Mem. Fac. Sci. Eng. Shimane Univ.
Series A
31, pp. 217-241 (1997)

Chemical compositions of kosmochlor and related minerals from tectonic blocks within the Osayama ultramafic body in the Sangun metamorphic belt, southwest Japan

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(Received September 19, 1997)

Abstract

The Osayama ultramafic body occurs in the high-P/T Sangun metamorphic belt, southwest Japan. The northeastern parts of the Osayama ultramafic body are a serpentinite melange with tectonic blocks of diverse lithology and metamorphic grade. Chemical compositions of the constituent minrals from the tectonic blocks such as kosmochlor-bearing and -free actinolite-tremolite rocks and jadeitites in the Osayama ultramafic body are provided in this paper.

Key words: *kosmochlor, ureyite, diopside, jadeite, actinolite-tremolite rock, jadeitite, serpentinite melange, Osayama ultramafic body, Sangun metamorphic belt, southewst Japan, chemical composition.*

Geology of the Osayama ultramafic body

Kosmochlor (ureyite), $NaCrSi_2O_6$, has been discrived from three localities in the world, i.e. Myanmar, Russia, Italy, before the first discovery of kosmochlor in Japan was reported from the Osayama ultramafic body occurring within the Sangun high-pressure type (glaucophanic) metamorphic belt (Fig. 1; Sakamoto and Takasu, 1996; Takasu and Sakamoto, 1996). The Osayama ultramafic body consists mainly of harzburgite with small amounts of dunite and metagabbro (Kobayashi et al., 1987; Matsumoto et al., 1995), although most parts of the body are severely serpentinized. The northeastern parts of the Osayama ultramafic body are of serpentinite melange (Tsujimori and Takasu, 1994) with tectonic blocks of diverse size, lithology and metamorphic grade. The tectonic blocks include spotted schists, non-spotted schists, garnet-glaucophane schists, metagabbros, metadiabases, albitites, omphacite rocks, jadeitites, stilpnomelane schists, pelitic schists and actinolite-tremolite rocks (Watanabe et al., 1987; Kobayashi et al., 1987; Tsujimori and Takasu, 1994; Sakamoto and Takasu, 1996). Kosmochlor and kosmochlor component-bearing clinopyroxenes occur in actinolite-tremolite blocks. It occurs as lenticular (25 cm × 130 cm) or vein (1–20 cm in width) shapes in serpentinite matrix (Figs. 2 and 3).

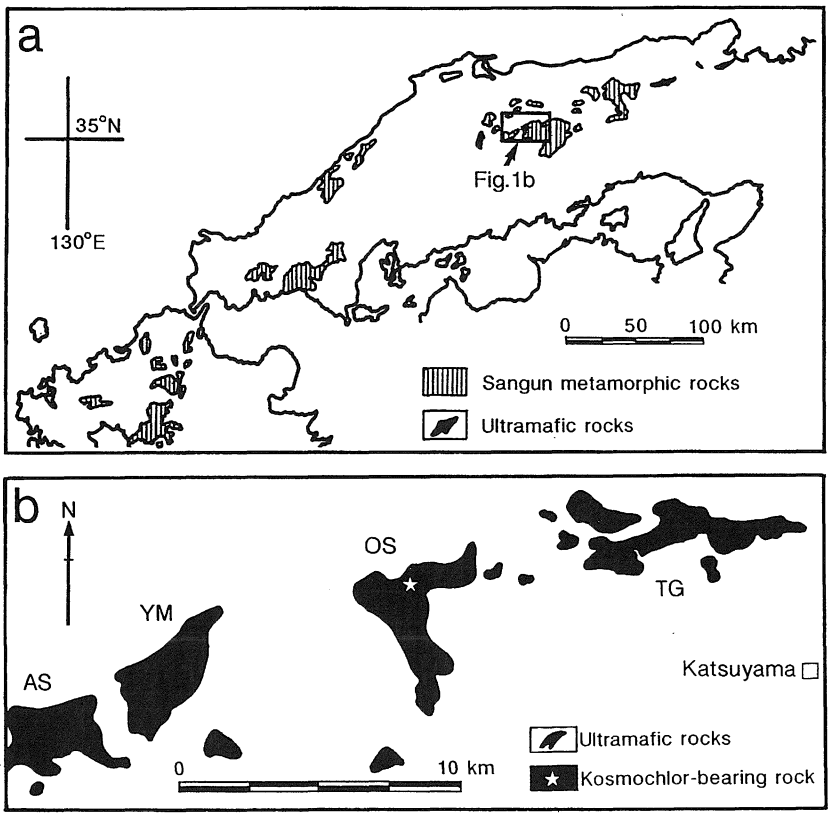

Fig. 1. **a.** Distribution of the Sangun metamorphic belt (after Shibata and Nishimura, 1989). **b.** Distribution of ultramafic bodies in the eastern parts of the Sangun belt (Mitsuno and Sugita, 1980; Matsumoto et al., 1995). AS: Ashidachi body; YM: Yanomine body; OS: Osayama body; TG: Taguchi body.

Petrography of actinolite-tremolite rocks, jadeite and basic schist

1. Kosmochlor-bearing actinolite-tremolite rocks

The kosmochlor-bearing actinolite-tremolite rock (Sakamoto and Takasu, 1996) consists of a white matrix with green veinlets of a few mm wide showing no preferred orientation. The matrix consists mostly of amphibole (actinolite-tremolite) with subordinate amounts of diopsidic clinopyroxene, albite, K-feldspar and serpentine. The green veinlets are composed of kosmochlor-rich clinopyroxene, uvarovite, Cr-bearing actinolite-tremolite series amphibole with small amounts of chromite.

Clinopyroxene occurs both in the matrix and the green veinlets. It forms subhedral columnar and acicular crystals up to 0.4 mm long. Kosmochlor-rich clinopyroxene is restricted to

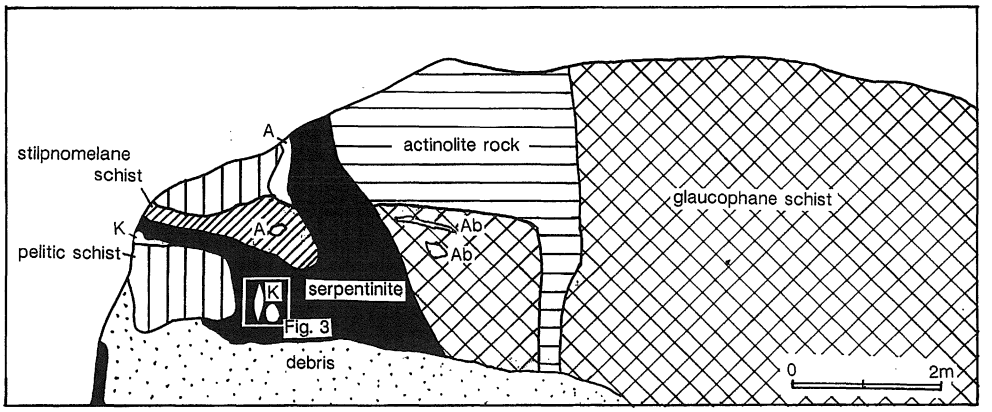

Fig. 2. Occurrence of tectonic blocks of various lithologies in serpentinite matrix. K: kosmochlor-bearing actinolite-tremolite rock; A: actinolite-tremolite rock; Ab: albitite.

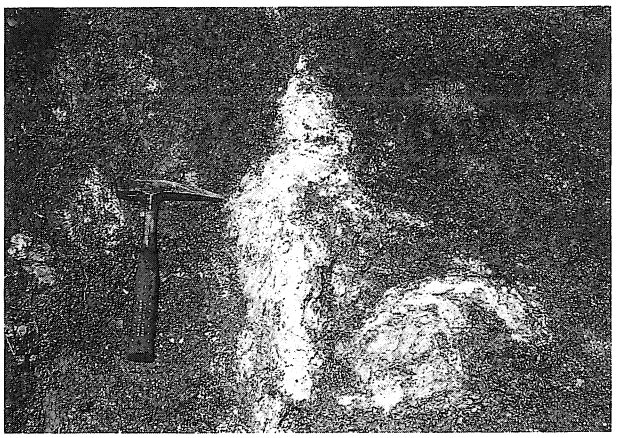

Fig. 3. Kosmochlor-bearing actinolite-tremolite rock block within srpentinite of the Osayama ultramafic body. Hammer as a scale is 33 cm long.

green veinlets. It shows a distinct pleochroism with X=yellow, Y=yellowish green and Z=green. Kosmochlor-rich clinopyroxene is compositionally heterogeneous, grading into diopside within a single crystal. It sometimes shows zoning with kosmochlor-rich clinopyroxene core and diopside rim. Occasionally very fine lamellae texture in kosmochlor is developed probably due to exsolution Fig. 8.

Amphibole occurs as aggregate of fine fibrous crystals (c. 0.1 mm) in the matrix, and interstice between diopside and kosmochlor-rich pyroxene in the green veinlets. A schistosity consisting mainly of matrix amphiboles sometimes shows crenulation fold. It is usually colorless, but

chromium-rich varieties are pale green. Albite and K-feldspar (<0.5 mm) shows a granoblastic texture in albite and K-feldspar pools (<2 mm) in the matrix. Uvarovite occurs as light to dark green euhedral crystals (<0.05 mm) in green veinlets. It also occurs at the boundary of between serpentine and amphibole in matrix. Chromite (<1 mm) occurs as resorbed anhedral crystal and is surrounded by uvarovite and kosmochlor-rich clinopyroxene.

2. Actinolite-tremolite rocks

Actinolite-tremolite rocks consist mainly of actinolite-tremolite series calcic amphibole with small amounts of serpentine, albite, K-feldspar, phengite, chlorite, diopside, uvarovite, sphene, fuchsite and opaque minerals.

Amphibole occurs as aggregate of fine fibrous crystals (<1 mm). Serpentine occurs as aggregate of fine fibrous crystals (<0.1 mm). Albite is of anhedral crystal (<0.5 mm). K-feldspar occurs as subhedral crystal (<0.3 mm). There are two modes of occurrence of K-feldspar, i.e., forming a schistosity with amphibole, and occurring associated with white mica. White mica occurs as tabular crystal (<0.4 mm). Chlorite occurs as tabular crystal (<0.1 mm). The elongation is negative, and shows pleochroism with X′=light brown and Z′=light brownish green. Diopside occurs as subhedral crystal (<0.6 mm). Uvarovite occurs as dark green very fine crystal (<0.01 mm). Sphane occurs as fine crystal (<0.02 mm). Opaque minerals is of anhedral crystal (<1 mm).

3. Jadeitites

Jadeitites consist mainly of jadeite with small amounts of omphacite, diopside, pectolite, analcime, sphene and rutile.

Jadeite occurs as euhedral to subhedral prismatic crystal (c. 1 mm; up to 4 mm). Omphacite and diopside occur as anhedral fine crystals (<0.3 mm). Pectolite occurs as columnar crystal (<0.2 mm). Analcime occurs in interstice of jadeite and pectolite. Rutile (<3 mm) is surrounded by sphene.

Kobayashi et al. (1987) reported stronalsite and Ba-rich minerals from the jadeitites.

4. Basic schists

Basic schists consist mainly of white mica, chlorite, amphibole with small amounts of albite, clinopyroxene, epidote, fuchsite and opaque minerals. A schistosity is defined by preferred orientation of white mica and chlorite. Schistosity is sometimes crenulated (c. 4 mm in wavelength).

White mica and chlorite occurs as tabular crystal (<2 mm) and amphibole occurs as acicular crystal (<2 mm). The elongation of chlorite is positive, and shows pleochroism with X′=brown and Z′=dark brown. Albite occurs as anhedral crystal (<0.5 mm), and shows albite twin. Some of them are porphyroblastic (albite spot). Clinopyroxene occurs as subhedral crystal (<0.3 mm). Epidote occurs as subhedral to anhedral crystal (<2 mm). It is sometimes surrounded by opaque minerals (0.5 mm). It is green in color close to the opaque minerals. Fuchsite occurs as tabular crystal (<1 mm), and is located around clinopyroxene. It shows

pleochroism with X′=yellowish green and Z′=bluish green.

Chemical composition of minerals

Chemical compositions of minerals have been analysed by EPMA (JEOL JXA-8800M) in the Reserch Center for Coastal Lagoon Environments, Shimane University. The analyses were performed at 15 kV of accelerating voltage and 2×10^{-8} A of specimen current, 3–10 μm of probe diameter and correction method of Bence and Albee (1968).

1. Clinopyroxenes

Clinopyroxenes from kosmochlor-bearing and -free actinolite-tremolite rocks and jadeitites have been chemically analyzed by EPMA (Table 1). They are classified into kosmochlor, diopside (sodic augite), omphacite and jadeite. Kosmochlor occurs in kosmochlor-bearing actinolite-tremolite rocks, and diopside (sodic augite) occurs in actinolite-tremolite rocks and jadeitites. Omphacite and jadeite are developed restrictedly in jadeitites.

a. Clinopyroxenes in kosmochlor-bearing actinolite-tremolite rocks

Clinopyroxene is classified into diopside and kosmochlor. It contains 0–19.2 wt.% Cr_2O_3 and 0.3–7.7 wt.% Na_2O. It consists of 0.0–56.3 mol% kosmochlor (Ko), 43.7–98.0 mol% diopside, including diopside and small amount of hedenbergite and orthopyroxene (Di), 0.0–10.1 mol% jadeite (Jd) and 0.0–4.5 mol% aegirine (Aeg) molecules (Fig. 4). The Jd component decreases with increasing Ko in diopside. These chemical compositions of the clinopyroxene indicate a wide range of Di–Ko solid solution with up to 56 mol% of Ko. Ko-free diopside contains up to 10.1 mol% of Jd.

The kosmochlor component-bearing clinopyroxenes from other actinolite-tremolite rock show kosmochlor-jadeite and kosmochlor-omphacite solid solution (Fig. 4). Kosmochlor component-bearing clinopyroxenes from the Osayama ultramafic body shows kosmochlor-diopside solid solution, with up to 56 mol% of kosmochlor in diopside (Fig. 4). Such chemical compositions of kosmochlor have been reported only from the Osayama area.

b. Clinopyroxenes in kosmochlor-free actinolite-tremolite rocks

Clinopyroxene contains 25.8–26.2 wt.% CaO, 17.5–17.6 wt.% MgO and 2.3 wt.% FeO, with low contents of Na_2O (<0.1 wt.%), and it does not contain Cr_2O_3. It is almost pure diopside (99.4–99.5 mol% of Di), with scarce amounts of aegirine content (<0.6 mol% of Aeg) (Fig. 5a).

c. Jadeitites

Clinopyroxene is classified into sodic augite, omphacite and impure jadeite following Essene and Fyfe (1967). It contains 1.2–14.6 wt.% Na_2O and 0.1–23.8 wt.% CaO. It consists of 2.6–99.6 mol% Jd, 0.4–91.6 mol% Aug and 0–10.2 mol% Aeg (Fig. 5b).

d. Basic schists

Clinopyroxene is classified into sodic augite following Essene and Fyfe (1967). It contains 0.9 wt.% Na_2O and 23.0 wt.% CaO. It consists of 6.2 mol% Jd, 93.8 mol% Aug (Fig. 5c).

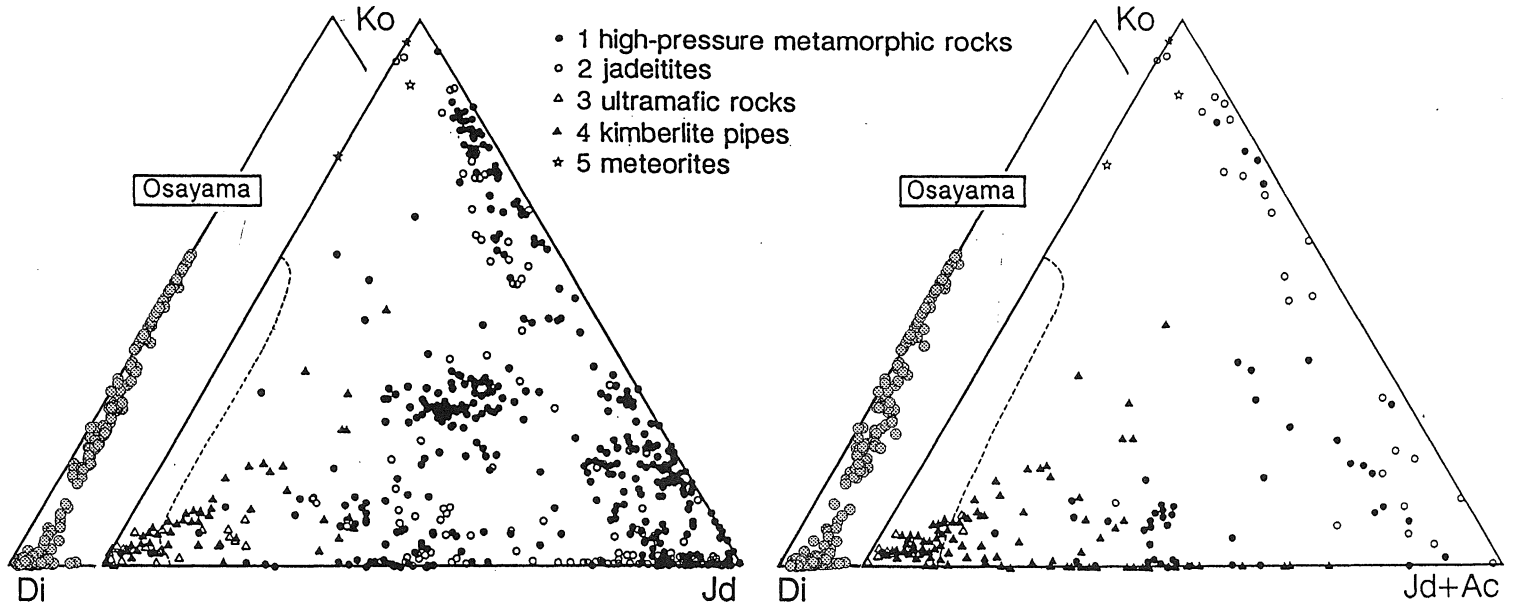

Fig. 4. Chemical compositions of kosmochlors and releted clinopyroxenes from the Osayama ultramafic body and the other localities. Ko: kosmochlor; Di: diopside, including minor hedenbergite and orthopyroxene; Jd: jadeite; Aeg: aegirine. 1: high pressure metamorphic rocks (French Alps: Mevel and Kienast, 1980; Italy: Carpenter, 1981; Abs-Wurmbach et al., 1985; Harlow and Olds, 1987; Philippot and Kienast, 1989; Myanmar: Harlow and Olds, 1987; Japan: Nishiyama et al., 1986; Banno, 1992, 1993); 2: jadeitites (artifacts in Mexico and Guatemala: Harlow and Olds, 1987; Guatemala: Harlow and Olds, 1987; Harlow, 1994; Myanmar: Lacroix, 1930; Harlow and Olds, 1983; Yang, 1984; Mevel and Kienast, 1986); 3: ultramafic rocks (Ross et al., 1954; Harlow and Olds, 1987); 4: kimberlite pipes (Russia: Sobolev, 1974; Sobolev et al., 1971, 1973, 1975; Egorov et al., 1992; South Africa: Sobolev; 1974); 5: meteorites (Frondel and Klein, 1965; Couper et al., 1981); Dashed-lined area: composition range of kosmochlor and related clinopyroxenes from the Osayama ultramafic body.

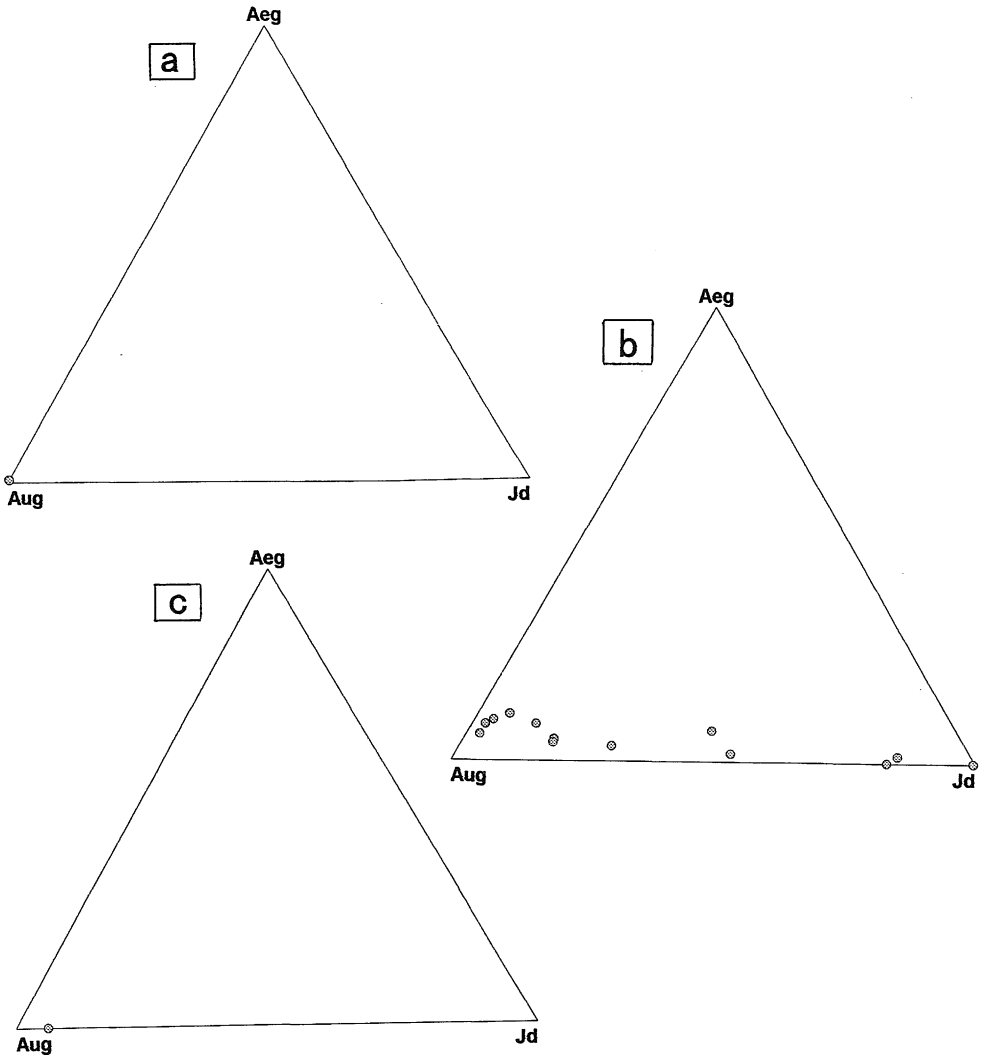

Fig. 5. Chemical compositions of Na-pyroxenes. Aeg: aegirine; Aug: augite; Jd: jadeite. **a**: kosmochlor-free actinolite-tremolite rock; **b**: jadeite; **c**: basic schist.

2. Amphiboles

Amphiboles from kosmochlor-bearing and -free actinolite-tremolite rocks and basic schists are classified into actinolite and tremolite on the basis of Leake et al. (1997). The estimation of Fe^{3+} is based on the assumption $Si+Ti+Al+Fe+Mn+Mg+Cr=13$. $Mg/(Mg+Fe^{2+})$ ranges from 0.73 to 1.00 (Table 2, Fig. 6), and Ca ranges from 1.55 to 2.04, with low contents of Al_2O_3 (0–2.0 wt.%), Na_2O (0–3.0 wt.%) and K_2O (0–0.3 wt.%). Some amphiboles con-

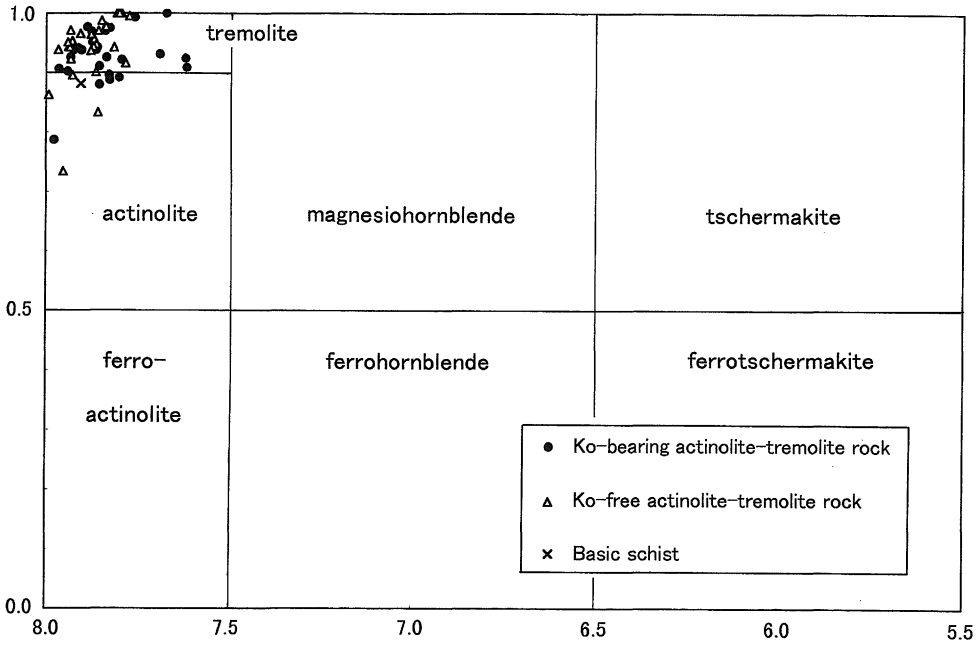

Fig. 6. Chemical compositions of Ca-amphiboles.

tains high Cr_2O_3 with up to 4.3 wt.%.

Amphibole from basic schist is classified into actinolite on the basis of Leake et al. (1997).

3. Feldspars

Plagioclase in kosmochlor-bearing and -free actinolite-tremolite rocks shows almost pure albite with Na/(Na+Ca)=0.99–1.00 (Table 3).

K-feldspar in kosmochlor-bearing and -free actinolite-tremolite rocks is pure K-feldspar with K/(K+Na+Ca)=0.96–1.00.

4. Garnets

Garnets occur in kosmochlor-bearing and -free actinolite-tremolite rocks. However, these from kosmochlor-free actinolite-tremolite rocks were not analyzed because of very fine grains.

Garnets in kosmochlor-bearing actinolite-tremolite rocks have high Cr_2O_3 (19.0–22.1 wt.%) and CaO (31.9–33.6 wt.%), consisting of uvarovite (62.7–70.8 mol%), grossular (11.0–19.7 mol%) and andradite (10.3–17.5 mol%) molecules, but no pyralspite molecules (Table 4, Fig. 7).

5. Serpentines

Serpentines occur in kosmochlor-bearing and -free actinolite-tremolite rocks.

Mg/(Mg+Fe) ranges from 0.85 to 0.89, with contents of Al_2O_3 (0.7–3.7 wt.%). Serpen-

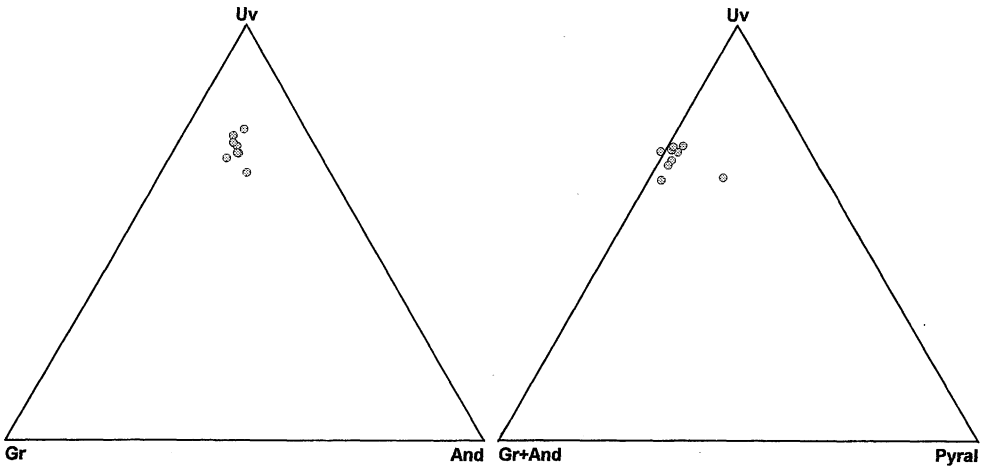

Fig. 7. Chemical compositions of garnets. Uv: uvarovite; Gr: grossular; And: andradite; Pyra: pyralspite.

tine close to chromite contains high Cr_2O_3 content (<1.4 wt.%) (Table 5).

6. Chlorites

Chlorites occur kosmochlor-bearing and -free actinolite-tremolite rocks.

Mg/(Mg+Fe) ranges from 0.86 to 0.91, Si/(Si+Al) ranges from 0.61 to 0.69. Chlorites located close to chromites contain high Cr_2O_3 content (<5.4 wt.%) (Table 6).

7. Phengites

Phengites occur in kosmochlor-free actinolite-tremolite rocks.

It has high Si content ranging from 6.69 to 6.87. Phengite being located close to chromite contains high Cr_2O_3 content (<6.9 wt.%) (Table 7).

8. Opaque minerals

Chromite and Cr-spinel are present in kosmochlor-bearing and -free actinolite-tremolite rocks, respectively. Both of them can not be analyzed. Because they are severely altered (Table 8).

9. Epidotes

Epidotes occur basic schist. Pistasite molecules of the epidotes range from 3.3–19.1 % (Table 9). Some of them have very high contains of Cr_2O_3 (<15.0 wt.%).

10. Prehites

Prehites occur in basic schist. Fe/(Fe+Al) ranges from 0.008 to 0.027 (Table 10).

11. Pumpellyites, Sphenes, Pectlites and Analcimes

Pumpellyites occur in basic schist. Sphenes occur in Ko-free actinolite-tremolite rock and basic schist. Pectlite and analcime occur in jadeitite. The chemical compositions of these minerals are shown in Tables 11–14.

Acknowledgments

Thanks are due to Dr. A. Takasu of Shimane University for his review of the manuscript.

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†: in Japanese
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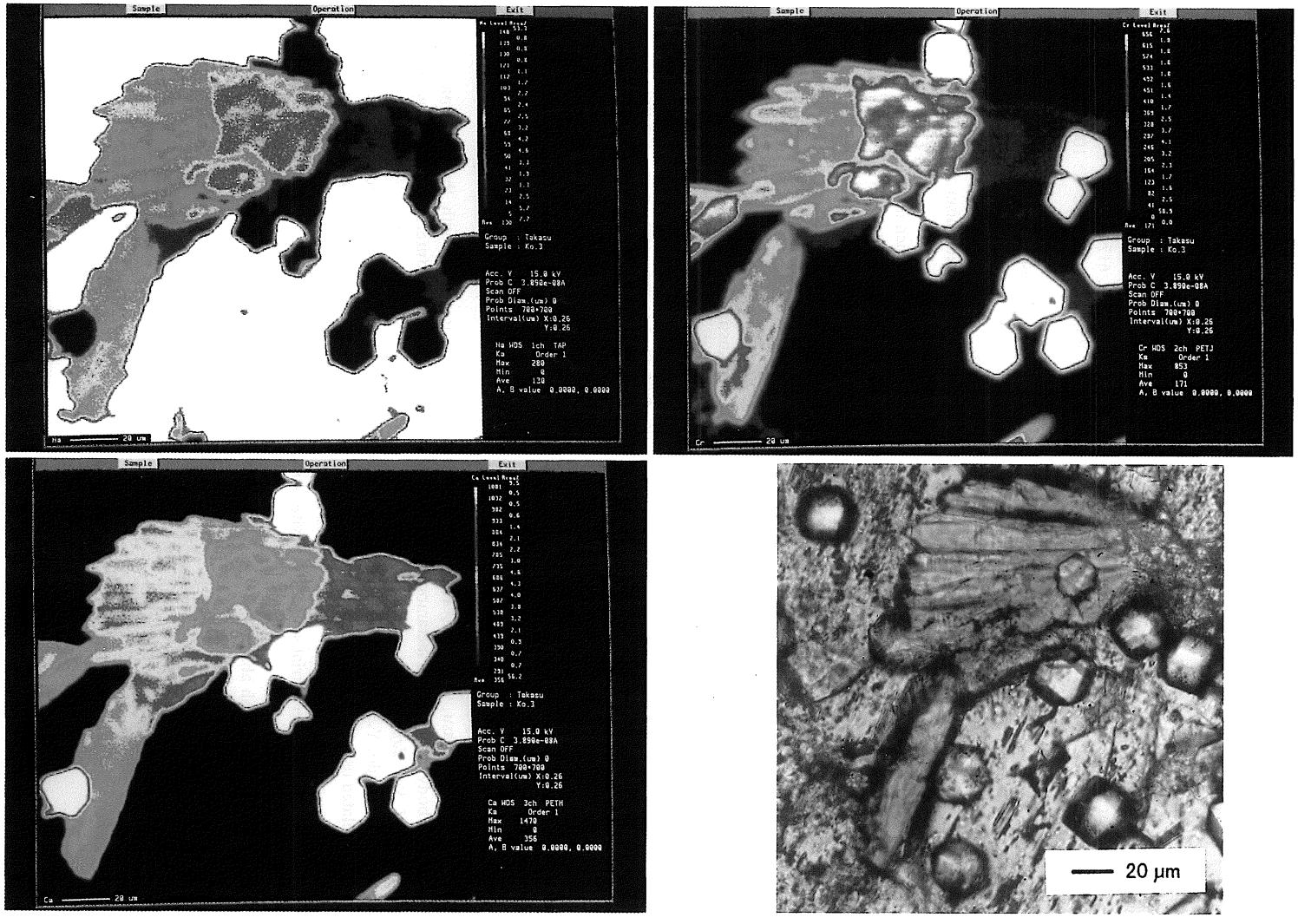

Fig. 8. Elemental color map photos of occurrence of kosmochlor. The color map analyses were made using the JEOL JXA 8800M electron microprobe analyzer of the Research Center for Coastal Lagoon Environments, Shimane University, under the following analytical conditions: accelerating voltage 15 kV; probe current 4×10^{-8} A; dwell time 56 msec.; no. of pixels 700×700; pixel size: 0.26×0.26 μm. The relative concentration of the element is represented by color (see color bar in the photo).

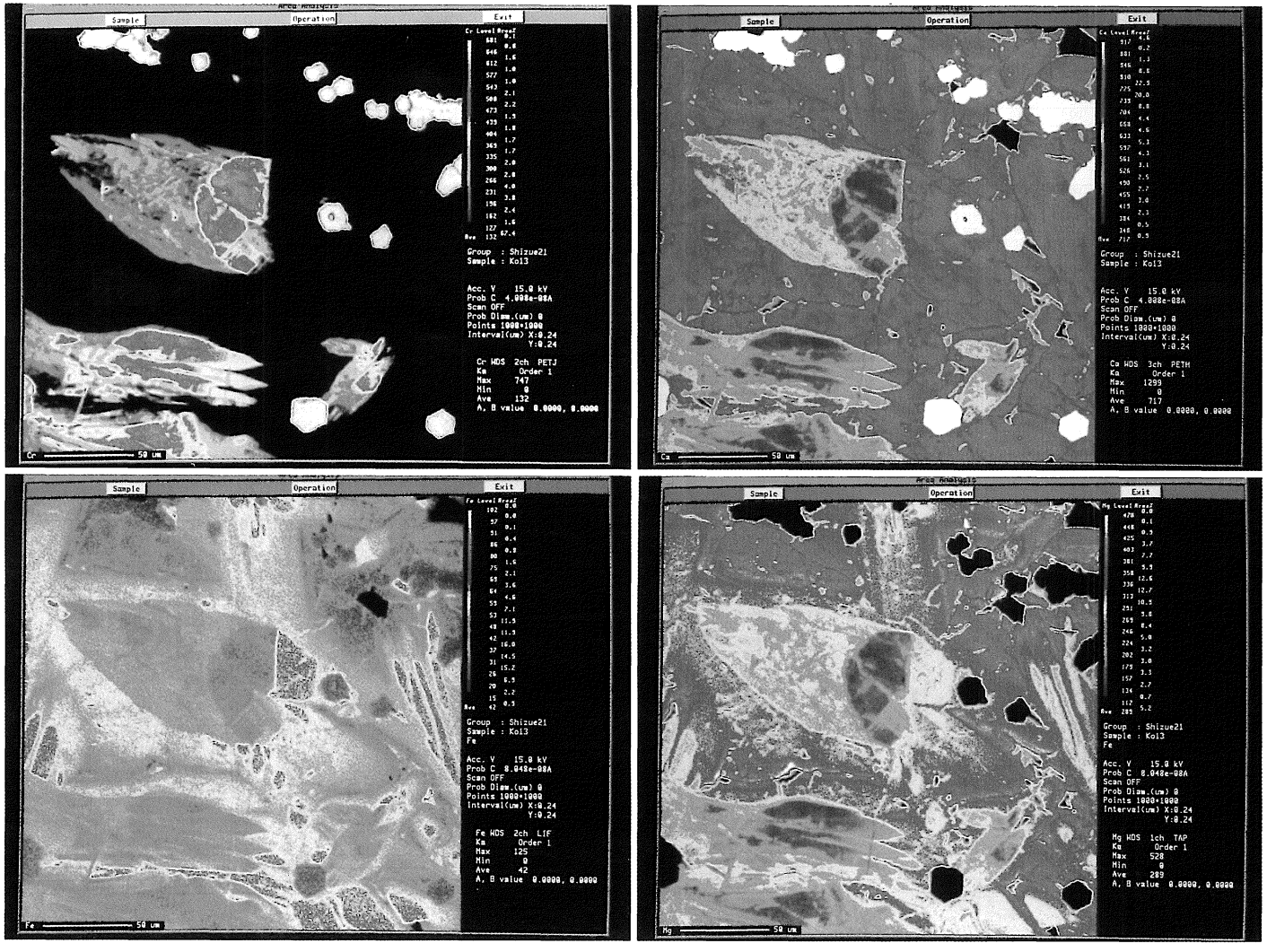

Fig. 9. Elemental color map photos of occurrence of kosmochlor. The analysis was done under the following conditions: accelerating voltage 15 kV; probe current $4\text{–}8 \times 10^{-8}$ A; dwell time 52–63 msec.; no. of pixels 1000×1000; pixel size: 0.24×0.24 μm. The relative concentration of the element is represented by color (see color bar in the photo).

Table 1. Chemical compositions of clinopyroxenes in kosmochlor-bearing and -free actinolite-tremolite rock, jadeitite and basic schist. Cations per 6 oxygens.

Lithology	Ko-bearing actinolite-tremolite rock																						
Sample	Ur1									Ur2				Ur1-10									
No.	2	14	29	32	35	37	40	45	49	54	2	12	17	35	51	55	61	66	70	81	96	105	133
SiO2	54.55	53.73	53.62	53.75	54.37	53.31	54.59	53.16	53.22	53.28	54.65	53.50	52.52	53.38	53.03	53.81	54.84	53.68	53.77	53.05	52.39	53.21	51.62
TiO2	0.01	0.00	0.11	0.07	0.00	0.16	0.01	0.05	0.09	0.17	0.01	0.14	0.11	0.29	0.04	0.12	0.07	0.10	0.05	0.10	0.01	0.15	0.03
Al2O3	0.72	0.73	0.90	0.62	0.95	0.72	0.80	0.79	0.79	0.87	0.84	1.41	0.74	0.96	0.76	0.88	0.70	0.62	0.62	0.44	0.49	0.56	0.41
FeO*	3.49	2.78	5.88	4.99	4.44	6.08	4.06	5.77	5.63	4.96	3.32	6.18	5.53	7.70	5.17	6.52	3.85	6.52	5.25	5.39	4.49	6.74	4.40
MnO	0.06	0.28	0.61	0.41	0.20	0.65	0.21	0.47	0.53	0.25	0.11	0.45	0.53	0.67	0.44	0.60	0.16	0.46	0.46	0.49	0.47	0.79	0.40
MgO	12.80	11.12	9.64	10.51	14.99	11.22	15.13	11.28	9.78	9.25	13.40	13.30	8.33	11.09	8.10	11.35	15.14	12.21	10.11	8.23	7.05	12.79	5.56
CaO	17.96	17.16	17.61	17.70	24.54	20.10	25.01	19.50	17.76	16.63	18.51	23.84	15.84	21.54	15.82	21.22	23.98	22.40	16.23	16.18	14.03	23.81	11.76
Na2O	3.17	4.38	3.47	3.84	0.73	2.56	0.54	2.75	3.78	4.43	3.03	1.11	4.53	1.84	5.28	2.28	0.76	1.52	4.37	4.77	6.18	0.76	7.57
Cr2O3	7.25	10.15	8.22	8.34	0.05	5.31	0.04	5.78	8.27	10.38	6.30	0.29	11.52	2.72	11.86	3.50	0.44	2.27	9.52	10.97	14.60	0.88	18.75
Total	100.01	100.33	100.06	100.23	100.27	100.11	100.39	99.55	99.85	100.02	100.17	100.22	99.65	100.19	100.50	100.28	99.94	99.78	100.38	99.62	99.71	99.69	100.50
Si	2.004	1.984	2.001	1.998	1.993	1.989	1.996	1.991	1.994	1.991	2.001	1.981	1.982	1.996	1.984	2.002	2.008	2.003	1.998	2.000	1.982	1.992	1.955
Ti	0.000	0.000	0.003	0.002	0.000	0.004	0.000	0.001	0.003	0.005	0.000	0.004	0.003	0.008	0.001	0.003	0.002	0.003	0.001	0.003	0.000	0.004	0.001
Al	0.031	0.032	0.040	0.027	0.041	0.032	0.034	0.035	0.035	0.030	0.036	0.062	0.033	0.042	0.034	0.039	0.030	0.027	0.027	0.020	0.022	0.025	0.018
Fe	0.107	0.086	0.183	0.155	0.136	0.190	0.124	0.181	0.176	0.155	0.102	0.191	0.174	0.241	0.162	0.203	0.118	0.203	0.163	0.170	0.142	0.211	0.139
Mn	0.002	0.009	0.019	0.013	0.006	0.021	0.007	0.015	0.017	0.008	0.003	0.014	0.017	0.021	0.014	0.019	0.005	0.016	0.014	0.016	0.015	0.025	0.013
Mg	0.700	0.612	0.536	0.582	0.819	0.624	0.824	0.629	0.546	0.515	0.731	0.734	0.468	0.618	0.452	0.629	0.826	0.679	0.560	0.462	0.397	0.713	0.314
Ca	0.707	0.678	0.704	0.705	0.963	0.803	0.979	0.782	0.712	0.666	0.726	0.946	0.640	0.862	0.634	0.845	0.940	0.895	0.646	0.653	0.568	0.955	0.477
Na	0.226	0.313	0.251	0.277	0.052	0.185	0.038	0.200	0.274	0.321	0.215	0.080	0.331	0.133	0.383	0.164	0.054	0.110	0.315	0.348	0.453	0.055	0.555
Cr	0.210	0.296	0.242	0.245	0.001	0.157	0.001	0.171	0.245	0.306	0.182	0.008	0.343	0.080	0.351	0.103	0.013	0.067	0.279	0.327	0.436	0.026	0.561
Total	3.988	4.009	3.980	4.003	4.012	4.005	4.005	4.005	4.001	3.996	3.997	4.020	3.992	4.002	4.014	4.007	3.996	4.002	4.004	3.998	4.016	4.006	4.033
End members																							
Ko	21.39	29.46	24.93	24.48	0.14	15.65	0.11	17.07	24.49	30.87	18.30	0.83	33.76	8.06	34.48	10.19	1.28	6.66	27.91	32.61	42.71	2.58	53.80
Jd	1.55	1.53	0.88	2.49	3.38	2.11	3.02	2.57	2.84	1.45	3.29	4.18	0.00	3.80	1.77	3.82	3.04	2.71	2.54	1.94	0.34	1.66	0.00
Ae	0.00	0.20	0.00	0.68	1.61	0.75	0.62	0.29	0.12	0.00	0.00	2.76	0.00	1.51	1.41	2.27	1.11	1.57	0.97	0.23	1.30	1.23	0.00
Di	71.83	67.54	72.40	70.43	94.89	80.33	96.24	78.09	71.29	67.06	72.89	92.23	65.25	86.53	62.35	83.72	94.58	89.06	64.50	65.21	55.65	94.54	46.20
Opx	5.23	1.27	1.79	1.92	0.00	1.16	0.00	1.99	1.26	0.62	5.53	0.00	0.99	0.10	0.00	0.00	0.00	0.00	4.07	0.00	0.00	0.00	0.00

* Total Fe as FeO.

Lithology	Ko-bearing actinolite-tremolite rock																						
Sample	Ur1-10				Ko1-8		Ur1	Ko1		Ko2				Ko3	Ko								
No.	151	156	164	171	172	15	5	30	39	2	19	30	58	4	2	14	18	20	22	30	35	39	42
SiO2	53.26	53.76	53.05	54.01	52.45	53.26	53.13	52.55	54.03	52.82	53.61	53.44	53.25	52.61	54.60	52.34	52.95	52.52	52.54	52.68	53.79	52.81	52.57
TiO2	0.09	0.13	0.24	0.10	0.22	0.07	0.21	0.02	0.00	0.00	0.02	0.02	0.07	0.02	0.05	0.11	0.00	0.00	0.00	0.00	0.05	0.00	0.17
Al2O3	0.75	0.77	0.87	0.78	0.74	0.62	0.92	0.33	0.70	0.49	0.73	0.70	0.52	0.69	2.72	0.41	0.67	0.51	0.28	0.41	0.75	0.49	0.42
FeO*	6.51	6.37	8.08	6.56	6.62	5.76	7.98	3.63	3.32	4.16	4.61	3.68	9.40	4.44	3.24	10.27	3.82	3.77	5.29	3.36	7.10	3.60	10.60
MnO	0.66	0.62	0.90	0.52	0.62	0.51	0.91	0.30	0.23	0.34	0.41	0.29	0.93	0.38	0.29	1.25	0.24	0.34	0.63	0.23	0.69	0.34	1.18
MgO	10.26	12.39	11.44	12.54	10.67	11.04	11.86	6.27	13.40	7.77	10.12	8.32	10.61	6.61	13.64	10.32	8.05	6.12	7.03	5.64	12.23	6.31	10.24
CaO	18.99	22.64	22.62	23.04	19.32	20.11	23.19	12.26	20.21	14.55	18.41	14.44	24.22	13.23	23.18	24.39	14.53	12.23	14.85	11.29	24.17	12.51	24.21
Na2O	3.22	1.48	1.24	1.08	3.18	3.11	1.20	7.14	2.82	5.97	3.84	6.00	0.42	6.15	1.54	0.41	5.70	7.09	5.55	7.50	0.63	7.03	0.41
Cr2O3	6.47	1.81	1.22	1.52	6.03	5.92	0.71	17.58	5.55	14.20	8.23	13.61	0.14	15.54	0.21	0.14	13.77	17.44	13.61	18.37	0.25	17.19	0.19
Total	100.21	99.97	99.66	100.15	99.85	100.40	100.11	100.08	100.26	100.30	99.98	100.50	99.56	99.67	99.47	99.64	99.73	100.02	99.78	99.48	99.66	100.28	99.99
Si	1.992	2.001	1.997	2.004	1.974	1.985	1.991	1.980	1.987	1.980	1.997	1.987	2.016	1.986	1.998	1.997	1.987	1.980	1.990	1.993	2.010	1.983	1.999
Ti	0.003	0.004	0.007	0.003	0.006	0.002	0.006	0.001	0.000	0.000	0.001	0.001	0.002	0.001	0.001	0.003	0.000	0.000	0.000	0.000	0.001	0.000	0.005
Al	0.033	0.034	0.039	0.034	0.033	0.027	0.041	0.015	0.030	0.022	0.032	0.031	0.023	0.031	0.117	0.018	0.030	0.023	0.012	0.018	0.033	0.022	0.019
Fe	0.204	0.198	0.254	0.204	0.208	0.179	0.250	0.114	0.102	0.130	0.144	0.114	0.298	0.140	0.099	0.328	0.120	0.119	0.167	0.106	0.222	0.113	0.337
Mn	0.021	0.020	0.029	0.016	0.020	0.016	0.029	0.010	0.007	0.011	0.013	0.009	0.030	0.012	0.009	0.040	0.008	0.011	0.020	0.007	0.022	0.011	0.038
Mg	0.572	0.687	0.641	0.693	0.598	0.613	0.662	0.352	0.734	0.434	0.562	0.461	0.598	0.372	0.744	0.586	0.450	0.344	0.397	0.318	0.681	0.353	0.580
Ca	0.761	0.902	0.912	0.916	0.779	0.803	0.930	0.495	0.796	0.584	0.735	0.575	0.982	0.535	0.909	0.996	0.584	0.494	0.602	0.457	0.967	0.503	0.986
Na	0.233	0.107	0.090	0.078	0.232	0.225	0.087	0.521	0.201	0.434	0.277	0.432	0.031	0.450	0.109	0.030	0.414	0.518	0.407	0.550	0.046	0.512	0.030
Cr	0.191	0.053	0.036	0.045	0.179	0.174	0.021	0.523	0.161	0.421	0.242	0.400	0.004	0.463	0.006	0.004	0.408	0.519	0.407	0.549	0.007	0.510	0.008
Total	4.010	4.005	4.004	3.992	4.030	4.024	4.016	4.011	4.018	4.015	4.002	4.009	3.984	3.990	3.993	4.004	4.000	4.006	4.003	3.998	3.990	4.006	3.999
End members																							
Ko	19.05	5.27	3.62	4.49	17.72	16.97	2.06	51.31	15.98	41.31	23.94	39.69	0.41	45.68	0.60	0.41	40.88	51.19	40.33	54.50	0.73	50.26	0.56
Jd	2.54	3.35	3.50	3.33	0.69	1.20	3.06	0.00	1.68	0.17	2.89	1.72	2.29	0.00	10.13	1.47	0.63	0.00	0.01	0.08	3.26	0.16	1.71
Ae	1.67	1.96	1.90	0.00	4.51	3.70	3.44	0.00	2.26	1.12	0.57	1.51	0.34	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.51	0.00	0.70
Di	75.81	89.42	90.98	92.18	76.98	78.14	91.44	48.69	78.87	57.39	72.60	57.08	96.96	54.32	89.27	97.05	58.49	48.81	59.66	45.41	95.50	49.58	97.03
Opx	0.93	0.00	0.00	0.00	0.09	0.00	0.00	0.00	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* Total Fe as FeO.

Table 1. (Continued)

Lithology	Ko-bearing actinolite-tremolite rock																							
Sample	Ko		Ko3	Ur1				Ko1-8						Ko1-3				Ko1-4					Ko6	Ko3
No.	44	50	4	2	14	18	21	7	15	17	20	22	25	2	5	7	1	4	6	9	11	2	8
SiO2	53.05	52.61	52.64	53.03	53.62	53.25	53.12	52.78	53.31	52.90	52.91	53.14	53.29	54.08	52.85	53.14	52.74	52.61	53.95	54.26	54.41	52.75	51.87
TiO2	0.01	0.11	0.00	0.08	0.17	0.09	0.07	0.00	0.08	0.01	0.03	0.06	0.05	0.02	0.00	0.01	0.01	0.21	0.06	0.06	0.04	0.30	0.01
Al2O3	0.53	0.31	0.43	0.81	1.19	0.62	0.74	0.61	0.59	0.51	0.56	0.77	0.91	0.91	0.56	0.42	0.63	0.76	1.14	0.88	0.69	0.94	0.55
FeO*	3.69	10.39	3.95	5.64	7.23	5.37	5.55	3.87	4.86	3.89	4.14	4.79	5.87	5.37	3.52	3.68	4.04	9.22	5.70	4.17	4.14	8.43	3.82
MnO	0.30	1.06	0.32	0.38	0.52	0.38	0.45	0.26	0.36	0.42	0.40	0.40	0.52	0.40	0.30	0.29	0.28	1.02	0.37	0.17	0.19	1.08	0.26
MgO	6.36	10.40	5.26	9.71	11.96	10.09	9.60	7.87	9.86	6.83	7.19	10.91	11.00	12.49	7.01	7.81	8.00	11.44	13.43	14.89	15.11	11.49	5.35
CaO	12.20	24.30	11.53	18.23	22.93	17.72	16.61	14.07	17.32	12.79	13.61	19.32	19.90	21.40	12.54	13.86	14.61	24.05	23.69	24.32	24.69	23.99	10.86
Na2O	7.12	0.31	7.56	3.73	1.36	3.97	4.07	5.88	4.44	6.47	5.93	3.24	2.79	2.01	6.52	5.97	5.61	0.62	1.06	0.92	0.71	0.71	7.72
Cr2O3	17.04	0.07	18.59	7.97	1.01	8.44	9.60	14.48	9.52	16.61	15.07	7.21	5.36	3.82	16.75	14.98	13.95	0.17	0.58	0.12	0.34	0.23	19.20
Total	100.30	99.56	100.28	99.58	99.99	99.93	99.81	99.82	100.34	100.43	99.84	99.84	99.69	100.50	100.05	100.16	99.87	100.10	99.98	99.79	100.32	99.92	99.64
Si	1.988	2.005	1.984	1.992	1.999	1.991	1.989	1.982	1.987	1.982	1.990	1.984	1.993	1.995	1.982	1.988	1.981	1.984	1.996	1.996	1.993	1.986	1.970
Ti	0.000	0.003	0.000	0.002	0.005	0.003	0.002	0.000	0.002	0.000	0.001	0.002	0.001	0.001	0.000	0.000	0.000	0.006	0.002	0.002	0.001	0.008	0.000
Al	0.023	0.014	0.019	0.036	0.052	0.027	0.033	0.027	0.026	0.023	0.025	0.034	0.040	0.040	0.025	0.019	0.028	0.034	0.050	0.038	0.030	0.042	0.025
Fe	0.116	0.331	0.124	0.177	0.225	0.168	0.174	0.122	0.151	0.122	0.130	0.150	0.184	0.166	0.110	0.115	0.127	0.291	0.176	0.128	0.127	0.265	0.121
Mn	0.010	0.034	0.010	0.012	0.016	0.012	0.014	0.008	0.011	0.013	0.013	0.013	0.016	0.012	0.010	0.009	0.009	0.033	0.012	0.005	0.006	0.034	0.008
Mg	0.355	0.590	0.295	0.543	0.664	0.562	0.535	0.440	0.547	0.381	0.403	0.607	0.613	0.686	0.392	0.435	0.448	0.643	0.740	0.816	0.825	0.644	0.303
Ca	0.490	0.992	0.465	0.733	0.915	0.710	0.666	0.566	0.691	0.513	0.548	0.773	0.797	0.845	0.504	0.555	0.588	0.972	0.939	0.958	0.969	0.967	0.442
Na	0.517	0.023	0.552	0.272	0.098	0.288	0.295	0.428	0.321	0.470	0.432	0.234	0.202	0.144	0.474	0.433	0.408	0.045	0.076	0.066	0.050	0.052	0.568
Cr	0.504	0.002	0.554	0.237	0.030	0.249	0.284	0.430	0.280	0.491	0.448	0.213	0.158	0.111	0.496	0.443	0.414	0.005	0.017	0.003	0.010	0.007	0.576
Total	4.003	3.995	4.005	4.005	4.005	4.010	3.992	4.003	4.017	3.995	3.989	4.008	4.005	4.000	3.992	3.997	4.002	4.012	4.006	4.013	4.010	4.006	4.013
End members																							
Ko	50.11	0.21	54.26	23.53	2.93	24.84	28.68	42.97	27.70	47.71	44.08	21.12	15.81	11.15	48.28	43.71	40.99	0.50	1.67	0.34	0.97	0.67	56.26
Jd	1.14	1.37	0.00	2.80	5.01	1.87	1.15	0.00	1.24	0.00	0.00	1.78	3.29	3.24	0.00	0.00	0.00	1.79	4.47	3.37	2.26	2.69	0.00
Ae	0.11	0.68	0.00	0.68	1.74	1.95	0.00	0.00	2.74	0.00	0.00	0.39	1.08	0.00	0.00	0.00	0.00	2.17	1.35	2.70	1.72	1.72	0.00
Di	48.64	97.74	45.74	72.98	90.31	70.71	67.28	56.83	68.31	52.13	55.92	76.72	79.57	84.66	51.32	56.08	59.01	95.54	92.51	93.59	95.05	94.92	43.74
Opx	0.00	0.00	0.00	0.00	0.00	0.63	2.90	0.21	0.00	0.16	0.00	0.00	0.24	0.95	0.40	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* Total Fe as FeO.

Lithology	Ko-bearing actinolite-tremolite rock																							
Sample	Ko3																Ko15							
No.	11	13	18	20	22	24	25	27	30	34	39	43	46	49	53	58	7	12	19	22	24	29	32
SiO2	53.34	53.02	53.25	53.03	54.35	53.69	53.61	53.36	51.81	51.39	52.25	53.74	54.02	53.99	54.38	52.45	53.41	52.96	53.43	53.02	53.16	53.70	53.75
TiO2	0.03	0.06	0.07	0.29	0.00	0.11	0.10	0.02	0.01	0.03	0.00	0.06	0.01	0.13	0.01	0.00	0.02	0.00	0.01	0.01	0.17	0.00	0.00
Al2O3	0.89	0.94	0.73	1.02	1.26	1.08	1.09	0.56	0.54	0.53	0.42	1.04	1.31	0.84	0.86	0.37	0.70	0.52	0.55	0.66	0.48	0.71	0.68
FeO*	4.42	5.85	5.52	7.86	4.23	5.30	4.92	5.91	3.82	3.83	4.17	4.92	4.72	4.73	3.58	4.55	3.94	3.66	3.94	3.93	9.41	3.55	3.48
MnO	0.35	0.43	0.49	0.66	0.27	0.30	0.22	0.52	0.38	0.28	0.32	0.23	0.25	0.18	0.20	0.50	0.29	0.33	0.38	0.34	1.14	0.34	0.21
MgO	9.90	10.39	10.09	12.06	14.73	13.99	14.13	10.20	5.15	5.18	5.49	14.29	14.49	14.45	15.43	5.63	11.25	7.04	8.20	7.93	11.33	10.60	10.09
CaO	17.22	19.15	18.48	23.35	24.26	23.70	23.39	18.35	10.66	10.83	11.68	24.26	24.23	23.97	24.87	11.99	18.13	12.53	14.79	14.21	23.74	17.27	16.74
Na2O	4.40	3.07	3.63	1.01	0.81	1.11	1.32	3.65	7.59	7.55	7.27	0.86	1.00	0.99	0.57	6.94	3.43	6.40	5.21	5.51	0.40	4.31	4.28
Cr2O3	9.72	6.73	7.61	0.29	0.12	0.54	0.79	7.55	19.11	19.20	18.24	0.18	0.08	0.56	0.16	17.26	8.36	16.41	13.46	14.33	0.25	9.91	10.66
Total	100.27	99.64	99.87	99.57	100.03	99.82	99.57	100.12	99.07	98.82	99.84	99.58	100.11	99.84	100.06	99.69	99.53	99.85	99.97	99.94	100.08	100.39	99.89
Si	1.984	1.987	1.993	1.992	1.994	1.987	1.987	1.995	1.977	1.969	1.980	1.990	1.986	1.992	1.992	1.989	1.989	1.989	1.997	1.986	2.003	1.987	1.996
Ti	0.001	0.002	0.002	0.008	0.000	0.003	0.003	0.001	0.000	0.001	0.000	0.002	0.000	0.004	0.000	0.000	0.001	0.000	0.000	0.000	0.005	0.000	0.000
Al	0.039	0.042	0.032	0.045	0.054	0.047	0.048	0.025	0.024	0.024	0.019	0.045	0.057	0.037	0.037	0.017	0.031	0.023	0.024	0.029	0.021	0.031	0.030
Fe	0.137	0.183	0.173	0.247	0.130	0.164	0.152	0.185	0.122	0.123	0.132	0.152	0.145	0.146	0.110	0.144	0.123	0.115	0.123	0.123	0.296	0.110	0.108
Mn	0.011	0.014	0.016	0.021	0.008	0.009	0.007	0.016	0.012	0.009	0.010	0.007	0.008	0.006	0.006	0.016	0.009	0.010	0.012	0.011	0.036	0.011	0.007
Mg	0.549	0.580	0.563	0.675	0.805	0.771	0.780	0.568	0.293	0.296	0.310	0.788	0.794	0.794	0.842	0.318	0.624	0.394	0.456	0.442	0.636	0.584	0.558
Ca	0.686	0.769	0.741	0.939	0.953	0.940	0.928	0.735	0.436	0.444	0.474	0.962	0.954	0.947	0.975	0.487	0.723	0.504	0.592	0.570	0.958	0.684	0.666
Na	0.317	0.223	0.263	0.074	0.058	0.080	0.095	0.264	0.561	0.560	0.534	0.062	0.071	0.071	0.040	0.510	0.248	0.466	0.377	0.400	0.029	0.309	0.308
Cr	0.286	0.199	0.225	0.009	0.003	0.016	0.023	0.223	0.576	0.581	0.546	0.005	0.002	0.016	0.005	0.517	0.246	0.487	0.397	0.424	0.007	0.290	0.313
Total	4.010	3.999	4.007	4.009	4.005	4.017	4.022	4.012	4.002	4.007	4.004	4.014	4.018	4.013	4.007	3.998	3.994	3.988	3.980	3.985	3.992	4.005	3.985
End members																							
Ko	28.43	20.01	22.41	0.85	0.34	1.55	2.26	22.17	56.30	55.78	52.97	0.51	0.23	1.60	0.46	51.15	24.92	47.65	38.93	41.10	0.75	28.89	31.51
Jd	2.31	2.38	2.52	3.65	4.75	3.39	3.33	1.96	0.00	0.00	0.00	3.45	4.22	2.84	2.83	0.00	0.16	0.00	0.00	0.00	2.15	1.76	0.00
Ae	0.82	0.00	1.29	2.76	0.60	2.87	3.67	2.16	0.00	0.00	0.00	2.06	2.51	2.51	0.70	0.00	0.00	0.00	0.00	0.00	0.05	0.17	0.00
Di	68.29	77.19	73.78	92.74	94.30	92.19	90.74	73.07	43.70	44.22	47.03	93.97	93.05	93.05	96.02	48.85	73.26	51.56	61.07	58.58	96.54	68.25	68.13
Opx	0.14	0.42	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.66	0.78	0.00	0.32	0.52	0.93	0.36

* Total Fe as FeO.

Table 1. (Continued)

Lithology	Ko-bearing actinolite–tremolite rock																						
Sample	Ko15	Ko19								Ko22													
No.	35	4	9	11	15	18	22	24	27	30	1	4	7	9	12	13	15	17	21	23	25	27	29
SiO2	53.26	53.72	53.24	53.64	53.46	53.16	54.19	53.38	52.82	54.06	52.62	52.82	52.77	53.47	53.69	54.50	54.60	53.72	53.64	52.48	52.85	53.29	53.08
TiO2	0.00	0.01	0.13	0.00	0.01	0.00	0.04	0.08	0.09	0.10	0.30	0.00	0.05	0.02	0.00	0.06	0.00	0.05	0.04	0.05	0.03	0.01	0.05
Al2O3	0.66	0.33	0.76	0.25	0.45	0.35	0.81	0.19	0.54	0.82	0.32	0.47	0.54	0.63	0.59	1.80	0.81	0.67	0.90	0.61	0.73	0.57	0.72
FeO*	3.55	3.20	8.88	3.29	3.50	3.46	5.27	5.81	10.03	4.55	10.21	4.81	4.30	4.87	7.00	4.53	3.46	7.12	4.76	4.00	4.64	4.91	5.04
MnO	0.25	0.16	0.95	0.19	0.13	0.14	0.32	0.51	1.12	0.14	1.30	0.38	0.31	0.35	0.61	0.28	0.14	0.55	0.50	0.35	0.46	0.45	0.35
MgO	7.99	8.52	11.94	7.88	8.61	7.49	13.44	7.23	11.23	10.74	10.65	6.69	6.83	9.47	12.98	14.31	15.45	12.93	10.29	6.99	8.39	9.15	8.34
CaO	14.31	14.39	23.97	13.62	14.66	13.28	22.44	14.38	23.85	18.60	23.87	13.49	13.56	17.30	24.53	23.91	24.85	24.11	18.78	13.11	15.62	16.70	15.50
Na2O	5.55	5.68	0.49	5.95	5.27	6.26	1.53	5.30	0.38	3.28	0.39	6.25	6.12	4.35	0.61	1.10	0.55	0.68	3.46	6.23	5.08	4.58	5.00
Cr2O3	14.19	14.42	0.13	15.64	13.87	15.97	2.14	13.48	0.12	7.71	0.34	15.49	15.28	9.51	0.19	0.10	0.00	0.21	7.51	15.74	12.01	10.75	11.94
Total	99.76	100.43	100.49	100.46	99.96	100.11	100.18	100.36	100.18	100.00	100.00	100.40	99.76	99.97	100.20	100.59	99.86	100.04	99.88	99.56	99.81	100.41	100.02
Si	1.993	1.995	1.992	1.996	1.994	1.989	1.999	2.004	1.995	2.004	1.996	1.985	1.989	1.998	1.998	1.989	2.000	2.000	1.999	1.981	1.986	1.989	1.990
Ti	0.000	0.000	0.004	0.000	0.000	0.000	0.001	0.002	0.003	0.003	0.009	0.000	0.002	0.001	0.000	0.002	0.000	0.001	0.001	0.001	0.001	0.000	0.001
Al	0.029	0.014	0.034	0.011	0.020	0.015	0.035	0.008	0.024	0.036	0.014	0.021	0.024	0.028	0.026	0.077	0.035	0.029	0.040	0.027	0.032	0.025	0.032
Fe	0.111	0.099	0.278	0.102	0.109	0.108	0.163	0.182	0.317	0.141	0.324	0.151	0.135	0.152	0.218	0.138	0.106	0.222	0.148	0.126	0.146	0.153	0.158
Mn	0.008	0.005	0.030	0.006	0.004	0.004	0.010	0.016	0.036	0.004	0.042	0.012	0.010	0.011	0.019	0.009	0.004	0.017	0.016	0.011	0.015	0.014	0.011
Mg	0.445	0.471	0.665	0.437	0.478	0.418	0.739	0.404	0.632	0.593	0.602	0.374	0.383	0.527	0.720	0.778	0.843	0.717	0.571	0.393	0.470	0.509	0.466
Ca	0.574	0.572	0.960	0.543	0.586	0.532	0.887	0.578	0.965	0.738	0.970	0.543	0.547	0.692	0.978	0.934	0.975	0.961	0.749	0.530	0.629	0.667	0.622
Na	0.402	0.409	0.036	0.429	0.381	0.454	0.109	0.386	0.028	0.236	0.029	0.455	0.447	0.315	0.044	0.078	0.039	0.049	0.250	0.456	0.370	0.331	0.363
Cr	0.420	0.423	0.004	0.460	0.409	0.472	0.062	0.400	0.004	0.226	0.010	0.460	0.455	0.281	0.006	0.003	0.000	0.006	0.221	0.469	0.356	0.317	0.354
Total	3.982	3.989	4.002	3.983	3.981	3.993	4.005	3.981	4.002	3.980	3.996	4.001	3.993	4.004	4.008	4.007	4.001	4.004	3.995	3.996	4.004	4.005	3.997
End members																							
Ko	41.24	41.59	0.38	44.09	39.29	46.03	6.22	39.50	0.36	23.18	1.02	45.60	44.95	27.87	0.55	0.28	0.00	0.61	22.12	46.22	35.68	31.61	35.65
Jd	0.00	0.00	2.55	0.00	0.00	0.00	3.43	0.00	1.90	1.01	1.08	0.00	0.00	2.53	2.35	6.52	3.41	2.91	2.88	0.00	1.34	1.36	0.97
Ae	0.00	0.00	0.62	0.00	0.00	0.00	1.26	0.00	0.52	0.00	0.77	0.00	0.00	0.87	1.41	0.88	0.44	1.33	0.00	0.00	0.00	0.07	0.00
Di	58.76	58.24	96.11	55.79	60.40	53.97	88.49	59.23	96.50	75.81	97.13	54.40	55.05	68.73	95.69	92.32	96.15	95.14	75.00	53.76	62.91	66.57	62.75
Opx	0.00	0.17	0.33	0.12	0.31	0.00	0.59	1.27	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.07	0.39	0.63

* Total Fe as FeO.

Lithology	Ko-bearing actinolite–tremolite rock																						
Sample	Ko22											Ko24											
No.	33	37	39	42	46	49	52	54	57	59	63"	65	3	10	12	15	20	26	29	32	38	43	45
SiO2	52.94	52.96	54.24	52.79	52.63	52.55	52.98	53.17	53.65	54.37	53.55	52.69	53.39	52.49	53.15	53.53	53.17	53.81	53.13	52.77	52.51	53.53	52.90
TiO2	0.26	0.22	0.07	0.35	0.28	0.32	0.28	0.25	0.06	0.08	0.18	0.26	0.01	0.28	0.01	0.01	0.00	0.01	0.20	0.00	0.01	0.10	0.00
Al2O3	0.37	0.49	0.81	0.44	0.47	0.32	0.75	0.65	0.79	1.52	0.84	0.42	0.72	0.49	0.78	0.74	0.86	0.92	0.70	0.43	0.60	1.38	0.47
FeO*	9.58	8.92	4.22	10.18	10.01	10.53	8.83	9.21	6.88	4.59	7.92	10.12	4.14	9.76	4.46	4.43	5.48	4.65	8.80	3.37	3.59	6.58	3.77
MnO	1.44	1.07	0.15	1.40	1.31	1.41	0.98	1.17	0.59	0.28	0.73	1.25	0.26	1.20	0.38	0.26	0.33	0.30	0.89	0.24	0.23	0.57	0.29
MgO	11.03	11.40	15.07	10.69	10.93	10.33	11.37	11.50	12.77	14.28	12.24	10.95	9.66	10.76	8.66	10.10	11.28	10.98	11.46	5.84	6.63	12.01	6.47
CaO	23.62	24.13	24.57	23.80	23.91	23.95	23.59	23.55	24.18	23.72	23.78	23.78	15.97	23.73	15.38	17.12	19.78	18.77	24.10	11.27	12.44	22.47	12.35
Na2O	0.61	0.51	0.76	0.52	0.44	0.39	0.70	0.69	0.66	1.15	0.88	0.42	4.52	0.49	5.21	4.17	2.92	3.32	0.57	7.18	6.66	1.60	6.63
Cr2O3	0.43	0.17	0.28	0.05	0.02	0.01	0.03	0.02	0.09	0.39	0.19	0.08	10.99	0.47	12.14	9.69	6.03	7.30	0.32	18.98	17.03	1.53	17.07
Total	100.28	99.87	100.17	100.22	100.00	99.81	99.51	100.21	99.67	100.38	100.31	99.97	99.66	99.67	100.17	100.05	99.85	100.06	100.17	100.08	99.70	99.77	99.95
Si	1.998	1.998	1.990	1.997	1.994	2.001	2.001	1.999	2.003	1.990	1.997	1.997	1.992	1.994	1.986	1.992	1.985	1.996	1.996	1.984	1.980	1.995	1.989
Ti	0.007	0.006	0.002	0.010	0.008	0.009	0.008	0.007	0.002	0.002	0.005	0.007	0.000	0.008	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.003	0.000
Al	0.016	0.022	0.035	0.020	0.021	0.014	0.033	0.029	0.035	0.066	0.037	0.019	0.032	0.022	0.034	0.032	0.038	0.040	0.031	0.019	0.027	0.061	0.021
Fe	0.302	0.281	0.129	0.322	0.317	0.335	0.279	0.289	0.215	0.140	0.247	0.321	0.129	0.310	0.139	0.138	0.171	0.144	0.276	0.106	0.113	0.205	0.119
Mn	0.046	0.034	0.005	0.045	0.042	0.045	0.031	0.037	0.019	0.009	0.023	0.040	0.008	0.039	0.012	0.008	0.010	0.009	0.028	0.008	0.007	0.018	0.009
Mg	0.620	0.641	0.824	0.603	0.617	0.586	0.640	0.644	0.710	0.779	0.680	0.618	0.537	0.609	0.482	0.560	0.627	0.607	0.641	0.327	0.372	0.667	0.362
Ca	0.955	0.975	0.966	0.964	0.970	0.977	0.954	0.948	0.967	0.930	0.950	0.965	0.638	0.966	0.615	0.682	0.791	0.746	0.969	0.454	0.502	0.897	0.497
Na	0.045	0.037	0.054	0.038	0.032	0.029	0.051	0.050	0.048	0.082	0.064	0.031	0.327	0.036	0.377	0.301	0.211	0.239	0.041	0.523	0.487	0.116	0.483
Cr	0.013	0.005	0.008	0.001	0.001	0.000	0.001	0.001	0.003	0.011	0.006	0.002	0.324	0.014	0.358	0.285	0.178	0.214	0.009	0.564	0.507	0.045	0.507
Total	4.002	4.000	4.013	4.000	4.002	3.996	3.998	4.004	4.000	4.009	4.007	4.000	3.987	3.997	4.004	3.998	4.012	3.995	3.998	3.985	3.996	4.006	3.988
End members																							
Ko	1.28	0.50	0.80	0.15	0.06	0.03	0.09	0.06	0.26	1.11	0.55	0.24	32.95	1.41	35.77	28.63	17.68	21.57	0.94	53.55	49.20	4.45	49.27
Jd	1.42	1.97	2.48	1.70	1.52	1.43	3.32	2.74	3.43	5.52	3.33	1.55	0.29	1.61	1.89	1.59	2.28	2.49	2.62	0.00	0.00	5.53	0.00
Ae	1.76	1.21	2.02	1.95	1.64	1.40	1.69	2.23	1.02	1.43	2.39	1.30	0.00	0.58	0.00	0.00	1.04	0.00	0.54	0.00	0.00	1.44	0.00
Di	95.54	96.32	94.70	96.20	96.78	97.14	94.90	94.96	95.29	91.94	93.72	96.87	64.92	96.40	61.45	68.59	78.63	75.20	95.90	46.45	50.80	88.59	50.73
Opx	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.04	1.84	0.00	0.89	1.18	0.37	0.74	0.00	0.00	0.00	0.00	0.00

* Total Fe as FeO.

Table 1. (Continued)

Lithology	Ko-bearing actinolite–tremolite rock																						
Sample	Ko24																						
No.	52	56	63	66	68	78	90	96	5	10	13	16	19	23	26	34	37	40	44	49	54	57	63
SiO2	52.81	52.10	54.04	54.05	53.54	53.30	53.82	53.21	52.79	53.28	52.77	53.90	53.30	53.30	53.43	54.73	53.97	53.79	53.79	53.27	52.88	53.54	52.44
TiO2	0.00	0.02	0.00	0.05	0.02	0.04	0.03	0.06	0.00	0.00	0.24	0.10	0.03	0.01	0.01	0.04	0.00	0.00	0.00	0.01	0.02	0.06	0.03
Al2O3	0.60	0.41	1.36	1.31	0.86	0.98	0.78	0.77	0.43	0.75	0.35	1.41	0.79	1.05	0.83	1.77	1.39	0.57	0.74	0.75	0.46	0.80	0.43
FeO*	3.91	3.47	4.44	4.63	4.46	4.17	5.84	4.78	4.02	4.53	9.87	5.84	5.57	4.75	5.73	3.62	4.53	6.26	4.98	4.55	4.28	5.68	3.75
MnO	0.36	0.30	0.18	0.37	0.31	0.41	0.35	0.38	0.29	0.28	1.28	0.35	0.48	0.40	0.43	0.23	0.29	0.54	0.27	0.35	0.48	0.54	0.25
MgO	6.91	5.96	14.37	14.53	9.66	10.52	13.73	10.19	6.32	8.80	11.07	13.50	10.69	10.92	10.85	14.86	14.27	13.59	10.26	9.50	8.56	11.40	6.18
CaO	13.00	11.16	23.71	24.22	16.96	17.68	23.41	17.10	12.52	16.22	24.22	23.60	19.10	18.79	19.04	23.70	24.05	24.75	17.93	17.28	15.45	20.02	12.05
Na2O	6.39	7.74	1.12	0.79	4.50	4.15	0.95	4.32	6.89	4.95	0.37	1.18	3.13	3.30	3.29	1.32	1.15	0.53	4.34	4.33	5.13	2.47	7.19
Cr2O3	15.95	18.61	0.39	0.03	9.61	8.73	0.64	8.96	17.21	11.36	0.10	0.13	6.71	7.17	6.64	0.15	0.26	0.19	8.34	9.71	12.36	4.99	17.31
Total	99.93	99.77	99.61	99.98	99.92	99.98	99.55	99.77	100.47	100.17	100.27	100.01	99.80	99.69	100.25	100.42	99.91	100.22	100.65	99.75	99.62	99.50	99.63
Si	1.985	1.972	1.993	1.989	1.996	1.984	2.000	1.988	1.981	1.990	1.994	1.993	1.992	1.986	1.988	1.992	1.988	1.995	1.993	1.993	1.989	2.000	1.984
Ti	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.002	0.000	0.000	0.007	0.003	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.002	0.001
Al	0.027	0.018	0.059	0.057	0.038	0.043	0.034	0.034	0.019	0.033	0.016	0.061	0.035	0.046	0.036	0.076	0.060	0.025	0.032	0.033	0.020	0.035	0.019
Fe	0.123	0.110	0.137	0.142	0.139	0.130	0.181	0.149	0.126	0.141	0.312	0.180	0.174	0.148	0.178	0.110	0.139	0.194	0.154	0.142	0.135	0.177	0.119
Mn	0.011	0.010	0.006	0.012	0.010	0.013	0.011	0.012	0.009	0.009	0.041	0.011	0.015	0.013	0.014	0.007	0.009	0.017	0.008	0.011	0.015	0.017	0.008
Mg	0.387	0.336	0.789	0.796	0.536	0.583	0.760	0.567	0.353	0.490	0.623	0.743	0.595	0.606	0.601	0.806	0.783	0.751	0.566	0.529	0.480	0.634	0.348
Ca	0.523	0.452	0.936	0.954	0.677	0.705	0.932	0.684	0.503	0.649	0.980	0.934	0.765	0.750	0.759	0.924	0.949	0.983	0.712	0.692	0.622	0.801	0.488
Na	0.465	0.568	0.080	0.056	0.325	0.299	0.068	0.313	0.501	0.358	0.027	0.085	0.227	0.238	0.237	0.093	0.082	0.038	0.312	0.314	0.374	0.179	0.527
Cr	0.474	0.556	0.011	0.001	0.283	0.257	0.019	0.265	0.510	0.335	0.003	0.004	0.198	0.211	0.195	0.004	0.008	0.006	0.244	0.287	0.367	0.147	0.517
Total	3.996	4.023	4.012	4.009	4.005	4.014	4.006	4.014	4.003	4.004	4.002	4.014	4.002	3.999	4.009	4.013	4.018	4.008	4.022	4.003	4.003	3.993	4.011
End members																							
Ko	47.07	54.55	1.12	0.09	28.24	25.50	1.87	26.28	49.89	33.28	0.30	0.37	19.80	21.18	19.43	0.42	0.73	0.55	23.86	28.52	36.73	14.82	50.95
Jd	0.00	0.00	5.11	4.50	3.39	2.63	3.40	2.23	0.00	2.25	0.95	5.30	2.69	2.73	2.41	6.68	4.66	1.94	2.51	2.61	0.66	3.17	0.27
Ae	0.00	1.10	1.65	0.98	0.81	1.60	1.55	2.58	0.00	0.04	1.44	2.62	0.16	0.00	1.77	2.05	2.57	1.25	4.09	0.06	0.00	0.00	0.70
Di	52.93	44.35	92.13	94.43	67.56	70.01	92.91	68.01	50.11	64.43	97.31	91.70	76.43	75.24	75.55	90.85	92.04	96.27	69.54	68.81	62.25	80.60	48.09
Opx	0.00	0.00	0.00	0.00	0.00	0.25	0.26	0.91	0.00	0.00	0.00	0.00	0.91	0.85	0.83	0.00	0.00	0.00	0.00	0.00	0.36	1.40	0.00

* Total Fe as FeO.

Lithology	Ko-bearing actinolite–tremolite rock																						
Sample	Ko24																					Ko13	
No.	69	72	77	87	89	99	102	142	158	161	163	165	167	170	172	176	179	181	183	187	190	194	40
SiO2	52.55	53.29	52.55	53.40	53.43	52.90	52.90	53.02	53.03	53.66	53.80	54.62	52.81	54.19	54.87	53.07	55.22	53.01	53.36	53.29	52.61	53.99	54.09
TiO2	0.00	0.02	0.00	0.00	0.03	0.04	0.01	0.05	0.03	0.03	0.02	0.09	0.03	0.06	0.00	0.16	0.00	0.12	0.01	0.05	0.01	0.07	0.03
Al2O3	0.51	0.17	0.31	0.34	0.73	0.70	0.79	0.71	0.64	0.63	0.96	2.34	0.35	0.74	1.13	0.72	0.47	0.41	0.81	0.77	0.43	1.02	0.77
FeO*	3.92	3.45	4.05	3.96	4.91	4.43	4.33	5.18	3.80	5.42	4.80	3.52	3.65	5.46	3.56	9.03	2.05	9.51	4.66	4.94	3.66	5.78	4.75
MnO	0.35	0.31	0.27	0.44	0.30	0.39	0.41	0.51	0.34	0.38	0.44	0.24	0.23	0.48	0.08	0.72	0.06	0.74	0.39	0.36	0.35	0.57	0.46
MgO	6.38	8.22	6.09	6.77	10.68	8.57	8.40	9.37	7.00	10.75	10.89	14.00	6.08	12.36	14.87	11.47	16.53	11.07	9.43	10.45	6.36	12.23	14.97
CaO	12.22	14.32	12.10	13.15	18.60	15.59	15.80	17.49	13.21	19.90	19.36	23.42	11.88	21.55	24.55	24.42	25.32	24.39	16.67	18.57	12.49	22.27	24.13
Na2O	6.91	5.67	7.16	6.54	3.61	5.06	5.16	4.32	6.35	3.01	3.00	1.40	7.04	2.03	0.87	0.45	0.32	0.27	4.45	3.74	6.86	1.77	0.83
Cr2O3	16.89	14.20	17.51	15.80	7.38	12.17	11.92	8.92	15.64	5.93	6.23	0.14	17.46	3.11	0.19	0.07	0.10	0.02	9.98	7.33	16.81	2.38	0.23
Total	99.73	99.65	100.04	100.40	99.67	99.85	99.72	99.57	100.04	99.71	99.50	99.77	99.53	99.98	100.12	100.11	100.07	99.54	99.76	99.50	99.58	100.08	100.26
Si	1.984	1.999	1.983	1.998	1.995	1.984	1.986	1.993	1.988	2.004	2.005	1.997	1.995	2.008	2.004	1.995	2.005	2.008	1.993	1.995	1.988	2.002	1.989
Ti	0.000	0.001	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.000	0.005	0.000	0.003	0.000	0.001	0.000	0.002	0.001
Al	0.023	0.008	0.014	0.015	0.032	0.031	0.035	0.031	0.028	0.028	0.042	0.101	0.016	0.032	0.049	0.032	0.020	0.018	0.036	0.034	0.019	0.045	0.033
Fe	0.124	0.108	0.128	0.124	0.153	0.139	0.136	0.163	0.119	0.169	0.150	0.108	0.115	0.169	0.109	0.284	0.062	0.301	0.146	0.155	0.116	0.179	0.146
Mn	0.011	0.010	0.009	0.014	0.009	0.012	0.013	0.016	0.011	0.012	0.014	0.007	0.007	0.015	0.002	0.023	0.002	0.024	0.012	0.011	0.011	0.018	0.014
Mg	0.359	0.459	0.342	0.377	0.594	0.479	0.470	0.525	0.391	0.598	0.604	0.762	0.342	0.682	0.809	0.642	0.894	0.625	0.525	0.583	0.358	0.675	0.820
Ca	0.494	0.575	0.489	0.527	0.744	0.626	0.635	0.704	0.530	0.796	0.773	0.917	0.481	0.855	0.960	0.983	0.985	0.989	0.667	0.744	0.505	0.884	0.950
Na	0.506	0.412	0.524	0.474	0.261	0.368	0.375	0.315	0.461	0.218	0.217	0.099	0.515	0.146	0.062	0.033	0.023	0.020	0.322	0.271	0.502	0.127	0.059
Cr	0.504	0.421	0.522	0.467	0.218	0.361	0.354	0.265	0.463	0.175	0.183	0.004	0.521	0.091	0.005	0.002	0.003	0.001	0.294	0.217	0.502	0.070	0.007
Total	4.004	3.992	4.010	3.997	4.008	4.001	4.005	4.014	3.993	4.002	3.988	3.997	3.993	4.001	3.999	3.999	3.994	3.989	3.995	4.011	4.002	4.002	4.019
End members																							
Ko	50.39	41.70	51.55	46.65	21.66	36.21	34.98	26.00	46.52	17.26	18.54	0.40	51.74	9.09	0.54	0.20	0.28	0.07	29.54	21.34	49.79	6.89	0.66
Jd	0.18	0.00	0.00	0.72	2.71	0.72	2.12	2.43	0.00	2.73	3.36	9.36	0.00	3.23	4.76	2.66	1.95	1.81	2.77	2.81	0.05	4.41	2.18
Ae	0.00	0.00	0.16	0.00	1.62	0.00	0.04	2.46	0.00	1.49	0.00	0.00	0.00	2.24	0.73	0.36	0.00	0.08	0.00	2.56	0.00	1.27	3.02
Di	49.43	58.20	48.29	52.64	74.01	62.88	62.86	69.11	53.48	78.51	78.10	90.24	48.26	85.44	93.97	96.77	97.76	98.04	66.90	73.29	50.16	87.43	94.14
Opx	0.00	0.10	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.79	0.00	0.00	0.00	0.00

* Total Fe as FeO.

Table 1. (Continued)

Lithology	Ko-free A-T rock		Jadeite													B schist
Sample	4-2		OsaJd2									OsaJd			2-5	
No.	13	15	2	3	10	12	13	14	15	17	18	19	1	4	5	12
SiO2	53.84	54.54	55.58	53.10	57.89	54.20	54.20	53.62	54.86	54.26	54.49	55.89	60.27	57.41	58.85	53.28
TiO2	0.06	0.05	0.37	0.16	0.06	0.28	0.20	0.28	0.24	0.42	0.43	0.22	0.02	0.40	0.04	0.04
Al2O3	0.00	0.03	4.06	3.68	21.35	0.79	0.92	5.21	8.13	1.72	0.91	12.41	24.94	12.51	20.37	1.70
FeO*	2.31	2.27	5.02	4.68	0.50	4.53	4.47	4.15	2.54	5.29	5.84	2.35	0.10	2.51	1.20	7.22
MnO	0.19	0.11	0.08	0.11	0.00	0.08	0.11	0.15	0.06	0.23	0.19	0.04	0.01		0.08	0.23
MgO	17.53	17.61	12.63	13.64	2.71	15.08	15.37	13.65	12.86	14.06	14.18	13.50	0.02	7.80	2.72	12.95
CaO	26.19	25.83	20.07	20.47	3.78	23.49	23.78	19.25	16.78	21.96	22.83	6.47	0.10	11.58	4.20	23.00
Na2O	0.09	0.08	3.15	2.89	13.66	1.53	1.21	3.06	4.72	2.39	1.82	8.11	14.57	7.86	12.32	0.86
Cr2O3	0.00	0.01	0.00	0.02	0.00	0.00	0.02	0.01	0.00	0.04	0.00	0.03	0.00	0.00	0.00	0.00
Total	100.21	100.53	100.96	98.75	99.95	99.98	100.28	99.38	100.19	100.37	100.69	99.02	100.03	100.07	99.78	99.28
Si	1.968	1.981	2.002	1.964	1.981	1.992	1.986	1.952	1.951	1.969	1.998	1.959	2.020	2.011	2.014	1.990
Ti	0.002	0.001	0.010	0.004	0.002	0.008	0.006	0.008	0.006	0.012	0.012	0.006	0.001	0.011	0.001	0.001
Al	0.000	0.001	0.172	0.160	0.861	0.034	0.040	0.224	0.341	0.074	0.039	0.513	0.985	0.516	0.821	0.075
Fe	0.071	0.069	0.151	0.145	0.014	0.139	0.137	0.126	0.076	0.162	0.179	0.069	0.003	0.074	0.034	0.225
Mn	0.006	0.003	0.002	0.003	0.000	0.002	0.003	0.005	0.002	0.007	0.006	0.001	0.000	0.000	0.002	0.007
Mg	0.955	0.953	0.678	0.751	0.138	0.826	0.839	0.740	0.681	0.768	0.774	0.705	0.001	0.407	0.139	0.720
Ca	1.025	1.005	0.774	0.811	0.139	0.925	0.933	0.751	0.639	0.862	0.896	0.243	0.004	0.434	0.154	0.920
Na	0.006	0.006	0.220	0.207	0.906	0.109	0.086	0.216	0.325	0.170	0.129	0.551	0.946	0.534	0.817	0.062
Cr	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000
Total	4.033	4.020	4.009	4.046	4.040	4.036	4.031	4.021	4.022	4.044	4.034	4.047	3.960	3.987	3.983	4.001
End members																
Ko	0.00	0.03	0.00	0.06	0.00	0.00	0.06	0.03	0.00	0.11	0.00	0.08	0.00	0.00	0.00	0.00
Jd	0.00	0.00	17.25	12.15	84.63	2.58	2.55	17.44	28.98	6.11	3.63	46.44	99.60	52.56	83.23	6.23
Ae	0.62	0.52	4.76	8.08	1.44	7.96	5.83	3.97	3.30	10.23	8.97	6.78	0.00	1.75	0.00	0.00
Di	99.38	98.71	77.51	79.41	13.93	89.46	91.57	74.55	63.44	83.55	87.39	23.90	0.38	44.22	15.68	92.11
Opx	0.00	0.74	0.48	0.31	0.00	0.00	0.00	4.01	4.28	0.00	0.00	22.79	0.03	1.47	1.09	1.66

* Total Fe as FeO.

Table 2. Chemical compositions of amphiboles in kosmochlor-bearing and -free actinolite-tremolite rock and basic schist. Cations per 23 oxygens.

Lithology	Ko-bearing A-T rock																							
Sample	Oea1				Ur1				Ur2	Ur1								Ko1			1-3b	1-3a		
No.	12	13	14	15	5	11	12	27	24	12	13	14	15	18	23	25	30	22	44	4	13	18	25	
SiO2	55.60	56.90	56.01	56.35	55.93	58.32	55.99	56.47	55.87	53.89	55.52	54.46	53.76	56.47	55.43	55.67	56.21	56.12	56.00	55.93	55.73	56.60	56.05	
TiO2	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.00	0.00	0.00	0.04	0.05	0.04	0.01	0.00	
Al2O3	0.04	0.01	0.02	0.03	0.97	0.04	0.26	0.21	1.05	1.69	0.85	2.03	1.65	0.68	0.75	0.69	0.16	0.12	0.20	0.15	0.17	0.05	0.18	
FeO*	3.17	3.23	3.89	3.44	4.30	3.41	4.09	3.89	4.06	3.85	3.11	3.03	2.57	4.71	5.01	5.24	4.28	5.49	3.99	3.64	4.24	4.18	3.45	
MnO	0.17	0.21	0.12	0.13	0.12	0.16	0.11	0.11	0.10	0.06	0.04	0.02	0.07	0.10	0.14	0.11	0.07	0.40	0.80	0.13	1.89	0.25	0.11	
MgO	22.66	22.88	22.19	22.85	19.15	23.32	21.21	21.17	18.82	19.90	20.53	20.18	19.44	21.35	20.46	20.10	22.01	20.61	21.54	22.88	22.26	21.92	22.67	
CaO	13.29	13.32	13.18	13.46	11.70	13.42	12.88	12.85	12.27	10.87	10.59	10.35	10.31	12.31	12.16	11.95	12.93	12.53	13.07	13.16	12.43	13.04	13.21	
Na2O	0.11	0.20	0.15	0.12	1.67	0.13	0.40	0.45	2.00	2.52	2.43	2.93	3.02	0.94	1.01	1.11	0.40	0.44	0.29	0.30	0.40	0.21	0.19	
K2O	0.06	0.06	0.07	0.08	0.24	0.09	0.15	0.15	0.14	0.11	0.18	0.20	0.15	0.17	0.18	0.24	0.17	0.19	0.10	0.12	0.18	0.15	0.10	
Cr2O3	0.00	0.01	0.00	0.03	3.57	0.00	0.27	0.41	3.73	4.00	3.59	4.33	4.29	0.71	1.16	1.54	0.16	0.17	0.24	0.41	0.18	0.07	0.09	
Total	95.13	96.84	95.64	96.49	97.65	98.89	95.36	95.76	98.04	96.89	96.84	97.53	95.26	97.46	96.33	96.65	96.39	97.07	96.27	96.77	97.52	96.48	96.05	
Si	7.838	7.878	7.876	7.840	7.828	7.890	7.942	7.966	7.802	7.619	7.795	7.622	7.692	7.837	7.829	7.857	7.862	7.857	7.866	7.760	7.674	7.905	7.828	
Ti	0.003	0.002	0.001	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.000	0.000	0.000	0.004	0.005	0.004	0.001	0.000	
Al	0.007	0.002	0.003	0.005	0.160	0.006	0.043	0.035	0.173	0.282	0.141	0.335	0.278	0.111	0.125	0.115	0.026	0.020	0.033	0.025	0.028	0.008	0.030	
Fe3+	0.257	0.223	0.219	0.253	0.000	0.275	0.000	0.000	0.000	0.032	0.000	0.009	0.000	0.191	0.093	0.041	0.220	0.338	0.171	0.389	0.488	0.187	0.283	
Fe2+	0.116	0.151	0.238	0.147	0.503	0.111	0.485	0.459	0.474	0.423	0.365	0.346	0.307	0.356	0.499	0.577	0.280	0.422	0.297	0.034	0.000	0.301	0.120	
Mn	0.020	0.025	0.014	0.015	0.014	0.018	0.013	0.013	0.012	0.007	0.005	0.002	0.008	0.012	0.017	0.013	0.008	0.047	0.095	0.015	0.220	0.030	0.013	
Mg	4.758	4.719	4.648	4.736	3.993	4.700	4.482	4.448	3.915	4.191	4.293	4.207	4.143	4.414	4.305	4.225	4.586	4.298	4.507	4.728	4.566	4.560	4.716	
Ca	2.006	1.975	1.985	2.006	1.754	1.944	1.957	1.941	1.835	1.646	1.592	1.551	1.580	1.830	1.839	1.806	1.937	1.879	1.966	1.955	1.833	1.950	1.976	
Na	0.030	0.054	0.041	0.032	0.453	0.034	0.110	0.123	0.541	0.690	0.661	0.795	0.837	0.253	0.276	0.304	0.108	0.119	0.079	0.081	0.107	0.057	0.051	
K	0.011	0.011	0.013	0.014	0.043	0.016	0.027	0.027	0.025	0.020	0.032	0.036	0.027	0.030	0.032	0.043	0.030	0.034	0.018	0.021	0.032	0.027	0.018	
Cr	0.000	0.001	0.000	0.003	0.395	0.000	0.030	0.046	0.411	0.447	0.398	0.479	0.485	0.078	0.129	0.172	0.018	0.019	0.027	0.045	0.020	0.008	0.010	
Total	15.047	15.039	15.038	15.052	15.142	14.994	15.090	15.063	15.189	15.356	15.282	15.382	15.359	15.113	15.148	15.153	15.075	15.032	15.063	15.057	14.971	15.034	15.045	

* Total Fe as FeO.

Lithology	Ko-bearing A-T rock						Ko-free A-T rock																	
Sample	1-3a		Ko13			1-Ga			1-Ga	2-2					3-5	3-6							3-7	
No.	26	27	28	46	49	58	6	8	13	20	4	5	7	8	12	12	7	8	9	10	11	12	5	
SiO2	56.90	56.06	56.53	55.68	57.80	58.32	56.65	56.36	55.68	57.37	57.01	56.56	55.69	55.60	57.78	57.31	55.09	55.91	57.17	57.30	55.02	56.08	56.94	
TiO2	0.00	0.01	0.00		0.00	0.01	0.01	0.02	0.04	0.00	0.00	0.00	0.01	0.02	0.01	0.05	0.03	0.02	0.00	0.00	0.00	0.03	0	
Al2O3	0.00	0.04	0.04	0.22	0.04	0.06	0.05	0.06	0.39	0.12	0.09	0.12	0.17	0.09	0.02	0.55	0.27	0.11	0.00	0.12	0.29	0.30	0.10	
FeO*	2.97	3.14	3.20	11.35	3.31	3.37	3.40	3.57	4.17	2.88	3.79	3.94	6.04	8.48	3.87	5.65	4.18	3.51	3.42	4.02	6.80	4.36	4.13	
MnO	0.12	0.10	0.11	1.02	0.18	0.11	0.20	0.16	0.27	0.15	0.13	0.19	0.29	0.76	0.08	0.26	0.15	0.16	0.19	0.12	0.31	0.21	0.11	
MgO	22.81	22.09	22.40	16.53	22.75	22.91	22.62	22.38	21.85	22.82	22.15	22.37	20.69	19.13	23.66	20.09	21.73	23.06	23.06	22.61	20.58	21.12	22.30	
CaO	13.69	13.38	13.31	12.26	13.52	13.25	13.25	12.94	11.89	13.31	13.37	13.34	13.06	13.24	13.40	12.58	12.99	13.41	13.53	13.60	12.79	13.14	13.35	
Na2O	0.11	0.24	0.23	0.54	0.13	0.27	0.31	0.28	0.34	0.22	0.24	0.23	0.14	0.12	0.09	0.56	0.40	0.14	0.13	0.13	0.35	0.34	0.26	
K2O	0.08	0.12	0.08	0.31	0.05	0.1	0.10	0.11	0.12	0.09	0.04	0.07	0.05	0.11	0.04	0.16	0.07	0.05	0.05	0.04	0.09	0.09	0.07	
Cr2O3	0.02	0.04	0.00	0.10	0.03	0.03	0.17	0.10	0.32	0.01	0.03	0.01	0.03	0.00	0.00	0.21	0.25	0.01	0.02	0.03	0.10	0.16	0.13	
Total	96.70	95.22	95.90	98.01	97.81	98.43	96.76	95.98	95.07	96.97	96.85	96.83	96.17	97.55	98.95	97.42	95.16	96.38	97.57	97.97	96.13	95.83	97.39	
Si	7.913	7.934	7.927	7.955	7.936	7.942	7.872	7.880	7.810	7.930	7.934	7.865	7.866	7.861	7.795	7.993	7.817	7.775	7.860	7.874	7.785	7.929	7.881	
Ti	0.000	0.001	0.000	0.000	0.000	0.001	0.001	0.002	0.004	0.000	0.000	0.000	0.001	0.002	0.001	0.005	0.003	0.002	0.000	0.000	0.000	0.003	0.000	
Al	0.000	0.007	0.007	0.037	0.006	0.010	0.008	0.010	0.064	0.020	0.015	0.020	0.028	0.015	0.003	0.090	0.045	0.018	0.000	0.019	0.048	0.050	0.016	
Fe3+	0.050	0.000	0.066	0.084	0.098	0.147	0.183	0.245	0.489	0.103	0.057	0.201	0.235	0.197	0.437	0.000	0.216	0.386	0.250	0.186	0.382	0.000	0.168	
Fe2+	0.296	0.372	0.309	1.271	0.282	0.237	0.212	0.173	0.000	0.230	0.384	0.257	0.478	0.805	0.000	0.659	0.280	0.022	0.143	0.276	0.399	0.515	0.310	
Mn	0.014	0.012	0.013	0.123	0.021	0.013	0.024	0.019	0.032	0.018	0.015	0.022	0.035	0.091	0.009	0.031	0.018	0.019	0.022	0.014	0.037	0.025	0.013	
Mg	4.725	4.657	4.679	3.518	4.653	4.647	4.682	4.661	4.565	4.699	4.592	4.634	4.353	4.029	4.755	4.174	4.593	4.777	4.723	4.628	4.338	4.448	4.598	
Ca	2.039	2.028	1.999	1.876	1.988	1.933	1.972	1.938	1.786	1.970	1.993	1.987	1.976	2.005	1.936	1.879	1.974	1.997	1.992	2.001	1.938	1.990	1.979	
Na	0.030	0.066	0.082	0.149	0.035	0.071	0.083	0.076	0.092	0.059	0.065	0.062	0.038	0.033	0.024	0.151	0.110	0.038	0.035	0.035	0.096	0.093	0.070	
K	0.014	0.022	0.014	0.056	0.009	0.017	0.018	0.020	0.021	0.016	0.007	0.012	0.009	0.020	0.007	0.028	0.013	0.009	0.009	0.007	0.016	0.016	0.012	
Cr	0.002	0.004	0.000	0.011	0.003	0.003	0.019	0.011	0.035	0.001	0.003	0.001	0.003	0.000	0.000	0.023	0.028	0.001	0.002	0.003	0.011	0.018	0.014	
Total	15.083	15.103	15.076	15.082	15.031	15.021	15.073	15.033	14.900	15.045	15.065	15.061	15.023	15.057	14.967	15.035	15.097	15.044	15.036	15.043	15.050	15.088	15.061	

* Total Fe as FeO.

Table 2. (Continued)

Lithology	Ko-free A-T rock								B schist
Sample	3-9			4-2			148a		2-3
No.	1	2	3	2	4	5	14	4	19
SiO2	56.61	57.85	57.47	57.12	56.25	57.97	57.40	56.11	55.99
TiO2	0.00	0.01	0.00	0.01	0.01	0.03	0.00	0.03	
Al2O3	0.01	0.06	0.00	0.26	0.39	0.04	0.05	0.48	0.97
FeO*	2.78	2.79	2.65	3.11	2.76	3.36	2.48	8.81	4.85
MnO	0.09	0.05	0.09	0.29	0.11	0.11	0.05	0.33	0.09
MgO	23.39	23.14	22.70	22.97	23.22	22.78	23.35	17.86	20.33
CaO	13.74	13.31	13.74	12.98	12.99	13.37	13.70	11.68	13.10
Na2O	0.09	0.08	0.10	0.40	0.03	0.23	0.05	1.05	0.56
K2O	0.04	0.02	0.03	0.09	0.04	0.07	0.03	0.08	0.07
Cr2O3	0.02	0.00	0.00	0.11	0.03	0.04	0.00	0.61	0.12
Total	96.77	97.31	96.78	97.34	95.83	98.00	97.11	97.04	96.08
Si	7.839	7.935	7.969	7.851	7.802	7.941	7.908	7.978	7.907
Ti	0.000	0.001	0.000	0.001	0.001	0.003	0.000	0.003	0.000
Al	0.002	0.010	0.000	0.042	0.064	0.006	0.008	0.080	0.161
Fe3+	0.211	0.182	0.000	0.298	0.320	0.106	0.114	0.027	0.000
Fe2+	0.110	0.138	0.307	0.059	0.000	0.279	0.172	1.020	0.573
Mn	0.011	0.006	0.011	0.034	0.013	0.013	0.006	0.040	0.011
Mg	4.825	4.728	4.689	4.703	4.797	4.648	4.792	3.783	4.277
Ca	2.038	1.955	2.040	1.911	1.930	1.961	2.021	1.779	1.981
Na	0.024	0.021	0.027	0.107	0.008	0.061	0.013	0.289	0.153
K	0.007	0.003	0.005	0.016	0.007	0.012	0.005	0.015	0.013
Cr	0.002	0.000	0.000	0.012	0.003	0.004	0.000	0.069	0.013
Total	15.069	14.980	15.047	15.033	14.945	15.035	15.040	15.082	15.089

* Total Fe as FeO.

Table 3. Chemical compositions of feldspars in kosmochlor-bearing and -free actinolite-tremolite rock and basic schist. Cations per 8 oxygens.

Lithology	Ko-bearing A-T rock																			Ko-free A-T rock				
Sample	Ur2	Ko1		Ko2	Ko22	Ko13														Ko13	148b	3-5		
No.	22	21	12	63	1	5	8	9	12	13	14	15	18	19	25	36	37	42	22	5	1	13	19	
SiO2	68.45	66.00	68.81	63.35	64.05	64.45	64.46	64.69	63.27	62.87	64.80	64.25	64.53	64.55	63.62	64.58	63.62	64.12	69.19	68.11	63.90	64.17	62.85	
TiO2	0.00	0.00	0.00	0.04	0.00	0.06	0.00	0.01	0.06	0.00	0.06	0.05	0.02	0.03	0.00	0.04	0.02	0.05	0.00	0.00	0.00	0.00	0.06	
Al2O3	19.45	20.68	19.68	18.42	18.48	19.05	18.13	17.93	18.54	18.65	19.13	19.19	17.76	17.85	18.01	17.70	17.87	18.77	19.17	20.31	19.49	19.43	20.02	
FeO*	0.10	0.00	0.00	0.08	0.03	0.02	0.01	0.00	0.00	0.00	0.06	0.00	0.01	0.05	0.01	0.08	0.03	0.05	0.00	0.00	0.02	0.15	0.02	
MnO	0.03	0.01	0.00	0.04	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.01	0.02	0.00	0.00	0.00	0.00	0.07	
MgO	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.34	0.00	
CaO	0.11	0.03	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.06	0.00	0.00	0.04	0.00	0.09	0.00	
Na2O	11.29	12.05	11.74	0.08	0.04	0.06	0.01	0.04	0.10	0.07	0.08	0.09	0.02	0.35	0.06	0.01	0.05	0.12	11.17	11.72	0.49	0.39	0.34	
K2O	0.14	0.02	0.07	16.54	17.06	16.78	17.71	17.73	16.9	16.48	16.63	16.56	17.55	17.04	17.27	17.78	17.17	16.72	0.07	0.06	16.83	16.12	16.63	
Cr2O3	0.14	0.02	0.01	0.04	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	
Total	99.93	98.81	100.31	98.68	99.66	100.42	100.35	100.40	98.87	98.07	100.76	100.14	99.89	99.88	98.97	100.29	98.84	99.85	99.60	100.27	100.73	100.69	99.99	
Si	2.992	2.928	2.994	2.978	2.984	2.973	2.993	3.001	2.973	2.971	2.975	2.969	3.007	3.003	2.991	3.003	2.995	2.977	3.023	2.968	2.947	2.949	2.920	
Ti	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.002	0.000	0.002	0.002	0.001	0.001	0.000	0.001	0.001	0.002	0.000	0.000	0.000	0.000	0.002	
Al	1.002	1.081	1.009	1.020	1.015	1.035	0.992	0.980	1.026	1.039	1.035	1.045	0.975	0.979	0.998	0.970	0.991	1.027	0.987	1.043	1.059	1.052	1.096	
Fe	0.004	0.000	0.000	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.002	0.000	0.003	0.001	0.002	0.000	0.000	0.001	0.006	0.001	
Mn	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.003	
Mg	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.023	0.000	
Ca	0.005	0.001	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.000	0.000	0.002	0.000	0.004	0.000	
Na	0.956	1.036	0.990	0.007	0.004	0.005	0.001	0.004	0.009	0.006	0.007	0.008	0.002	0.032	0.005	0.001	0.005	0.011	0.946	0.990	0.044	0.035	0.031	
K	0.008	0.001	0.004	0.991	1.014	0.987	1.049	1.049	1.013	0.993	0.974	0.976	1.043	1.011	1.035	1.054	1.031	0.990	0.004	0.003	0.990	0.945	0.985	
Cr	0.005	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Total	4.987	5.049	4.998	5.009	5.017	5.004	5.036	5.034	5.023	5.009	4.996	4.999	5.027	5.028	5.030	5.038	5.027	5.008	4.959	5.007	5.040	5.014	5.038	

* Total Fe as FeO.

Lithology	Basic schist			
Sample	131			
No.	4	6	8	9
SiO2	68.59	68.66	68.35	68.48
TiO2			0.01	0.00
Al2O3	20.41	20.20	20.11	20.15
FeO*	0.04	0.03	0.05	0.05
MnO	0.01			
MgO			0.01	0.02
CaO	0.07	0.05	0.07	0.14
Na2O	11.31	11.59	11.90	11.69
K2O	0.10	0.11	0.08	0.08
Cr2O3	0.01		0.00	
Total	100.54	100.64	100.58	100.61
Si	2.976	2.979	2.972	2.975
Ti	0.000	0.000	0.000	0.000
Al	1.043	1.033	1.030	1.031
Fe	0.001	0.001	0.002	0.002
Mn	0.000	0.000	0.000	0.000
Mg	0.000	0.000	0.001	0.001
Ca	0.003	0.002	0.003	0.007
Na	0.951	0.974	1.003	0.984
K	0.006	0.006	0.004	0.004
Cr	0.000	0.000	0.000	0.000
Total	4.981	4.995	5.016	5.004

* Total Fe as FeO.

Table 4. Chemical compositions of garnets in kosmochlor-bearing actinolite-tremolite rock. Cations per 12 oxygens.

Lithology	Ko-bearing A-T rock								
Sample	Ur1			Ur2		Ko1-4	Ko2		Ko13	
No.	1	8	33	9	23	1	1	13	52
SiO2	36.98	35.46	34.96	34.72	35.90	35.33	33.60	35.07	36.30
TiO2	0.05	0.02	0.75	0.71	0.08	0.32	0.55	0.16	0.21
Al2O3	3.74	3.76	3.47	3.37	3.81	3.66	4.32	3.56	4.41
Fe2O3*	6.00	4.04	4.20	4.33	4.70	3.83	6.39	3.83	4.11
MnO	0.14	0.14	0.15	0.24	0.18	0.15	0.34	0.15	0.13
MgO	0.71	0.12	0.11	0.10	0.18	0.09	0.05	0.10	0.02
CaO	32.58	33.25	33.30	33.59	33.64	33.45	31.86	33.50	33.63
Cr2O3	18.96	21.45	21.28	20.94	21.00	22.13	21.54	21.66	20.62
Total	99.16	98.24	98.22	98.00	99.49	98.96	98.65	98.03	99.43
Si	3.033	2.963	2.930	2.921	2.963	2.937	2.821	2.945	2.984
Ti	0.003	0.001	0.047	0.045	0.005	0.020	0.035	0.010	0.013
Al	0.361	0.370	0.343	0.334	0.371	0.359	0.427	0.352	0.427
Fe	0.370	0.254	0.265	0.274	0.292	0.240	0.403	0.242	0.254
Mn	0.010	0.010	0.011	0.017	0.013	0.011	0.024	0.011	0.009
Mg	0.087	0.015	0.014	0.013	0.022	0.011	0.006	0.013	0.002
Ca	2.862	2.976	2.989	3.027	2.973	2.978	2.864	3.013	2.961
Cr	1.228	1.416	1.409	1.392	1.369	1.453	1.428	1.437	1.339
Total	7.954	8.006	8.006	8.023	8.007	8.009	8.009	8.022	7.990

* Total Fe as Fe2O3.

Table 5. Chemical compositions of serpentines in kosmochlor-bearing and -free actinolite-tremolite rock. Cations per 7 oxygens.

Lithology	Ko-bearing A-T rock	Ko-free A-T rock				
Sample	Osa2	1-3b	1-Ga		1-Gb	
No.	7	5	1	3	10	18
SiO2	41.11	39.83	41.52	40.20	41.99	39.98
TiO2	0.00	0.01	0.00	0.01	0.01	0.00
Al2O3	0.67	3.69	1.78	1.95	1.70	1.15
FeO*	7.31	8.29	7.98	8.27	9.27	8.65
MnO	0.19	0.09	0.12	0.04	0.22	0.25
MgO	34.75	31.87	32.86	31.94	30.36	33.81
Cr2O3	0.13	1.42	0.19	0.18	0.74	0.20
Total	84.16	85.20	84.45	82.59	84.29	84.04
Si	2.032	1.953	2.041	2.027	2.078	1.997
Ti	0.000	0.000	0.000	0.000	0.000	0.000
Al	0.039	0.213	0.103	0.116	0.099	0.068
Fe	0.302	0.340	0.328	0.349	0.384	0.361
Mn	0.008	0.004	0.005	0.002	0.009	0.011
Mg	2.558	2.330	2.406	2.398	2.238	2.516
Cr	0.005	0.055	0.007	0.007	0.029	0.008
Total	4.944	4.895	4.891	4.899	4.838	4.960

* Total Fe as FeO.

Table 6. Chemical compositions of chlorites in kosmochlor-bearing and -free actinolite-tremolite rock. Cations per 28 oxygens.

Lithology	Ko-bearing A-T rock	Ko-free A-T rock							
Sample	Ur1	2-2	3-7	4-2					
No.	17	28	3	3	4	1	3	9	10	12
SiO2	32.20	31.18	31.38	30.01	31.22	31.91	33.75	29.78	30.94	30.68
TiO2	0.00	0.02	0.00	0.03	0.00	0.03	0.00	0.00	0.00	0.00
Al2O3	12.14	11.85	15.68	16.15	15.07	14.54	13.88	14.31	14.64	14.35
FeO*	7.36	7.73	8.09	8.63	8.66	6.41	5.75	6.31	6.54	6.38
MnO	0.14	0.02	0.09	0.11	0.15	0.12	0.10	0.10	0.14	0.04
MgO	29.73	30.03	30.08	29.13	29.12	31.21	33.41	29.78	29.91	30.73
Cr2O3	5.40	4.90	1.32	1.75	2.43	2.77	0.70	5.28	5.11	4.85
Total	86.97	85.73	86.64	85.81	86.65	86.99	87.59	85.56	87.28	87.03
Si	6.300	6.217	6.112	5.938	6.118	6.166	6.402	5.920	6.015	5.978
Ti	0.000	0.003	0.000	0.004	0.000	0.004	0.000	0.000	0.000	0.000
Al	2.799	2.784	3.599	3.765	3.480	3.311	3.102	3.352	3.354	3.295
Fe	1.204	1.289	1.317	1.428	1.419	1.036	0.912	1.049	1.063	1.039
Mn	0.023	0.003	0.015	0.018	0.025	0.020	0.016	0.017	0.023	0.007
Mg	8.665	8.919	8.728	8.586	8.500	8.983	9.440	8.818	8.662	8.919
Cr	0.835	0.772	0.203	0.274	0.376	0.423	0.105	0.829	0.785	0.746
Total	19.825	19.988	19.975	20.013	19.916	19.942	19.976	19.984	19.903	19.983

* Total Fe as FeO.

Table 7. Chemical compositions of phengites in kosmochlor-free actinolite-tremolite rock and basic schist. Cations per 22 oxygens.

Lithology	Ko-free A-T rock					Basic schist					
Sample	3-5			3-6	148a	2-3					
No.	5	7	18	2	1	1	4	5	6	7	16
SiO2	50.91	51.02	51.06	51.11	51.06	49.70	51.17	51.48	51.44	50.89	51.03
TiO2	0.00	0.02	0.07	0.01	0.05	0.07	0.03	0.07	0.04	0.05	0.03
Al2O3	26.71	26.77	27.04	24.30	22.52	22.77	24.50	22.83	22.52	25.63	22.60
FeO*	1.16	1.05	1.29	1.64	1.61	1.86	1.64	1.46	1.57	1.28	1.47
MnO	0.00	0.00	0.00	0.25	0.08	0.02	0.02	0.03	0.08	0.03	0.03
MgO	4.74	4.82	5.03	5.90	4.35	4.87	4.34	5.11	4.83	4.15	4.78
CaO	0.00	0.01	0.08	0.07	0.04	0.08	0.04	0.08	0.24	0.07	0.07
Na2O	0.10	0.13	0.10	0.03	0.13	0.25	0.23	0.20	0.12	0.29	0.13
K2O	11.27	11.21	10.60	10.63	10.96	10.79	10.68	10.66	11.20	10.86	10.36
Cr2O3	0.81	0.73	0.49	1.68	5.45	6.37	5.48	6.46	6.46	3.57	6.85
Total	95.70	95.76	95.76	95.62	96.25	96.78	98.13	98.38	98.50	96.82	97.35
Si	6.778	6.778	6.762	6.838	6.870	6.694	6.737	6.782	6.797	6.747	6.790
Ti	0.000	0.002	0.007	0.001	0.005	0.007	0.003	0.007	0.004	0.005	0.003
Al	4.189	4.191	4.220	3.831	3.570	3.614	3.801	3.544	3.507	4.004	3.543
Fe	0.129	0.117	0.143	0.183	0.181	0.209	0.181	0.161	0.173	0.142	0.184
Mn	0.000	0.000	0.000	0.028	0.009	0.002	0.002	0.003	0.009	0.003	0.003
Mg	0.940	0.954	0.992	1.176	0.872	0.977	0.851	1.003	0.951	0.820	0.947
Ca	0.000	0.001	0.011	0.010	0.006	0.012	0.006	0.011	0.034	0.010	0.010
Na	0.026	0.033	0.026	0.008	0.034	0.065	0.059	0.051	0.031	0.074	0.034
K	1.913	1.899	1.790	1.814	1.880	1.853	1.793	1.791	1.887	1.836	1.758
Cr	0.085	0.077	0.051	0.178	0.579	0.678	0.570	0.672	0.674	0.374	0.720
Total	14.057	14.052	14.003	14.067	14.007	14.112	14.001	14.024	14.067	14.015	13.971

* Total Fe as FeO.

Table 8. Chemical compositions of opaque minerals in kosmochlor-bearing and -free actinolite-tremolite rock and basic schist. Cations per 4 oxygens.

Lithology	Ko-bearing A-T rock							Ko-free A-T rock								B schist	
Sample	Ko1-4		Ur1		Ko1		Ko2	Ko13	2-2		3-5	4-2			148a	2-3	
No.	2	3	10	11	1	2	5	51	9	11	17	7	8	2	10		
SiO2	0.83	6.29	8.09	5.95	7.18	5.17	10.10	15.06	7.27	10.37	13.41	17.58	18.13	1.32	0.91		
TiO2	2.25	2.53	0.97	1.16	2.38	2.65	1.06	1.31	0.00	0.00	2.16	1.03	0.91	0.20	0.23		
Al2O3	0.66	1.19	2.20	1.64	1.38	1.24	1.79	1.48	5.32	7.07	5.27	7.22	7.38	8.10	6.65		
FeO*	28.32	29.18	27.55	29.64	28.40	30.87	24.51	19.43	60.75	57.23	53.25	21.73	20.72	34.65	38.86		
MnO	2.46	2.95	2.15	2.11	2.48	2.98	2.34	1.72	0.00	0.02	0.22	1.54	1.52	3.93	2.54		
MgO	0.17	0.14	5.11	3.37	0.14	0.09	0.12	0.13	0.37	0.79	0.39	18.51	19.14	0.26	0.71		
CaO	0.45	6.17	0.20	0.21	7.46	5.15	9.39	14.83	0.30	0.62	1.20	0.05	0.04	0.08	0.03		
Na2O	0.26	0.19	0.19	0.18	0.16	0.17	0.15	0.11	0.05	0.09	0.19	0.01	0.02	0.22	0.04		
K2O	0.06	0.04	0.62	0.41	0.01	0.03	0.04	0.04	0.01	0.02	0.48	0.06	0.03	0.13	0.04		
Cr2O3	36.65	43.04	46.38	48.08	40.95	41.66	43.04	40.13	2.07	2.12	0.59	23.74	23.74	42.28	45.29		
Total	70.11	91.72	93.46	92.75	90.54	90.01	92.54	94.24	76.14	78.33	77.16	91.47	91.63	91.17	95.30		
Si	0.044	0.243	0.295	0.225	0.279	0.207	0.371	0.519	0.372	0.485	0.616	0.564	0.576	0.053	0.035		
Ti	0.091	0.074	0.027	0.033	0.069	0.080	0.029	0.034	0.000	0.000	0.075	0.025	0.022	0.006	0.007		
Al	0.042	0.054	0.094	0.073	0.063	0.058	0.078	0.060	0.321	0.390	0.285	0.273	0.276	0.380	0.303		
Fe	1.177	0.944	0.840	0.937	0.921	1.032	0.753	0.559	2.601	2.237	2.043	0.583	0.550	1.154	1.257		
Mn	0.111	0.097	0.066	0.068	0.081	0.101	0.073	0.050	0.000	0.001	0.009	0.042	0.041	0.133	0.083		
Mg	0.014	0.008	0.277	0.190	0.008	0.005	0.007	0.007	0.028	0.055	0.027	0.884	0.905	0.015	0.041		
Ca	0.026	0.256	0.008	0.009	0.310	0.221	0.370	0.547	0.016	0.031	0.059	0.002	0.001	0.003	0.001		
Na	0.027	0.014	0.013	0.013	0.012	0.013	0.011	0.007	0.005	0.008	0.017	0.001	0.001	0.017	0.003		
K	0.004	0.002	0.029	0.020	0.000	0.002	0.002	0.002	0.001	0.001	0.028	0.002	0.001	0.007	0.002		
Cr	1.549	1.315	1.335	1.436	1.255	1.316	1.250	1.092	0.084	0.078	0.021	0.601	0.595	1.330	1.384		
Total	3.085	3.007	2.985	3.004	2.999	3.034	2.942	2.876	3.428	3.286	3.179	2.976	2.968	3.098	3.117		

* Total Fe as FeO.

Table 9. Chemical compositions of epidotes in basic schist. Cations per 12.5 oxygens.

Lithology	Basic schist							
Sample	2-3							
No.	2	3	11	12	13	14	15	17
SiO2	36.68	36.71	32.95	35.69	36.60	35.82	36.90	37.14
TiO2	0.05	0.05	0.09	0.05	0.05	0.07	0.07	0.08
Al2O3	19.98	20.01	16.83	18.42	18.31	17.19	23.01	24.48
Fe2O3*	1.63	1.68	6.22	1.82	1.58	1.59	1.62	1.31
MnO	0.30	0.25	0.43	0.28	0.28	0.25	0.34	0.41
MgO	3.71	3.60	3.29	3.31	3.55	3.38	3.65	3.76
CaO	22.23	22.28	19.55	21.68	21.79	21.65	22.40	22.59
Na2O	0.21	0.31	0.27	0.29	0.31	0.25	0.26	0.28
K2O	0.02		0.03	0.05	0.04	0.03	0.04	0.03
Cr2O3	8.44	8.03	15.03	10.37	10.78	12.39	3.60	2.17
Total	93.25	92.92	94.69	91.96	93.29	92.62	91.89	92.25
Si	3.049	3.059	2.800	3.034	3.063	3.040	3.081	3.051
Ti	0.003	0.003	0.006	0.003	0.003	0.004	0.004	0.005
Al	1.957	1.965	1.685	1.845	1.805	1.719	2.250	2.370
Fe	0.102	0.105	0.397	0.116	0.099	0.101	0.101	0.081
Mn	0.021	0.018	0.031	0.020	0.020	0.018	0.024	0.029
Mg	0.459	0.447	0.416	0.419	0.443	0.427	0.451	0.460
Ca	1.979	1.988	1.779	1.974	1.953	1.968	1.990	1.988
Na	0.034	0.050	0.044	0.048	0.050	0.041	0.042	0.045
K	0.002	0.000	0.003	0.005	0.004	0.003	0.004	0.003
Cr	0.554	0.529	1.009	0.696	0.713	0.831	0.236	0.141
Total	8.160	8.164	8.172	8.161	8.153	8.152	8.164	8.172

* Total Fe as Fe2O3.

Table 10. Chemical compositions of prehites in kosmochlor-free actinolite-tremolite rock and basic schist. Cations per 11 oxygens.

Lithology	Basic schist					
Sample	2-3		2-5			
No.	20	21	22	3	4	5
SiO2	43.05	43.19	43.25	44.11	43.83	44.72
TiO2	0.01	0.02		0.02	0.00	0.00
Al2O3	23.95	24.14	23.76	24.76	24.70	24.47
FeO*	0.64	0.42	0.93	0.27	0.28	0.45
MnO		0.04	0.02	0.01	0.00	0.00
MgO	0.15	0.11	0.21	0.01	0.00	0.00
CaO	27.07	27.20	27.07	27.41	27.27	27.52
Na2O	0.04	0.03	0.04	0.02	0.05	0.02
K2O	0.04	0.01	0.02	0.02	0.07	0.05
Cr2O3	0.01		0.03	0.01	0.00	0.00
Total	94.96	95.16	95.33	96.64	96.20	97.23
Si	2.992	2.992	2.998	3.001	2.997	3.025
Ti	0.001	0.001	0.000	0.001	0.000	0.000
Al	1.961	1.970	1.941	1.985	1.990	1.951
Fe	0.037	0.024	0.054	0.015	0.016	0.025
Mn	0.000	0.002	0.001	0.001	0.000	0.000
Mg	0.016	0.011	0.022	0.001	0.000	0.000
Ca	2.015	2.018	2.010	1.997	1.997	1.994
Na	0.005	0.004	0.005	0.003	0.007	0.003
K	0.004	0.001	0.002	0.002	0.006	0.004
Cr	0.001	0.000	0.002	0.001	0.000	0.000
Total	7.031	7.024	7.034	7.007	7.014	7.003

* Total Fe as FeO.

Table 11. Chemical compositions of pumpellyites in kosmochlor-free actinolite-tremolite rock and basic schist. Cations per 26.5 oxygens.

Lithology	Basic schist						
Sample	2-3	2-5		131			
No.	8	9	7	9	1	2	3
SiO2	36.65	36.30	38.67	38.61	36.91	36.92	36.78
TiO2	0.08	0.13	0.07	0.10	0.11	0.11	0.11
Al2O3	22.55	22.37	26.05	26.02	24.79	24.94	25.40
FeO*	1.44	1.42	2.04	2.03	3.77	3.95	3.31
MnO	0.28	0.36	0.26	0.26	0.41	0.36	0.40
MgO	3.61	3.56	3.50	3.47	2.82	2.67	2.85
CaO	22.53	22.64	23.03	22.94	22.36	22.49	22.46
Na2O	0.21	0.22	0.39	0.45	0.27	0.21	0.18
K2O	0.04	0.03	0.02	0.04	0.02	0.04	0.04
Cr2O3	4.08	4.04	0.00	0.03			
Total	91.47	91.07	94.03	93.95	91.46	91.69	91.53
Si	6.506	6.482	6.582	6.579	6.533	6.523	6.488
Ti	0.011	0.017	0.009	0.013	0.015	0.015	0.015
Al	4.717	4.707	5.225	5.225	5.170	5.192	5.280
Fe	0.214	0.212	0.290	0.289	0.558	0.583	0.488
Mn	0.042	0.054	0.037	0.038	0.061	0.054	0.060
Mg	0.955	0.947	0.887	0.881	0.743	0.703	0.749
Ca	4.283	4.330	4.198	4.187	4.238	4.256	4.243
Na	0.072	0.076	0.129	0.149	0.093	0.072	0.062
K	0.009	0.007	0.004	0.009	0.005	0.009	0.009
Cr	0.572	0.570	0.000	0.004	0.000	0.000	0.000
Total	17.380	17.403	17.363	17.372	17.416	17.407	17.393

* Total Fe as FeO.

Table 12. Chemical compositions of sphene in kosmochlor-free actinolite-tremolite rock. Cations per 4 oxygens.

Lithology	Ko-f A-T B schist	
Sample	3-5	2-5
No.	20	11
SiO2	27.52	31.66
TiO2	35.57	40.38
Al2O3	3.24	1.10
FeO*	0.59	0.12
MnO	0.01	0.00
MgO	0.00	0.00
CaO	27.58	28.08
Na2O	0.00	0.05
K2O	0.13	0.05
Cr2O3	0.02	0.00
Total	94.66	101.44
Si	0.762	0.811
Ti	0.741	0.777
Al	0.106	0.033
Fe	0.014	0.003
Mn	0.000	0.000
Mg	0.000	0.000
Ca	0.818	0.770
Na	0.000	0.002
K	0.005	0.002
Cr	0.000	0.000
Total	2.446	2.398

* Total Fe as FeO.

Table 13. Chemical compositions of pectlite in jadeite. Cations per 6 oxygens.

Lithology	Jadeitite
Sample	OsaJd
No.	2
SiO2	54.75
TiO2	0.00
Al2O3	0.00
FeO*	0.00
MnO	0.13
MgO	0.01
CaO	34.02
Na2O	8.87
K2O	0.02
Cr2O3	0.00
Total	97.80
Si	2.124
Ti	0.000
Al	0.000
Fe	0.000
Mn	0.004
Mg	0.001
Ca	1.413
Na	0.667
K	0.001
Cr	0.000
Total	4.210

* Total Fe as FeO.

Table 14. Chemical compositions of analcime in jadeite.
Cations per 6 oxygens.

Lithology	Jadeitite
Sample	OsaJd
No.	3
SiO2	58.71
TiO2	0.00
Al2O3	23.89
FeO*	0.05
MnO	0.02
MgO	0.00
CaO	0.00
Na2O	12.84
K2O	0.04
Cr2O3	0.00
Total	95.55
Si	2.046
Ti	0.000
Al	0.981
Fe	0.001
Mn	0.001
Mg	0.000
Ca	0.000
Na	0.867
K	0.002
Cr	0.000
Total	3.898

* Total Fe as FeO.

日本語要旨

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