

## SOME NEW DATA ON THORTVEITITE

JOHN PUTNAM MARBLE, *U. S. National Museum*

AND

JEWELL J. GLASS, *U. S. Geological Survey*.\*

The rare mineral thortveitite, chiefly of interest as the only available source of scandium in quantity, was first described by J. Schetelig, and has also been studied by A. Lacroix. The data so far presented by both these workers are adequately covered by the former.<sup>1</sup> The crystal structure has been studied by F. Zachariassen.<sup>2</sup> A description of the original locality in Norway, and a discussion of the paragenesis of the mineral has been published by H. Bjørlykke.<sup>3</sup>

Recently the original dyke has been re-opened and a considerable quantity of fresh clean thortveitite has been mined for scientific purposes. Specimens have been added to the collections of the Norges Tekniske Høiskole at Trondhjem, Norway, and the U. S. National Museum, but the greater part of the material is being employed in an investigation of the atomic weight of scandium. As no mineralogical studies have appeared during nearly 20 years, it was thought worth while to investigate this new supply, and briefly report on it, particularly as slight differences from previous work are shown.

The exact source of the material is the dyke described by Bjørlykke as "85 Eptevann 2" on p. 237 of ref. 4. It is situated on the farm Eptevann, Iveland District, about 50 km. N. of Kristiansand S, Southern Norway, 7° 51' E. Long., 58° 27' N. Lat.<sup>4</sup>

The mineral was mined by Olav Landsverk of Iveland, and carefully separated from other minerals by Dr. Harald Bjørlykke of the Tekniske Høiskole, Trondhjem. We are deeply indebted to Dr. Bjørlykke for his kindness in making all the arrangements for the supply of material, as well as for the separations, and for much information. The optical and mineralogic studies were made by one of us (J. J. G.) and the chemical analysis by the other (J. P. M.).

Several clean crystal fragments were taken, one being used for optical studies, and portions of four others ground for analysis.

Optical and allied properties were determined on an incomplete section of a grayish-green prismatic crystal measuring 2.5×1.5×1.5 cm. H.

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<sup>1</sup> Brøgger, W., Vogt, Th., and Schetelig, J., *Die Mineralien der südnorvegischen Granit-Pegmatitgänge. II. Silikate der seltenen Erden (Y-Reihe und Ce-Reihe): Videnskapsselskapets Skrifter. I. Mat.-naturv. Kl.*, 1922, No. 1, 51-87, Oslo (1922).

<sup>2</sup> Zachariassen, F., *Zeits. Krist.*, **73**, 1 (1930).

<sup>3</sup> Bjørlykke, H., *Norsk Geol. Tids.*, **14**, 211-310 (1934).

<sup>4</sup> Bjørlykke, H., Private communication.

= 6-7.  $G = 3.58$ . Optically negative,  $2V$  large, calculated  $60^\circ$ - $65^\circ$ . Dispersion distinct,  $r > v$ , apparently crossed in some grains. Straight cleavage edges are rarely observed. Polysynthetic twinning is distinct but infrequent. Extinction against twinning lamellae,  $10^\circ$ .

The indices of refraction (Table 1) were determined by the immersion method in white light.

TABLE 1. INDICES OF REFRACTION

	$\alpha$	$\beta$	$\gamma$	$B$
	1.752	1.790	1.802	0.050
	1.751	1.789	1.803	0.052
	1.750	1.788	1.803	0.053
	1.751	1.789	1.803	0.052
Average	1.751	1.789	1.803	0.052
By Schetelig <sup>5</sup>	1.756	1.793	1.809	0.053
	(-) $2V = 66^\circ$			
By Lacroix <sup>6</sup>	1.750		1.802	0.052
	(-) $2V = 60^\circ$ - $70^\circ$			

It will be noted that our indices are consistently about 0.005 lower than those reported by Schetelig, but agree with those obtained by Lacroix on material from Madagascar.

The analysis gave the following results:

TABLE 2. THORTVEITITE FROM EPTEVANN, NORWAY  
J. P. Marble, analyst

SiO <sub>2</sub>	45.79%
CaO	0.24
MgO	0.17
MnO	0.53
ThO <sub>2</sub>	0.09
Sc <sub>2</sub> O <sub>3</sub>	34.32
La <sub>2</sub> O <sub>3</sub> , etc.	1.48
Y <sub>2</sub> O <sub>3</sub> , etc.	9.52
Fe <sub>2</sub> O <sub>3</sub>	2.95
Al <sub>2</sub> O <sub>3</sub>	4.95
TiO <sub>2</sub>	< 0.01
U <sub>3</sub> O <sub>8</sub>	0.00
Pb	0.00
ZrO <sub>2</sub>	0.00
H <sub>2</sub> O (-110°)	0.07
H <sub>2</sub> O (+110°)	0.00
Total	100.11% Density (25°/4°) = 3.58

<sup>5</sup> Schetelig, J., *Norsk. Geol. Tids.*, **6**, 233 (1922).

<sup>6</sup> Lacroix, A., *Comptes Rendus*, **171**, 421 (1920).

All the above figures are the mean of at least two closely agreeing determinations.

A few notes on the analysis may be made. The mineral is very refractory, requiring at least three prolonged fusions with sodium carbonate for decomposition. The resulting large excess of sodium salts interferes with the separations in the rare-earth group. For these determinations, the mineral was repeatedly evaporated with hydrofluoric acid to remove silica, and the insoluble fluorides dissolved by evaporation with nitric acid. Repeated precipitation of the rare-earth group with oxalic acid in a faintly acid solution free from ammonium salts left all other ions in solution. The oxalates were reconverted to nitrates, and after removal of thorium as peroxy-nitrate, to fluorides. Scandium was removed by solution as the double acid ammonium fluoride in slightly warm acid ammonium fluoride solution, following a suggestion by Noyes and Bray.<sup>7</sup> This seems to give quantitative results. Three experiments gave 34.71, 34.12, 34.13 per cent  $\text{Sc}_2\text{O}_3$ . The lanthanum group oxides as reported, are those whose double potassium sulfates are insoluble. The test is not delicate, and their presence is doubtful. They have not been previously reported in this mineral. Both groups of rare-earth oxides were pale buff in color. The small amount of  $\text{ThO}_2$  found was checked by a rough Geiger-counter test by Dr. Wm. D. Urry of the Geophysical Laboratory of the Carnegie Institution of Washington. He estimated the  $\text{ThO}_2$  content as "1/20 to 1/10 of 1 per cent."<sup>8</sup> Lead and uranium could not be detected analytically. A trace of lead must be present as the result of radioactive decay of thorium, but this is estimated at about 0.001 per cent, or less than 0.005 mg. in the size of the samples used. The  $\text{H}_2\text{O}$  ( $-110^\circ$ ) is probably moisture adsorbed on the very fine powder. The  $\text{MnO}$  and  $\text{Al}_2\text{O}_3$  are higher than reported by Schetelig in his earlier analyses. Our material may be less pure.  $\text{ZrO}_2$  has been reported in thortveitite from Madagascar, but we did not succeed in isolating it in our material. There may be traces thereof in the  $\text{Al}_2\text{O}_3$ . A partial analysis in which the rare-earths and thorium were weighed together shows 45.55 per cent of this group. The sum of the separate oxides is 45.41 per cent, so that little of these oxides seems to have been lost.

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<sup>7</sup> Noyes, A., and Bray, W., *A System of Qualitative Analysis for the Rare Elements*, New York, pp. 221, 446 (1927).

<sup>8</sup> Private communication.