Madruga, fragments of what appears to be altered Jurassic limestone are found in later volcanics and contain liquid hydrocarbons.

STRATIGRAPHY OF WESTERN CUBA

The oldest rocks in Cuba are highly metamorphosed schists, slates, limestones, marbles, and granites. Various igneous rocks have been intruded at different times. Dr. Carlos de la Torre, of the University of Havana, has informed the writers that no Triassic has been identified, although some black altered limestones in the province of Santa Clara, near the town of Trinidad, may be of that age.

The Oxfordian, Kimmeridgian, and Portlandian of Middle and Upper Jurassic have been identified by Barnum Brown, Marjorie O'Connell, and Dr. de la Torre, and are the oldest sediments identified on the island. At Vinales these formations are well exposed, and their combined thickness is 2,000 feet or more. All are petroliferous and emit a distinct odor of petroleum when struck with the hammer.

The Oxfordian consists of thick strata of blue-black limestone and thin shales, with cavities and calcite seams containing residues of petroleum. This is a fossiliferous, marine formation containing ammonites, fishes, and reptiles.

The Kimmeridgian contains gray-black to black limestones with thick parting shales. Calcite veins cross the formation, and black concretions, frequently inclosing ammonites, are numerous.

The Portlandian is made up of hard gray and gray-black limestone, fossiliferous and thin-bedded at top with intercalated shales and occasional chalcedony lenses.

These three divisions appear to have been laid down under conditions favorable to the generation of petroleum, as is evidenced by their color and character.

The Jurassic beds of Cuba have been correlated by Barnum Brown and Marjorie O'Connell with those of Mexico. Burckhardt has described the Middle and Upper Jurassic of Mexico, and, according to Dr. de la Torre, who has inspected these sediments in both Mexico and Cuba, they are very similar lithologically and paleontologically, and are also bituminous. Professor A. W. Grabau has published a map correlating the Neo-Jurassic sea, which indicates that these beds underlie the entire oil-producing areas of Mexico, Colombia and Venezuela, and southwestern Texas. His map also includes the western part of Cuba.

The vast amounts of oil produced in Mexico indicate a great thickness of oil-generating strata, and the Upper and Middle Jurassic, estimated by Burckhardt to range from 400 to 1,700 meters, are considered by the writers as a much more likely origin than the Tamasopa, San Felipe, or Mendez formations. The Tamasopa, which is considered by many

to be the original source, has been observed in some localities entirely unattended by hydrocarbons. The San Felipe and Mendez shales as described do not compare with the Jurassic in petroliferous character. Again, all oil so far produced in Mexico has been associated with faulting or igneous intrusion, either of which may cause the upward migration of the oil from Jurassic rocks.

Lying unconformably upon the Jurassic is the Lower Cretaceous series of felspathic sands, sandy shales, and shales with occasional limestones. A conglomerate at the base varies in thickness, and in Pinar del Rio province represents continental deposition, while in Havana province it contains marine fossils and resembles a shore deposit. In Pinar del Rio it is impregnated with bitumens along the joints and in the interstices of the matrix. The fractured sands and shales near the base yield a foul odor when broken, and contain bitumens.

The Middle Cretaceous is represented by white marly shales in the lower phase, with open granular limestone grading into limestone conglomerate in the upper phase.

The Upper Cretaceous consists of thick arkosic conglomerate at the base succeeded above by felspathic sands and shales.

A series of limestones and shales recorded as "caving" or "rotten" in well logs is referred doubtfully to the Eocene. The Oligocene consists of hard crystalline limestones.

PROBABILITY OF COMMERCIAL OIL UNDER SUITABLE COVER

The search for commercial oil has not been well rewarded in Cuba. The question arises: Do the asphalt deposits represent all that remains of an oil supply that has leaked away, or does a considerable part remain? Let us postulate the conditions under which petroleum theoretically should occur in western Cuba, and then examine actual experience of drilling.

There are the highly bituminous Jurassic strata outcropping in Pinar del Rio province which apparently extend over the western part of Cuba. Unconformably upon the Jurassic lie the Lower Cretaceous shales, sands, and basal conglomerate. When there is a suitable structure, this Lower Cretaceous conglomerate might reasonably contain oil.

The only other porous beds with capping are the felspathic sands and conglomerate together with the underlying granular limestone of the Upper Cretaceous. Oil could reach these beds only in case of faulting, or fracturing caused by igneous intrusion, thus allowing the

oil to rise through the Lower Cretaceous shales. Shattering caused by igneous intrusion or folding of strata against igneous masses ought to open up favorable reservoirs.

Comparisons are unreliable, but in this connection it may be pointed out that in Mexico igneous plugs have been associated with fracturing and have influenced folding as in Cuba, and have formed reservoirs holding oil.

A reference to well logs shows that actually there have been two classes of wells drilled in Cuba: those beginning in the Tertiary or, in some cases, Cretaceous strata; and those in serpentine. None of the former have reached the Lower Cretaceous sands, and it is doubtful if any reached the Upper Cretaceous sands; and if so, not in a zone reached by oil migration from lower beds. In the second class are wells which have been drilled directly into serpentine. This class produces practically all the oil now found on the island. The serpentine is a poor container, being a mass of fractured, decomposed igneous rock without sufficient capping.

The writers believe that under suitable structure in the Lower Cretaceous so far not reached by the drill, oil will most likely be found in commercial quantities.

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CARBON RATIOS OF CRETACEOUS COALS IN NEW MEXICO IN THEIR POSSIBLE RELATION TO OIL

The purpose of this paper is to present the results of a compilation of the carbon ratios (fixed carbon content) of coals in formations of Cretaceous age in New Mexico in an effort to interpret their possible relations to oil. Since there are, at present, only widely scattered oil fields in New Mexico, the relation of the carbon ratios of the Cretaceous coals to oil in Cretaceous sediments is, at best, a matter of conjecture. The theory of the relation between the carbon ratios of coal and petroleum deposits as developed by David White[1] and applied by Fuller[2] has been

[1] David White, "Some Relations in Origin between Coal and Petroleum," *Wash. Acad. Sci.*, Vol. 6, March 16, 1915.

[2] Myron L. Fuller, "Relation of Oil to Carbon Ratios of Pennsylvanian Coals in North Texas," *Econ. Geol.*, Vol. 14 (Nov., 1919), No. 7; "Carbon Ratios in Carboniferous Coals of Oklahoma and Their Relation to Petroleum," *ibid.*, Vol. 15 (April-May, 1920), No. 3.