UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

THORIUM, CERIUM, AND MONAZITE SURVEY OF THE CHARLOTTE 1° x 2° QUADRANGLE, NORTH CAROLINA AND SOUTH CAROLINA

By

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INTRODUCTION

This map is part of a folio of maps of the Charlotte 1° x 2° quadrangle, North and South Carolina, prepared under the Conterminous United States Mineral Appraisal Program. The purpose of the program is to assess the mineral potential of the area by integrated geologic, geophysical, and geochemical investigations.

This map shows the distribution of anomalous thorium values in the moderately magnetic fraction of heavy-mineral concentrates and the distribution of anomalous cerium values in the <149 micrometer mesh fraction of stream sediments.

HISTORY OF MONAZITE PLACER MINING AND PREVIOUS GEOLOGIC WORK

Monazite (Ce, La, Nd, Th) (PO_4, SiO_4), is a yellow, brown, reddish brown, and/or gray monoclinic mineral. It is a rare-earth phosphate with appreciable substitution of thorium for rare-earths and silicon for phosphorus. Monazite is the principal ore of the rare-earths in the study area.

The area between the Savannah River in South Carolina and the Catawba River in North Carolina was the principal monazite producing district in the United States between the years of 1887 and 1917. A total of 5,476 short tons of monazite was produced (Overstreet and others, 1968).

An extensive study of the monazite placers in the southeastern United States was made in the early 1950's (Overstreet and others, 1968). This study provides much of the background information for this report.

GEOLOGIC SETTING FOR MONAZITE

The source rocks for monazite placers in the Charlotte 1° x 2° quadrangle are, in order of decreasing importance, sillimanite schist, granitic rocks (quartz monzonite, pegmatite, granite, granodiorite), biotite schist, and biotite gneiss. In the Inner Piedmont Belt (the major monazite producer), the minerals sillimanite, rutile, ilmenite, and garnet are characteristic of the high-grade metamorphic core of the belt, while epidote, staurolite, kyanite, magnetite, and amphiboles characterize the lower-grade flanks. The authors refer the reader to Griffitts and others (1983) for a map and discussion of a few of these minerals in the Charlotte 1° x 2° quadrangle. Monazite distribution in panned concentrates closely parallels that for sillimanite and garnet. The concentration of ThO_2 in the monazite from granitic rocks is higher than that found in monazite from metamorphic rocks. Rare earths in some of the low monazite or monazite free samples may be attributable to the appearance of rare-earth-bearing minerals like fergusonite $Y(Nb,Ta)O_4$, euxenite $[(Y,Ca,Ce,U,Th)\ (Nb,Ta,O)_2O_6]$, thorite ($ThSiO_4$), xenotime ($YPO_4$), and allanite $[(Ce,Ca,Y)\ (Al,Fe)_3\ (SiO_4)_3\ (OH)]$.

Placers in the flood plains a mile or two downstream from the headwaters, and from that point to the trunk streams are possible economic monazite placers.

COLLECTION AND PREPARATION OF SAMPLES

The <149 micrometer mesh stream sediments were collected by Van Price and his associates as part of the National Uranium Resource Evaluation (NURE) Program. Their sample collection and preparation procedures are discussed by Heffner and Ferguson (1978).

The heavy mineral concentrates were collected along active first or second order streams, which range from 1-8 kilometers in length. Samples were composited from four or five sites across the active part of the stream channel.

Heavy minerals were wet-panned at the sample site to reduce the amount of quartz and feldspars. The panned concentrates were then air-dried and sieved through a 1.4 mm mesh sieve. Remaining quartz, feldspars, and minerals of specific gravity less than 2.89 were removed by flotation in bromoform, and the resultant "heavy" portion was then separated magnetically into four fractions. The first of these fractions was removed with a hand magnet and not studied. The remaining concentrate was passed through a Frantz Isodynamic Separator at successive current settings of 0.5 and 1 ampere with a 15° side slope and a 25° forward slope. All three remaining fractions were analyzed mineralogically and spectrographically, but only the thorium results from the portion magnetic between 0.5 and 1 ampere (herein referred to as the M1 fraction) were employed for this study.

The M1 fraction most commonly contained monazite, epidote, clinozoisite, mixed mineral grains, ilmenite partly converted to leucoxene, staurolite, and locally abundant spinel. Minor amounts of thorite, thorianite, and columbite occur locally in the M1 fraction.

ANALYTICAL PROCEDURES

The analyses for cerium in the <149 micrometer mesh stream sediment samples were performed by automated neutron activation techniques as described by Heffner and Ferguson, 1978.

The heavy mineral concentrates were analyzed semiquantitatively for 31 elements by a six-step D.C. arc optical emission spectrographic method (Grimes and Marranzino, 1968). All spectrographic values are reported as six steps per order of magnitude (1, 0.7, 0.5, 0.3, 0.2, 0.15, or multiples of ten of these numbers) and are approximate geometric midpoints of the concentration ranges. The precision is shown to be within one adjoining reporting interval on each side of the reported value 83 percent of the time and within two adjoining intervals 96 percent of the time (Motooka and Grimes, 1976).

GENERATION OF MAPS

Computer-plotted contour maps for the cerium values and point plot maps for the thorium values were prepared using the U.S. Geological Survey's computer STATPAC program (VanTrump and Miesch, 1977). The program for the contour map calculates average values for cerium within square cells to form a basis for contouring. The contours of these averaged values show regional distributions but do not show exact locations of exploration targets or the cerium content of individual samples. Contour intervals of 250, 500, 750, and

1000 parts per million were chosen to outline weakly to strongly anomalous areas for cerium.

The circles represent sample sites that yield values of $\geq$ 5000 parts per million thorium in the M1 fraction of the heavy mineral concentrates. The dots on the map represent other sample sites where a panned concentrate was obtained and yielded a thorium value <5000 parts per million in the M1 fraction.

DISCUSSION OF ANOMALOUS OCCURRENCES

A discussion of the anomalous areas 1-8, outlined as heavier inward hachured areas, will be founded upon three different anomaly patterns: (1) areas of both high cerium and high thorium values (Area 1), mainly in the Inner Piedmont Belt; (2) areas of high cerium and low thorium valuess (Areas 2 and 3), in the Charlotte Belt; and (3) areas of high thorium values with low cerium anomalies (Areas 4-8), mainly near and on both sides of the eastern Inner Piedmont boundary and the Blue Ridge belt. Geologic units referred to in this discussion are shown on the geologic map of the Charlotte 1° x 2° quadrangle (Goldsmith and others, 198).

HIGH CERIUM-HIGH THORIUM

The combination of high cerium values and high thorium values is due to the presence of abundant monazite. This correlation is displayed within the monazite belt of the Inner Piedmont. All sample sites in Area 1 are high in thorium except for a few scattered sites 20 to 25 kilometers north of Forest City in the South Mountains. High (1000 ppm) cerium isopleths with high thorium anomalies trend north, from the southwest corner of the quadrangle, 20-25 kilometers to the area of the McDowell-Rutherford county line. This trend then heads northeast through the towns of Hickory and Hiddonite. Thus a continuation of monazite belt northeast of the area studied by Overstreet is indicated. There is a lack of thorium data between the towns of Hickory, Lenoir, and Taylorsville, but there is a strong suggestion of monazite due to the high cerium isopleths in the area, and a favorable geologic setting of high rank metamorphic rocks.

HIGH CERIUM-LOW THORIUM

The presence of high cerium values with few, if any, thorium anomalies indicates either a thorium poor monazite occurrence or the presence of other rare-earth minerals. The high cerium values, just west of Concord (Area 3), may reflect the presence of allanite in the area as described by Sundelius and Bell (1964). Allanite is a cerium-bearing mineral of the epidote family and is an accessory mineral in igneous rocks (granite, syenite, diorite, and pegmatite) and in their metamorphic equivalents. Allanite is substantially lower in thorium content than monazite.

The anomalous cerium values northwest of Lexington in the Charlotte Belt (Area 2) are associated with the Churchland pluton and may reflect the occurrence of monazite, allanite, or both.

HIGH THORIUM-LOW CERIUM

High thorium values concurrent with low cerium values may be interpreted to mean: (1) the presence of thorite, thorianite, or uranothorite; (2) the occurrence of a high thorium-low cerium rare-earth mineral; (3) the occurrence of monazite; and (4) a combination of all the above.

High thorium values just south of Statesville (Area 4) are associated with a mixture of metamorphic rocks and may coincide with a higher content of uranium in the sediments in this area as reported by Heffner and Ferguson, 1978.

Area 5, in the northeast part of the Inner Piedmont Belt, displays high thorium values associated with granitic and metamorphic rocks.

Area 6, in the southern part of the Kings Mountain Belt, contains the York and Clover plutons. Although there are no cerium isopleths shown on the map there are scattered high cerium values reported in the area and this may reflect local high abundances of monazite.

The Cherryville pluton is the predominant host rock for the high thorium values east of Shelby in the Inner Piedmont Belt (Area 7). Monazite from the Cherryville Quartz monzonite contains an average of 6.4 percent ThO_2 as reported by Overstreet and others (1963). The monazite in the Cherryville quartz monzonite contains an unusually large average amount of U_3O_8 (2.34%).

The Blue Ridge Belt (Area 8) has been found to contain monazite, thorite, and allanite as reported by Crandall and others (1982), and shows much promise for future uranium vein-type resources. The monazite in this particular area is a gray monazite and is rich in europium. Other occurrences of gray monazite are described by Rosenblum and Mosier (1983). The monazite is associated with the granitic gneiss of the Wilson Creek Gneiss Formation, and to a lesser extent with the basal arkosic sandstone and siltstone of the Grandfather Mountain Formation.

SCATTERED THORIUM ANOMALIES

Scattered high thorium values are found throughout the Charlotte Belt and could represent isolated monazite and rare-earth occurrences in the plutons, metamorphic rocks, and pegmatite rocks. Transportation of material from the Inner Piedmont east could be responsible for local monazite highs in old stream channels. These anomalies may or may not be related to country rocks in the area.

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REFERENCES

Crandall, T. M., Ross, R. B., Jr., Whitlow, J. W., and Griffitts, W. R., 1982, Mineral resource potential map of the Lost Cove and Harper Creek roadless areas, Avery and Caldwell Counties, North Carolina: U.S. Geological Survey Miscellaneous Field Studies Map 1391-A.

Goldsmith, Richard, Milton, D. J., and Horton, J. W., Jr., 198 , Geologic map of the Charlotte 1° x 2° quadrangle, North Carolina and South Carolina: U.S. Geological Survey Miscellaneous Investigations Series Map I-1251-E, scale 1:250,000.

Griffitts, W. R., Duttweiler, K. A., and Whitlow, J. W., 1983, Distribution of Garnet and aluminous minerals in heavy mineral concentrates from the Charlotte 1° x 2° quadrangle, North Carolina and South Carolina: U.S. Geological Survey Miscellaneous Field Studies Map.

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

Heffner, J. D., and Ferguson, R. B., 1978, Preliminary raw data release, Charlotte 1° x 2° NTMS area, North Carolina and South Carolina: DPST-78-146-1.

Motooka, J. M., and Grimes, D. J., 1976, Analytical precision of one-sixth order semiquantitative spectrographic analysis: U.S. Geological Survey Circular 738, 25 p.

Overstreet, W. C., Yates, R. G., and Griffitts, W. R., 1963, Heavy minerals in the saprolite of the crystalline rocks in the Shelby quadrangle, North Carolina: U.S. Geological Survey Bulletin 1162-F, p. 11-16.

Overstreet, W. C., White, A. M., Whitlow, J. W., Theobald, P. K., Jr., Dabney, C. W., and Cuppels, N. P., 1968, Fluvial monazite deposits in the southeastern United States: U.S. Geological Survey Professional Paper 568.

Rosenblum, Sam, and Mosier, E. L., 1983, Mineralogy and occurrence of europium-rich dark monazite: U.S. Geological Survey Professional Paper 1181.

Sundelius, H. W., and Bell, H., 3rd, 1964, An unusual radioactive, rare-earth-bearing sulfide deposit in Caberrus County, North Carolina: Southeastern Geology, v. 5, p. 207-221.

VanTrump, G., Jr., and Miesch, A. T., 1977, The U.S. Geological Survey RASS-STATPAC system for management and statistical reduction of geochemical data: Computers and Geosciences, v. 3, p. 475-488.