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CHEMICAL COMPOSITION AND OPTICAL PROPERTIES OF YUGAWARALITE FROM THE TYPE LOCALITY

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ABSTRACT

Pure crystals of yugawaralite from the type locality analyzed SiO_2 59.58, Al_2O_3 18.54, Fe_2O_3, 0.19, MgO tr, CaO 8.96, Na_2O 0.19, K_2O 0.05, total H_2O 13.00, total 100.51, corresponding to a formula proposed by Barrer. Cell dimensions and optical data are given.

Yugawaralite was first described by Sakurai and Hayashi (1952) as a new zeolite with $CaAl_2Si_5O_{14} \cdot 4H_2O$, on the sample from Hudō-no-taki (a fall) near Yugawara Hot Spring, Kanagawa Prefecture, Japan. At the locality, it occurs as veinlets (2–5 cm wide), closely associated with laumontite and quartz, in andesitic tuff breccia. Yugawaralite seems to be classified into a metamorphic mineral belonging to the laumontite stage proposed by Coombs *et al.* (1959) and, recently, a regional occurrence was confirmed by Seki and Okumura (1968).

Sakurai and Hayashi (1952) gave morphological, physical, optical, chemical and thermal (DTA and TGA) data for this new zeolite. Recently, Barrer and Marshall (1965) made X-ray and chemical studies on yugawaralite from Heinabergsjökull in Southern Iceland and the crystal structure of the same specimen was determined by Kerr and Williams (1967). Seki and Haramura (1966) also advocated the same formula for yugawaralite after considering the packing index, the specific gravity and a new chemical analyses of yugawaralite from the type locality. However, as mentioned by Seki and Haramura (1966) the sample of yugawaralite analyzed contained small amounts of calcite, wairakite and laumontite. Now, the reexamination of yugawaralite from the type locality was intended to confirm the chemical formula and X-ray data given by Berrer and Marshall (1965) and Seki and Haramura (1966). The optical orientation of yugawaralite, which has not been presented, was also studied. The presentation of detailed chemical and optical data for yugawaralite from the type locality thus seems warranted because of the frequent occurrences of this species *e.g.*, Erd *et al.* (1968).

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Crystals of yugawaralite are colorless and transparent with a strong vitreous luster. It has parting along {010} that is less distinct than in heulandite. Hardness is 4.5. It is very brittle. The specific gravity measured by pycnometer gave 2.23 at 20°C. Dominant crystal faces are *a* {100}, *b* {010}, *c* {001}, *m* {110} and *l* {120}. Twinning is not found. The above data well confirm the previous description (Sakurai and Hayashi, 1952).

Optical properties of yugawaralite are found to be biaxial positive with (+)2V(meas) 78°, $r > v$ weak, α 1.496, β 1.497, γ 1.504 and γ-α 0.008 using Na light. Optical orientation is $b = Z$, $c \wedge Y$ 6°–7° and the optical plane is perpendicular to {010}. Optical orientations are shown in Figure 1.

The following cell dimensions were obtained from the powder data; *a* 6.72 Å, *b* 13.98 Å and *c* 10.05 Å, all ± 0.02 Å. These values are slightly larger but very close to those given by Barrer, *et al.* (1965). Silicon metal was used as the internal standard and the β angle of 111°31′ of Kerr and Williams (1967) was adapted. V is 878.3 Å^3.

About two grams of hand-picked pure transparent crystals were care-

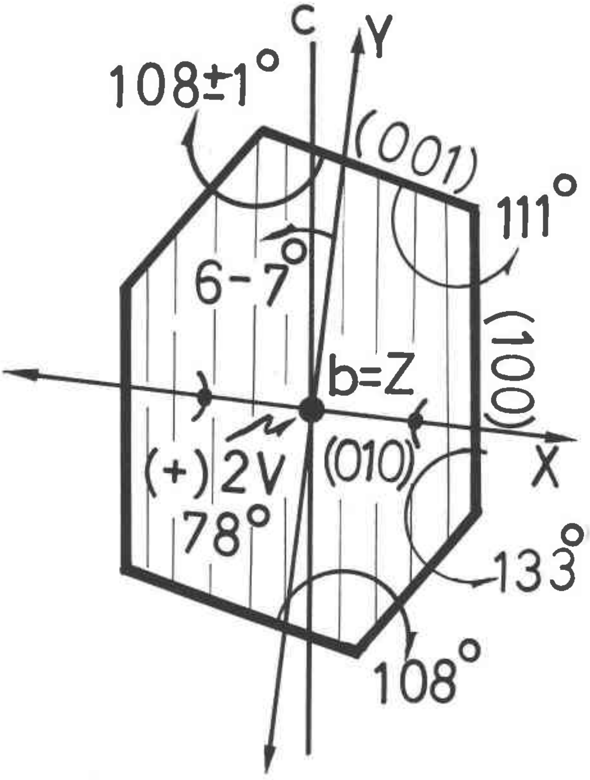

FIG. 1. Optical orientation of yugawaralite.

TABLE 1. VARIOUS ANALYSES OF YUGAWARALITE FROM THE TYPE LOCALITY

	1	2	3
SiO_2	57.94	59.29	59.58
Al_2O_3	17.65	17.43	18.54
Fe_2O_3	0.35	0.05	0.19
FeO	none	0.25	none
MgO	0.86	0.11	trace
CaO	9.79	9.90	8.96
Na_2O	0.38	0.26	0.19
K_2O	0.41	trace	0.05
H_2O^+	10.70	12.85	
H_2O^-	1.80	0.10	13.00
Total	99.80	100.24	100.51

1. Analyst, A. Hayashi (quoted from Sakurai and Hayashi, 1952).
2. Analyst, H. Haramura (quoted from Seki and Haramura, 1966).
3. Analyst, K. Nagashima and K. Nakao (present study).

fully analysed by K. Nagashima and K. Nakao. Various analyses of yugawaralite from the type locality including the present study are shown in Table 1.

The writers' analysis corresponds to:

$$(Ca_{0.948}\,Na_{0.037}\,K_{0.006})(Fe_{0.014}\,Al_{2.158}\,Si_{5.585})O_{16}\cdot 4.28H_2O$$
$$= (Ca, Na, K)_{0.989}(Fe, Al, Si)_{8.057}O_{16}\cdot 4.28\ H_2O,$$

and agree quite well with the chemical formula of $CaAl_2Si_6O_{16}\cdot 4\ H_2O$ proposed by Barrer *et al* (1965) and further advocated by Seki and Haramura (1966). A considerable replacement of Si for Al was recognized. The specific gravity calculated adopting the analysis and the cell parameter is 2.26. This agrees well with the measured value 2.23.

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CRYSTALLOGRAPHIC NOMENCLATURE AND TWINNING IN THE HUMITE MINERALS

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Abstract

The several crystallographic settings previously used for the humite minerals have led to mistakes and confusion in space group, cleavage and twinning descriptions. The Taylor and West setting is preferred because it allows ready comparison of humites and structurally analogous olivines. Twinning on (001) in chondrodite yields single crystal diffraction patterns consistent with orthorhombic rather than monoclinic symmetry.

The humite minerals (norbergite, $Mg_2SiO_4 \cdot Mg(OH,F)_2$; chondrodite, $2Mg_2SiO_4 \cdot Mg(OH,F)_2$; humite, $3Mg_2SiO_4 \cdot Mg(OH,F)_2$; and clinohumite, $4Mg_2SiO_4 \cdot Mg(OH,F)_2$) are structurally similar to the olivine group minerals in that they consist of a hexagonal closest-packed array of anions, zig-zag chains of edge-sharing, M-filled octahedra and isolated tetrahedra (Ribbe, Gibbs and Jones, 1968). Norbergite and humite are orthorhombic and chondrodite and clinohumite are monoclinic with interaxial angles of approximately 109° and 101°, respectively.

During the course of a microprobe and single-crystal study of these minerals (Jones, 1968) it was noted that there is considerable confusion in the literature regarding the choice of crystallographic axes and space groups. Some of the choices which have been made are shown in Table 1. Apparently this profusion of axial choices has led to some of the mistakes found in descriptions of the humite minerals. Thus, as noted in Table 1, certain of the space groups adopted by Sahama (1953; after Strunz,

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