Short communications

Yugawaralite from Nukabira, Hokkaido. HIROSHI KONNO and MORIHIRO AOKI, *Institute of Mineralogy, Petrology and Economic Geology, Tohoku University, Sendai 980, and Miyagi University of Education, Sendai 980.*

Yugawaralite was newly found by M. Aoki from Nukabira district, central Hokkaido. It was possible to separate very pure samples suitable for chemical analysis. This paper describes the result of chemical analysis, together with its mineralogical properties.

At the present time, chemical compositions of yugawaralite are known for samples from the following three localities. 1) Type locality, Yugawara Hot Spring, Kanagawa Pref., Japan (Sakurai and Hayashi, 1952; Seki and Haramura, 1966; Harada *et al.*, 1969). 2) Shimoda district, Shizuoka Pref. (Sameshima, 1969). 3) Near Chena Hot Springs, Alaska (Eberlein *et al.*, 1971).

The new locality of yugawaralite is situated at Nukabira approximately 47 km north of Obihiro city, central Hokkaido (Fig. 1). In the vicinity of Nukabira, sediments of the Neogene Tertiary Horoka Formation are intruded by hornblende pyroxene andesite and quartz porphyry (Yamagishi, 1974). Yugawaralite, associated closely with large amounts of laumontite and calcites (Fig. 2), occurs in druses of the altered basalt lavas and pillow breccia in the Horoka Formation, which suffered from low-grade metamorphism to form morde-nite, heulandite, laumontite, pumpellyite and prehnite.

Fig. 1. Locality of yugawaralite.

Fig. 2. Photograph of yugawaralite from Nukabira.

Y : yugawaralite L : laumontite C : calcite

Mineralogical properties

Yugawaralite occurs as monoclinic tabular crystals, elongated along the c -axis. It attains 5 mm (a -axis), 2 mm (b -axis) and 8 mm (c -axis) in size. Crystal faces are as follows: a (100), b (010), c (001), m (110), u (011), p ($\bar{1}11$) (Fig. 3). Twinning is not observed. Most crystals are colorless transparent or white semi-transparent with a strong vitreous lustre. Streak: white. Fracture: conchoidal. Cleavage: imperfect on (010). Hardness: 4.5. Specific gravity: 2.23 (meas.).

Fig. 3. Crystal faces of yugawaralite from Nukabira.

a (100) b (010) c (001) m (110) u (011) p ($\bar{1}11$)

Optically, it is biaxial (+), with no pleochroism. The refractive indices are; $\alpha=1.495$, $\beta=1.500$, $\gamma=1.504$, $\gamma-\alpha=0.009$ and optical axial angle $2V=76-82^\circ$. Optical orientation: $X \div a$, $Y \div c$, $Z=b$, $Y \wedge c=7^\circ$. Optical axial plane $\perp$ (010).

X-ray powder data are listed in Table 1. As shown in this table, the strongest X-ray diffraction lines (in $\text{\AA}$) are 7.01 (50), 5.83 (50), 4.65 (100), 4.30 (30), 3.23 (40), 3.05 (80), 2.681 (30). The (010) reflection was detected at 14.09 $\text{\AA}$.

Table 1. X-ray powder diffraction data for yugawaralite.

d (Å)	I	d (Å)	I	d (Å)	I
14.09	5	2.478	5	1.567	5
7.81	5	2.428	10	1.540	10
7.01	50	2.405	5	1.524	5
6.28	5	2.368	10	1.512	10
5.83	50	2.330	5	1.496	5
4.65	100	2.194	5	1.487	5
4.42	10	2.151	5	1.470	10
4.30	30	2.137	5	1.455	5
4.18	20	2.105	5	1.430	5
3.90	10	2.091	10	1.394	5
3.77	15	2.017	5	1.376	5
3.30	10	2.004	10	1.356	5
3.23	40	1.977	15	1.344	5
3.05	80	1.953	10	1.338	5
2.999	5	1.932	10	1.315	5
2.939	25	1.907	5	1.310	5
2.909	20	1.899	10	1.294	5
2.863	10	1.874	5	1.288	5
2.766	15	1.787	5	1.278	5
2.718	25	1.752	5	1.250	5
2.681	30	1.722	15	1.232	5
2.646	15	1.698	10	1.227	5
2.578	10	1.681	5	1.222	5
2.561	5	1.648	5		
2.516	5	1.615	5		

CuK α , Ni-filter, 30kV, 15mA, glancing angle 5°, scanning speed 1°/min., Slit divergence 1°, slit receiv. 0.3, time const. 2 sec., full scale 500 cps.

200 mg of powdered samples of yugawaralite were analyzed in air with a DTA and TGA thermobalance simultaneous system at a heating rate of 10°C per minute. The DTA curve for yugawaralite shows three endothermic reactions at 130°C, 315°C and 540°C (Fig. 4).

The thermal change of yugawaralite was examined by X-ray on specimens heated for one hour at various temperatures. Yuga-

Fig. 4. DTA and TGA curves of yugawaralite from Nukabira.

waralite progressively decomposed to anorthite, tridymite and a calcium aluminium silicate hydrate (ASTM 15-179) at the temperatures, ranging from 500° to 700°C. Anorthite and cristobalite were observed at 1000°C.

The TGA indicates three stages of weight loss. These are in well agreement with the TGA curves obtained by Sakurai and Hayashi (1952), and Sakurai (1953) for yugawaralite from the type locality.

Chemical analyses

Yugawaralite was separated from the host rock, laumontite and calcite by hand picking method and washed with HCl (1:1) solution after crushing the samples under 48 meshes. Chemical analyses for major elements were made by gravimetric method (SiO_2 , Al_2O_3 , CaO), flame photometry (Na_2O , K_2O), atomic absorption (MgO , Fe_2O_3 , SrO), colorimetric method (TiO_2 , MnO) and titration method (FeO). H_2O (+) was obtained as loss on ignition for materials dried at 110°C. The results are listed in Table 2. Atomic ratios calculated on the basis

Table 2. Chemical composition of yugawaralite.

	(1)	(2)	(3)	Atomic ratio (O=16)	
SiO ₂	59.58	61.47	61.14	Si	5.982
TiO ₂	—	<0.01	none		
Al ₂ O ₃	18.54	17.38	17.65	Al	2.034
Fe ₂ O ₃	0.19	<0.04	0.05	Fe ³⁺	0.004
FeO	none	—	none		
MnO	—	—	none		
MgO	tr.	<0.01	0.002		
CaO	8.96	8.51	9.24	Ca	0.968
SrO	—	0.21	0.04	Sr	0.002
Na ₂ O	0.19	0.06	0.08	Na	0.015
K ₂ O	0.05	0.09	0.03	K	0.004
H ₂ O(+)	13.00	9.33	9.07	H ₂ O	3.86
H ₂ O(—)		2.79	2.73		
Total	100.51	99.90	100.03		

- (1) Harada, Nagashima and Sakurai (1969), Analyst: K. Nagashima and K. Nakao.
 (2) Eberlein *et al.* (1971), Analyst: L.B. Beatty.
 (3) Konno and Aoki, Analyst: K. Konno.

of O=16 in the anhydrous part and the coordinated position of the atoms are listed in Table 2. The chemical formula for yugawaralite can be expressed as $(\text{Ca}_{0.968}\text{Sr}_{0.002}\text{Na}_{0.015}\text{K}_{0.004})(\text{Fe}_{0.004}\text{Al}_{2.034}\text{Si}_{5.982})\text{O}_{16} \cdot 3.86\text{H}_2\text{O}$. This formula corresponds to the ideal formula $(\text{CaAl}_2\text{Si}_6\text{O}_{16} \cdot 4\text{H}_2\text{O})$ of yugawaralite proposed by Barrer and Marshall (1965).

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