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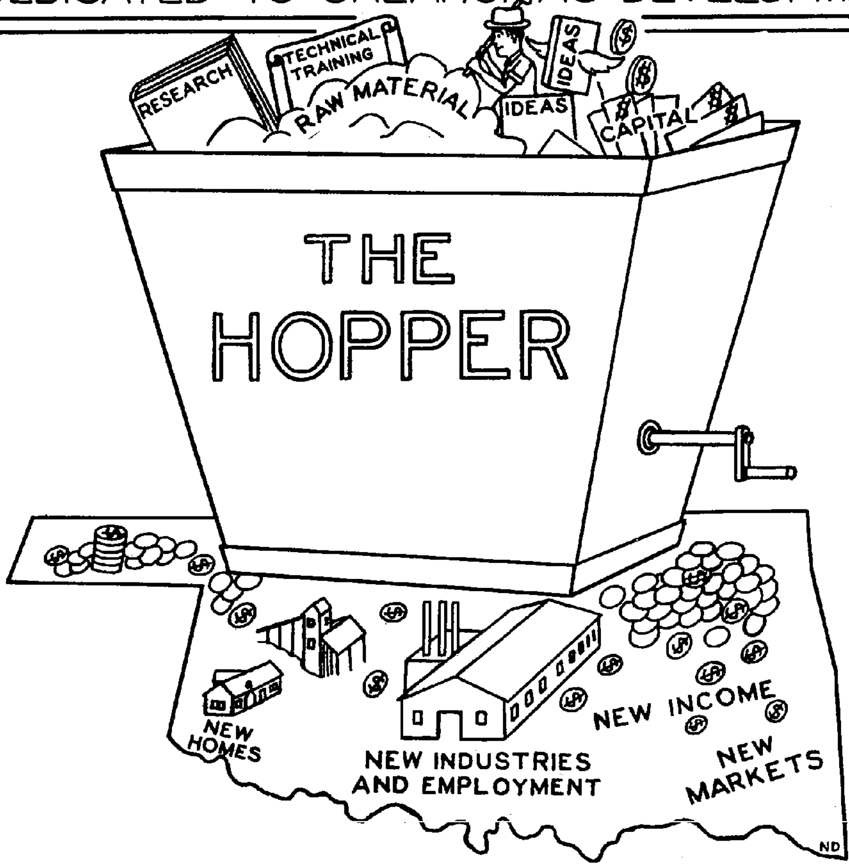

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TITANIUM IN BLACK SANDS OF WICHITA MOUNTAINS

by
Gerald W. Chase
Oklahoma Geological Survey

The presence of the iron-titanium mineral ilmenite as black sand in alluvial deposits of the Wichita Mountains has been known for many years, but little information was available as to its occurrence or its economic possibilities. Gabbroic rocks (anorthosite and gabbros) of the area contain ilmenite and magnetite and are the probable source of the ilmenite grains of the black sands. Professor C.A. Merritt, 1939, described the iron ore in gabbroic rocks of the area, and found that magnetite and ilmenite are intimately associated as small, intergrown crystals, and occur in massive dikes. The presence of titanium is a serious detriment to the use of the ore for making pig iron.

Use of titanium has increased many fold during the past decade, owing to discovery that it makes an excellent white pigment for paints and other uses. Production of titanium dioxide in the United States, chiefly from the mineral ilmenite, has grown from 43,794 tons in 1940 to 195,349 tons in 1949. Titanium-bearing iron ore in the Adirondack Mountains of New York, that had been known for over 100 years, came into production in 1942, and, more recently, black sands in beach deposits in Florida have been developed as domestic sources of titanium dioxide. Hitherto, practically all supplies had come from overseas, principally from India.

Further investigation of the primary, vein-like deposits of the titanium-bearing iron ore of the Wichita Mountains showed that the fine crystal size and the intimate intergrowth of ilmenite and magnetite preclude their separation by methods in use on the New York ores, and attention was turned to the possibility of finding alluvial deposits in which a natural separation may have been effected. and in which ilmenite might be in sufficient concentration to rank as commercial ore. Studies were made to determine the nature of the sands and their mode of occurrence, as a guide to future prospecting and possible exploitations.

Area investigated. The area investigated is located in southwestern Oklahoma, covering parts of northwestern Comanche County and east-central Kiowa County. The area is served by a branch of the Rock Island Railway, serving Lawton, Comanche County, and two branches of the Frisco Railway, which cross at Snyder, Kiowa County.

Exposed rocks. The rocks exposed in this area range in age from pre-Cambrian to Recent, and consist of metamorphic and igneous rocks of pre-Cambrian age; upper Cambrian and lower Ordovician limestone, sandstone, and dolomite, belonging to the Timbered Hills and Arbuckle groups; red shales, siltstones, and sandstones of Permian age; sands, gravels, and clays comprising high-level terraces of Pleistocene age; and Recent stream alluvium.

Topography. East-central Kiowa County contains a number of disconnected hills composed of anorthosite that rise to a maximum height of 450 feet above the surrounding plains. These hills are part of the Raggedy Mountain group. They trend southeast and extend into northwestern Comanche County, where the igneous rocks are of both the granitic and gabbroic types. The hills in Comanche County are divided into the Wichita Mountain group and the Quannah Mountain group, composed mostly of granites. These mountains reach a maximum height in Mount Scott, which rises to 1,130 feet above Lake Lawtonka.

Hills in Kiowa County are rounded and have gentle slopes; whereas those in Comanche County are steeper, with many sheer cliffs 200 to 300 feet high. These igneous hills are surrounded by a Per-

Table I, Rocks exposed in Wichita Mountains

Age	Rock Units	Remarks
Quaternary	Recent	Alluvium, containing black sands
	Pleistocene	Ancient alluvium on high-level terraces. Locally contains some black sands
Permian	Undifferentiated	Red shales, sandstones, conglomerates; may contain black sands locally
Ordovician	Arbuckle group	Limestone, some dolomite
Cambrian	Timber Hills gp.	Limestone, dolomite, sandstone
pre-Cambrian		Granite Porphyry Anorthosite Gabbro, containing titanium-bearing magnetite, in basic pegmatites
	Meers	Quartzite

mian red beds plain that extends for miles in all directions.

Drainage. The drainage system of the area is composed of intermittent streams that, with the exception of a few pools, are dry during all but the rainy season. Elk Creek, Otter Creek, Glen Creek, and Dry Otter Creek make up the main drainage in the Raggedy Mountain group and flow south as tributaries of the North Fork of Red River.

The Wichita and Quannah Mountain groups are drained by three main intermittent drainage systems. Sugar Creek is the main stream in the northwest part of the Wichita Mountain group and flows north as a tributary of the Washita River. Medicine Creek flows southeast along the northern flank of the Wichita Mountain group and its drainage system is the main water shed for Lake Lawtonka. Sandy Creek, Post Oak Creek, Rock Creek, and West Cache Creek drain the southern half of the Wichita and Quannah Mountains and flow south as tributaries of the North Fork of Red River.

Field sampling. Two types of sampling were employed during the investigation, one consisting of sampling alluvial sands along stream channels, and the second in collecting samples from test holes drilled in alluvium-filled valleys.

Samples from stream channels were collected on sand bars with no obstructions for distances of 300 yards upstream. Twenty-five pound samples were secured from the downstream end of the bars, where the heavy mineral concentrations were the greatest. Where a tributary entered the main stream, samples were collected above and below the mouth of the tributary. In a few instances banks of the streams were sampled to ascertain the heavy mineral content of the alluvial fill.

The boring of test holes in old stream channels was first undertaken with a hand-operated basket auger, but was unsuccessful as the sands were saturated with water, and the samples ran out of the auger before they could be brought to surface. Sampling with a portable rotary drilling unit was more successful. Test holes were drilled a foot at a time, with each foot of sample from the hole being collected by stopping the bit's rotation and continuing water circulation until all sand or clay particles had been recovered. Then the next foot was drilled and the same procedure repeated. This method of sampling was successful in all test holes but two, where the size of the sand grains was so large that sides of the hole caved in, preventing recovery of a representative sample. The samples from each foot of hole were split and 15 pounds of sand saved for future studies in the laboratory.

Method of separation. Samples were air dried in the laboratory and quartered on a Jones sample splitter until a 100-gram sample was obtained. Samples contained ilmenite, magnetite, augite, plagioclase feldspar, orthoclase feldspar, and quartz. These minerals were separated by the sink-float method recommended by Krumbein and Pettijohn.

The sands were placed in bromoform (Sp. Gr. 2.89) and the orthoclase and plagioclase feldspars and the quartz separated from the heavy minerals by floating. This light fraction was further separated by using bromoform solution whose gravity was adjusted with acetone to just float orthoclase feldspar and yet allow the quartz and plagioclase feldspar to sink. The heavy mineral fraction was placed in Clerici's solution (Sp. Gr. 4.2-32° C.) which floated the augite and allowed the ilmenite and magnetite to sink. The magnetite was then removed magnetically from the ilmenite. All fractions of like minerals were combined from each one-foot sample to form composites. These composite samples were then seived to determine the mineral size frequency distribution of each mineral species occurring in the sand from the test hole.

Identification of minerals. The magnetic and nonmagnetic fractions of the opaque minerals were identified by chemical analysis and the silicate minerals were identified by their index of refraction, using the oil immersion method with a petrographic microscope. Chemical analyses were made in the laboratory of the Oklahoma Geological Survey by A.L. Burwell or under his supervision.

Samples from stream channels. Samples of alluvial sands of eight major intermittent streams show ilmenite to be present in only two. Streams containing no ilmenite or only a trace were Dry Otter Creek, Deep Red Creek, Sandy Creek, Post Oak Creek, Rock Creek, and West Cache Creek. These drain the southern part of the Wichita and Quannah Mountain Groups and head in granite hills. Such ilmenite as was found in the samples is intergrown with magnetite, showing there has been no natural separation of the two minerals.

Glen Creek. Glen Creek, in Kiowa County, flows southwestward through the eastern half of T. 4 N., R. 17 W. and was the first stream chosen for study, as the black sands are in greater concentration in this stream than in any other in the area. The stream heads near Iron Mountain in Sec. 7, T. 4 N., R. 16 W. where vein-like masses of magnetite occur in gabbro. The stream flows south through Sec. 14, T. 4 N., R. 17 W. passing over a body of hornblende olivine magnetite.

Samples were collected along Glen Creek at half-mile intervals. Heavy mineral fractions contain 26 to 58 percent augite and 2 to 16 percent magnetite with free ilmenite not present. Magnetite sand grains contain ilmenite intergrown along the octahedral planes of the magnetite and so locked with the magnetite that stream abrasion does not separate the two minerals.

The augite and magnetite are contributed to the alluvial sediments from the weathered gabbro that occurs in the drainage system. The anorthosite and granite contribute little, if any, magnetite, and no augite, to the sands of Glen Creek.

Medicine Creek. Medicine Creek, in Comanche

County, flows east along the northern part of the Wichita Mountain Group through T. 4 N., Rs. 14 and 13 W., forming the main water shed for Lake Lawtonka. Sediments contributed to the stream come from the weathered gabbro and granite in the area.

Samples were collected from the alluvial deposits in the upper reaches of the stream channel, and studies show that ilmenite is absent or present only as a trace in the heavy mineral fraction. Samples from the Mount Sheridan area were found to contain free ilmenite in small quantities, indicating contribution from a local source.

Examination of the sands occurring in the road ditch on the east side of Mount Sheridan and samples of alluvial sand from beneath the Medicine Creek bridge south of the Meers Post Office revealed the presence in nearly equal amounts of both ilmagnetite and ilmenite. The chemical analyses of these heavy mineral fractions, after removal of the augite, are given in Table II.

Table II

Lab. No.	9761A	9761B	C
Fe	60.9	33.9	34.0
TiO_2	13.8	42.8	44.0
V_2O_3	0.6	0.16	

9761A - Magnetic (magnetite) heavy mineral fraction from road ditch on east side of Mount Sheridan.

9761B - Nonmagnetic (ilmenite) heavy mineral fraction from road ditch on east side of Mount Sheridan.

C - Ilmenite fraction from sand beneath Medicine Creek bridge south of Meers Post Office.

Examination of gabbro forming the lower part of Mount Sheridan and that surrounding the Meers quartzite disclosed a small amount of free ilmenite in these basic rocks. As these break down by weathering the ilmagnetite and ilmenite are released and transported with other sediments by the stream.

Deposit near Lake Lawtonka. Following the discovery of free ilmenite in the alluvial sands of Medicine Creek a search was begun to find a filled valley or basin in which a large body of these ilmenite-bearing sediments might have been trapped.

Lake Lawtonka was created by the City of Lawton about 1910, as a water reservoir, by damming of Medicine Creek in the northern part of Section 18, T. 3 N., R. 12 W. The Lake covers parts of Section 6, 7, 8, and 18, T. 3 N., R. 12 W.; the eastern half of Sec. 1, T. 3 N., R. 13 W.; and parts of Sec. 35 and 36, T. 4 N., R. 13 W. and is now a catch basin for sediments being carried by that part of Medicine Creek located above the lake.

Reserves

Test drilling. Along the north shore of Lake Lawtonka is a flat area whose formation antedates the lake. This was chosen for test drilling because it is so situated that, conceivably, it could have been the site of deposition of sediments brought down during geologic time by Medicine Creek, and it is easily accessible to drilling equipment. Thirteen holes were drilled in the area covering the southern half of Sec. 36, T. 4 N., R. 13 W.; SW$\frac{1}{4}$ Sec. 31, T. 4 N., R. 12 W.; and NE, NE$\frac{1}{4}$ Sec. 1, T. 3 N., R. 13 W. All but four of the test holes encountered a zone of ilmenite-bearing sands.

Logs of the test holes indicate that the ilmenite-bearing sands fill an ancient southeast-trending valley and range from 10 to 25 feet thick. On the basis of 9 holes, the volume of sand contained in this ancient valley beneath the overburden, is approximately 180 million cubic feet, and represents, on a dry basis 8,382,000 short tons. The southeasternmost test hole, at the edge of the lake encountered 35 feet of ilmenite-bearing sand, without having reached the bottom of the deposit. These samples showed the highest percentage of ilmenite--6.8 percent. It is concluded that a substantial, unmeasured reserve exists beneath the lake, in that direction. The overburden ranges from 4 to 16 feet thick, and three-fourths of the area tested has a cover of only 4 to 6 feet.

Minerals in samples. Augite is the predominate heavy mineral, with ilmenite and magnetite occurring in nearly equal amounts. One test hole had an overall average of 6.8 percent and another 5.5 percent ilmenite. The remaining test holes averaged 3.5 percent recoverable ilmenite. The average percentage of ilmenite recoverable from this body of sand, excluding overburden, based on test holes drilled, is 4.4 percent. Thus, it is estimated that this body of sand represents an ilmenite reserve of 335,280 long tons, or 368,808 short tons.

The dam that impounds the water in Lake Lawtonka was originally built about 1910, and was raised in 1940, to provide increased storage. This second construction was necessitated in part by increase in water use in Lawton and Fort Sill, but more especially because sediment brought in by Medicine Creek had greatly reduced the storage capacity of the reservoir. This sediment must contain ilmenite, which would have been dropped near the head of the lake. Consequently, the upper end of Lake Lawtonka, between its present head and the position occupied by the original lake may constitute a substantial reserve.

It is worthy of note that the body of sand discovered near Lake Lawtonka by drilling is considerably richer in ilmenite than deposits now being worked at Trail Ridge, Florida. Whereas the Oklahoma deposit contains an average of 4.4 percent ilmenite, according to an article by W.L. Lenhart in the December, 1951, issue of Rock Products, the Florida deposit contains 1.8 percent.

RESEARCH LABORATORY INACTIVATED

There's an old saying that two moves equal one fire. The Oklahoma Geological Survey has not had a blazing fire, but the moves have been made so far as the research laboratory, sample storage, and general utility services are concerned. Temporarily, at least, the equipment is as usable as ashes, charred wood, and twisted metal after a hot fire--it's all in cold storage, so to speak.

The Survey has never had its own general service and utility building, except for a small one-room structure which was vacated and torn down for the erection of another building. Although not conveniently located with reference to the Survey offices, buildings assigned to the Survey on the Naval Aviation Technical Training Center, "South Navy Base," Norman, following close of World War II provided ample space for large laboratory equipment, grinding and sample preparation equipment, sample storage, storage space for groundwater division, and general utility storage and work space. With reactivation of the Navy Base, the Oklahoma Geological Survey activities on the base came to a halt.

The latter part of December and the first two weeks of January were devoted to dismantling equipment, tearing down shelving, and generally getting ready for moving. The Department of the Physical Plant, University of Oklahoma, assigned to the Survey a large garage with a concrete floor on the North Campus to be used for storage of equipment. Into this space, containing a scant 1,000 sq. ft., all the industrial laboratory equipment has been stacked.

For all practical purposes most of the Survey's large-scale experimental and testing equipment and some phases of its work are inactivated until when, and if, adequate quarters can be provided for again setting up for operation.