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AN OCCURRENCE OF CYMRITE IN THE FRANCISCAN FORMATION, CALIFORNIA

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The mineral cymrite, $BaAl_2Si_2O_8 \cdot H_2O$, heretofore found only in Wales and Alaska,[2] was discovered by the writer with W. S. Fyfe near the only serpentinite body exposed on the Pacheco Pass Road (San Benito County, Calif.) about 2¾ miles west of the summit. It is found at the west end of the serpentinite in a jadeite metagraywacke at the well-exposed contact with the ultramafic rock. The metagraywacke is bleached and desilicated at the contact, and is shot through with calcite, albite, lawsonite, and more rarely cymrite veins. The cymrite is seen in hand specimen as coarse platelets easily confused with the common albite. In thin section the rock is laced with laths of lawsonite and cymrite, and albitized jadeite relicts remain. Veinlets of cymrite-lawsonite may be found, although the coarsely disseminated cymrite is often penetrated by fine lawsonite. The lawsonite, albite and cymrite show no signs of reaction. Optical properties of the cymrite closely match those described for material from the type locality (Smith *et al.*, 1949), and its powder pattern is similar to that published by Smith *et al.*, and Seki and Kennedy (1964a). The cymrite is often partially altered to a cloudy brown material, and with the inclusions of lawsonite, the alteration would make it difficult to obtain perfectly pure material for wet chemical analysis. Relatively pure splits were obtained by magnetic separation.

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[2] Two cymrite occurrences have been recorded in Alaska, one at Bonanza Creek by Brosge (1960) and Carron *et al.*, (1964), and one at Ruby Creek by Runnells (1964).

TABLE 1. ANALYSES OF CYMRITE

	Microprobe analysis uncorrected[a]	Microprobe analysis corrected[b]	Stoichiometric $BaAl_2Si_2O_8 \cdot H_2O$	$BaAlSi_3O_7 \cdot H_2O$ Smith *et al*, (1949)	$Ba_2Al_5Si_5O_{19.4} \cdot 3.65\ H_2O$ Runnells (1964)	$BaAl_2Si_2O_8 \cdot H_2O$ Carron *et al*, (1964)
SiO_2	28.4	30.3	30.51	45.8	32.69	30.86
TiO_2	0.00	0.00	—	—	0.06	0.41
Al_2O_3	27.7	25.9	25.91	13.0	27.53	25.25
BaO	38.4	38.7	39.00	39.00	31.98	38.15
CaO	0.00	0.00	—	—	0.35	0.35
Na_2O	0.00	0.00	—	—	—	—
K_2O	0.03	0.03	—	—	0.22	—
H_2O+	—	4.56[c]	4.58	2.3	7.17	4.56
H_2O	—	—	—	—	—	0.10
other	—	—	—	—	—	0.32[e]
total	—	99.5	100.00	100.00[d]	100.00.[d]	100.00[d]
Molecular formulae (calculated on anhydrous basis about O=8.000)						
O		8.000	8.000	8.000	8.000	8.000
Si		2.00	2.000	2.67	2.06	2.00
Al		2.01	2.000	0.89	2.04	1.92
Ti		0.00	—	—	0.003	0.020
Ba		1.00	1.000	0.89	0.79	0.97
Ca		0.00	—	—	0.023	0.024
Na		0.00	—	—	—	—
K		0.002	—	—	0.014	—
H_2O		1.000[c]	1.000	0.45	1.50	0.98
cation sum		5.01	5.000	4.46	4.93	4.93

[a] Standards used: benitoite for SiO_2 and BaO; celsian 15278 for Al_2O_3; adularia for K_2O.

[b] Corrections include absorption, atomic number, and fluorescence—see Smith (1965) for procedures. The corrections were calculated from the assumed formula—$BaAl_2Si_2O_8 \cdot H_2O$.

[c] Water is given in wt. % equivalent to stoichiometric amounts in assumed formula—$BaAl_2Si_2O_8 \cdot H_2O$.

[d] The published analyses have been adjusted for impurities.

[e] Unspecified.

The microprobe analysis of cymrite (Table 1) gives a formula of $BaAl_2Si_2O_8 \cdot H_2O$, identical to that proposed by Carron *et al.*, (1964). Earlier formulae for cymrite, $BaAlSi_3O_8(OH)$ and $Ba_2Al_5Si_5O_{19.4} \cdot 3.65H_2O$, inferred from analyses of contaminated materials by Smith *et al.*, (1949) and Runnells (1964) respectively, must be questioned in the light of Carron *et al.*, and the writer's analyses. The water content of the writer's

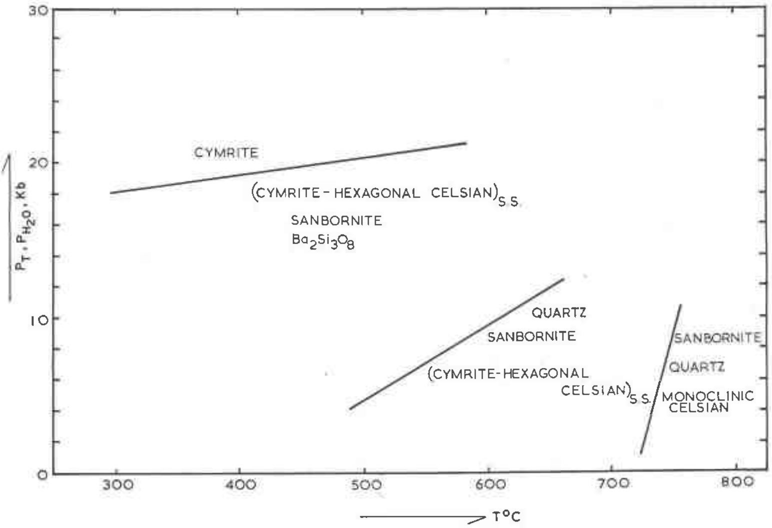

FIG. 1. Stability of cymrite after Seki and Kennedy (1964a).

cymrite was not directly measured, so that Seki and Kennedy's (1964a) suggestion that cymrite and hexagonal celsian may form a solid solution could not be checked, but the total of the microprobe analysis would be low if less than the assumed stoichiometric water were present (see Table 1). With the new formula, solid solution of cymrite and hexagonal celsian would be equivalent to partial dehydration of cymrite. Carron *et al.*, conclusively showed from infrared studies that the water in their cymrite is present as H_2O and not as OH, and their analysis of water gives close to one water for eight oxygens. The only other element detected in the microprobe analysis of the Pacheco Pass cymrite was 0.03 percent K_2O, possibly substituting for Ba as $KAlSi_3O_8 \cdot H_2O$, as suggested by Seki and Kennedy (1964b). Although cymrite ($BaAl_2Si_2O_8 \cdot H_2O$) and lawsonite ($CaAl_2Si_2O_8 \cdot 2H_2O$) are closely associated at Pacheco Pass, they show no mutual solid solution, and the small amounts of Ca reported in previously published analyses of cymrite may be contaminants.

Seki and Kennedy's (1964a) paper dealt with experimental equilibria of cymrite, but unfortunately they used the earlier formula—$BaAlSi_3O_8(OH)$ instead of $BaAl_2Si_2O_8 \cdot 2H_2O$—and their equilibria must be reexamined. It is difficult to interpret their experiments (see Fig. 1) in the light of the new formula, since any production of sanbornite ($BaSi_2O_5$) or $Ba_2Si_3O_8$ from cymrite requires comcomitant development of a more aluminous[1] phase than celsian if the new formula is correct.

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[1] Though kyanite could have been missed, as its main peaks correspond to sanbornite, cymrite and $Ba_2Si_3O_8$ peaks.

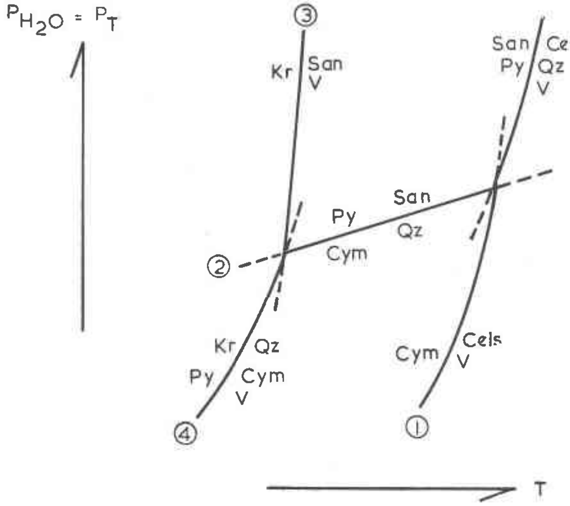

FIG. 2. Schematic equilibria for cymrite-quartz.

Their starting materials had the composition $BaAlSi_3O_8+H_2O$, which is equivalent to $BaAl_2Si_2O_8 \cdot H_2O+BaSi_2O_5+2SiO_2+H_2O$, and it is difficult to understand how they made cymrite alone from this starting composition. Possibly their synthetic product (and Smith *et al.*,'s mineral?) have a different composition than Carron *et al.*, and the writer's minerals. There is no evidence that cymrite and hexagonal celsian form a solid solution in natural occurrences, and it seems unlikely in the light of the natural occurrences that pure cymrite is restricted to pressures greater than 18 kb. as suggested by Seki and Kennedy's experiments.

If the new formula is correct, one must consider instead the reaction

$$\Delta V$$

(1) $\underset{\text{cymrite}}{BaAl_2Si_2O_8 \cdot H_2O} = \underset{\text{celsian}}{BaAl_2Si_2O_8} + \underset{\text{water}}{H_2O} \qquad \Delta V = -5\text{cc} + V_{H_2O} > 0$

The ΔV will be small and positive at medium water pressures and low to medium temperatures, and it is likely that this will be a steep-sloped dehydration curve similar to the lawsonite-anorthite equilibrium (Crawford and Fyfe, 1965). In systems oversaturated in silica, possible reactions are

$$\Delta V$$

(2) $\underset{\text{cymrite}}{BaAl_2Si_2O_8 \cdot H_2O} + \underset{\text{quartz}}{4\ SiO_2} = \underset{\text{sanbornite}}{BaSi_2O_5} + \underset{\text{pyrophyllite}}{Al_2Si_4O_{10}(OH)_2} \qquad \Delta V = -6.1\text{cc}$

(3) $\underset{\text{krauskopfite}^1}{BaSi_2O_5 \cdot 3H_2O} = \underset{\text{sanbornite}}{BaSi_2O_5} + \underset{\text{water}}{3\ H_2O} \qquad \Delta V = -31.8\text{cc} + 3V_{H_2O} > 0$

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[1] Krauskopfite is a new mineral described by Alfors *et al.*, 1965.

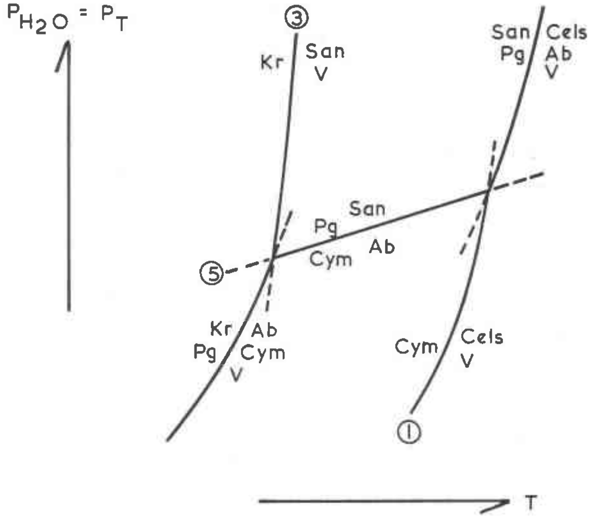

FIG. 3. Schematic equilibria for cymrite-albite.

Abbreviations for Figs. 2 and 3. Pg=Paragonite, Cels=Celsian, San=Sanbornite, Cym=Cymrite, Qz=Quartz, Ab=Albite, Py=Pyrophyllite, Kr=Krauskopfite, V=Water Vapor.

(4) $BaSi_2O_5 \cdot 3H_2O + Al_2Si_4O_{10}(OH)_2 = BaAl_2Si_2O_8 \cdot H_2O + 4\ SiO_2 + 3\ H_2O$
krauskopfite pyrophyllite cymrite quartz water

$$\Delta V = -25.7\text{cc} + 3V_{H_2O} > 0$$

If a field of stability exists for cymrite-quartz (as suggested by Runnell's observations), a possible geometry for these reactions is schematically shown in Figure 2. For most rocks, alkali ions are present in the fluids if feldspars are available, and pyrophyllite becomes unstable with respect to micas. In this case equilibria for the system cymrite-feldspar must be considered instead, for example cymrite-albite as schematically shown in Figure 3. The anhydrous equilibria 2) and 5) may provide pressure-sensitive transitions, but would of course be only rarely applicable to rocks due to the rarity of cymrite. The albite-cymrite assemblage in the silica-deficient high-pressure Franciscan rocks compared to the quartz-cymrite assemblage in the lower-pressure greenschist facies of Alaskan rocks, suggests that the albite-cymrite assemblage is stable to higher pressures than quartz-cymrite.

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VARIATIONS IN THE UNIT-CELL DIMENSIONS OF TOPAZ AND THEIR SIGNIFICANCE

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INTRODUCTION

Variations in the optical properties of topaz due to substitution of OH^- for F^- have been known for many years (Penfield and Minor, 1894) and have recently been reviewed by Deer, Howie and Zussman (1962). Although the structure of topaz is well known (Alston and West, 1928; Pauling, 1928) and unit-cell dimensions have been determined for a number of natural samples (Swanson, *et al.*, 1962; Fiedler, 1962), systematic variations in the unit cell dimensions of topaz have not been reported to date. The present investigation concerns variations in the unit-cell dimensions of topaz and their relation to the extent of substitution of OH^- for F^-.

DATA AND THEIR IMPLICATIONS

The unit-cell dimensions and optic axial angles ($2V_\gamma$) of 14 natural samples are given in Table 1.

Unit-cell dimensions were determined from average powder-diffraction data using a Norelco X-ray diffractometer and NaCl as an internal standard. 2θ values for the topaz (320), (031), (211), (220) and (021) X-ray reflections were obtained by averaging four measurements (scan rate $\frac{1}{4}$°/min.) per reflection. 2θ values of the standard reflections