

## MINERALOGICAL NOTES

### CYMRITE IN A COPPER DEPOSIT, BROOKS RANGE, ALASKA

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#### INTRODUCTION

During the summers of 1960 and 1961 the writer collected a large number of samples of drill-core from a copper prospect at Ruby Creek, in the Cosmos Hills, Brooks Range, Alaska, x-ray and optical examination shows the presence of cymrite, a rare hydrous barium aluminum silicate ( $2 \text{ BaO} \cdot 2\frac{1}{2} \text{ Al}_2\text{O}_3 \cdot 5 \text{ SiO}_2 \cdot 3.65 \text{ H}_2\text{O}$ ) in many of the specimens. The cymrite occurs from near the surface to depths of several hundred feet.

The Ruby Creek prospect is located at 67°05' N. latitude, 157°00' W. longitude, about 300 miles northwest of Fairbanks, Alaska. The Cosmos Hills comprise one of the many outlying groups of foothills on the south side of the Brooks Range. The geology of the Ruby Creek prospect is described briefly by Smith (1913), Chadwick (1960), Herreid (1961), and the mineralogy in detail by the present writer (1963).

#### PREVIOUSLY REPORTED OCCURRENCES

Cymrite was originally described by Smith *et al.* (1949) from the Benallt manganese mine, Rhiw, Carnarvonshire, Great Britain. The name comes from the Welsh for Wales, *Cymru* (pronounced Kumry).

The Benallt cymrite occurs as colorless plates up to seven millimeters in diameter and about 0.5 mm thick and as white hexagonal prisms about 1 mm long. The cymrite is, apparently, restricted to veinlets which cut across the hydrothermally-derived manganese-silicate ore (Woodland, 1956).

Cymrite was also recognized by Brosgé (1960) in his work in the south-central portion of the Brooks Range. Brosgé mentions only that the mineral was identified in samples collected from a pyritized zone near the head of Bonanza Creek in the Wiseman Quadrangle.

#### OCCURRENCE AND ASSOCIATIONS

The Ruby Creek cymrite occurs in dolomitic and sideritic wallrock as crudely hexagonal plate-like crystals up to 4 mm in diameter and 0.5 mm thick. Figures 1 and 2 show the mode of occurrence of the cymrite.

The average diameter of the interlocking anhedral grains of dolomite in the carbonate host-rock is 0.02 to 0.05 mm, and the cymrite crystals are randomly scattered through this fine-grained matrix. Even in those

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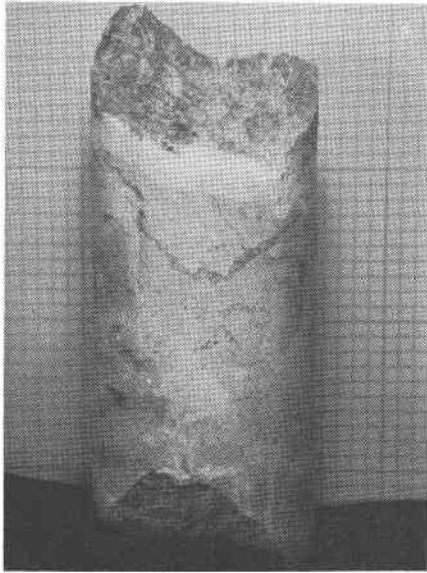


FIG. 1. Specimen of drill-core with small crystals of cymrite (black flakes) scattered through a dolomite breccia. Pyrite-filled stylolite and a veinlet of calcite are also present. Small squares equal 0.1 inch.

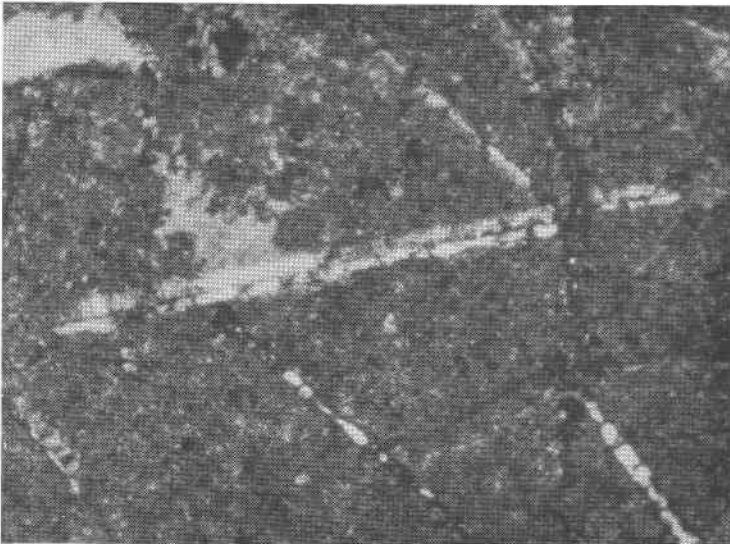


FIG. 2. Thin-section of siderite-rich wallrock with crystals of cymrite. Recrystallized borders of carbonate, such as that shown here, are normally present adjacent to the crystals of cymrite. Crossed nicols. Width of view is 3 mm.

specimens in which cymrite is most abundant, it comprises only two or three volume per cent of the rock. The intersecting plate-like crystals may impart a coarsely granular appearance to the fine-grained carbonate matrix.

The host-rock was originally a normal dolomite of marine origin, but it is now mineralized and contains pyrite, chalcopyrite, bornite, chalcocite, sphalerite, galena and cymrite, together with small amounts of chlorite, fluorite, pyrrhotite, dickite, and bementite,  $Mn_5(OH)_6Si_4O_{10}(?)$ . Calcite, muscovite and quartz occur as original sedimentary minerals in some of the rocks. The siderite and ankerite which are also present may be of either sedimentary or alteration origin. Cymrite is observed in contact with one or more of the following: dolomite, siderite, ankerite, pyrite, fluorite, quartz and chlorite.

#### PHYSICAL AND OPTICAL PROPERTIES

Cymrite is colorless when pure, but it is commonly dark green or brown because of inclusions and various alteration products. The crystal system is hexagonal; there is a perfect basal  $\{0001\}$  cleavage and an imperfect prismatic cleavage which is probably  $\{10\bar{1}0\}$ . The luster is vitreous to satiny, and the fracture is irregular. The calculated specific gravity is 3.44<sub>7</sub>. The measured value for 470 mg of minus 60-mesh material in a two-milliliter pycnometer is 3.4<sub>1</sub>. Smith *et al.* (1949) give a measured specific gravity of  $3.413 \pm 0.05$ . Moh's hardness is two to three, and the mineral is brittle.

Nearly all grains are uniaxial negative, but a few are anomalously biaxial negative with a small 2V. The extinction is parallel to both cleavages. The indices of refraction are somewhat variable;  $\epsilon = 1.603$ – $1.606$  and  $\omega = 1.611$ – $1.617 \pm 0.002$  in sodium light.

#### X-RAY DATA

Smith *et al.* (1949) report that cymrite has a pseudo-unit cell with  $a' = 5.33 \text{ \AA}$  and  $c = 7.67 \text{ \AA}$ ; the true cell is stated to have  $a = 42.6 \text{ \AA}$  and  $c = 7.67 \text{ \AA}$ . A lack of good single crystal material prevents the present writer from verifying this conclusion.

Rotating-crystal and zero-level Weissenberg photographs of crystals rotated about  $[0001]$  gave preliminary values of the lattice constants of the pseudo-cell. Using the preliminary values of  $a'$  and  $c$ , a powder pattern was easily and completely indexed on a hexagonal scheme (Table 1). An extrapolation ( $\cos^2\theta/\sin^2\theta + \cos^2\theta/\theta$ ) from the indexed powder pattern yields refined values for the lattice constants of the pseudo-cell of  $a' = 5.334 \pm 0.001 \text{ \AA}$  and  $c = 7.705 \pm 0.005 \text{ \AA}$ .

Although the samples used for powder patterns were carefully sorted

TABLE 1. X-RAY POWDER DATA FOR CYMRITE

$a' = 5.334 \pm 0.001$  Å (pseudocell),  $c = 7.705 \pm 0.005$  Å. FeK $\alpha$  radiation = 1.9373 Å. Mn filter. Debye-Scherrer camera with a diameter of 114.56 mm. Straumanis mount

d (obs.)	I (est.)	hkil
7.71 Å	50	0001
4.62	10	10 $\bar{1}$ 0
3.96	90	10 $\bar{1}$ 1
3.85	10	0002
2.96	100	10 $\bar{1}$ 2
2.67	70	11 $\bar{2}$ 0
2.57	10	0003
2.53	10	11 $\bar{2}$ 1
2.31	20	20 $\bar{2}$ 0
2.24	40	10 $\bar{1}$ 3
2.21	40	20 $\bar{2}$ 1
2.195	10	11 $\bar{2}$ 2
1.982	10	20 $\bar{2}$ 2
1.925	30	0004
1.850	40	11 $\bar{2}$ 3
1.778	5	10 $\bar{1}$ 4
1.703	20	21 $\bar{3}$ 1
1.591	30	21 $\bar{3}$ 2
1.560	20	11 $\bar{2}$ 4
1.541	20	0005, 30 $\bar{3}$ 0
1.496	5	30 $\bar{3}$ 1, 20 $\bar{2}$ 4
1.462	20	10 $\bar{1}$ 5
1.445	10	21 $\bar{3}$ 3
1.334	15	11 $\bar{2}$ 5, 22 $\bar{4}$ 0
1.321	5	30 $\bar{3}$ 3, 22 $\bar{4}$ 1
1.294	5	21 $\bar{3}$ 4
1.282	20	0006, 31 $\bar{4}$ 0, 20 $\bar{2}$ 5
1.264	5	31 $\bar{4}$ 1, 22 $\bar{4}$ 2
1.236	5	10 $\bar{1}$ 6
1.216	5	31 $\bar{4}$ 2
1.203	5	30 $\bar{3}$ 4
1.185	5	22 $\bar{4}$ 3
1.155	20	11 $\bar{2}$ 6, 40 $\bar{4}$ 0
1.146	5	21 $\bar{3}$ 5, 31 $\bar{4}$ 3
1.123	10	20 $\bar{2}$ 6
1.098	10	0007, 22 $\bar{4}$ 4
1.071	10	31 $\bar{4}$ 4, 10 $\bar{1}$ 7
1.050	5	40 $\bar{4}$ 3, 32 $\bar{5}$ 1
1.035	5	21 $\bar{3}$ 6
1.017	15	32 $\bar{5}$ 4, 11 $\bar{2}$ 7
1.008	10	41 $\bar{5}$ 0, 22 $\bar{4}$ 5
0.985	5	31 $\bar{4}$ 5, 30 $\bar{3}$ 6

under a binocular microscope, from three to five faint lines of impurities appeared in each of the several photographs. These lines are attributable to the strongest reflections of quartz, dolomite, calcite, and siderite.

The powder data for cymrite are presented in Table 1.

#### INFRARED DATA

The infrared absorption chart is presented in Fig. 3. Ten milligrams of cymrite were ground with 1000 milligrams of KBr and pressed into a pellet for the infrared analysis; the instrument used was a Perkin-

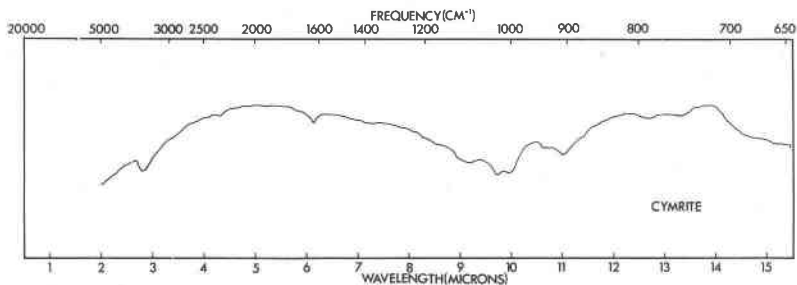


FIG. 3. Infrared spectrum of cymrite.

Elmer Double Beam Infrared Spectrophotometer, Model 21. The pattern bears a striking resemblance to that of anthophyllite given by Keller *et al.* (1952).

#### CHEMICAL DATA

Cymrite is slightly soluble in cold 1:1 HCl and cold 1:1 HNO<sub>3</sub>, and when heated to redness in an open tube it exfoliates to a puffy aggregate of tiny micaceous flakes.

A quantitative analysis of a 780-mg sample is given in Table 2. Emission spectrographic analysis shows trace amounts of Mo, Cu, Sr and Mn. Extreme difficulty is encountered in obtaining a pure sample of cymrite. Practically all of the grains contain inclusions of the wallrock gangue and various alteration products, principally chlorite. The 780-mg sample submitted for analysis is hand-picked and is as pure as possible, but tiny specks of pyrite and fluorite can still be seen under the binocular microscope. Some of the fluorine of the analysis may be a component of the mineral, but it is not possible to determine this for certain. The MgO is believed to be present as inclusions of dolomite, and the iron probably represents pyrite. Column (2) of Table 2 is the recalculated analysis after subtracting FeS<sub>2</sub>, F, MgO and the corresponding amounts of CaO, as impurities.

TABLE 2. QUANTITATIVE CHEMICAL ANALYSIS OF CYMRITE

	(1)	(2)	(3)	(4)
SiO <sub>2</sub>	32.06	32.69	0.544 <sub>3</sub>	1.088 <sub>6</sub>
TiO <sub>2</sub>	0.06	0.06	0.000 <sub>8</sub>	0.001 <sub>6</sub>
Al <sub>2</sub> O <sub>3</sub>	27.00	27.53	0.540 <sub>0</sub>	0.810 <sub>0</sub>
MgO	0.14	0.00		
CaO	0.85	0.35	0.006 <sub>2</sub>	0.006 <sub>2</sub>
BaO	31.36	31.98	0.208 <sub>5</sub>	0.208 <sub>5</sub>
K <sub>2</sub> O	0.22	0.22	0.004 <sub>6</sub>	0.002 <sub>3</sub>
Na <sub>2</sub> O	nil	nil		
H <sub>2</sub> O (+)	7.03	7.17	0.796 <sub>0</sub>	0.398 <sub>0</sub>
H <sub>2</sub> O (-)	nil	nil		
F	0.3	0.0		
FeS <sub>2</sub>	1.46	0.0		
	100.48	100.00		2.515 <sub>2</sub>

(1) Analyst: Jun Ito. University of Tokyo, 1962.

(2) Analysis recalculated to 100 per cent after subtraction of FeS<sub>2</sub>, F (+CaO) as fluorite, and MgO (+CaO) as dolomite.

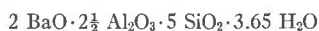
(3) Cation moles.

(4) Oxygen moles.

The best empirical formula corresponding to columns (3) and (4) is:



The above formula approximates:



The formula of cymrite given above is not in agreement with that of BaAlSi<sub>3</sub>O<sub>8</sub>(OH) suggested by Smith *et al.* (1949). The present formula is believed to be preferable because of the larger amount of material (780 mg) analyzed; the earlier writers were able to obtain only micro-analyses of 7- and 10-mg samples.

Four formula units per pseudo (?) -unit cell are assumed in calculating the specific gravity of 3.44<sub>7</sub>.

#### ORIGIN AND ALTERATION

Pseudomorphs of pyrite, chalcopyrite, bornite and primary chalcocite after cymrite are observed in polished surfaces. Figure 4 shows that good pseudomorphs of chlorite and quartz after cymrite also are present. The cymrite thus appears to be an early mineral in the paragenetic sequence. It is closely associated in space with the sulfides and seems to be a product of solution alteration of the impure carbonate host-rock. The aluminum, silicon and barium could be derived from the walrock itself.

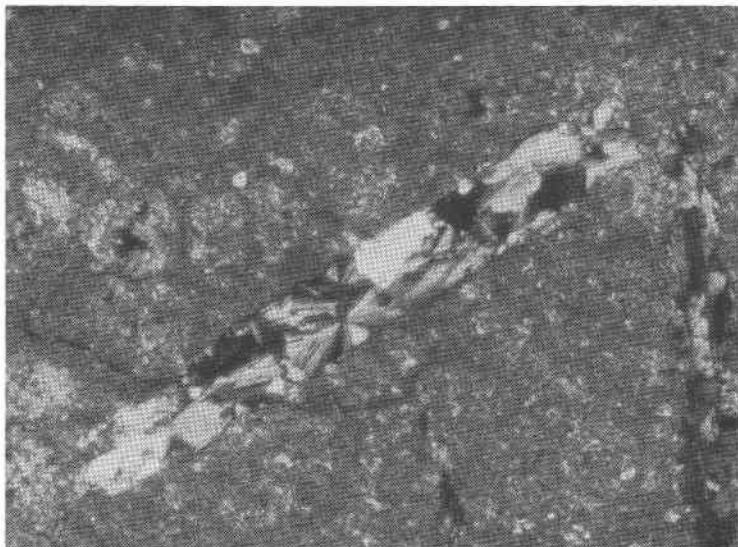


FIG. 4. Thin-section of siderite-rich wallrock with a pseudomorph of chlorite plus quartz after cymrite. Crossed nicols. Width of view is 3 mm.

It is noted in some instances that the disseminated crystals of cymrite are most abundant near veinlets of pyrite, decreasing in abundance outward into the wallrock. This suggests that diffusion of the components of cymrite away from the veinlet may have taken place.

The alteration of cymrite itself is interesting. Where subjected to supergene processes, the mineral alters to an extremely fine-grained mixture of kaolinite and barite. Pseudomorphs of a 10 Å clay mineral, possibly 1-M muscovite (Yoder and Eugster, 1955) after cymrite are also present, but only away from the zone of supergene alteration. In the latter occurrence, barite is absent. As noted above, pseudomorphous replacement of cymrite by the copper sulfides, pyrite and chlorite plus quartz also occurs.

#### ACKNOWLEDGMENTS

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## AZIMUTHALLY DISPERSED POLARIZED LIGHT

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In a thin section being observed between crossed polarizers, the probability of adjacent grains having identical interference colors is high for any single position of the rotating stage. The usefulness of the rotating stage, when one is studying rock textures comes from the much lower probability that two adjacent grains have identical extinction directions. It is almost always possible to find one position of the rotating stage in which the two grains are visually distinguishable.

In limestone and dolomite sections of standard thickness, the interference "colors" are mostly light gray shades in the seventh to ninth orders and the only visual contrast between grains is based on the difference in intensity as the grain is turned from its extinction position. By rotating the stage to those azimuths near the extinction position where the light transmission varies rapidly with azimuth, it is possible

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