ALASKAN OIL SHALE

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Deposits of oil shale were first reported in Alaska north of the Arctic Circle in the latter part of the 19th Century. Before this time, according to evidence near old camp sites, shale had been used for fuel in interior Alaska, as it is being used now, 1967, by the Eskimos of Anaktuvak Pass in the central part of the Brooks Range.

Fragments of oil shale were found by early explorers as far north as the basin bordering the Arctic Ocean, and during early geological investigations of the area north of the Arctic Circle oil shale was collected and identified by Collier (1906), and later by Smith and Mertie (1930) in gravel bars and outcrops in stream cuts. Other deposits, too, were described in several early reports but were erroneously identified as coal.

Detailed geologic mapping in 1950-51 by U.S. Geological Survey field parties in connection with the geologic evaluation of Naval Petroleum Reserve No. 4 delineated additional oil-shale localities. In 1964, Tailleur published a short article in U.S. Geological Survey Professional Paper 475-D giving Fischer assay results from oil-shale samples of marine oil shales collected by these Survey field parties. These samples yielded from 6.7 to 146 gallons of oil per ton of rock. In the summer of 1964, Tailleur collected oil-shale samples from 12 localities in the Southern Foothills belt of the Brooks Range, and also obtained larger samples from some of the localities previously tested. These samples were routinely assayed for oil content, were examined petrographically and mineralogically, and were analyzed chemically for major constituents and minor elements. The results of this examination were reported in an open-file report by Tourtelot and Tailleur (1965).

As a result of the analytical work of 1964 a reconnaissance project was initiated, headed by Tailleur, to attempt to determine the thickness, value, and extent of the oil-shale deposits on the Arctic Slope. This project was funded by the Office of Naval Petroleum and Oil Shale Reserves, Washington, D.C., and was logistically supported in great part by the Arctic Research Laboratory at Point Barrow.

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The area north of the Arctic Circle, and more particularly that part immediately north of the Brooks Range, a west-trending mountain range that is the northernmost mountain range in Alaska, was of principal interest.

From south to north the area is divided physiographically into the Brooks Range, a mountainous area with a maximum relief of 5,000 feet; the Southern Foothills belt, an area consisting of hills having a maximum relief of 1,500 feet; the Northern Foothills belt, consisting of more broadly rounded hills having possibly as much as 500 feet of relief; and the Arctic Slope, a flat poorly drained plain with a maximum relief of 150 feet. Most of the exposed oil shale is in the Southern Foothills belt. This area is north of timberline and its vegetation consists chiefly of arctic tundra that forms a very effective cover on the steep slopes of the hills and the adjacent gently sloping river terraces. Willows with a maximum height of 15 feet and a trunk diameter of no more than several inches are in and adjacent to the major drainages.

In the area north of the Brooks Range the weather is cold and dry, and because of the low mean annual temperature permafrost is present at depths ranging from a few inches under the tundra-covered slopes to several feet on many gravel bars.

Much of the Southern Foothills belt is structurally complex and is characterized by west-trending isoclinal folds, thrust faults, and high-angle reverse faults. The thrusting, probably post-Cretaceous in age, has resulted in a maximum horizontal displacement of 75 miles to the north.

Underlying the north slope from the Brooks Range to the Arctic Ocean are mostly marine sedimentary rocks that range in age from Devonian through Quaternary. In this sequence only rocks of Pennsylvanian age are missing. In the Southern Foothills belt, rocks range in age from Mississippian to Early Cretaceous. The Mississippian through Jurassic rocks are dominantly black shale, chert, and black organic limestone, and the overlying Cretaceous rocks are dominantly beds of sandstone, grit, and conglomerate. The oil shales are contained in the Mississippian through Lower Cretaceous rock sequence.

The Mississippian oil shale submitted for assay by Tailleur in 1964 yielded only 6.7 gallons of oil per ton; therefore, during the 1965 reconnaissance oil-shale field study, no additional Mississippian samples were taken. In rocks ranging in age from Triassic to Early Cretaceous, however, several different types of oil shale were noted and sampled. These were:

1) *Tasmanite.*—Tasmanite is a woody-appearing oil shale that is a lustrous dusky brown on fresh fracture and a moderate brown on weathered surface. Tasmanite is composed almost entirely of a sporelike alga and is named for its occurrence in Tasmania. Frequently the Alaskan tasmanite

contains white bands that, by unaided eye, resemble quartzite but under high magnification is identified as diagenetic silica, which occurs within each alga. The Alaskan tasmanite also contains small quantities of barite. The tasmanite ranges in thickness from a few inches to 4 feet 7 inches and yields up to 160 gallons of oil per ton at the localities sampled. At one locality a sample of tasmanite that was 4 feet 7 inches thick yielded an average of 130 gallons of oil; however, the tasmanite at that locality is bounded by claystone barren of oil, which in turn is enclosed by a thick sequence of thin-bedded varicolored chert. In comparison, the richest 1-foot bed of the Rocky Mountain area oil shale in the Eocene Green River Formation yields about 95 gallons of oil per ton, and a maximum thickness of 2,000 feet of almost pure oil shale will yield an average of 15 gallons of oil per ton. Specific gravity of the richer tasmanite is 1.2 or less and it is commonly carried by streams to places many miles from the outcrop. Tasmanite probably is the material that has been found strewn along the beach bordering the Arctic Ocean. Tasmanite becomes highly contorted when subjected to high pressures possibly because of the high percentage of a single type of organic material; at most localities it occurs as elongate blebs or pods several feet long and a foot or two thick.

2) *A type of black oil shale superficially resembling the Green River oil shale.* This shale is dark brown to black on fresh fracture and locally weathers bluish gray. Microscopically the organic matter in this black shale ranges from red to reddish-brown fibrous-appearing material to black opaque material. Commonly it is interbedded with thin-bedded black organic cherts and limestones. At one locality thin units of black shale yield more than 50 gallons of oil per ton but at some other localities black shale units up to 20 feet thick yield an average of about 15 gallons of oil per ton. Black shale at one locality is 20 feet thick, relatively free of chert, yields an average of 15 gallons of oil per ton, and contains an average of 6,300 ppb Ag and 630 ppb Hg. Another sequence of black shale, 20 feet thick, consists of about 50 percent thin-bedded black limestone and chert, yields an average of 15 gallons of oil per ton and contains 1,500 ppb silver, 120 ppb gold, and abnormally high amounts of barium, copper and zinc.

3) *A type of oil shale locally called whale-blubber rock.* This type was found east of the Naval Oil Reserve and about 20 miles southwest of the Eskimo village of Anaktuvak Pass. This deposit is greatly valued by the Eskimos in the area as a source of fuel and the location was shown to the Survey field party by the chief of the Eskimos of Anaktuvak Pass. The material is black on both fresh and weathered surface, is extremely flexible, and closely resembles a piece of hard rubber. The largest pieces of shale were found along the stream bed, and were about 4 feet by 2 feet by 2 feet—

they probably weighed 200 to 300 pounds. The pieces almost invariably were covered with thin parallel to subparallel grooves that the Eskimos claimed were animal tooth marks. An abundance of fragments of this shale was found in a dominantly black fissile marine shale slope. Trenches were dug at several likely looking spots on this slope and large pieces of the shale were unearthed but it could not be determined with any degree of certainty that any were in place. Upon assay this material yielded 85 gallons of oil per ton.

Thin slivers of tasmanite and the whale-blubber rock were easily ignited and burned readily. The other black oil shales also could be ignited but only with the help of gasoline; however, once started they burned readily for a long period of time.

Specific gravity of the oil from Alaskan oil shale ranges from 0.70 to 0.97 at 15.6°C and most of the oil flows freely at temperatures near 0°C. The specific gravity of the oil from most of the tasmanite sample is less than 0.90.

In addition to the Fischer assays of the shales sampled, six-step spectrographic analyses were made to determine the elemental composition of the shale. Content of barium is unusually high in most all samples and is as high as 7 percent in a few samples. Unusually high concentrations of other minor elements were found. Some maximum concentrations are:

B	0.05%	Mo	0.2%
Cr	.1%	Ni	0.07%
Cu	.05%	Sr	.3%
Co	.02%	V	.15%
Pb	.02%	Zn	.5%

In addition to six-step spectrographic methods, more precise chemical analyses were run for gold, silver, and mercury. Maximum quantities found were:

Gold	350 ppb
Silver	20,000 ppb
Mercury	2,800 ppb

Amounts above 100 ppb for gold and 300 ppb for mercury are considered anomalous.

In general, an inverse relationship exists between the organic content and trace-metal content of the shale. However, many samples of tasmanite are very high in mercury and silver. One example is the sample of 4 feet 7 inches of tasmanite that contains 530 ppb silver and 1,820 ppb mercury.

Some of the Alaskan oil shales that are rich in both oil and trace metals would in another setting ordinarily be attractive industrially. However, because of adverse weather conditions, remoteness from market, estimated high cost of mining and processing, and last but certainly not least, the thinness and limited extent of the presently known deposits, initiation of any commercial oil-shale operation in Alaska in the foreseeable future is doubtful.

REFERENCES

1. Collier, A. J., 1906, Geology and coal resources of the Cape Lisburne region, Alaska : U.S. Geol. Survey Bull. 278, 54 p.
2. Smith, P.S., and Mertie J. B., Jr., 1930, Geology and mineral resources of northwestern Alaska: U.S. Geol. Survey Bull. 815, 351 p.
3. Tailleur, I. L., 1964, Rich oil shale from northern Alaska, *in* Short papers in geology and hydrology: U.S. Geol. Survey Prof. Paper 475-D, p. D131-D133.
4. Tourtelot, H. A., and Tailleur, I. L., 1965, Oil yield and chemical composition of shale from northern Alaska: U.S. Geol. Survey open-file report, 17 p., 5 tables.