

Article

Variety of chemical compositions of amphiboles from eclogites in the Aktyuz area, northern Kyrgyz Tien-Shan

Akira Takasu* and Rustam Orozbaev*

Abstract

Amphiboles in the Aktyuz eclogites (Northern Kyrgyz Tien-Shan) have a variety of modes of occurrence and a wide range of compositions, including sodic-, sodic-calcic- and calcic-amphiboles. Amphibole inclusions in garnets are classified as glaucophane, Mg-taramite, Mg-katophorite, barroisite, and taramite, whereas amphibole inclusions within clinopyroxene are glaucophane, Mg-katophorite, barroisite, winchite, actinolite and edenite. Amphiboles replacing amphibole inclusions in garnet and clinopyroxene are classified as Fe-hornblende, actinolite, hastingsite and Fe-tschermakite. Amphibole inclusions within phengite are Mg-katophorite or Mg-taramite. Amphibole occurring as a constituent of amphibole + plagioclase aggregates after garnet has Mg-taramite composition. Amphibole in the matrix of the eclogites is zoned from Mg-taramite or taramite cores to Fe-pargasite/pargasite or Mg-hastingsite rims. Amphibole replacing porphyroblastic clinopyroxene is classified as barroisite, whereas amphibole replacing clinopyroxene as clinopyroxene + plagioclase symplectites is Mg-hastingsite. Porphyroblastic amphibole in retrograded eclogites is zoned from Mg-taramite cores to Mg-hastingsite or Fe-pargasite rims. Combining the petrography and chemistry of amphiboles in this study with previous studies, we conclude that the amphiboles formed at different stages of the metamorphic evolution of the Aktyuz eclogites.

Key words: Aktyuz, eclogite, amphibole, glaucophane, Kyrgyzstan, Tien-Shan

Introduction

The Aktyuz Formation is located in the Zaili Range of the Northern Kyrgyz Tien-Shan (Fig. 1). The main lithotypes are pelitic gneisses, gneissose-granites and migmatites, accompanied by exotic blocks or layers of eclogites, garnet amphibolites and amphibolites (Sobolev et al., 1986; Bakirov, 1989; Bakirov and Maksumova, 2001). The Aktyuz eclogites experienced multi-stage metamorphic evolution. Tagiri et al. (1995) estimated peak metamorphic conditions for the Aktyuz eclogites of $T=600\text{ }^{\circ}\text{C}$ and $P > 12\text{ kbar}$. Orozbaev et al. (2007) proposed two metamorphic events for the Aktyuz eclogites, namely a pre-eclogitic, relatively *MP-HT* metamorphic event of amphibolite facies conditions ($T=560\text{--}650\text{ }^{\circ}\text{C}$, $P=4\text{--}10\text{ kbar}$), and a *HP-LT* eclogitic metamorphic event in prograde epidote-blueschist facies ($T=330\text{--}570\text{ }^{\circ}\text{C}$, $P=8\text{--}16\text{ kbar}$) and peak eclogite facies ($T=600\text{--}710\text{ }^{\circ}\text{C}$, $P=15\text{--}25\text{ kbar}$) conditions. A third *HP-HT* metamorphic event after the second *HP-LT* eclogitic metamorphic event has also been identified in the Aktyuz eclogites, garnet amphibolites and country rock gneisses (Orozbaev et al., 2009). This complex metamorphic history led to the formation of various minerals in the Aktyuz eclogites at different stages of the evolution.

In this paper, we describe the variety and chemical composition of amphiboles in three Aktyuz eclogites (KG-426, KG-427 and 03-18). The samples were collected from a lenticular garnet amphibolite - eclogite body (60 m × 500 m)

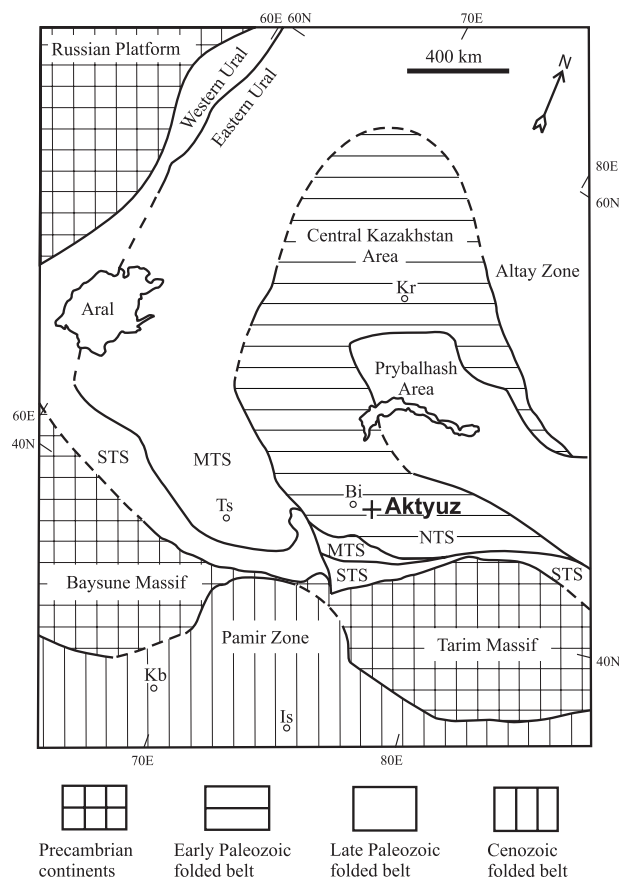


Fig. 1. Generalized tectonic division of central Asia (after Bakirov et al., 1998). NTS, Northern Tien-Shan; MTS, Middle Tien-Shan; STS, Southern Tien-Shan; Bi, Bishkek; Ts, Tashkent; Kr, Karaganda; Kb, Kabul; Is, Islamabad. Cross shows the location of the Aktyuz area.

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in the south-western part of the Aktyuz Formation.

The mineral abbreviations used in the text, tables and figures follow Kretz (1983), except for Amp=amphibole, Na-Amp=sodic amphibole, Na-Ca-Amp=sodic-calcic amphibole, Ca-Amp=calcic amphibole, Mg-Trm=Mg-taramite, Trm=taramite, Brs=barroisite, Wnc=winchite.

Petrography and modes of occurrence of amphibole

Eclogites in the Aktyuz area consist mainly of garnet, clinopyroxene, Na-Ca- and Ca-amphibole and phengite, with minor plagioclase, epidote, paragonite, quartz, Na-amphibole, biotite, chlorite, apatite, rutile and ilmenite.

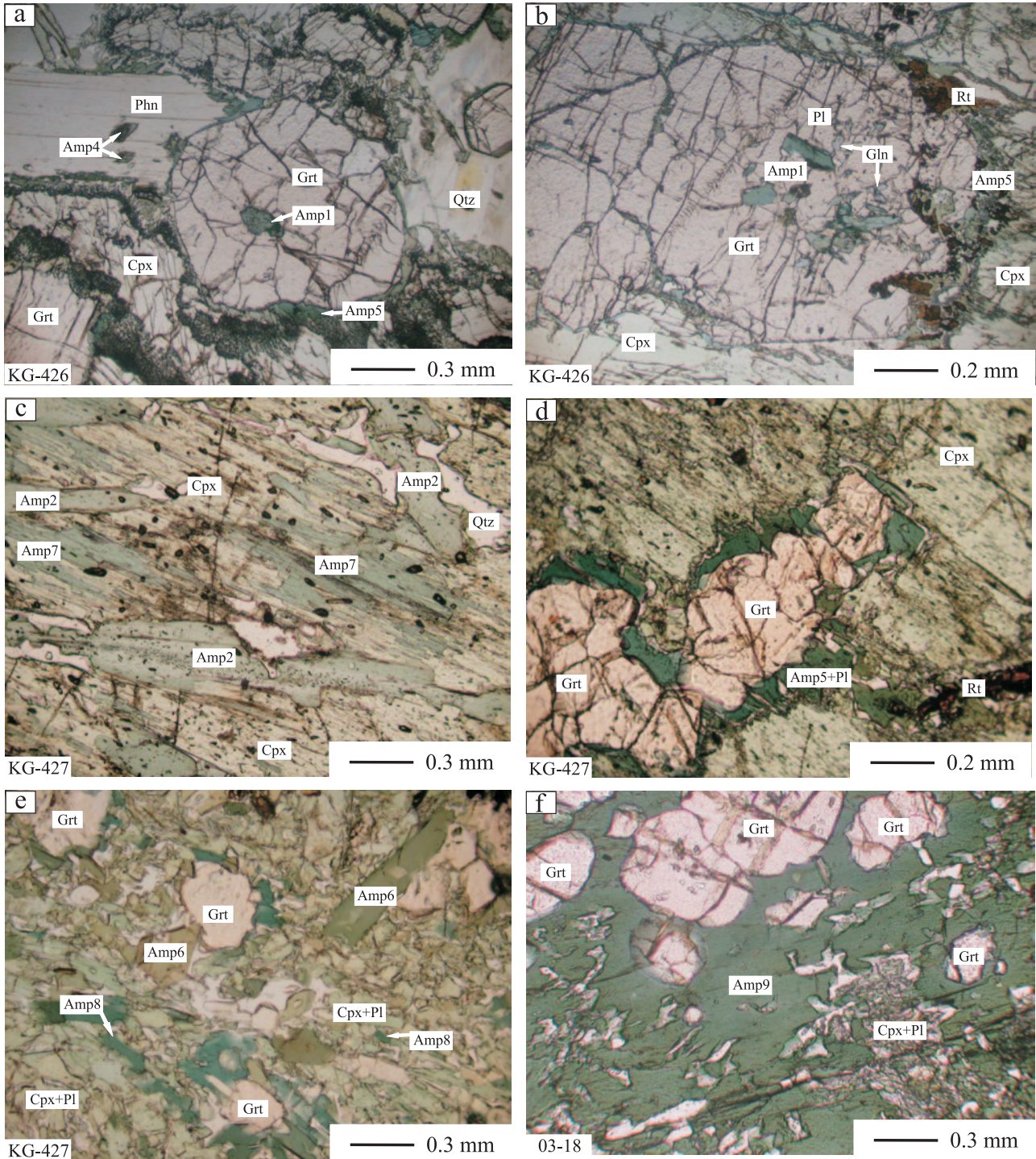


Fig. 2. Photomicrographs showing textures and modes of occurrence of amphiboles in the eclogites. (a) Garnet, clinopyroxene and phengite coexisting in the matrix. Amp1 is included within garnet, whereas Amp4 is included within phengite. Amp5 occurs between garnet and clinopyroxene; (b) Amp1 (glaucophane) inclusions in garnet; (c) Amp2 inclusions in clinopyroxene, being replaced by Amp7; (d) Amp5 + Pl aggregate developed at the boundary between garnet and clinopyroxene; (e) Amp6 occurring in the matrix of the eclogite and Amp8 replacing clinopyroxene in Cpx+Pl symplectites; (f) Amp9 porphyroblasts containing garnet inclusions and symplectitic aggregates of Cpx+Pl.

Accessory minerals include titanite, hematite, staurolite, zircon and K-feldspar. The eclogites are medium- to coarse-grained, and have granoblastic texture (Fig. 2a).

The amphiboles in the eclogites exhibit nine different modes of occurrence. Amp1 occurs as inclusions in garnets (Fig. 2a, b), whereas Amp2 is found as inclusions in clinopyroxene (Fig. 2c). These amphiboles have previously been described by Orozbaev et al. (2007). Amp3 replaces both Amp1 and Amp2 at their rims and along cracks in garnets and clinopyroxenes, whereas Amp4 forms inclusions in phengite and Amp5 is a constituent of aggregates of amphibole and plagioclase after garnet, and occurs at the contacts between garnets and clinopyroxenes (Fig. 2a, b,

d). Amp6 occurs in the matrix of less-retrograded eclogites (samples KG-426 and KG-427) (Fig. 2e). Amp6 occurs as subhedral to anhedral prismatic crystals up to 0.5 mm across, with pleochroism in the cores varying from X'=blueish green to brownish green, and Z'=green to deep green. Their rims have similar pleochroism, but with slightly paler color. Amp7 directly replaces clinopyroxene, and exhibits pleochroism of X'=pale greenish yellow and Z'=greenish blue (Fig. 2c). Amp8 forms subhedral prismatic crystals up to 0.2 mm, replacing clinopyroxene in later-stage clinopyroxene + plagioclase symplectites, and has pleochroism of X'=yellow green to brownish green and Z'=green (Fig. 2e). Amp9 occurs as subhedral to euhedral porphyroblastic crystals up

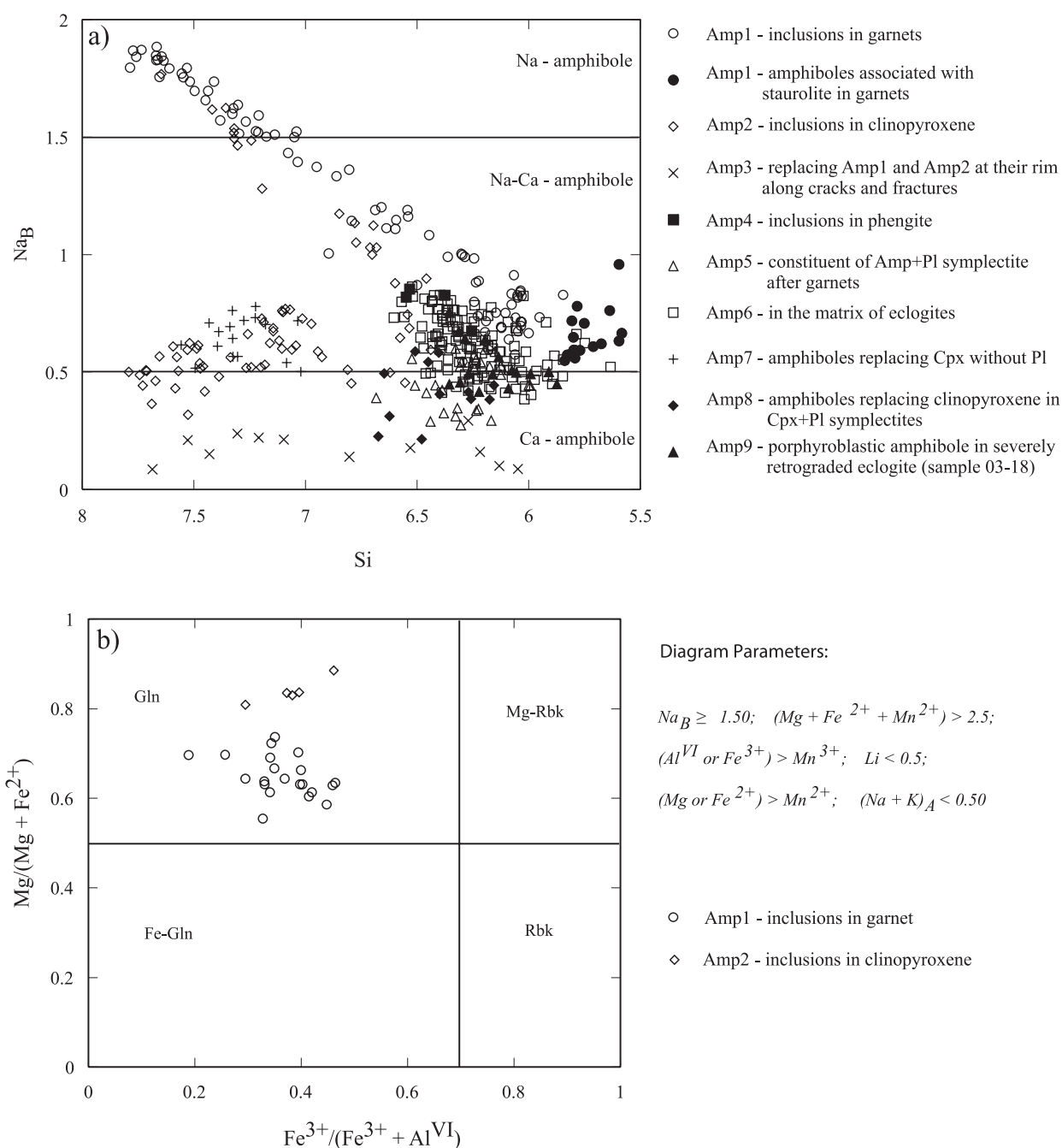


Fig. 3. Chemical compositions of amphiboles. (a) Na_B vs. Si plot of the amphiboles (after Leake et al., 1997); (b) compositions of Na-amphiboles.

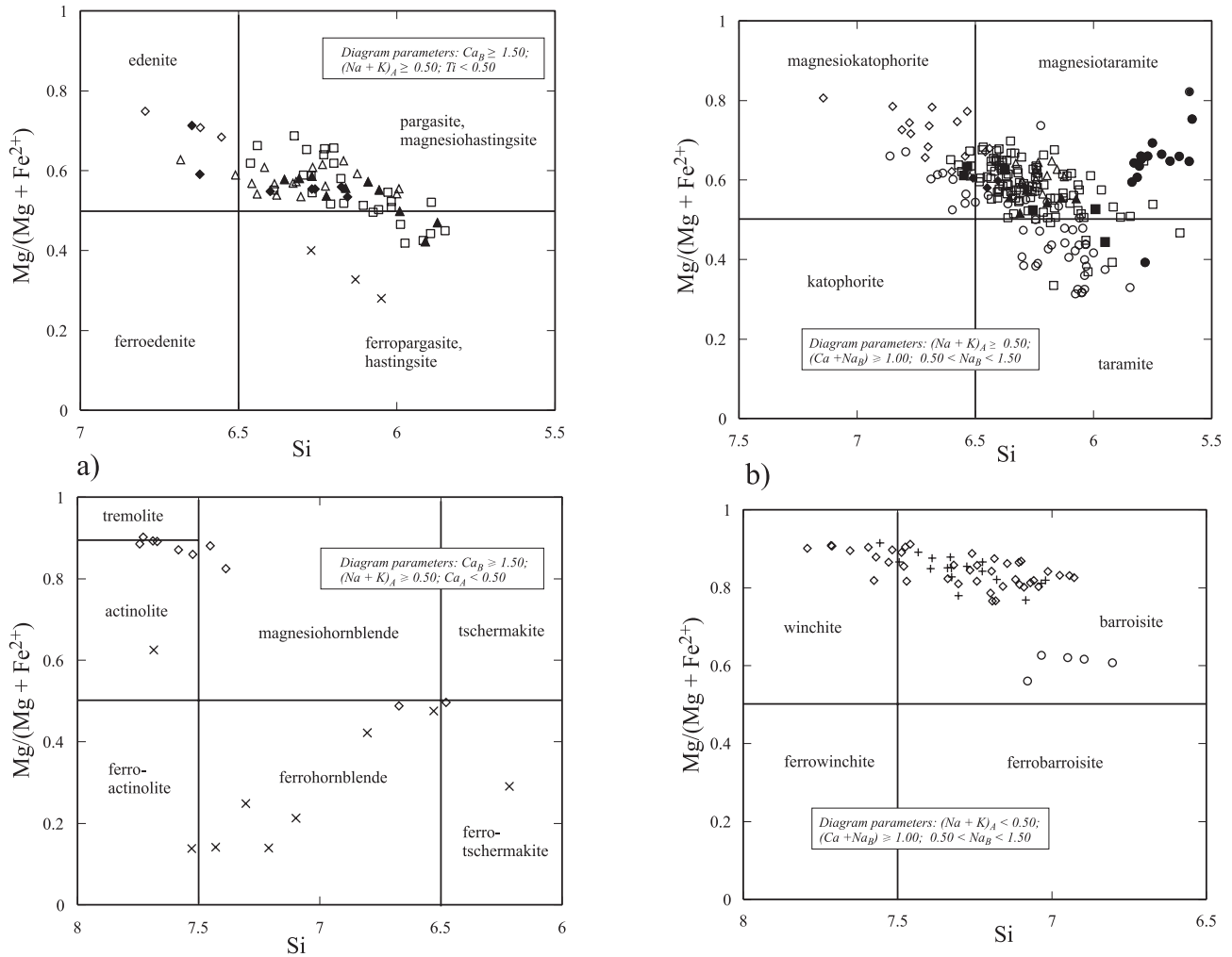


Fig. 4. Chemical compositions of (a) calcic and (b) sodic-calcic amphiboles from the Aktyuz eclogites. Legend as in Fig. 3.

to 3 mm across in severely retrograded eclogite (sample 03-18) (Fig. 2f). These amphiboles contain inclusions of clinopyroxene, garnet, phengite, epidote, rutile and ilmenite, along with aggregates of clinopyroxene and plagioclase, and biotite + plagioclase after phengite (Fig. 2f). Amp9 is sometimes replaced by biotite or chlorite at its margin, and exhibits pleochroism similar to Amp6.

Chemistry of the amphiboles

Mineral compositions of the amphiboles were determined using an electron probe microanalyser (JEOL JXA-8800M) in the Department of Geoscience, Shimane University. The analytical conditions used were 15 kV accelerating voltage, 20 nA beam current and 5 μ m beam diameter. Corrections were carried out using the procedures of Bence and Albee (1968). Ferric iron contents in the amphiboles were estimated as total cations $13 = \text{Si} + \text{Al} + \text{Ti} + \text{Cr} + \text{Mg} + \text{Fe} + \text{Mn}$ [(for $O = 23$; 13eCNK method of Schumacher, in Leake et al. (1997)].

Amphiboles in the eclogites consist mainly of Na-Ca-amphibole and Ca-amphibole with minor Na-amphibole

(Leake et al., 1997) (Fig. 3a; Table 1). Orozbaev et al. (2007) previously described Amp1 (glaucophane, Mg-taramite, Mg-katophorite, barroisite, taramite) and Amp2 (glaucophane, Mg-katophorite, barroisite, winchite, actinolite and edenite) occurring as inclusions in garnet and clinopyroxene, respectively (Figs. 3 and 4). Amp1 associated with staurolite inclusions within garnets has lower Si content (5.6-5.8 p.f.u.). Orozbaev et al. (2007) reported the first occurrence of glaucophane in the Aktyuz eclogites. The glaucophane inclusions in clinopyroxene have higher $X_{\text{Mg}} = \text{Mg}/(\text{Mg} + \text{Fe}^{2+})$ than the glaucophane inclusions in garnets (Fig. 3b). Amp3 replacing Amp1 and Amp2 is classified as Fe-hornblende, actinolite, hastingsite and Fetschermakite ($\text{Si} = 6.05\text{-}7.67$ p.f.u., Na_B (Na in the M4 site of amphibole) = 0.09-0.29, $X_{\text{Mg}} = 0.14\text{-}0.63$ and $\text{TiO}_2 = 0.02\text{-}0.64$ wt%). Amp4 inclusions in phengite are Mg-katophorite and Mg-taramite with $\text{Si} = 6.38\text{-}6.55$ p.f.u., $\text{Na}_B = 0.82\text{-}0.86$, $X_{\text{Mg}} = 0.61\text{-}0.63$ and $\text{TiO}_2 = 0.33\text{-}0.61$ wt% (Fig. 4b). Amp5 as a constituent of amphibole + plagioclase aggregate after garnet has a Mg-taramite composition ($\text{Si} = 6.15\text{-}6.33$ p.f.u.; $\text{Na}_B = 0.51\text{-}0.61$; $X_{\text{Mg}} = 0.57\text{-}0.65$ and $\text{TiO}_2 = 0.21\text{-}0.78$ wt%). Amp6 in the matrix of the eclogites is zoned, with

mainly Mg-taramite (Si = 5.92-6.48 p.f.u.; Na_B = 0.50-0.81; X_{Mg} = 0.50-0.68 and TiO₂ = 0.10-1.10 wt%) and rare taramite (Si = 6.03-6.20 p.f.u.; Na_B = 0.50-0.61; X_{Mg} = 0.44-0.49 and TiO₂ = 0.27-0.54 wt%) cores to Fe-pargasite (Si = 5.85-6.11 p.f.u.; Na_B = 0.37-0.48; X_{Mg} = 0.42-0.50 and TiO₂ = 0.22-0.62 wt%) or pargasite/Mg-hastingsite (Si = 5.89-6.46 p.f.u.; Na_B = 0.39-0.49; X_{Mg} = 0.50-0.69 and TiO₂ = 0.11-1.06 wt%) rims (Figs. 3a and 4a, b). Amp7 is classified as barroisite (Si = 7.04-7.50 p.f.u.; Na_B = 0.52-0.78; X_{Mg} = 0.77-0.92 and TiO₂ = 0.17-0.59 wt%). Amp8 replacing clinopyroxene as a constituent of clinopyroxene + plagioclase is Mg-hastingsite (Si = 6.16-6.40 p.f.u.; Na_B = 0.38-0.45; X_{Mg} = 0.53-0.66 and TiO₂ = 0.33-0.87 wt%). Amp9 occurring as porphyroblasts is zoned, from Mg-taramite cores (Si = 6.07-6.36 p.f.u.; Na_B = 0.51-0.75; X_{Mg} = 0.51-0.57 and TiO₂ = 0.32-0.68 wt%) to Mg-hastingsite (Si = 6.06-6.36 p.f.u.; Na_B = 0.42-0.49; X_{Mg} = 0.52-0.59 and TiO₂ = 0.40-0.80 wt%) or Fe-pargasite (Si = 5.87-5.99 p.f.u.; Na_B = 0.45-0.49; X_{Mg} = 0.42-0.50 and TiO₂ = 0.31-0.66 wt%) rims, similar to Amp6 (Figs. 3a and 4; Table 1).

Discussion and conclusions

The amphiboles from the Aktyuz eclogites occur in various modes of occurrences. Their chemistry shows an equally wide range of composition, including sodic-, sodic-calcic- and calcic-amphiboles. Amphibole (Amp1; Mg-taramite) associated with staurolite inclusions in garnets is regarded as a relict mineral that formed during a pre-eclogitic, relatively *MP-HT* metamorphic event under amphibolite facies conditions (Orozbaev et al., 2007). Other amphibole inclusions within garnets (Amp1; glaucophane, Mg-taramite, Mg-katophorite, barroisite, taramite) and clinopyroxenes (Amp2; glaucophane, Mg-katophorite, barroisite, winchite, actinolite and edenite) are the products of the prograde stage of epidote-blueschist facies conditions during a subsequent *HP-LT* eclogitic metamorphic event. The amphibole inclusions within matrix phengites (Amp4; Mg-katophorite and Mg-taramite) formed at this stage. Amphibole forming a constituent of aggregates of amphibole and plagioclase after garnet (Amp5; Mg-taramite) and those in the cores of the matrix amphiboles (Amp6; Mg-taramite and taramite) in the eclogites formed in epidote-amphibolite facies conditions during the retrograde stage of the second *HP-LT* eclogitic metamorphic event (Orozbaev et al., 2009). Porphyroblastic clinopyroxene was replaced by amphibole (Amp7; barroisite) at this stage. A third *HP-HT* metamorphic event following the second *HP-LT* eclogitic metamorphic event was responsible for the replacement of clinopyroxene + pla-

gioclase symplectites by amphibole (Amp8; Mg-hastingsite) and the formation of rims on the matrix amphiboles (Amp6; Fe-pargasite, hastingsite) and porphyroblastic amphibole (Amp9; Fe-pargasite, hastingsite) (Orozbaev et al., 2009).

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* In Russian with English abstract.

(要 旨)

Takasu, A・Orozbaev, R., 2009, キルギス北部天山アクチュツ地域に分布するエクロジャイト中の角閃石の化学組成の多様性, 島根大学地球資源環境学研究報告, 28, 51-63

キルギス北部天山アクチュツ地域に分布するエクロジャイト中の角閃石の産状と化学組成を記載した。角閃石はエクロジャイト中で多様な産状を示し、ナトリウム角閃石、ナトリウム-カルシウム角閃石及びカルシウム角閃石に分類される化学組成をもつ。ざくろ石に包有される角閃石は藍閃石、マグネシオタラマ閃石、マグネシオカタフォル閃石、バロワ閃石、タラマ閃石に分類され、一方単斜輝石中に包有される角閃石は藍閃石、マグネシオカタフォル閃石、バロワ閃石、ウインチ閃石、アクチノ閃石及びエデン閃石である。ざくろ石及び単斜輝石中に包有されている角閃石を置換している角閃石はフェロホルンブレンド、アクチノ閃石、ヘスチング閃石及びフェロチェルマック閃石である。フェンジャイト中に包有される角閃石はマグネシオカタフォル閃石及びマグネシオタラマ閃石である。エクロジャイトのざくろ石を置換する角閃石と斜長石の集合体をなす角閃石はマグネシオタラマ閃石の化学組成を示す。エクロジャイトの基質の角閃石は顕著な累帯構造をしている。核部はマグネシオタラマ閃石またはタラマ閃石、縁部はフェロパーガス閃石、パーガス閃石またはマグネシオヘスチング閃石である。エクロジャイトの単斜輝石を置換する角閃石はバロワ閃石に分類され、単斜輝石を斜長石とともにシンプレクタイトとして置換する角閃石はマグネシオヘスチング閃石である。後退変成作用の影響を強く受けたエクロジャイトにみられる斑状変晶の角閃石はマグネシオタラマ閃石の核部からマグネシオヘスチング閃石またはフェロパーガス閃石の縁部への累帯構造を示す。

Table 1. Chemical compositions of amphiboles from the Aktuz eclogites.

Sample No.	KG-426																																									
	4		5		6		55		59		60		73		81		85		86		87		91		92		93		94		102		107		111		120		121			
	Mineral	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln	amp1	Gln			
	core																																									
SiO ₂	53.82	56.25	52.49	48.65	51.28	50.95	49.17	52.89	51.15	52.03	52.21	54.32	55.43	54.96	50.60	50.44	54.50	55.10	55.57	54.15	53.82	56.25	52.49	48.65	51.28	50.95	49.17	52.89	51.15	52.03	52.21	54.32	55.43	54.96	50.60	50.44	54.50	55.10	55.57	54.15		
TiO ₂	0.02	0.00	0.02	1.05	0.08	0.12	0.15	0.07	0.12	0.17	0.29	0.06	0.06	0.04	0.13	0.21	0.11	0.05	0.02	0.03	0.02	0.00	0.02	1.05	0.08	0.12	0.15	0.07	0.12	0.17	0.29	0.06	0.06	0.04	0.13	0.21	0.11	0.05	0.02	0.03		
Al ₂ O ₃	10.77	10.83	11.23	11.28	10.77	11.08	12.23	10.55	10.61	10.81	10.59	10.11	10.06	10.03	11.88	11.67	10.25	10.37	10.26	10.87	10.77	10.83	11.23	11.28	10.77	11.08	12.23	10.55	10.61	10.81	10.59	10.11	10.06	10.03	11.88	11.67	10.25	10.37	10.26	10.87		
FeO*	14.49	11.16	12.84	16.22	16.71	16.82	17.78	16.80	16.97	15.40	15.97	14.94	14.64	14.09	15.90	15.01	14.85	13.83	12.15	12.81	14.49	11.16	12.84	16.22	16.71	16.82	17.78	16.80	16.97	15.40	15.97	14.94	14.64	14.09	15.90	15.01	14.85	13.83	12.15	12.81		
MnO	0.01	0.07	0.01	0.00	0.02	0.05	0.01	0.06	0.01	0.00	0.02	0.00	0.07	0.00	0.06	0.00	0.00	0.03	0.06	0.06	0.01	0.07	0.01	0.00	0.02	0.05	0.01	0.06	0.01	0.00	0.02	0.00	0.07	0.00	0.06	0.00	0.03	0.06	0.06			
MgO	9.55	10.39	10.69	9.07	8.72	8.66	8.11	8.04	8.79	8.85	8.90	8.90	9.63	9.23	8.85	9.40	9.12	9.70	10.11	10.37	9.55	10.39	10.69	9.07	8.72	8.66	8.11	8.04	8.79	8.85	8.90	8.90	9.63	9.23	8.85	9.40	9.12	9.70	10.11	10.37		
CaO	1.38	1.37	2.84	3.08	2.47	2.84	3.25	1.73	2.37	1.98	1.73	1.01	0.78	0.86	2.67	3.13	1.04	1.16	0.88	1.54	1.38	1.37	2.84	3.08	2.47	2.84	3.25	1.73	2.37	1.98	1.73	1.01	0.78	0.86	2.67	3.13	1.04	1.16	0.88	1.54		
Na ₂ O	7.43	6.96	6.66	6.96	6.90	6.76	6.68	7.29	6.89	7.20	7.26	7.19	7.16	7.33	6.97	6.82	7.38	6.97	7.29	6.99	7.43	6.96	6.66	6.96	6.90	6.76	6.68	7.29	6.89	7.20	7.26	7.19	7.16	7.33	6.97	6.82	7.38	6.97	7.29	6.99		
K ₂ O	0.13	0.13	0.25	0.12	0.18	0.20	0.21	0.10	0.14	0.11	0.13	0.08	0.07	0.08	0.11	0.15	0.06	0.07	0.05	0.16	0.13	0.13	0.25	0.12	0.18	0.20	0.21	0.10	0.14	0.11	0.13	0.08	0.07	0.08	0.11	0.15	0.06	0.07	0.05	0.16		
Cr ₂ O ₃	0.01	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.01	0.02	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.05	0.01	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.00	0.00		
Total	97.61	97.19	97.02	96.45	97.14	97.50	97.59	97.53	97.05	96.54	97.14	96.62	97.90	96.62	97.16	96.84	97.30	97.27	96.36	96.97	97.61	97.19	97.02	96.45	97.14	97.50	97.59	97.53	97.05	96.54	97.14	96.62	97.90	96.62	97.16	96.84	97.30	97.27	96.36	96.97		
Cations on the basis of 23 oxygens																																										
Si	7.531	7.787	7.383	7.041	7.323	7.268	7.050	7.518	7.303	7.435	7.410	7.671	7.667	7.735	7.210	7.645	7.669	7.773	7.553	7.531	7.787	7.383	7.041	7.323	7.268	7.050	7.518	7.303	7.435	7.410	7.671	7.667	7.735	7.210	7.645	7.669	7.773	7.553				
Ti	0.002	0.000	0.002	0.014	0.008	0.013	0.016	0.007	0.013	0.018	0.031	0.006	0.006	0.004	0.014	0.022	0.012	0.005	0.002	0.003	0.002	0.000	0.002	0.014	0.008	0.013	0.016	0.007	0.013	0.018	0.031	0.006	0.006	0.004	0.014	0.022	0.012	0.005	0.002	0.003		
Al	1.777	1.766	1.862	1.923	1.813	1.863	2.067	1.767	1.785	1.821	1.771	1.683	1.640	1.664	1.995	1.966	1.695	1.701	1.691	1.786	1.777	1.766	1.862	1.923	1.813	1.863	2.067	1.767	1.785	1.821	1.771	1.683	1.640	1.664	1.995	1.966	1.695	1.701	1.691	1.786		
Fe ³⁺	0.702	0.360	0.652	0.835	0.824	0.801	0.907	0.627	0.924	0.651	0.796	0.672	0.852	0.586	0.797	0.687	0.662	0.701	0.507	0.724	0.702	0.360	0.652	0.835	0.824	0.801	0.907	0.627	0.924	0.651	0.796	0.672	0.852	0.586	0.797	0.687	0.662	0.701	0.507	0.724		
Fe ²⁺	0.993	0.932	0.858	1.128	1.172	1.206	1.225	1.370	1.103	1.189	1.100	1.093	0.841	1.073	1.097	1.107	1.080	0.900	0.915	0.771	0.993	0.932	0.858	1.128	1.172	1.206	1.225	1.370	1.103	1.189	1.100	1.093	0.841	1.073	1.097	1.107	1.080	0.900	0.915	0.771		
Mn	0.001	0.009	0.001	0.000	0.003	0.006	0.001	0.007	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.006	0.001	0.009	0.001	0.000	0.003	0.006	0.001	0.007	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.006			
Mg	1.992	2.144	2.241	1.957	1.857	1.842	1.734	1.704	1.871	1.885	1.884	1.873	1.985	1.937	1.880	2.003	1.907	2.013	2.108	2.156	1.992	2.144	2.241	1.957	1.857	1.842	1.734	1.704	1.871	1.885	1.884	1.873	1.985	1.937	1.880	2.003	1.907	2.013	2.108	2.156		
Ca	0.206	0.203	0.428	0.478	0.378	0.433	0.499	0.264	0.363	0.303	0.263	0.153	0.115	0.129	0.407	0.479	0.156	0.173	0.132	0.230	0.206	0.203	0.428	0.478	0.378	0.433	0.499	0.264	0.363	0.303	0.263	0.153	0.115	0.129	0.407	0.479	0.156	0.173	0.132	0.230		
Na	2.017	1.869	1.816	1.953	1.911	1.870	1.856	2.010	1.909	1.994	1.997	1.969	1.920	2.000	1.926	1.892	2.007	1.880	1.978	1.890	2.017	1.869	1.816	1.953	1.911	1.870	1.856	2.010	1.909	1.994	1.997	1.969	1.920	2.000	1.926	1.892	2.007	1.880	1.978	1.890		
K	0.023	0.023	0.044	0.023	0.032	0.036	0.039	0.018	0.025	0.021	0.023	0.014	0.011	0.013	0.021	0.027	0.011	0.013	0.009	0.028	0.023	0.023	0.044	0.023	0.032	0.036	0.039	0.018	0.025	0.021	0.023	0.014	0.011	0.013	0.021	0.027	0.011	0.013	0.009	0.028		
Cr	0.001	0.002	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.005	0.001	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.001	0.002	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.005	0.001	0.000	0.000	0.000	0.000	0.002	0.000	0.000		
Total	15.246	15.095	15.287	15.453	15.321	15.340	15.394	15.292	15.296	15.318	15.282	15.136	15.047	15.142	15.354	15.398	15.174	15.066	15.119	15.148	15.246	15.095	15.287	15.453	15.321	15.340	15.394	15.292	15.296	15.318	15.282	15.136	15.047	15.142	15.354	15.398	15.174	15.066	15.119	15.148		
* Total Fe as FeO																																										
Sample No.	KG-426																																									
	123		2		61		67		71		72		76		78		80		84		88		89		90		96		98		101		103		77		82		23			
	Mineral	amp1	Mg-Ktp	Mg-Trm	Trm	Trm	Mg-Trm	Mg-Ktp	Trm	Trm	Trm	Brs	Mg-Ktp	Trm	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Trm	Trm	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp				
	core																																									
SiO ₂	53.67	47.18	42.46	39.90	38.70	43.19	44.69	40.52	42.07	41.28	48.68	45.53	41.56	45.91	44.64	45.87	45.24	40.19	40.60	40.34	53.67	47.18	42.46	39.90	38.70	43.19	44.69	40.52	42.07	41.28	48.68	45.53	41.56	45.91	44.64	45.87	45.24	40.19	40.60	40.34		
TiO ₂	0.02	0.29	0.23	0.14	0.08	0.15	0.26	0.20	0.47	0.72	0.40	0.17	0.34	0.43	0.45	0.45	0.43	0.42	0.32	0.33	0.31	0.02	0.29	0.23	0.14	0.08	0.15	0.26	0.20	0.47	0.72	0.40	0.17	0.34	0.43	0.45	0.45	0.43	0.42	0.32	0.33	0.31
Al ₂ O ₃	9.70	12.77	15.22	16.97	18.23	14.92	14.56	16.91	15.61	15.47	11.80	13.21	15.18	14.05	14.68	13.66	14.10	15.88	15.21	15.01	9.70	12.77	15.22	16.97	18.23	14.92	14.56	16.91	15.61	15.47	11.80	13.21	15.18	14.05	14.68	13.66	14.10	15.88	15.21	15.01		
FeO*	15.27	15.04	18.91	22.08	23.15	18.86	18.40	21.15	21.36	21.07	17.58	17.10	20.87	16.19	17.06	16.15	16.80	21.30	21.37	21.01	15.27	15.04	18.91	22.08	23.15	18.86	18.40	21.15	21.36	21.07	17.58	17.10	2									

Table 1. (continued)

Sample		KG-426																			
No.	49	50	8	36	38	40	42	118	119	121	129	12	110	111	115	116	120	130	8	11	
Mode	amp1	amp1	amp1	amp1	amp1	amp1	amp1	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	
Mineral	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Gln	Gln	Gln	Gln	Gln	Gln	Brs	Mg-Ktp	Brs	Brs	Mg-Ktp	Mg-Ktp	Mg-Ktp	
	i-st	i-st	i-st	i-st	i-st	i-st	i-st							core	rim						
SiO ₂	39.79	39.30	38.49	38.87	38.08	36.91	38.36	52.30	53.12	52.24	53.12	55.13	51.74	46.43	51.79	52.14	47.71	46.17	44.69	46.65	
TiO ₂	0.00	0.00	0.33	0.06	0.03	0.10	0.08	0.13	0.09	0.13	0.18	0.18	0.31	0.78	0.36	0.26	0.36	0.84	0.86	0.52	
Al ₂ O ₃	19.60	18.82	20.28	21.06	20.79	21.29	20.72	10.86	10.58	10.77	10.63	10.35	10.63	13.38	10.82	10.19	12.68	11.86	12.64	11.49	
FeO*	16.50	15.60	15.61	16.32	16.31	17.50	16.34	10.52	10.36	10.56	10.99	9.92	10.68	11.93	11.09	10.80	11.66	14.63	15.42	14.63	
MnO	0.00	0.05	0.01	0.06	0.01	0.03	0.08	0.03	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.03	0.02	0.02	0.04	0.04	
MgO	8.89	9.13	8.35	8.43	8.19	7.59	7.97	12.64	12.58	12.68	12.64	12.04	12.51	11.66	12.66	12.87	11.98	11.10	9.98	11.19	
CaO	8.34	9.12	8.73	6.75	8.69	8.47	7.86	3.21	2.55	3.09	2.53	1.56	3.54	5.67	3.44	3.35	5.38	6.43	7.09	6.09	
Na ₂ O	4.95	4.72	4.70	4.98	4.86	4.48	5.23	6.80	7.09	6.89	6.72	7.20	6.60	6.42	6.38	6.44	5.99	5.80	5.22	5.60	
K ₂ O	0.21	0.22	0.09	0.73	0.29	0.33	0.25	0.21	0.15	0.18	0.12	0.08	0.20	0.43	0.21	0.20	0.33	0.51	0.56	0.44	
Cr ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	
Total	98.28	96.95	96.59	97.64	97.26	96.71	96.89	96.70	96.52	96.54	96.97	96.47	96.21	96.69	96.73	96.30	96.10	97.36	96.50	96.64	
<i>Cations on the basis of 23 oxygens</i>																					
Si	5.752	5.794	5.677	5.595	5.595	5.448	5.637	7.322	7.419	7.321	7.357	7.647	7.304	6.696	7.243	7.319	6.850	6.701	6.600	6.774	
Ti	0.000	0.000	0.037	0.006	0.003	0.011	0.009	0.013	0.009	0.014	0.019	0.019	0.033	0.085	0.038	0.028	0.039	0.092	0.096	0.056	
Al	3.338	3.269	3.524	3.572	3.601	3.703	3.590	1.791	1.742	1.778	1.736	1.692	1.768	2.274	1.783	1.686	2.145	2.028	2.199	1.966	
Fe ³⁺	1.148	0.871	0.929	1.621	1.026	1.353	1.107	0.692	0.692	0.721	0.935	0.561	0.646	0.538	0.858	0.822	0.697	0.662	0.566	0.819	
Fe ²⁺	0.846	1.053	0.996	0.391	0.978	0.807	0.901	0.539	0.519	0.517	0.338	0.590	0.615	0.900	0.439	0.446	0.703	1.113	1.339	0.959	
Mn	0.000	0.006	0.001	0.007	0.001	0.004	0.010	0.003	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.003	0.003	0.002	0.004	0.005	
Mg	1.915	2.007	1.836	1.808	1.795	1.671	1.746	2.638	2.619	2.600	2.610	2.490	2.634	2.507	2.639	2.694	2.564	2.402	2.196	2.422	
Ca	1.292	1.441	1.379	1.041	1.368	1.340	1.237	0.482	0.382	0.464	0.375	0.232	0.536	0.876	0.515	0.504	0.827	0.999	1.121	0.948	
Na	1.388	1.348	1.344	1.389	1.385	1.281	1.489	1.845	1.919	1.872	1.806	1.936	1.805	1.796	1.729	1.752	1.666	1.631	1.496	1.576	
K	0.038	0.042	0.017	0.134	0.054	0.062	0.047	0.037	0.027	0.033	0.020	0.014	0.036	0.079	0.037	0.036	0.060	0.095	0.105	0.082	
Cr	0.000	0.000	0.000	0.000	0.000	0.003	0.001	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	
Total	15.717	15.830	15.741	15.564	15.807	15.807	15.774	15.363	15.327	15.368	15.202	15.183	15.377	15.751	15.281	15.293	15.554	15.725	15.722	15.606	

* Total Fe as FeO: i-st = amphiboles associated with staurolite in garnets

Sample		KG-426																			
No.	66	75	76	78	101	56	83	95	99	105	108	109	112	123	124	17	79	24	96	34	
Mode	amp2	amp2	amp2	amp2	amp2	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp4	
Mineral	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Mg-Ktp	Hs	Hs	Fe-Hbl	Fe-Hbl	Fe-Hbl	Fe-Hbl	Fe-Hbl	Fe-Hbl	Fe-Hbl	Fe-Hbl	Fe-Hbl	Fe-Hbl	Fe-Hbl	Fe-Hbl	Mg-Ktp	
SiO ₂	46.95	50.35	45.85	45.90	44.37	39.17	40.51	45.22	44.92	46.31	47.34	46.24	52.65	51.33	52.12	42.71	40.64	39.81	38.56	44.40	
TiO ₂	0.63	0.24	0.63	0.79	1.07	0.01	0.25	0.31	0.64	0.29	0.27	0.30	0.04	0.04	0.02	0.04	0.07	0.07	0.03	0.61	
Al ₂ O ₃	12.75	11.35	10.64	11.22	12.56	11.72	10.75	4.32	5.02	4.30	3.39	3.13	0.84	2.02	1.51	8.93	9.83	10.83	13.16	14.05	
FeO*	12.48	10.77	15.11	16.31	16.63	26.85	25.35	32.44	29.99	28.57	31.21	31.73	18.72	17.73	17.40	23.97	27.63	28.57	26.53	13.98	
MnO	0.05	0.04	0.08	0.04	0.00	0.10	0.18	0.16	0.14	0.25	0.27	0.06	0.03	0.14	0.06	0.25	0.18	0.13	0.13	0.06	
MgO	11.48	12.10	11.80	10.40	10.34	5.04	6.25	2.49	3.85	4.56	2.61	2.66	12.07	12.55	13.11	7.82	4.81	4.40	4.35	10.16	
CaO	5.60	4.70	6.21	6.19	7.07	11.32	10.28	10.41	10.56	10.42	10.51	10.74	12.45	12.40	11.81	11.13	11.93	11.00	11.38	7.26	
Na ₂ O	6.05	6.03	5.43	5.76	5.11	1.55	2.79	1.27	1.43	1.25	1.08	1.11	0.23	0.34	0.62	1.46	1.55	1.54	1.89	5.10	
K ₂ O	0.27	0.24	0.31	0.49	0.64	1.01	0.32	0.31	0.40	0.44	0.26	0.22	0.08	0.12	0.16	0.73	0.90	0.90	1.03	0.93	
Cr ₂ O ₃	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.03	0.00	0.02	0.00	0.00	0.01	
Total	96.24	95.81	96.08	97.10	97.79	96.77	96.60	96.93	96.97	96.26	96.91	96.42	97.13	96.55	96.91	96.84	97.61	97.29	97.06	96.56	
<i>Cations on the basis of 23 oxygens</i>																					
Si	6.780	7.194	6.683	6.713	6.459	6.132	6.271	7.211	7.098	7.306	7.529	7.430	7.834	7.643	7.686	6.531	6.383	6.219	6.049	6.536	
Ti	0.068	0.025	0.070	0.087	0.117	0.001	0.029	0.037	0.076	0.034	0.032	0.036	0.004	0.004	0.002	0.005	0.008	0.008	0.003	0.068	
Al	2.169	1.911	1.827	1.934	2.154	2.163	1.961	0.811	0.934	0.799	0.636	0.593	0.147	0.355	0.262	1.609	1.820	1.994	2.432	2.438	
Fe ³⁺	0.659	0.497	1.132	0.804	0.926	1.102	1.126	0.683	0.623	0.528	0.274	0.383	0.126	0.275	0.421	1.098	0.729	1.227	0.857	0.436	
Fe ²⁺	0.848	0.790	0.710	1.191	1.099	2.414	2.157	3.642	3.341	3.242	3.877	3.881	2.203	1.933	1.725	1.967	2.900	2.505	2.623	1.285	
Mn	0.006	0.005	0.010	0.005	0.000	0.013	0.013	0.024	0.021	0.018	0.033	0.036	0.008	0.004	0.017	0.007	0.033	0.024	0.018	0.007	
Mg	2.471	2.578	2.565	2.267	2.245	1.175	1.442	0.592	0.906	1.072	0.619	0.638	2.677	2.787	2.883	1.782	1.125	1.024	1.017	2.230	
Ca	0.866	0.720	0.970	0.969	1.102	1.899	1.705	1.779	1.787	1.617	1.791	1.849	1.985	1.978	1.865	1.823	2.008	1.840	1.912	1.145	
Na	1.694	1.670	1.535	1.634	1.443	0.470	0.836	0.391	0.438	0.381	0.334	0.346	0.065	0.098	0.176	0.433	0.473	0.466	0.576	1.454	
K	0.050	0.043	0.057	0.090	0.120	0.201	0.064	0.062	0.081	0.088	0.053	0.045	0.016	0.022	0.030	0.142	0.179	0.180	0.206	0.175	
Cr	0.000	0.000	0.002	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.003	0.000	0.000	0.003	0.000	0.002	0.000	0.000	0.001	
Total	15.610	15.433	15.562	15.694	15.665	15.570	15.605	15.232	15.306	15.230	15.177	15.240	15.065	15.098	15.071	15.397	15.660	15.486	15.694	15.774	

* Total Fe as FeO

Table 1. (continued)

Sample No.	KG-426																	KG-427			
	9	16	19	35	36	37	52	66	87	10	16	13	14	94	95	49	51	53	55		
Mode	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp1	amp1	amp1	amp1		
Mineral	Mg-Trm	Prg	Mg-Trm	Mg-Trm	Mg-Trm	core rim	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Trm	Trm	Trm	Trm		
SiO ₂	39.75	41.41	42.47	39.87	42.33	42.64	40.72	42.20	40.30	41.53	41.60	40.71	38.70	39.07	41.85	43.03	39.16	39.55	39.38	39.60	
TiO ₂	0.19	0.22	0.49	0.10	0.44	0.43	0.26	0.44	0.40	0.18	0.39	0.37	0.12	0.03	0.25	0.21	0.08	0.06	0.06	0.08	
Al ₂ O ₃	16.09	13.84	15.41	15.42	15.90	12.86	18.33	16.45	17.14	17.16	14.88	15.80	19.92	19.73	17.04	16.06	17.11	17.30	17.37	17.49	
FeO*	17.48	14.90	15.32	17.15	14.66	15.31	14.44	14.08	16.99	15.38	16.55	17.12	16.97	14.82	15.94	15.49	21.76	21.63	21.77	21.93	
MnO	0.05	0.09	0.01	0.04	0.09	0.03	0.09	0.02	0.00	0.01	0.12	0.05	0.06	0.04	0.02	0.06	0.04	0.07	0.05	0.00	
MgO	8.78	10.74	8.80	8.38	9.69	10.95	8.52	9.47	7.73	9.29	8.67	8.71	7.38	8.71	8.37	8.87	4.38	4.35	4.35	4.46	
CaO	9.29	9.41	7.46	8.87	7.70	7.94	8.23	8.10	8.22	8.19	8.68	9.31	8.65	8.43	7.96	8.10	7.08	7.09	7.19	7.06	
Na ₂ O	4.22	4.09	5.23	4.25	5.34	4.94	4.86	5.00	4.94	5.10	3.97	3.67	4.64	5.16	5.01	5.08	5.53	5.48	5.36	5.54	
K ₂ O	1.14	1.08	0.67	1.30	0.72	0.65	0.95	0.74	0.94	0.85	1.26	1.51	1.01	0.12	0.88	0.84	0.68	0.68	0.64	0.66	
Cr ₂ O ₃	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.02	0.00	0.00	0.00	0.00	
Total	96.98	95.79	95.86	95.37	96.86	95.75	96.39	96.49	96.66	97.69	96.12	97.27	97.44	96.11	97.38	97.76	95.82	96.20	96.17	96.83	

Cations on the basis of 23 oxygens

Si	5.966	6.228	6.350	6.100	6.241	6.352	6.060	6.246	6.053	6.094	6.267	6.086	5.749	5.788	6.183	6.331	6.050	6.077	6.049	6.037
Ti	0.021	0.025	0.056	0.011	0.049	0.048	0.029	0.049	0.045	0.019	0.044	0.042	0.013	0.003	0.028	0.024	0.009	0.006	0.007	0.009
Al	2.847	2.453	2.716	2.779	2.762	2.258	3.214	2.869	3.035	2.967	2.641	2.784	3.488	3.445	2.967	2.785	3.116	3.132	3.144	3.143
Fe ³⁺	0.744	0.606	0.441	0.576	0.564	0.856	0.402	0.398	0.501	0.621	0.531	0.624	0.710	0.790	0.485	0.344	0.629	0.600	0.657	0.692
Fe ²⁺	1.451	1.268	1.474	1.617	1.243	1.052	1.395	1.346	1.633	1.266	1.553	1.517	1.399	1.046	1.484	1.562	2.183	2.179	2.140	2.104
Mn	0.006	0.012	0.001	0.005	0.011	0.004	0.011	0.002	0.000	0.001	0.016	0.007	0.007	0.005	0.003	0.007	0.005	0.009	0.007	0.000
Mg	1.964	2.407	1.962	1.910	2.130	2.431	1.889	2.090	1.732	2.031	1.947	1.941	1.634	1.923	1.843	1.945	1.008	0.996	0.997	1.014
Ca	1.494	1.517	1.194	1.454	1.216	1.268	1.313	1.285	1.323	1.288	1.401	1.491	1.376	1.339	1.260	1.277	1.173	1.167	1.182	1.153
Na	1.228	1.193	1.516	1.259	1.526	1.428	1.402	1.435	1.439	1.452	1.159	1.065	1.335	1.483	1.435	1.449	1.657	1.634	1.597	1.637
K	0.218	0.207	0.128	0.253	0.136	0.124	0.180	0.139	0.181	0.158	0.243	0.289	0.192	0.023	0.166	0.157	0.135	0.133	0.125	0.128
Cr	0.000	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	0.007	0.002	0.000	0.000	0.000	0.000
Total	15.940	15.917	15.837	15.967	15.878	15.819	15.895	15.859	15.943	15.898	15.803	15.845	15.903	15.844	15.860	15.884	15.964	15.934	15.905	15.919

* Total Fe as FeO

Sample No.	KG-427																			
	29	31	15	35	37	63	145	146	148	156	157	158	159	160	1	2	3	13	14	15
Mode	amp1	amp1	amp1	amp1	amp1	amp1	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2
Mineral	Trm	Trm	Trm	Trm	Trm	Brs	Wnc	Brs	Brs	Brs	Wnc	Brs	Brs	Brs	Brs	Wnc	Brs	Wnc	Brs	Brs
SiO ₂	41.91	40.91	41.29	41.79	47.81	40.22	54.15	49.61	49.74	53.76	55.55	53.62	50.62	50.37	54.84	50.89	53.76	51.21	49.52	49.52
TiO ₂	0.34	0.24	0.29	1.00	0.46	0.04	0.10	0.46	0.54	0.16	0.05	0.18	0.30	0.35	0.09	0.17	0.31	0.06	0.27	0.44
Al ₂ O ₃	14.28	15.12	15.95	14.84	11.33	17.35	3.63	8.03	7.37	4.05	2.23	4.00	7.72	7.58	3.68	3.53	7.47	4.22	6.82	8.38
FeO*	19.13	20.63	20.22	19.72	16.79	22.56	9.84	12.34	13.35	9.49	8.79	9.69	11.41	11.25	8.82	9.78	10.79	9.75	11.53	11.79
MnO	0.14	0.10	0.00	0.01	0.00	0.06	0.06	0.05	0.08	0.00	0.00	0.00	0.07	0.09	0.02	0.06	0.02	0.05	0.05	0.03
MgO	7.66	6.60	7.00	7.17	9.78	4.39	17.58	14.20	14.36	18.17	18.80	17.89	15.46	15.54	17.98	17.79	15.40	17.45	15.77	14.87
CaO	9.04	8.68	8.24	7.90	6.44	6.72	9.98	8.04	8.10	9.92	10.03	9.79	8.24	8.24	10.44	9.38	8.40	9.18	8.57	8.39
Na ₂ O	4.34	4.67	4.97	4.89	5.07	5.74	2.15	4.05	4.01	2.50	2.08	2.46	3.97	4.03	2.06	2.43	3.74	2.77	3.46	3.91
K ₂ O	0.65	0.16	0.18	0.56	0.31	0.63	0.13	0.32	0.29	0.13	0.12	0.16	0.30	0.26	0.15	0.14	0.30	0.17	0.24	0.31
Cr ₂ O ₃	0.00	0.00	0.02	0.00	0.02	0.03	0.00	0.01	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Total	97.49	97.12	98.15	97.89	98.00	97.75	97.62	97.11	97.83	98.19	97.64	97.81	98.07	97.70	97.29	98.11	97.32	97.37	97.91	97.64

Cations on the basis of 23 oxygens

Si	6.298	6.178	6.123	6.228	6.896	6.066	7.570	7.091	7.070	7.460	7.716	7.475	7.107	7.100	7.584	7.595	7.196	7.518	7.187	7.013
Ti	0.039	0.028	0.033	0.112	0.050	0.004	0.011	0.050	0.058	0.017	0.005	0.018	0.031	0.037	0.010	0.018	0.033	0.007	0.028	0.047
Al	2.528	2.691	2.787	2.606	1.926	3.085	0.598	1.352	1.234	0.663	0.365	0.656	1.277	1.259	0.608	0.576	1.245	0.695	1.128	1.399
Fe ³⁺	0.498	0.690	0.820	0.668	0.716	0.798	0.646	0.723	0.885	0.739	0.629	0.736	0.835	0.831	0.477	0.741	0.607	0.723	0.881	0.806
Fe ²⁺	1.906	1.916	1.687	1.790	1.309	2.048	0.504	0.752	0.701	0.363	0.392	0.394	0.506	0.495	0.558	0.392	0.606	0.417	0.473	0.591
Mn	0.017	0.013	0.000	0.002	0.000	0.008	0.007	0.006	0.009	0.000	0.000	0.000	0.008	0.011	0.002	0.006	0.003	0.002	0.005	0.003
Mg	1.715	1.485	1.548	1.593	2.102	0.988	3.664	3.026	3.042	3.758	3.893	3.718	3.235	3.266	3.761	3.672	3.246	3.638	3.298	3.140
Ca	1.456	1.405	1.309	1.262	0.995	1.086	1.495	1.231	1.233	1.475	1.493	1.462	1.239	1.244	1.570	1.391	1.273	1.376	1.289	1.273
Na	1.266	1.368	1.428	1.413	1.417	1.678	0.583	1.122	1.106	0.672	0.559	0.666	1.080	1.100	0.562	0.651	1.025	0.750	0.941	1.074
K	0.125	0.030	0.034	0.107	0.058	0.122	0.023	0.059	0.052	0.023	0.021	0.028	0.053	0.047	0.027	0.024	0.055	0.031	0.042	0.055
Cr	0.000	0.000	0.002	0.000	0.002	0.003	0.000	0.001	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000
Total	15.846	15.803	15.770	15.782	15.470	15.886	15.100	15.412	15.391	15.171	15.072	15.156	15.372	15.392	15.158	15.067	15.353	15.156	15.272	15.402

* Total Fe as FeO

Sample No.	KG-427																			
	17	77	78	76	77	78	79	84	85	86	23	5	38	48	53	58	45	64	65	67
Mode	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3	amp3
Mineral	Wnc	Mg-Ktp	Mg-Trm	Brs	Brs	Wnc	Act	Mg-Hbl	Act	Mg-Ktp	Trm	Fe-Hbl	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Hs	Mg-Trm	Mg-Hs	Mg-Trm
SiO ₂	55.16	44.90	43.70	53.25	48.51	53.06	53.18	52.37	53.84	49.25	40.53	44.84	42.31	41.61	41.71	43.08	40.15	41.86	40.68	41.52
TiO ₂	0.16	0.73	1.32	0.14	0.43	0.14	0.38	0.17	0.09	0.36	0.11	0.00	0.78	0.63	0.75	0.72	0.17	0.25	0.21	0.21
Al ₂ O ₃	3.02	13.82	11.41	4.01	8.37	3.89	3.41	3.59	2.32	7.30	16.18	7.39	13.99	14.24	14.54	13.58	15.5			

Table 1. (continued)

Sample		KG-427																			
No.	3	5	9	13	16	1	2	11	28	29	32	40	42	48	49	50	51	58	59	97	
Mode	amp5	amp5	amp5	amp5	amp5	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	
Mineral	Mg-Hs	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Prg	Mg-Trm	Mg-Trm	Prg	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Prg	Mg-Trm	Mg-Trm	Mg-Trm	
						core	rim			core							core				
SiO ₂	42.36	41.70	42.29	42.35	42.46	42.58	40.82	43.18	42.97	43.72	43.79	42.13	42.67	43.25	43.03	42.69	41.90	43.46	43.81	40.45	
TiO ₂	0.79	0.65	0.62	0.22	0.26	0.43	0.50	1.15	0.47	0.47	0.66	0.37	0.26	0.56	0.49	0.32	0.31	0.67	1.05	0.70	
Al ₂ O ₃	13.34	14.98	13.81	13.00	12.78	14.12	13.15	12.63	13.50	12.85	14.56	13.64	14.59	15.04	14.34	13.90	13.24	13.43	12.76	16.59	
FeO*	16.90	17.28	16.36	18.44	18.75	18.44	17.63	15.18	14.38	14.61	14.59	16.68	17.62	17.15	16.52	16.80	17.03	15.98	16.41	15.64	
MnO	0.12	0.06	0.13	0.01	0.04	0.10	0.13	0.06	0.12	0.11	0.06	0.08	0.14	0.06	0.13	0.11	0.08	0.08	0.04	0.05	
MgO	10.05	9.49	10.29	9.45	9.41	8.44	8.80	10.05	10.38	11.22	9.76	8.72	9.20	9.04	8.96	9.21	9.72	10.24	10.28	9.27	
CaO	9.63	9.36	9.16	9.16	9.27	8.46	9.31	8.12	8.42	9.53	7.81	8.20	8.88	7.94	8.00	8.24	9.57	8.16	8.56	8.88	
Na ₂ O	4.24	4.35	4.47	4.11	4.11	4.35	4.21	4.74	4.41	3.91	5.04	4.42	4.41	4.80	4.50	4.54	4.06	4.68	4.48	4.52	
K ₂ O	0.21	0.23	0.30	0.42	0.37	0.67	0.36	0.67	0.67	0.61	0.56	0.76	0.74	0.74	0.70	0.73	0.56	0.68	0.65	0.78	
Cr ₂ O ₃	0.01	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.00	
Total	97.64	98.09	97.43	97.16	97.48	97.61	94.91	95.77	95.32	97.01	96.82	95.00	98.50	98.60	96.71	96.54	96.47	97.37	98.04	96.86	
<i>Cations on the basis of 23 oxygens</i>																					
Si	6.266	6.125	6.236	6.302	6.309	6.316	6.268	6.478	6.433	6.440	6.450	6.406	6.259	6.297	6.384	6.365	6.295	6.385	6.419	6.012	
Ti	0.088	0.072	0.069	0.024	0.029	0.048	0.058	0.130	0.053	0.052	0.073	0.042	0.029	0.061	0.055	0.036	0.035	0.074	0.116	0.207	
Al	2.325	2.594	2.399	2.280	2.238	2.469	2.379	2.233	2.382	2.230	2.527	2.444	2.521	2.580	2.508	2.442	2.344	2.325	2.204	2.970	
Fe ³⁺	0.662	0.783	0.764	0.879	0.876	0.732	0.582	0.438	0.536	0.547	0.419	0.534	0.725	0.730	0.639	0.672	0.622	0.728	0.646	0.635	
Fe ²⁺	1.429	1.339	1.254	1.416	1.453	1.555	1.681	1.466	1.264	1.253	1.379	1.587	1.436	1.358	1.411	1.423	1.512	1.236	1.365	1.310	
Mn	0.015	0.008	0.016	0.001	0.005	0.013	0.017	0.007	0.015	0.013	0.008	0.010	0.018	0.007	0.016	0.014	0.010	0.010	0.005	0.006	
Mg	2.216	2.078	2.262	2.096	2.085	1.867	2.014	2.248	2.316	2.465	2.144	1.976	2.012	1.963	1.983	2.047	2.176	2.242	2.246	2.053	
Ca	1.525	1.473	1.447	1.461	1.476	1.345	1.531	1.304	1.350	1.504	1.233	1.337	1.395	1.239	1.272	1.316	1.541	1.285	1.344	1.414	
Na	1.216	1.238	1.279	1.186	1.183	1.252	1.253	1.378	1.280	1.118	1.438	1.303	1.253	1.356	1.294	1.313	1.184	1.332	1.272	1.304	
K	0.040	0.043	0.056	0.080	0.070	0.127	0.071	0.128	0.129	0.114	0.104	0.148	0.135	0.137	0.132	0.138	0.108	0.128	0.122	0.148	
Cr	0.001	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.004	0.001	0.000	0.000	0.000	
Total	15.781	15.754	15.781	15.727	15.729	15.724	15.855	15.810	15.759	15.735	15.775	15.788	15.784	15.732	15.699	15.767	15.833	15.744	15.738	15.865	

* Total Fe as FeO

Sample		KG-427																			
No.	98	99	100	101	108	109	113	114	120	121	122	123	125	132	134	21	22	23	25	35	
Mode	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	
Mineral	Mg-Hs	Mg-Hs	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Hs	Mg-Hs	Mg-Trm	Mg-Trm	Mg-Ktp	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Ktp	Mg-Trm	Mg-Hs	Mg-Ktp	Mg-Ktp	
	core	rim	core	rim	rim			core		core		rim			core			rim			
SiO ₂	43.58	41.65	41.69	41.92	43.29	42.78	41.85	43.11	43.64	45.10	43.38	41.85	42.49	42.58	44.44	45.19	44.18	42.19	45.56	44.78	
TiO ₂	0.41	0.41	0.12	0.14	0.56	0.57	0.51	0.51	0.49	0.45	0.53	1.00	1.02	1.04	0.70	0.98	0.97	1.06	0.77	0.80	
Al ₂ O ₃	12.90	14.09	15.26	13.62	12.31	12.26	13.25	13.22	15.03	12.90	13.13	13.66	12.90	13.46	12.72	11.57	11.95	12.26	10.83	13.75	
FeO*	15.37	15.55	17.38	17.48	15.17	15.57	16.53	15.54	14.85	16.51	17.06	17.43	18.17	16.85	16.14	18.02	17.99	18.29	17.58	15.06	
MnO	0.12	0.08	0.09	0.13	0.10	0.09	0.03	0.08	0.17	0.10	0.11	0.14	0.10	0.07	0.10	0.05	0.06	0.02	0.14	0.06	
MgO	11.05	10.52	9.41	9.75	11.26	11.53	10.47	10.82	9.95	10.29	9.41	8.88	9.11	9.58	10.59	9.98	9.71	9.87	10.69	10.10	
CaO	8.73	9.50	8.98	9.33	9.29	9.87	9.60	8.87	7.89	7.33	7.55	8.15	8.57	8.50	7.62	8.14	8.60	9.92	8.17	7.55	
Na ₂ O	4.43	4.05	4.48	4.10	4.07	3.78	4.08	4.35	4.81	4.99	5.12	4.55	4.40	4.68	4.91	4.35	4.26	3.88	4.43	4.92	
K ₂ O	0.67	0.64	0.61	0.56	0.60	0.58	0.58	0.66	0.57	0.36	0.46	0.67	0.45	0.54	0.39	0.35	0.34	0.28	0.51	0.56	
Cr ₂ O ₃	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.01	0.02	0.02	0.01	
Total	97.25	96.51	98.01	97.02	96.67	97.03	96.90	97.16	97.39	98.02	96.74	96.32	97.18	97.31	97.61	98.65	98.08	97.77	98.68	97.59	
<i>Cations on the basis of 23 oxygens</i>																					
Si	6.400	6.199	6.131	6.239	6.410	6.324	6.231	6.349	6.367	6.524	6.435	6.280	6.326	6.314	6.467	6.559	6.484	6.271	6.605	6.519	
Ti	0.046	0.046	0.013	0.015	0.062	0.063	0.057	0.057	0.054	0.049	0.059	0.112	0.114	0.116	0.077	0.107	0.107	0.118	0.084	0.088	
Al	2.233	2.472	2.644	2.389	2.149	2.136	2.326	2.294	2.584	2.199	2.295	2.416	2.264	2.352	2.182	1.979	2.067	2.147	1.851	2.359	
Fe ³⁺	0.742	0.715	0.848	0.836	0.675	0.772	0.748	0.729	0.642	0.915	0.756	0.724	0.770	0.639	0.897	0.870	0.768	0.744	0.894	0.578	
Fe ²⁺	1.146	1.220	1.290	1.341	1.204	1.154	1.311	1.185	1.169	1.082	1.361	1.464	1.492	1.451	1.068	1.318	1.440	1.529	1.237	1.256	
Mn	0.014	0.011	0.012	0.016	0.012	0.011	0.004	0.010	0.021	0.012	0.014	0.018	0.013	0.009	0.013	0.007	0.007	0.003	0.017	0.007	
Mg	2.419	2.335	2.063	2.164	2.486	2.540	2.323	2.376	2.163	2.218	2.280	1.986	2.021	2.117	2.297	2.160	2.125	2.186	2.310	2.192	
Ca	1.374	1.515	1.415	1.488	1.474	1.563	1.531	1.400	1.234	1.137	1.201	1.311	1.366	1.350	1.188	1.265	1.353	1.579	1.269	1.178	
Na	1.260	1.169	1.277	1.183	1.170	1.084	1.177	1.242	1.359	1.400	1.473	1.324	1.269	1.345	1.386	1.223	1.212	1.118	1.244	1.388	
K	0.125	0.121	0.114	0.106	0.112	0.108	0.110	0.124	0.106	0.066	0.087	0.129	0.085	0.102	0.072	0.066	0.064	0.054	0.094	0.105	
Cr	0.000	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.002	0.001	0.002	0.002	0.001	
Total	15.759	15.805	15.806	15.777	15.756	15.755	15.818	15.766	15.699	15.603	15.760	15.764	15.720	15.797	15.646	15.554	15.629	15.751	15.606	15.670	

Table 1. (continued)

Sample	03-18																				
No.	88	89	90	91	92	93	94	95	135	137	36	38	41	45	66	70	74	109	113	116	
Mode	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp2	amp3	amp3	amp5	amp5	amp5	amp5	amp5	amp5	amp5	amp5	amp5	amp5	
Mineral	Mg-Hbl	Act	Wnch	Brs	Wnc	Brs	Brs	Brs	Mg-Hbl	Mg-Hbl	Mg-Hs	Ed	Mg-Hs	Mg-Hs	Mg-Hs	Mg-Hs	Mg-Hs	Mg-Hs	Mg-Kfp	Ed	
	rim	core	→	→	→	→	→	→	rim	core	→	→	→	→	→	→	→	→	→	→	
SiO ₂	51.66	55.08	52.90	51.10	55.80	52.36	49.33	49.85	50.33	51.78	42.15	45.01	42.07	41.88	42.47	40.88	40.98	42.33	43.52	43.03	
TiO ₂	0.32	0.02	0.17	0.45	0.06	0.16	0.59	0.70	0.52	0.33	1.55	0.78	0.37	1.41	0.64	0.50	0.46	0.21	0.46	0.60	
Al ₂ O ₃	4.26	1.74	3.68	4.75	1.65	4.16	6.58	6.37	6.12	4.84	10.90	9.30	10.26	11.08	10.57	11.34	11.28	11.45	10.64	10.19	
FeO*	11.49	9.82	10.84	11.78	9.26	11.05	11.88	12.26	11.67	11.33	18.51	16.79	19.86	18.02	18.54	20.43	19.64	19.30	18.66	18.57	
MnO	0.13	0.09	0.05	0.12	0.01	0.04	0.04	0.10	0.04	0.04	0.11	0.07	0.06	0.05	0.13	0.06	0.15	0.10	0.12	0.08	
MgO	16.28	18.13	16.28	15.80	18.48	16.33	14.81	14.77	15.55	16.49	9.48	11.31	9.26	10.01	10.05	9.12	8.94	9.33	9.79	9.93	
CaO	9.91	10.04	9.35	9.34	9.82	9.05	8.85	9.51	9.82	10.06	10.33	10.13	10.43	10.43	9.61	10.17	10.47	9.75	8.98	9.61	
Na ₂ O	2.59	1.83	2.67	2.89	1.85	2.72	3.31	3.20	2.75	2.39	2.96	3.01	2.74	3.12	3.29	2.85	2.68	3.55	3.57	3.44	
K ₂ O	0.24	0.19	0.26	0.31	0.18	0.27	0.46	0.33	0.33	0.24	1.07	0.74	1.00	1.02	0.90	1.33	1.26	0.57	0.56	0.56	
Cr ₂ O ₃	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.03	0.01	0.00	0.00	0.00	0.02	0.06	0.00	0.02	
Total	96.87	96.94	96.20	96.53	97.11	96.13	95.83	97.09	97.12	97.53	97.06	97.17	96.04	97.02	96.19	96.68	95.88	96.65	96.30	96.02	
<i>Cations on the basis of 23 oxygens</i>																					
Si	7.388	7.743	7.578	7.337	7.793	7.481	7.159	7.182	7.197	7.329	6.380	6.684	6.442	6.328	6.419	6.226	6.304	6.387	6.525	6.511	
Ti	0.034	0.002	0.019	0.049	0.006	0.017	0.064	0.075	0.056	0.035	0.177	0.087	0.042	0.160	0.072	0.058	0.053	0.024	0.051	0.069	
Al	0.718	0.289	0.621	0.803	0.271	0.700	1.126	1.081	1.031	0.808	1.945	1.628	1.851	1.973	1.883	2.036	2.045	2.035	1.880	1.818	
Fe ³⁺	0.636	0.664	0.529	0.691	0.659	0.731	0.660	0.514	0.631	0.711	0.517	0.599	0.751	0.564	0.886	0.980	0.742	0.833	0.937	0.789	
Fe ²⁺	0.738	0.490	0.770	0.723	0.422	0.589	0.782	0.963	0.765	0.631	1.827	1.487	1.791	1.713	1.458	1.621	1.785	1.602	1.403	1.561	
Mn	0.016	0.011	0.006	0.015	0.001	0.004	0.005	0.013	0.005	0.005	0.014	0.008	0.008	0.007	0.016	0.008	0.020	0.012	0.015	0.010	
Mg	3.470	3.800	3.478	3.382	3.848	3.477	3.204	3.171	3.315	3.480	2.139	2.504	2.114	2.256	2.265	2.071	2.049	2.099	2.189	2.240	
Ca	1.519	1.513	1.435	1.437	1.470	1.385	1.376	1.468	1.504	1.526	1.675	1.611	1.711	1.688	1.556	1.659	1.725	1.577	1.443	1.558	
Na	0.718	0.497	0.740	0.803	0.500	0.753	0.931	0.893	0.763	0.656	0.868	0.866	0.812	0.913	0.964	0.841	0.799	1.038	1.037	1.008	
K	0.044	0.033	0.047	0.057	0.032	0.049	0.085	0.061	0.061	0.044	0.206	0.139	0.195	0.197	0.173	0.258	0.247	0.110	0.108	0.108	
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.003	0.001	0.000	0.000	0.000	0.002	0.007	0.000	0.003	
Total	15.282	15.044	15.223	15.297	15.003	15.187	15.392	15.422	15.328	15.226	15.748	15.617	15.719	15.799	15.693	15.758	15.772	15.725	15.588	15.673	
* Total Fe as FeO																					
Sample	03-18																				
No.	119	22	23	24	25	26	66	67	68	69	70	72	73	74	79	76	77	78	75	81	
Mode	amp5	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	amp6	
Mineral	Mg-Hs	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Fe-Prg	Mg-Trm	Mg-Trm	Trm	Trm	Fe-Prg	Mg-Trm	Mg-Trm	Fe-Prg	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	Mg-Trm	
	core	→	→	→	→	rim	core	→	→	rim	core	→	→	rim	core	→	→	→	→	→	
SiO ₂	42.88	42.86	42.94	42.61	42.12	39.77	42.37	41.52	40.73	39.13	38.66	41.11	41.53	38.22	43.64	42.51	42.72	43.30	42.88	41.13	
TiO ₂	0.76	0.75	0.77	0.69	0.60	0.62	0.37	0.36	0.33	0.41	0.22	0.38	0.32	0.33	0.58	0.76	0.69	0.63	0.57	0.67	
Al ₂ O ₃	10.08	14.19	14.19	14.19	14.22	15.42	14.51	15.04	15.11	15.86	15.59	14.97	14.92	17.46	14.09	14.34	12.64	11.20	13.13	15.38	
FeO*	19.70	17.33	16.62	17.70	17.70	18.12	18.34	18.65	18.87	19.39	21.19	19.10	18.93	19.42	15.34	15.91	16.44	16.55	15.51	17.78	
MnO	0.10	0.11	0.07	0.11	0.11	0.10	0.12	0.12	0.08	0.03	0.14	0.11	0.09	0.14	0.05	0.03	0.01	0.08	0.03	0.06	
MgO	9.67	8.59	8.71	8.44	8.39	7.68	7.86	7.83	7.40	6.68	6.09	7.50	7.50	6.41	9.90	9.48	10.06	10.80	10.30	8.08	
CaO	9.84	7.61	7.70	7.75	7.14	9.29	8.15	8.42	8.55	9.08	9.26	8.46	8.31	9.26	7.43	8.03	8.63	8.74	8.79	8.63	
Na ₂ O	3.43	4.79	4.59	4.60	4.36	3.64	4.38	4.30	4.08	3.51	3.43	4.06	4.17	3.71	4.84	4.52	4.11	3.83	4.26	4.17	
K ₂ O	0.60	0.69	0.64	0.68	0.83	1.41	0.83	0.92	1.07	1.54	1.39	1.00	0.97	1.29	0.57	0.72	0.70	0.64	0.53	1.01	
Cr ₂ O ₃	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	0.00	0.00	
Total	97.05	96.92	96.23	96.77	96.46	96.05	96.93	97.15	96.20	95.64	95.98	96.69	96.75	96.23	96.45	96.30	96.01	95.76	96.00	96.92	
<i>Cations on the basis of 23 oxygens</i>																					
Si	6.459	6.365	6.403	6.343	6.314	6.075	6.338	6.213	6.182	6.032	5.974	6.194	6.245	5.848	6.424	6.320	6.392	6.471	6.398	6.165	
Ti	0.087	0.084	0.087	0.077	0.067	0.071	0.041	0.040	0.037	0.048	0.026	0.043	0.036	0.038	0.064	0.085	0.077	0.071	0.064	0.076	
Al	1.790	2.483	2.494	2.490	2.512	2.776	2.558	2.653	2.703	2.882	2.840	2.658	2.645	3.148	2.445	2.513	2.228	1.973	2.309	2.716	
Fe ³⁺	0.827	0.688	0.617	0.741	0.682	0.537	0.642	0.720	0.671	0.609	0.792	0.759	0.711	0.692	0.744	0.681	0.738	0.914	0.625	0.626	
Fe ²⁺	1.655	1.464	1.456	1.463	1.537	1.778	1.653	1.614	1.723	1.891	1.947	1.648	1.670	1.792	1.145	1.297	1.319	1.154	1.310	1.604	
Mn	0.012	0.013	0.009	0.014	0.013	0.013	0.015	0.015	0.010	0.004	0.019	0.014	0.011	0.018	0.006	0.004	0.001	0.010	0.004	0.008	
Mg	2.171	1.902	1.936	1.873	1.874	1.750	1.753	1.745	1.673	1.535	1.402	1.683	1.682	1.463	2.172	2.100	2.244	2.406	2.290	1.806	
Ca	1.588	1.210	1.231	1.237	1.308	1.521	1.306	1.349	1.390	1.499	1.533	1.365	1.339	1.518	1.173	1.279	1.384	1.399	1.405	1.386	
Na	1.001	1.379	1.327	1.327	1.268	1.077	1.271	1.248	1.200	1.050	1.028	1.187	1.216	1.100	1.382	1.304	1.193	1.108	1.231	1.213	
K	0.115	0.131	0.122	0.130	0.160	0.275	0.159	0.175	0.207	0.302	0.273	0.192	0.187	0.252	0.107	0.136	0.134	0.122	0.101	0.192	
Cr	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	0.000	0.000	
Total	15.704	15.721	15.680	15.693	15.735	15.873	15.736	15.773	15.797	15.852	15.834	15.744	15.742	15.870	15.662	15.718	15.711	15.630	15.737	15.791	
* Total Fe as FeO																					
Sample	03																				

Table 1. (continued)

Sample	03-18																			
No.	143	145	163	17	24	35	13	22	37	47(a)	47(b)	47(c)	109	48	60	69	77	78	79	85
Mode	amp8	amp8	amp8	amp8	amp9	amp9	amp9	amp9	amp9	amp9	amp9	amp9	amp9	amp9	amp9	amp9	amp9	amp9	amp9	amp9
Mineral	Mg-Trm	Mg-Kip	Ed	Mg-Hs	Mg-Hs	Mg-Trm	Mg-Trm	Mg-Hs	Mg-Trm	Mg-Hs	Mg-Hs	Mg-Hs	Mg-Trm	Mg-Trm	Fe-Prg	Mg-Hs	Mg-Hs	Mg-Trm	Fe-Prg	Fe-Prg
SiO ₂	43.15	43.62	44.28	40.70	40.61	41.24	41.11	40.56	40.00	41.11	42.17	42.30	42.38	42.52	39.45	41.92	41.38	42.65	38.50	38.80
TiO ₂	0.56	0.44	0.81	0.33	0.59	0.55	0.48	0.52	0.53	0.80	0.53	0.46	0.61	2.70	0.66	0.58	0.51	0.68	0.31	0.39
Al ₂ O ₃	11.29	11.04	9.54	11.90	14.55	14.35	14.70	14.07	14.24	12.99	12.68	11.20	13.88	13.16	16.37	12.41	13.27	13.71	16.66	17.15
FeO*	19.17	18.57	17.35	19.39	19.50	19.27	18.37	18.52	18.85	20.04	18.78	19.67	18.32	17.33	18.35	18.63	19.35	18.43	19.83	20.10
MnO	0.03	0.07	0.06	0.11	0.11	0.11	0.13	0.13	0.16	0.11	0.06	0.12	0.23	0.18	0.13	0.01	0.07	0.16	0.11	0.09
MgO	9.40	9.76	10.88	8.90	8.43	8.45	8.04	9.01	8.39	8.63	9.50	9.47	8.66	8.60	7.31	9.27	8.57	8.30	6.83	6.14
CaO	9.10	8.83	10.53	9.79	9.39	9.00	8.43	9.75	9.17	9.40	9.45	9.65	8.54	8.33	9.26	9.58	9.83	7.82	9.48	9.19
Na ₂ O	3.65	3.73	2.96	3.03	3.70	4.02	4.14	3.60	3.80	3.57	3.85	3.52	3.92	4.60	3.48	3.25	3.12	4.38	3.40	3.64
K ₂ O	0.69	0.70	0.87	1.37	1.14	0.86	0.83	1.11	1.13	0.90	0.80	0.77	0.92	0.61	1.22	0.92	1.23	0.78	1.56	1.46
Cr ₂ O ₃	0.03	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.02	0.05	0.06	0.00	0.00	0.04	0.00	0.00	0.00
Total	97.06	96.78	97.28	95.52	98.02	97.86	96.23	97.27	96.28	97.55	97.84	97.17	97.49	98.09	96.23	96.56	97.35	96.91	96.68	96.95
<i>Cations on the basis of 23 oxygens</i>																				
Si	6.450	6.510	6.623	6.259	6.056	6.136	6.196	6.091	6.074	6.161	6.269	6.355	6.285	6.312	5.991	6.308	6.223	6.355	5.873	5.911
Ti	0.063	0.050	0.091	0.038	0.066	0.062	0.055	0.059	0.061	0.090	0.060	0.052	0.068	0.302	0.076	0.065	0.057	0.076	0.036	0.044
Al	1.988	1.942	1.681	2.156	2.558	2.516	2.611	2.490	2.549	2.295	2.222	1.983	2.426	2.302	2.930	2.201	2.351	2.407	2.996	3.079
Fe ³⁺	0.879	0.901	0.493	0.851	0.909	0.892	0.796	0.814	0.858	0.973	0.846	0.921	0.847	0.373	0.660	0.838	0.772	0.821	0.779	0.651
Fe ²⁺	1.518	1.417	1.677	1.642	1.524	1.505	1.520	1.512	1.536	1.538	1.489	1.551	1.425	1.779	1.671	1.507	1.662	1.476	1.752	1.910
Mn	0.004	0.009	0.008	0.014	0.014	0.013	0.017	0.016	0.020	0.014	0.008	0.015	0.028	0.022	0.017	0.001	0.009	0.021	0.014	0.011
Mg	2.094	2.171	2.427	2.039	1.873	1.874	1.806	2.018	1.900	1.928	2.106	2.120	1.915	1.903	1.655	2.080	1.921	1.844	1.552	1.393
Ca	1.457	1.412	1.687	1.613	1.501	1.435	1.361	1.568	1.492	1.509	1.506	1.553	1.357	1.326	1.507	1.545	1.583	1.248	1.550	1.501
Na	1.058	1.079	0.858	0.903	1.069	1.160	1.210	1.048	1.119	1.038	1.111	1.027	1.128	1.323	1.024	0.948	0.909	1.265	1.005	1.076
K	0.132	0.133	0.166	0.269	0.218	0.163	0.160	0.212	0.218	0.171	0.151	0.147	0.173	0.116	0.237	0.176	0.236	0.148	0.304	0.283
Cr	0.003	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.002	0.000	0.000	0.002	0.006	0.007	0.000	0.000	0.004	0.000	0.000	0.000
Total	15.646	15.625	15.711	15.786	15.788	15.759	15.731	15.828	15.829	15.719	15.768	15.726	15.658	15.765	15.768	15.669	15.728	15.660	15.859	15.859

* Total Fe as FeO