RESOURCES OF THORIUM AND URANIUM IN MONAZITE PLACERS IN THE WESTERN PIEDMONT, NORTH CAROLINA AND SOUTH CAROLINA

By William C. Overstreet, Paul K. Theobald, Jr., and Jesse W. Whitlow

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Trace Elements Investigations Report 699

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*This report concerns work done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

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USGS - TEI-699

GEOLOGY AND MINERALOGY

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ABSTRACT

Monazite placers in the western Piedmont of North and South Carolina were explored by the U. S. Geological Survey in 1951-54 and are estimated to contain at least 53,000 short tons of ThO_2 and 4,600 short tons of U_3O_8. None of these deposits is being mined.

INTRODUCTION

Acknowledgments

The work leading to this report was sponsored by the Division of Raw Materials of the U. S. Atomic Energy Commission and was conducted by the U. S. Geological Survey between July 1951 and June 1954. The choice of the area examined and many ideas related to methods were influenced by previous investigations made by John B. Mertie, Jr., (1953) in North and South Carolina, Georgia, Alabama, and Virginia. Amos M. White, Norman P. Cuppels, and Dabney W. Caldwell of the Survey did much of the field work upon which this report is based. Jerome Stone of the Survey surpervised the mineralogical examination of the grab samples

collected by the field party. Robert F. Griffith and Leland A. Hansen directed exploration done by the U. S. Bureau of Mines (Griffith and Overstreet, 1953a, 1953b, and 1953c; Hansen and White, 1954; Hansen and Cuppels, 1954, 1955; Hansen and Caldwell, 1955; and Hansen and Theobald, 1955).

Location

This report concerns a region 5,200 square miles in area that extends northeastward along the western part of the Piedmont from the Savannah River in South Carolina to the Catawba River in North Carolina. The altitude of much of the region is between 700 and 1,100 feet above sea level. Gentle hills and broad interfluves give a local relief of 100 to 200 feet. The local relief increases to 1,700 feet at the west margin of the area near the east flank of the Blue Ridge in South Carolina and in the South Mountains in North Carolina.

Monazite mining in the Carolinas

The monazite placers in North Carolina were discovered in 1879 by W. E. Hidden (Pratt, 1916) and mining began in 1886. The area was a major world source for thorium and the lanthanides until 1895 when Brazilian monazite entered the trade. Total output from the Carolinas has been nearly 5,500 tons, but the placers have been idle since 1911 except for 48 tons produced between 1915 and 1917.

GEOLOGY AND MINERALOGY

The geology of the monazite placer district between the Savannah and Catawba Rivers has been described in two recent papers (Overstreet, Cuppels, and White, 1956; Overstreet and Griffitts, 1955) and the general geology of the region has been reviewed by P. B. King (1955). These reports show that the placers are in locally derived alluvial sediments that cover the floors of shallow, narrow valleys in an area underlain by monazite-bearing metamorphic and igneous rocks. The monazite-bearing metamorphic rocks are a sedimentary sequence of unknown age which were metamorphosed to biotite gneiss and sillimanite-almandine schist in Ordovician time. Intruded into these metamorphic rocks are monazite-bearing, conformable masses of quartz monzonite and pegmatite. Bodies of monazite-free quartz monzonite, pegmatite, and diabase cut across the other rocks.

The stream sediments are well bedded, poorly graded, unconsolidated, and possess a similar stratigraphy from the Savannah to the Catawba Rivers. They are deposited on deeply weathered rocks of flat valley floors in successive, sheet-like layers of differing lithology. The lowermost layer is quartz-pebble gravel with a matrix of sandy clay. Overlying the gravel, or resting on bedrock where gravel is absent, is dense gray clay. Quartz pebbles and fragments of carbonized wood are scattered through the clay, and locally the clay grades into peat or muck. Above the clay is coarse- to fine-grained gray, buff, or brown sand overlain by buff, brown, or gray clayey silt. The uppermost sedimentary deposit is red to brown sandy silt. The average thickness of the sediments is 14.6 feet. The layer of gravel at the bottom of the deposits averages

1.5 feet thick, the layer of clay is about 3.6 feet in thickness, and the sand and silt is about 9.5 feet thick. The age of the deposits is Recent, except for small areas of pre-Wisconsin sediment in the heads of some streams. The uppermost red to brown sandy silt has been deposited since the region was cleared for agriculture in the nineteenth century.

Individual flood plains in the monazite district range in area from less than 5,000 square yards to 7 million square yards. Thousands of small valleys, the traditional sites of mining, at the extreme heads of the creeks have areas of 2,000 to 200,000 square yards. Between the headwaters and the trunk streams about half of the valleys have flood plains which exceed 1 million square yards in area. The largest flood plains reach 2,500 feet in width, but ordinarily they are 400 to 800 feet wide. The average tenor of the flood-plain deposits is 0.8 pound of monazite and 0.4 pound of zircon per cubic yard of sediment. The average tenor of the 84 deposits classed by the Survey as placers is 1.3 pounds of monazite and 0.6 pound of zircon. Their average volume is 6.8 million cubic yards of sediment.

Monazite is the main thorium- and uranium-bearing mineral in the deposits. It ranges in abundance from 1 to 80 percent of the concentrate and commonly makes up 10 to 30 percent of the concentrate. Monazite from placers in North Carolina, South Carolina, and Georgia was shown by John B. Mertie, Jr., (1953) to average 5.67 percent of ThO_2 and 0.38 percent of U_3O_8 in 53 samples. Similar percentages

were reported by the U. S. Bureau of Mines (Griffith and Overstreet, 1953a, 1953b, and 1953c; Hansen and White, 1954; Hansen and Cuppels, 1954, 1955; Hansen and Caldwell, 1955; and Hansen and Theobald, 1955) in analyses of 19 samples of placer monazite from North and South Carolina. Average amounts of ThO_2 and U_3O_8 in placer monazite in the drainage basins from the Savannah to the Catawba Rivers are (in percent):

River basin	Number of analyses	ThO_2	U_3O_8
Savannah (in South Carolina)	1	4.21	0.44
Saluda	8	5.96	0.39
Enoree	1	5.56	0.55
Tyger	2	5.77	0.70
Pacolet	4	5.04	0.52
Broad	47	5.94	0.41
Catawba (southern tributaries)	6	4.39	0.39

Other thorium- and uranium-bearing minerals noted in the concentrates include zircon, xenotime, sphene, and unidentified radioactive opaque minerals. Zircon was found in about 65 percent of the samples of alluvium. It makes up from 1 to 50 percent of the concentrate and ordinarily constitutes 1 to 10 percent of the heavy minerals. We believe that the zircon in the placers is derived chiefly from the schists, possibly 20 percent comes from granitic rocks and pegmatite, and infer that the placer zircon contains 0.01 percent of ThO_2 and 0.04 percent U_3O_8.

Xenotime is not abundant. It constitutes 20 percent of the heavy minerals in two samples and 1 percent of the concentrate from samples in 27 small areas. Elsewhere it is present but is less than 1 percent of the concentrate. Xenotime from a tributary to the Catawba River is reported (Palache, and others, 1951) to contain a trace of ThO_2 and 4.26 percent of U_3O_8, and xenotime from a tributary to the Broad River (Griffith and Overstreet, 1953c) has 0.20 percent of ThO_2 and 1.40 percent of U_3O_8.

Sphene is not a source for thorium and uranium between the Savannah and Catawba Rivers.

Unidentified radioactive opaque minerals make up less than 0.1 percent of the heavy minerals in tributaries to the Catawba River (Hansen and White, 1954) and in several tributaries to the Broad River (Hansen and Cuppels, 1954; and Hansen and Theobald, 1955). Minor amounts of fergusonite, gadolinite, and euxenite have been detected in concentrates from the monazite placers and reported in the older literature (Pratt, 1916, and Sloan, 1908), but they are mineralogical curiosities and contribute practically nothing to the amount of thorium and uranium in the placers.

RESOURCES

Monazite and zircon

The resources of monazite and zircon in the stream sediments were appraised by reconnaissance methods. For the appraisal the streams were divided into 534 segments which group into 44 drainage basins (fig. 1),

and the volume and tenor of the alluvium, except in the valleys at the extreme heads of the creeks, were estimated. The composition, volume, and tenor of the alluvium, and the resources of monazite estimated for the deposits are given in table 1. Columns headed "Estimated volume of sediment explored" contain sums of the volumes of the separate classes of sediments estimated to be in the flood plains in the 534 segments. Nothing is implied about the continuity of the flood plains; indeed, in many places they are interrupted by narrows and rapids.

The columns headed "Estimated resources of monazite" contain the sums of the weights of monazite estimated to be in the sediment in the 534 segments. The estimate for a segment was made by multiplying the volume of each class of sediment in that segment by its appropriate tenor in monazite. The tenor was estimated from the amount of monazite recovered by panning measured volumes of each class of alluvium. Descriptions of the procedures used in panning have been reported by Theobald (1957) and the methods used for mineralogical analyses of the panned concentrate have been described by Overstreet and others (1956).

The columns in table 1 headed "Tenor" have been compiled by dividing the volume of sediment into the resources of monazite. No check is available for these tenors, but checks are available for the average tenor in several of the segments and in several contiguous segments where flood plains appraised by the Survey were subsequently drilled by the U. S. Bureau of Mines:

Flood plain	Reconnaissance appraisal by the U. S. Geological Survey	Exploration with churn drill by U. S. Bureau of Mines	
	Resources (lbs./cu yd.)	Inferred (lbs./cu yd.)	Indicated (lbs./cu yd)
Knob Creek, N. C. (Griffith and Overstreet, 1953b)	2.0	---	1.67
Buffalo Creek, N. C. (Griffith and Overstreet, 1953a)	1.1	---	1.25
South Muddy Creek, N. C. (Hansen and White, 1954)	0.8	0.6	0.64
Silver Creek, N. C. (Hansen and White, 1954)	1.0	0.6	0.83
North Tyger and Middle Tyger Rivers, S. C. (Hansen and Cuppels, 1955)	0.3	0.4	--
Hinton Creek, N. C. (Hansen and Cuppels, 1954)	1.2	0.72	--
Wards Creek, N. C. (Hansen and Cuppels, 1954)	1.2	0.72	--

These checks suggest that the volumes, resources, and tenors listed in table 1 are of the proper order of magnitude.

The resources of monazite shown in table 1 are summarized in table 2, where an estimate of the resources of zircon is given.

Table 2.--Resources of monazite and zircon

Drainage basin	Volume of sediment explored (million cu yds)	Estimated average tenor (lb per cu yd)		Estimated resources (1000 short tons)	
		Monazite(a)	Zircon	Monazite(a)	Zircon
Savannah River (in South Carolina)	236.2	0.5	0.4	59	47
Saluda River	244.6	.6	.2	73	24
Enoree River	127.0	.7	.1	44	6
Tyger River	207.5	.4	.6	42	62
Pacolet River	190.6	.8	.4	76	38
Broad River	690.1	1.0	.4	345	138
Catawba River (southern tributaries)	413.2	.7	.4	145	83
	2,109.2	0.8	0.4	784	398

(a) Includes xenotime.

Thorium and uranium

The resources of thorium and uranium in the alluvial monazite deposits listed in table 1 amount to 40,000 short tons of ThO_2 and 3,500 short tons of U_3O_8 (table 3). The small contribution to these resources made by the hundreds of thousands of tons of zircon in the deposits shows that this mineral is not an important source for thorium and uranium.

Table 3.--Resources of thorium and uranium in explored alluvial monazite deposits between the Savannah and Catawba Rivers, S. C. and N. C.

Drainage basin	Monazite (a)					Zircon				
	(Short tons)(b)	ThO_2 (percent)	(Short tons)(b)	U_3O_8 (percent)	(Short tons)	(Short tons)(b)	ThO_2 (percent)	(Short tons)	U_3O_8 (percent)	(Short tons)
Savannah River (in South Carolina)	59,000	4.21	2,000	0.44	300	47,000	Estimated 0.01	4.7	Estimated 0.04	18.8
Saluda River	73,000	5.96	4,000	.39	300	24,000		2.4		9.6
Enoree River	44,000	5.56	2,000	.55	200	6,000		.6		2.4
Tyger River	42,000	5.77	2,000	.70	300	62,000		6.2		24.8
Pacolet River	76,000	5.04	4,000	.52	400	38,000		3.8		15.2
Broad River	345,000	5.94	20,000	.41	1,400	138,000		13.8		55.2
Catawba River (southern tributaries)	145,000	4.39	6,000	.39	600	83,000		8.3		33.2
Total	784,000		40,000		3,500	398,000		39.8		159.2

(a) Includes traces of xenotime.

(b) To nearest 1,000 tons.

The best of the small alluvial deposits upstream from the flood plains appraised for table 1 are estimated to contain 250,000 short tons of monazite which, at an average of 5.4 percent of ThO_2 and 0.44 percent of U_3O_8, has 13,000 short tons of ThO_2 and 1,100 short tons of U_3O_8.

CONCLUSIONS

The resources of thorium and uranium in deposits of alluvial monazite in the western Piedmont of North and South Carolina between the Savannah and Catawba Rivers amount to some 53,000 tons of ThO_2 and 4,600 tons of U_3O_8. None of these resources is minable at prices that obtained in 1957.

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