

Veatchite from the Permian evaporites of Yorkshire.

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SOME years ago a few small grains of an unknown mineral were separated by F. H. Stewart from well cuttings from the Permian lower evaporite bed of the Eskdale no. 2 borehole, sunk by the D'Arcy Exploration Company near Aislaby, north Yorkshire. The mineral (not then identified) was mentioned in an account of the mineralogy of this evaporite bed (Stewart, 1949, p. 626). Flame tests suggested that boron and strontium were present, and this was confirmed by Dr. R. L. Mitchell of the Macaulay Institute for Soil Research in Aberdeen, who, by spectrographic work, found that these were the main constituents, and that very much smaller quantities of Ca, Mg, Ba, Na, and K were present.

The mineral appeared to be a strontium borate, and was found to be optically similar to veatchite, which was then considered to be a calcium borate (Switzer, 1938). When Switzer and Brannock (1950) showed that veatchite was actually a strontium borate (the only natural one known) it became apparent that the Yorkshire mineral was identical with veatchite. The identification has been confirmed by a microchemical analysis by R. A. Chalmers and X-ray work by R. Phillips.

PHYSICAL AND OPTICAL CHARACTERS.

The mineral occurs in Yorkshire as colourless transparent crystals of acicular and platy habits. The needles occasionally reach 3 mm. in length and 0.5 mm. in thickness. The plates (flattened on (010)) reach 2 mm. in maximum width and 0.5 mm. in thickness. Some of the crystals show parallel growth. Several prism, dome, and ill-developed pyramid faces can be seen, but all these faces are striated and dull, and no reasonable reflections were obtained on the goniometer. Several of the crystals are doubly terminated.

There are three cleavages—perfect (010), good (001), fair (100). The (100) cleavage has not previously been recorded. The angle from the

(001) cleavage to the prism zone (59°) as measured microscopically, agrees with that of Murdoch (1939). The lustre is pearly on (010) and vitreous elsewhere. Specific gravity, determined by suspension in bromoform-benzene mixtures, is 2.6, which is in general agreement with the value 2.58 given by Murdoch, but is lower than that (2.69) given by Switzer. The mineral does not fluoresce in ultra-violet light.

One crystal was found to contain small euhedral rectangular crystals of anhydrite. Otherwise the veatchite grains contain no visible impurity.

The optical properties are: α 1.551, β 1.553, γ 1.621 (± 0.002) for sodium-light; Positive $2V$ 37° ; $\beta = b$; $\gamma:c = -30^\circ$. These agree with those of Switzer (1938), with the exception of the angle $\gamma:c$, which he gives as -38° .

CHEMICAL CHARACTERS.

A microchemical analysis of hand-picked material has been made by R. A. Chalmers, using 0.013 gm. of material. Two determinations of each of the three major constituents were made. The results are quoted in table I, with analyses of Californian veatchite for comparison. From chromatographic tests it was estimated that not more than 0.5 % of CaO is present. Spectrographic work also shows that Ca is present in very small quantity.

From the American analyses, Switzer and Brannock (1950) give two possible formulae— $3(\text{Sr,Ca})\text{O} \cdot 8\text{B}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ or $\text{SrO} \cdot 3\text{B}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$. The Yorkshire analysis agrees closely with the second of these, the atomic ratios to 12 oxygens being $\text{Sr}_{1.01}\text{B}_{6.00}\text{H}_{4.03}$, with a small quantity of Ca replacing Sr. The first formula would not be satisfied even if the maximum indeterminate errors quoted below by Chalmers were accepted. The first formula is the one given tentatively in Dana's System of Mineralogy, 7th edition, 1951, vol. 2.

X-RAY DATA.

X-ray powder photographs of material from Lang and from Yorkshire have been compared and found to be similar. Powder data in kX units for an acicular crystal from Yorkshire is given in table II.

OCCURRENCE.

Veatchite has previously been recorded from only one locality, at Lang, California, where it occurs in very small quantity in boulders on the dump of an old colemanite mine. It is a constituent of thin cross-fibre veins cutting limestone and howlite (Switzer, 1938), and also forms

TABLE I. Chemical analyses of veatchite.

			1.	2.	3.	4.	5.	
SrO	29.9	30.0	29.8	30.3	29.7	31.20
	30.1					
CaO	—	—	1.4	1.7		
B ₂ O ₃	60.3	60.3	59.8	58.6	57.8	59.26
	60.3					
H ₂ O	10.4	10.5	10.4	9.7	—	9.54
	10.5					
			100.8	100.0	100.0	—	100.0	

1. Veatchite from Eskdale no. 2 borehole, north Yorkshire.* Figure for SrO includes not more than 0.5 % CaO. Analyst, R. A. Chalmers.

2. The above analysis recalculated to 100 %.

3. Veatchite from Lang, California, recalculated to 100 % (original total 98.4). Analyst, W. W. Brannock (Switzer and Brannock, 1950).

4. Partial analysis of veatchite from Lang, California, recalculated to correct for 1 % insoluble material. Analyst, W. W. Brannock (Switzer & Brannock, 1950).

5. Veatchite from Lang, California, recalculated to 100 % (original total 100.23). Analyst, F. A. Gonyer (Switzer, 1938).

TABLE II. X-ray spacings for veatchite.

<i>d.</i>	I/I ₀ .	<i>d.</i>	I/I ₀ .	<i>d.</i>	I/I ₀ .	<i>d.</i>	I/I ₀ .
10.3	vs ¹	2.69	vvw	1.832	vvw	1.311	vvw
5.64	m	2.59	s ³	1.797	vw	1.287	vvw
5.12	m	2.52	vw	1.757	w b	1.270	vw
4.46	w	2.39	m	1.673	vvw	1.247	vvw
4.00	m	2.20	m	1.650	vvw	1.225	vw
3.47	w	2.147	w	1.583	vw b	1.167	vvw
3.32	vs ²	2.078	m	1.534	vw	1.113	vvw
3.19	w	2.033	m	1.506	vw	1.086	vw
2.98	w b	1.992	vw	1.426	vvw	1.064	vvw
2.86	m	1.932	m	1.399	vvw	1.046	vw
2.76	vvw	1.859	vw	1.353	vw		

Order of intensities: vs¹, vs², s³, m, w, vw, vvw. b indicates broad line. 9 cm. camera cut off at 10.8 kX. Cu-K α radiation ($\lambda = 1.5374$ kX).

* Methods of analysis:

Water.—Determined once by the Penfield method, and once indirectly as loss on ignition at a temperature not sufficiently high to cause loss of boric oxide. The indeterminate error was computed to be about ± 0.3 % H₂O.

Strontia.—Determined once directly, by precipitation as the oxalate and subsequent titration of the oxalate with ceric sulphate; once indirectly, after the indirect water determination, by removing boron by volatilization with hydrofluoric and sulphuric acids, and final weighing of the strontium as the sulphate. The error was computed to be about ± 0.2 % SrO.

Boric oxide.—Determined twice by the same method. The mineral was fused with sodium carbonate, and the melt cooled and dissolved in hydrochloric acid. The solution was titrated with caustic soda to a known pH in the range 7.3 to 7.6. Mannitol was added, and the solution was re-titrated to the same pH, measured by a pH meter. The caustic soda was standardized empirically with boric acid under similar conditions. The error was computed to be about ± 0.5 % B₂O₃.

platy aggregates lining irregular fractures in clay (Murdoch and Webb, 1940). It is associated with colemanite (Murdoch, 1939; Switzer and Brannock, 1950).

In the Eskdale no. 2 borehole in Yorkshire, the mineral has been found in well cuttings from the following depths: 4360, 4365, 4380, 4385, 4390, 4430, 4435, 4445, 4480, 4500, 4505, 4550 feet below surface. These depths include parts of the polyhalite, upper anhydrite, and upper halite-anhydrite zones of the lower evaporite bed (Stewart, 1949). Several of the crystals are complete, and it is possible that they were enclosed in halite, since all other minerals of this evaporite bed tend to be euhedral towards halite.

This provides the only record of veatchite in evaporites of marine origin. It is the first record of a borate in this lower evaporite bed, but an analysis of a polyhalite-kieserite-rock from the Eskdale no. 3 borehole at this horizon in Yorkshire shows Sr 0.9 and B 0.02 % (Armstrong, Dunham, and others, 1951). Boracite has been recorded from the middle evaporite bed in the Eskdale no. 2 borehole (Guppy, 1944). Celestine has been recorded as a rare constituent in the Eskdale no. 2 borehole (Stewart, 1949).

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