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BASTNAESITE,
AN ACCESSORY MINERAL
IN THE REDSTONE GRANITE,
WESTERLY, RHODE ISLAND

By William Lee Smith and Evelyn A. Cisney

Trace Elements Investigations Report 465
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY



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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WASHINGTON 25, D. C.

OCT 13 1954

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Dr. T. H. Johnson, Director
Division of Research
U. S. Atomic Energy Commission
16th Street and Constitution Avenue, N. W.
Washington 25, D. C.

Dear Dr. Johnson:

Transmitted herewith is one copy of TEI-465, "Bastnaesite,
an accessory mineral in the Redstone granite, Westerly, Rhode Island,"
by William Lee Smith and Evelyn A. Cisney, September 1954.

We plan to submit this report for publication in *American
Mineralogist*.

Sincerely yours,

for
W. H. Bradley
Chief Geologist

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Geology and Mineralogy

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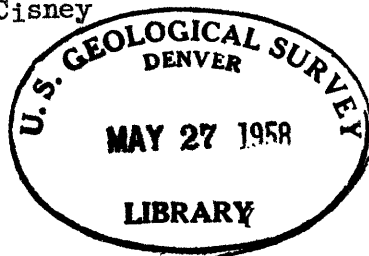
UNITED STATES DEPARTMENT OF THE INTERIOR
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BASTNAESITE, AN ACCESSORY MINERAL IN THE REDSTONE GRANITE,
WESTERLY, RHODE ISLAND

By William Lee Smith and Evelyn A. Cisney

ABSTRACT

Bastnaesite, $CeFCO_3$, has been found in the Redstone granite of the Sterling batholith near Westerly, R. I. It has not previously been recorded as an accessory mineral in granite. X-ray diffraction powder patterns of the bastnaesite compare closely with a pattern obtained from bastnaesite from Mountain Pass, Calif. The three strongest diffraction lines are: 2.88 A, 3.56 A, and 1.895 A. A mean index of refraction measured on fine-grained material is 1.71. Spectrographic analysis showed a major amount of cerium and minor amounts of lanthanum, neodymium, calcium, and fluorine.

INTRODUCTION

The Redstone granite of Martin (1925) is a phase of the Sterling granite and is one of the last differentiates of the Sterling batholith. The Sterling batholith, underlying the greater part of the state of Rhode Island and extending into Connecticut and Massachusetts (Hawkins, 1918), is of Pennsylvanian age (Loughlin, 1910). The Redstone granite occurs as sheets roughly parallel to the southern margin of the batholith and intrudes the flow-banded Sterling granite and a metamorphic complex known as the ancient schists. The granites of the Sterling batholith are rich in accessory minerals, several having a high rare-earth content.

In a heavy mineral study of the Redstone granite, a mineral resembling a finely granular xenotime was found. Martin (1925) mentioned a rare "rust producing" crystal as probably allanite. Kemp (1899) noted these rust blemishes in the Westerly rocks spreading from a dark nucleus and staining quartz and feldspar, and he considered the mineral to be altered allanite, adding that it was a poor petrographic subject. Iddings and Cross (1885) described allanite in Westerly granites. Allanite occurs in the Westerly monumental granite (Quinn, 1943); however the writers found no allanite in the Redstone. Derby (1891) described monazite in the Redstone granite and the writers have also noted the presence of monazite. Xenotime is described as present in the Westerly gray granite (Kemp, 1899), however none was found in the Redstone. Young (1938) found keilhauite, a sphene rich in rare earths, in the Sterling granite gneiss. The small amount of sphene present in the Redstone granite and in the Westerly monumental stone (Quinn, 1943) is normal.

Optical, spectrographic, and X-ray analyses clearly establish the "rust producing" mineral in the Redstone granite to be bastnaesite, a fluocarbonate of cerium earth minerals. Its occurrence in coarse-grained granite, free of pegmatite or inclusions, and its intimate association with monazite suggest that it is a primary constituent of the rock. Bastnaesite has not previously been described as an accessory mineral in granite other than in contact metamorphic zones or pegmatites.

At Mountain Pass, Calif., bastnaesite occurs in carbonate rock associated with potassium-rich intrusives (Olson, et al., 1954). It is present in skarn at Bastnas, Vastmanland, Sweden (Geijer, 1920). It has also been reported in contact zones at Kychtym, Russia (Silberminz, 1929); in

the Torendrika-Ifasino region of Madagascar (Koechlin, 1912); and at Jamestown, Colo., (Goddard and Glass, 1940). At Pikes Peak, Colo., bastnaesite is found with tysonite in granite pegmatite (Allen and Comstock, 1880). Glass and Smalley (1945) describe bastnaesite as being present in a brecciated zone near the contact of igneous rock with metamorphosed sediments, in the Gallinas Mountains, N. Mex.

SAMPLE LOCATION

At Westerly, R. I., the Redstone granite makes up a ridge half a mile wide and two miles long north of Chapman Road. The specimen studied was obtained from the Redstone quarry, shown on the Ashaway (Conn.-R. I.) quadrangle north of the New York, New Haven, and Hartford railroad tracks, one-half mile northeast of Westerly. Commercially this granite is known as the "Westerly Red" and should not be confused with the Westerly monumental granite. The sample collected for study was coarse-grained granite obtained near the center of the body and was free of inclusions and pegmatite.

MINERAL SEPARATION

A 10-kg sample of the granite was crushed to pass a 40-mesh screen. The 80-200 mesh fraction of the product of the rolls crusher was separated by means of a hand magnet, bromoform, methylene iodide, and a Frantz isodynamic magnetic separator. Bastnaesite has a specific gravity greater than methylene iodide and separates on the Frantz isodynamic separator between 0.4 and 0.7 amp at cross and longitudinal settings of 10^0 . A few grains of bastnaesite remained nonmagnetic up to 1.0 amp. Several grams of bastnaesite were concentrated.

OPTICAL AND X-RAY EXAMINATION

The bastnaesite occurs in the rock in two forms, as prismatic crystals measuring 0.05 x 0.15 mm, and as irregular aggregates averaging 0.1 mm in diameter. Both forms are finely granular. The mineral is reddish brown as seen under the petrographic microscope. In immersion liquids an intermediate index of 1.71 can be determined where the coating (probably cerium oxide) has been partly removed by tartaric acid. Dana (Ford, 1932) describes bastnaesite as uniaxial (+), $\omega = 1.717$, $\xi = 1.818$.

X-ray powder diffraction patterns were made of the concentrates of bastnaesite that separated magnetically on the Frantz isodynamic separator at 0.5, 0.7, and 1.0 amp. These concentrates were mostly the aggregate form of the mineral. In each of the photographs the bastnaesite pattern occurred with a very faint monazite pattern. Monazite had not yet been identified as a component mineral and it was considered that the monazite and bastnaesite could be intergrown. Monazite subsequently was identified in immersions and separated by hand-picking the sample.

Hand-picked separates of pure bastnaesite of the aggregate variety, magnetic at 0.5 amp., and of the prismatic variety, magnetic at 0.7 amp., were photographed. Both varieties showed bastnaesite powder patterns without the monazite lines. There is no difference between the powder patterns of the prismatic and the aggregate forms of the mineral.

In table 1 the X-ray powder diffraction pattern of the bastnaesite from the Redstone granite is compared with that for bastnaesite from Mountain Pass, Calif. The three strongest diffraction lines of the Redstone granite bastnaesite are 2.88 A, 3.56 A and 1.895 A. These are in close agreement with the three strongest diffraction lines of the Mountain

Table 1.--X-ray diffraction powder pattern measurements of
 bastnaesite from Mountain Pass, Calif., and
 Westerly, R. I. (CuK α radiation).

Mountain Pass, California (Film no. 255)		Westerly, Rhode Island (Film no. 4889)	
d(Å)	<u>I</u>	d (Å)	<u>I</u>
4.85	M	4.87	W
3.55	S	3.56	S
2.87	S	2.88	M
2.44	F	2.45	VF
2.06	S	2.06	M
2.01	S	2.01	M
1.895	S	1.895	M
1.784	M	1.784	W
1.672	S	1.670	W
1.575	M	1.578	F
1.482	M	1.482	F
1.439	M	1.441	F
1.347	M	1.347	F
1.301	S	1.299	W
1.280	W		VF
1.204	W		VF
1.191	W		VF
1.181	M	1.183	F
1.158	M	1.157	F

The error in measurements is $\pm 0.05^\circ$, 2θ

Pass mineral.

Both the aggregate and prismatic forms of the Redstone granite bastnaesite are composed of minute crystallites and as a result the patterns produced are faint and diffuse. The measurements were made from the centers of the diffuse lines.

COMPOSITION OF THE BASTNAESITE

Qualitative spectrographic analysis of the bastnaesite shows cerium to be the only major element. Lanthanum, neodymium, calcium, and fluorine occur as minor components. Aside from detectable contaminants, thorium showed as a minor component. Upon heating the sample, however, the X-ray powder pattern showed the presence of uranoan thorianite; this indicates that the thorium is present in another mineral and is not necessarily a substitution for one of the rare earths in the bastnaesite. Phosphorus occurs as a minor constituent and cannot be accounted for by contamination. Phosphorus, however, has a normal affinity for the rare earths as does fluorine (Rankama and Sahama, 1950).

Semiquantitative spectrographic analysis for the trace elements shows yttrium to be present from 0.1 to 0.5 percent and scandium to be present from 0.01 to 0.05 percent.

The rare earths are distributed as follows:

10.	percent	Ce
1.-5.	percent	La Nd
0.1-0.5	percent	Pr Gd Sm
0.01-0.05	percent	Dy Er Eu Lu Tb
0.005-0.01	percent	Ho Yb

Of the Ce-earth metals, $Ce > La \cong Nd > Pr \cong Sm > Eu$.

Of the Y-earth metals, $Gd > Dy \cong Er \cong Lu \cong Tb > Ho > Yb$.

This places this bastnaesite intermediate between the apatite assemblage of Goldschmidt and Thomassen (1924) where $Ce \cong Nd > Sm \cong Gd \cong Dy \cong Er \cong Yb$, and the allanite-monazite type (Rankama and Sahama, 1950) which is predominantly Ce earths, $Ce > Nd > Sm \cong Gd$, but impoverished of the Y earths.

PETROGRAPHY

The Redstone is a coarse-grained red granite. Pink orthoclase feldspar comprises about 45 percent of the rock. The other major components are approximately: plagioclase 30, smoky quartz 20, and biotite 5 percent. The plagioclase feldspar was determined by Martin (1925) to be oligoclase with oligoclase-albite rims. Separates were made of the accessory minerals and the following percentages were estimated for the whole rock:

Magnetite and ilmenite	0.13
Apatite	0.05
Bastnaesite	0.02
Pyrite	0.005
Monazite	0.002
Sphene	0.001
Zircon	0.001
Uranoan thorianite	0.001
Allanite	none
Xenotime	none
Garnet	none

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