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Geology and oil characteristics of tar sand near Santa Rosa, New Mexico

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Sands or sandstones occurring at shallow depth (to 2,000 ft) and containing quantities of heavy oil are commonly referred to as tar sands, bituminous sands, or heavy-oil sands. The largest known deposits in the world are in Venezuela and Colombia (estimated 1.8 trillion bbl) and on the Island of Malagasy (1.7 trillion bbl). In Alberta, Canada, the Athabasca tar sands contain an estimated 1 trillion bbl of oil in place, of which 200 billion bbl are considered recoverable as synthetic crude oil; two plants are in operation near Fort McMurray. The Great Canadian Oil Sands, Ltd., plant produces 150,000 bbl/day, while the Syncrude Canada plant has an output of 100,000 bbl/ day. A high degree of government cooperation has contributed to the rapid growth of a synthetic crude industry in western Canada. Incentives include direct financial support, favorable income tax treatment, and a massive research and development effort funded by Alberta. Also industry has met and even surpassed environmental regulations, and cooperates with the government at all levels. The future of the Canadian oil sand industry appears bright, with a projected production of 750,000 bbl/day by 1995.

U.S. reserves of oil from tar sands have been estimated at 26 billion bbl, most of them in Utah. The main occurrence of tar sand in New Mexico is in an asphalt quarry about 7 miles north of Santa Rosa in Guadalupe County (fig. 1). Between 1930 and 1939 about 153,000 tons of bituminous sandstone were produced for road surfacing. The quarry has not been operated since 1939. Gorman and Robeck (1946) documented some of the drilling and mapped the geology of the surrounding area. In 1976-1977 additional core holes were drilled. Information from these holes was used in preparing this report.

The U.S. Corps of Engineers is building Los Esteros Dam on the Pecos River, about 0.5 mi downstream from the asphalt quarry (fig. 1). When completed in 1980 the lake created behind the dam will cover a part of the tar sands.

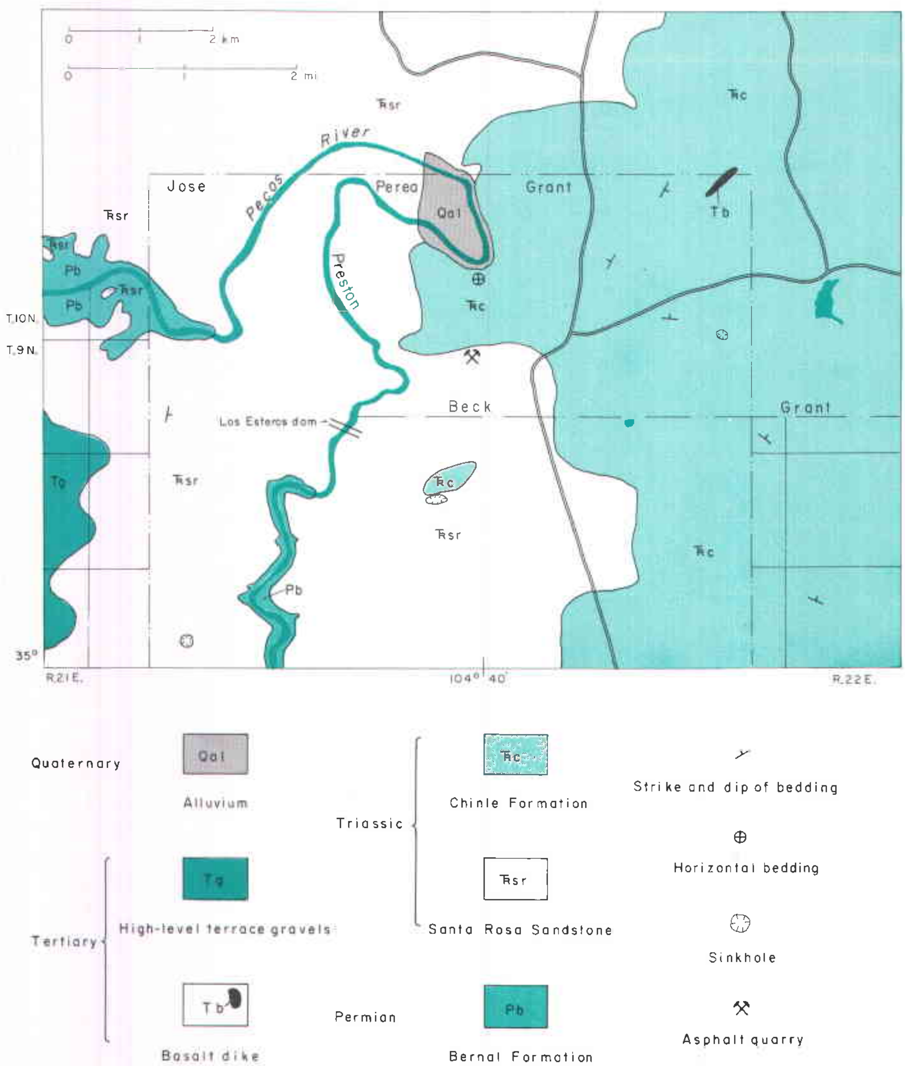

FIGURE 1—GEOLOGIC MAP OF ASPHALT QUARRY, SANTA ROSA, NEW MEXICO. Modified after Gorman and Robeck, 1946.

General geology

The oil occurs in the Santa Rosa Sandstone (Upper Triassic) which has an average thickness of 250 ft. Oil is oozing from the sandstone in the quarry (fig. 2), and can also be observed in outcrops in roadcuts and workings near the dam (fig. 3).

FIGURE 2—BROKEN, WEATHERED SANDSTONE SHOWING BLEEDING ASPHALT.

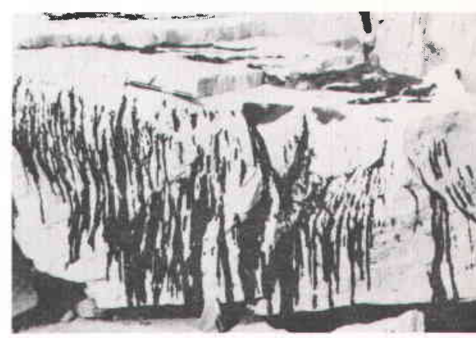

FIGURE 3—POST-QUARRYING BLEEDING ASPHALT.

The Santa Rosa Sandstone has been divided into four members from top to bottom: Upper Sandstone Member, Shale Member, Middle Sandstone Member, and Lower Sandstone Member (Gorman and Robeck, 1946, and McDowell, 1972). The sandstones are cross-bedded, calcareous quartz-sandstones with silt and shale partings and several conglomerate zones. Variation of lateral thickness make recognition of individual members in drill holes difficult, particularly where the Shale Member pinches out.

Stratigraphic relations are further complicated by the fact that thin arenaceous layers occur within the lower part of the overlying Chinle Formation (Triassic). The Chinle is predominantly brown to red shale with discontinuous sandstone interbeds.

Microscopic examination of the Santa Rosa Sandstone shows the rock is a fine- to coarse-grained, angular to subrounded, poorly sorted arkosic sandstone with calcite cement. Major constituents are quartz (35-70%), silt (0-10%), colorless mica (1-3%), lithic grains, mostly limestone and siltstone (0-23%), feldspar (1-5%), and opaques (1-2%). The calcareous cement makes up 18–41% of the rock.

Rocks underlying the Santa Rosa Sandstone are, in descending order, the Bernal Formation, the San Andres Limestone, and the Glorieta Sandstone (all Permian). These rocks are exposed in the canyon of the Pecos River west of the asphalt quarry and are also encountered in some of the deeper drill holes. The Bernal consists of 235 ft of red to yellow claystone and siltstone with gypsum. The San Andres is a dark-gray, massive, dolomitic limestone, cherty in places; the Glorieta is a buff to white, medium- to coarse-grained sandstone. The San Andres and Glorieta have an aggregate thickness of 635 ft.

Formation of the Santa Rosa Sandstone took place under terrestrial conditions, perhaps by large streams, that deposited sand and silt over a floodplain or deltaic environment. Occasional freshwater ponds and lakes may have existed as indicated by the remains of fossil fishes in the Triassic rocks.

The only igneous rock in the area is a northeast-trending basalt dike, probably of Tertiary age, cutting across the Chinle Formation. The exposed portion of the dike, about 500 ft long and 75 ft wide, is a black basalt composed of labradorite (66%), clinopyroxene (17%), olivine (10%), magnetite (6%) and biotite (1%).

The areal extent of the dike (explored with the aid of a magnetometer survey, fig. 1) indicates the dike may extend beyond the exposed part for 3,000 ft to the southwest, and for 1,300 ft to the northeast.

Oil characteristics

Three samples of oil-bearing sandstone have been analyzed for bituminous material by GeoChem Laboratories in Houston. Samples 1 and 2 are cores from drill holes in the vicinity of the asphalt quarry, from 120 ft and 80 ft below the surface respectively. Sample 3 was obtained from a large block in the asphalt quarry. The following table lists the components of the bituminous material in weight percent.

Sample No.	Extract weight %	Hydrocarbons		Nonhydrocarbons	
		Paraffin-naphthene	Aromatic	NSO-compound	Asphaltene
1	2.1	10.3	19.4	7.0	63.3
2	2.9	6.5	9.9	4.2	79.4
3	3.6	23.4	30.4	15.0	31.3

On the basis of the organic geochemical analyses, the bituminous material can be characterized as a moderately immature, naphthenic oil that has undergone extensive bacterial degradation. The biodegraded character of the oil is indicated by the very low content of alkanes, ranging from 1.5-2.2% of the C_{15+} paraffin-naphthene fraction. In bacterial attack on crude oil, the bacteria preferentially remove the straight-chain hydrocarbons in the first phase of alteration.

The low degree of maturation is indicated by the preponderance of C_{25} to C_{28} compounds among the cycloalkanes, causing a hump in the naphthene fraction envelope (characteristic of oils in the immature oil zone).

Immature oils appear to have a predominance of odd-numbered alkanes over even-numbered; organic material of terrestrial derivation in Recent sediments shows this odd-preference very clearly. Thermal maturation of organic matter in the rock generates new alkanes without predominance, and the odd-over-even preference disappears. Quantitatively, the odd-preference can be expressed by the carbon preference index (C.P.I., Bray and Evans, 1961), as follows:

$$\text{C.P.I.} = \frac{1}{2}\,\frac{C_{25}+C_{27}+\ldots+C_{33}}{C_{24}+C_{26}+\ldots+C_{32}} + \frac{C_{25}+C_{27}+\ldots+C_{33}}{C_{26}+C_{28}+\ldots+C_{34}}$$

The Santa Rosa oils show C.P.I. values near unity, ranging from 0.94 to 1.19. The low C.P.I. of the Santa Rosa oil may be due to the lack of terrestrial organic matter in the original material from which the oil was derived, suggesting the Santa Rosa Sandstone is not the source rock of the oil, but migrated into its present position from some other source in which the organic material was of marine origin.

Another indication as to the origin of the oil can be derived from the pristane-to-phytane ratio. These isomers of the alkane series (C_{19} and C_{20}) are derived from chlorophyll in the original plant material. Depending on reductive or oxidative pathways, diagenesis will produce a preponderance of phytane or pristane. The pristane-to-phytane ratio in the Santa Rosa oils ranges from 0.52 to 0.67, suggesting a reducing environment in which the organic matter was formed. Reducing conditions are unlikely to have existed during the deposition of the Santa Rosa Sandstone but may well have occurred in a marine basin similar to the one in which the San Andres Limestone was deposited.

Stable carbon isotope data support the idea that the San Andres may have been the source of the oil. Through the cooperation of I. D. Went and W. J. Stahl of the Federal Institute for Geosciences and Natural Resources in Hanover, Federal Republic of Germany, the three oil-bearing rock samples were analyzed for C^{12}/C^{13} ratios. Results indicate the oil has been biodegraded and that all three extracts are derived from the same source rock. On the basis of the so-called type curve (Stahl, 1978), the original bituminous material had a $\delta^{13}C$ equal to or larger than -26.6 ‰. This value compares with δ values of -25.8 ‰ to -27.2 ‰ reported for Permian oils of the northwest shelf of the Permian Basin (Holmquest and others, 1968). Pennsylvanian and older oils from the Permian Basin show δ values that are less than -28.9 ‰.

Other characteristics of the oil and reservoir rock include a porosity of the Santa Rosa Sandstone of 10–13%, average permeability of 100 to 200 md, oil gravity of 11.9° A.P.I., and oil viscosity of 30,000 cp at 60°F.

Estimate of oil in place

Estimating reserves of oil, particularly in unexplored or partially explored areas, is fraught with uncertainties. Estimates made before drilling can vary by as much as a factor of 10 from the eventual potential of an area (Uman and others, 1979).

To obtain an estimate of the oil in place in the Santa Rosa Sandstone, the following procedure was used: A total of 23 core holes from which bituminous material had been reported were considered in the calculation. These holes cover an area of about 4,800 acres. Sections with oil saturation averaging 4% range from 16 to 201 ft. Many holes did not penetrate the full thickness of the Santa Rosa Sandstone. The following estimate, therefore, should be considered a minimum. The oil-bearing section in each core hole was considered representative of a circular area with radius equal to half the average distance to neighboring drill holes.

The calculated total amount of oil is 90.9 million bbl, compared to estimate of 57.2 million bbl formerly reported for the Santa Rosa occurrence.

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References

Bray, E. E., and Evans, E. D., 1961, Distribution of n-paraffins as a clue to the recognition of source beds: Geochimica et Cosmochimica Acta, v. 22, p. 2015

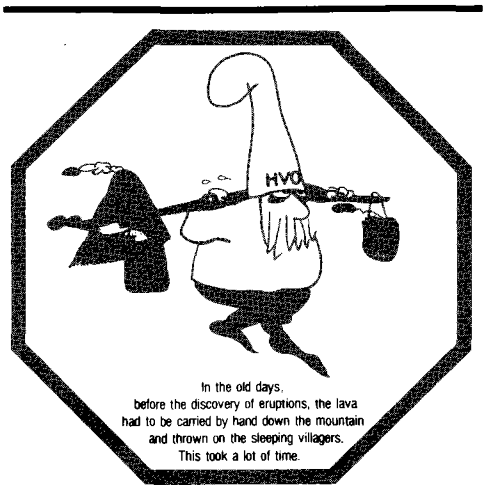
Gorman, J. M., and Robeck, R. C., 1946, Geology and asphalt deposits of north-central Guadalupe County, New Mexico: U.S. Geological Survey, Oil and Gas Investigations, Prelim. Map 44

Holmquest, H. J., Smith, H. M., and Johansen, R. T., 1968, Introduction to the compositional and stratigraphic relationships of Permian Basin oils, Texas and New Mexico, *in* Basins of the Southwest: West Texas Geological Society

McDowell, T. E., 1972, Geology of the Los Esteros Dam site: New Mexico Geological Society, Guidebook 23rd field conference, p. 178-183

Stahl, W. J., 1978, Source rock-crude oil correlation by isotopic-type curves: Geochimica et Cosmochimica Acta, v. 42, p. 1573-1577

Uman, M. J., James, W. R., and Tomlinson, H. R., 1979, Oil and gas in offshore tracts—estimates before and after drilling: Science, v. 205, p. 489-491 □



Courtesy Hawaiian Volcano Observatory, U.S. Geological Survey