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Article

Chemical compositions of white-micas (muscovite, phengite and paragonite) from the Seba eclogitic basic schists in the Sambagawa metamorphic belt, central Shikoku, Japan

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Abstract

The Seba eclogitic basic schists in the Besshi district of central Shikoku consist mainly of garnet, clinopyroxene (omphacite and aegirine-augite), sodic, sodic-calcic and calcic-amphiboles, epidote, and phengite, along with small amounts of rutile, titanite, albite, hematite, and quartz. Chlorite, paragonite, and carbonate minerals occur occasionally. White micas in the eclogites exhibit several modes of occurrence (Ms1, Ph1-5 and Pg1-2). Muscovite (Ms1) inclusions are restricted to the cores of porphyroblastic garnets, whereas phengite (Ph1) and paragonite (Pg1) are included in their mantles. Phengite (Ph2) occurs as inclusions in omphacites in the matrix. Schistosity-forming phengite (Ph3) and some paragonite (Pg2) occurs in the matrix. Large grains of phengite (Ph4) occasionally grow oblique to the matrix schistosity, and phengite (Ph5) also surrounds porphyroblastic garnets. Phengites in the Sebadani area show several modes of occurrence and an extensive range of chemical compositions, suggesting a variety of equilibrium metamorphic *P-T* conditions. Muscovite inclusions in the cores of the garnets probably represent relict minerals of a precursor stage, and show relatively high-*T*/*P* metamorphic conditions. Phengite (Ph1) and paragonite (Pg1) inclusions in the porphyroblastic garnets and phengite (Ph2) inclusions in the omphacites are the products of prograde to peak metamorphic conditions from the epidote-amphibolite facies to the eclogite facies. Phengites (Ph3) in the matrix represent peak metamorphism of the eclogite facies, coexisting with the outermost mantles of the porphyroblastic garnet, omphacite and barroisitic amphibole. Phengites (Ph4) occurring at random orientation to the matrix schistosity suggests the eclogites in the Sebadani area were affected by deformation to varying degrees. Phengites (Ph5) surrounding porphyroblastic garnets are the product of retrograde metamorphism after the eclogite facies peak.

Key words: Sambagawa (Sanbagawa), Besshi district, Seba eclogite, phengite, paragonite.

Introduction

The Sambagawa metamorphic belt of southwest Japan is one of the best-studied examples of subduction-type high-pressure metamorphic belts world-wide. The Sambagawa metamorphic belt extends for about 800 km throughout southwest Japan. Metamorphic grades range from the pumpellyite-actinolite facies through the blueschist / greenschist facies transition to the epidote-amphibolite facies (e.g. Banno, 1964; Higashino, 1990; Enami *et al*., 1994). Most parts of the Sambagawa metamorphic belt underwent high-*P*/*T* metamorphism during the Cretaceous period (e.g. Itaya and Takasugi, 1988; Takasu and Dallmeyer, 1990).

The Sambagawa belt in central Shikoku consists of the Oboke nappe complex and the structurally overlying Besshi nappe complex. The Oboke nappe complex consists of low-grade psammitic and pelitic schists with minor basic, siliceous and conglomeratic schists, whereas the Besshi nappe complex is dominated by pelitic schists, intercalated basic schists, and minor amounts of siliceous and calcareous schists. In the Besshi district the metamorphism is divided into four zones based on index minerals in the pelitic schists, namely the chlorite, garnet, albite-biotite, and oligoclase-biotite zones (Fig. 1; Enami, 1983; Enami *et al*., 1994). The higher-grade albite-biotite and oligoclase-biotite zones are equivalent to those of the epidote-amphibolite facies. Several eclogite-bearing bodies occur in the higher-grade zones (Takasu 1984, 1989; Kunugiza *et al*., 1986; Aoya, 2001; Kugimiya and Takasu, 2002; Ota *et al*., 2004).

The Sebadani area is located in the central part of the Besshi district, and lies within the albite-biotite zone (Higashino, 1990) (Fig. 1). The Seba area is composed of the Sebadani metagabbro mass (150 × 250 m) and surrounding Seba basic schists and pelitic schists (Takasu and Makino, 1980; Takasu, 1984). The eclogitic mineral assemblage of garnet and omphacite is sporadically preserved in both the Sebadani metagabbro mass and in the Seba basic schists (Takasu, 1984; Naohara and Aoya, 1997; Aoya and Wallis, 1999).

In this paper we describe the modes of occurrence and chemistry of white micas in the Seba eclogitic basic schists. The mineral abbreviations used in the text, tables and figures follow Whitney and Evans (2010).

Petrography and mode of occurrence of white micas in Seba eclogite

The Seba eclogitic basic schists consist mainly of garnet, clinopyroxene (omphacite and aegirine-augite), sodic, sodic-calcic and calcic-amphiboles, epidote, and phengite, with minor amounts of rutile, titanite, albite, hematite

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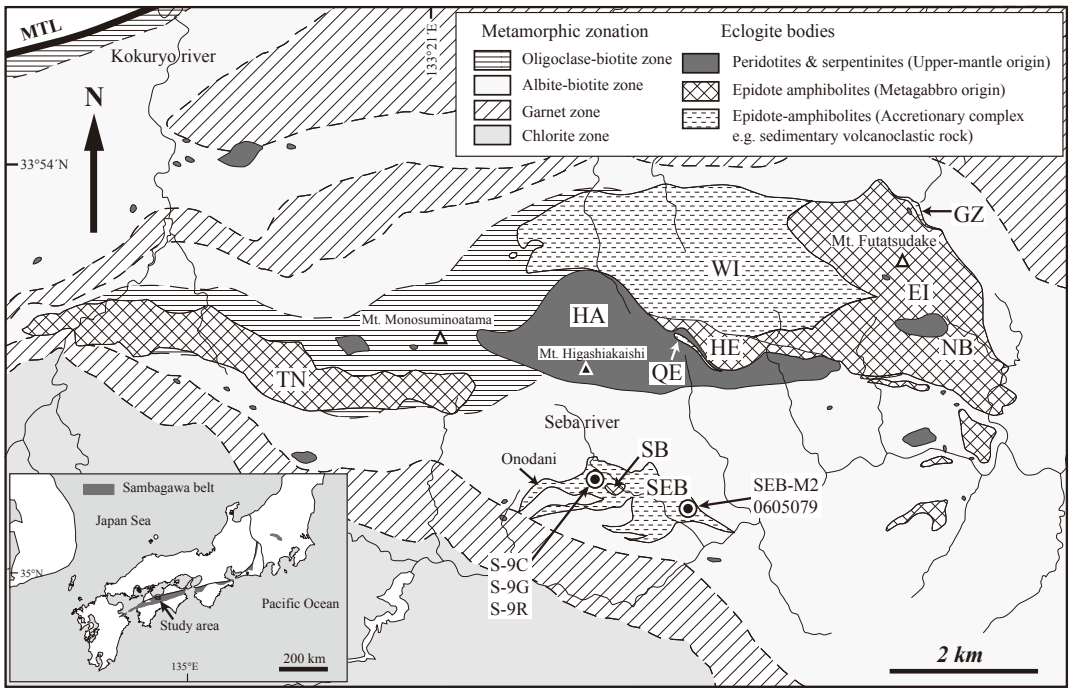

Fig. 1. Geological and metamorphic zonation map of the Sambagawa metamorphic belt in the Besshi district, central Shikoku, Japan (compiled from Higashino, 1990; Takasu and Makino, 1980; Takasu, 1989; Kugimiya and Takasu, 2002; Sakurai and Takasu, 2009, Kabir and Takasu, 2010a). SB, Seba metagabbro mass; SEB, Seba basic schists; TN, Tonaru metagabbro mass; WI, Western Iratsu mass; EI, Eastern Iratsu mass; HA, Higashi-akaishi peridotite mass; QE, Quartz eclogite mass; HE, Hornblende eclogite mass; NB, Nikubuchi peridotite mass; GZ, Gazo eclogite mass; MTL, Median Tectonic Line.

and quartz (Fig. 2a). Chlorite, paragonite and carbonates (calcite and ankerite) occur occasionally. Garnets occur as euhedral to subhedral porphyroblasts up to 5 mm in diameter (Figs. 2a-b, d). The cores of the porphyroblastic garnets contain inclusions of sodic and sodic-calcic amphiboles (e.g. glaucophane, winchite, barroisite, taramite, Mg-taramite), epidote (X_{Ps} 0.24-0.29), paragonite, muscovite (Si 6.04-6.22 pfu), albite (An < 3), titanite, hematite, chlorite, calcite, and quartz. The mantles of the garnets contain inclusions of omphacite (X_{Jd} 0.25-0.39), sodic-calcic amphiboles (e.g. barroisite, ferro-barroisite, taramite, Mg-taramite, katophorite, Mg-katophorite), epidote (X_{Ps} 0.24-0.32), phengite (Si 6.60-6.79 pfu), rutile, titanite, albite (An < 3), chlorite, and quartz (Kabir and Takasu, 2010b). A schistosity is defined by preferred orientation of phengite, and a lineation on the schistosity is defined by aligned prismatic omphacite and sodic-calcic / calcic-amphibole (Kabir and Takasu, 2010b).

White micas in the eclogite exhibit several modes of occurrence (Ms1, Ph1-5, and Pg1-2). Phengites (Ph1) occur as inclusions in the porphyroblastic garnets, mostly in their mantle. These phengites developed an internal schistosity in the garnets, along with other minerals. Some phengites in the garnets reach diameters of 1.5 mm (Fig. 2b). The cores of the garnets contain inclusions of paragonite (Pg1) and muscovite (Ms1) (Fig. 2d). Phengites (Ph2) occurring as inclusions in the matrix omphacites are fine grained, and up to 0.2 mm in size (Fig. 2c). Schistosity forming phengites (Ph3) in the matrix occur as euhedral to subhedral grains up to 2 mm across (Fig. 2e), containing inclusions of epidote, quartz, rutile and calcite. The rims of phengites (Ph3) are occasionally replaced by biotite. Large phengite grains (Ph4) occasionally grow oblique to the matrix schistosity (Fig. 3a). These are euhedral to subhedral, occurring as grains up to 1.5 mm across. Phengites (Ph5) occur surrounding porphyroblastic garnets together with epidote (X_{Ps} 0.23-0.29), Na-Ca amphibole (e.g. barroisite, Mg-katophorite, Mg-taramite), albite (An < 2), chlorite, and quartz (Kabir and Takasu, 2010b) (Fig. 3b). Paragonites (Pg2) also occur as discrete grains, or in association with phengite (Ph3 / Ph4) in the matrix (Fig. 2f).

Chemistry of white micas

The chemical compositions and zoning of the phengites in the Seba eclogitic basic schists were investigated by electron microprobe analysis in Shimane University, using JEOL JXA 8800M and 8530F electron probe microanalyzers. The analytical conditions used for quantitative analysis were 15 kV accelerating potential, 20 nA specimen current, and 5 μm beam diameter. Correction procedure was carried out as described by Bence and Albee (1968).

Muscovite (Ms1) inclusions restricted to the cores of the porphyroblastic garnets are low in Si (6.04-6.22 pfu), X_{Na} (Na / Na + K) (0.01-0.25) and Ti (0-0.03 pfu), and Ca contents reach 0.20 pfu (Fig. 4; Table 1). Paragonite (Pg1) inclusions in the porphyroblastic garnet cores show a range of Si contents from 5.79 to 6.06 pfu, X_{Na} 0.79-0.99 and Ca content of 0.02-

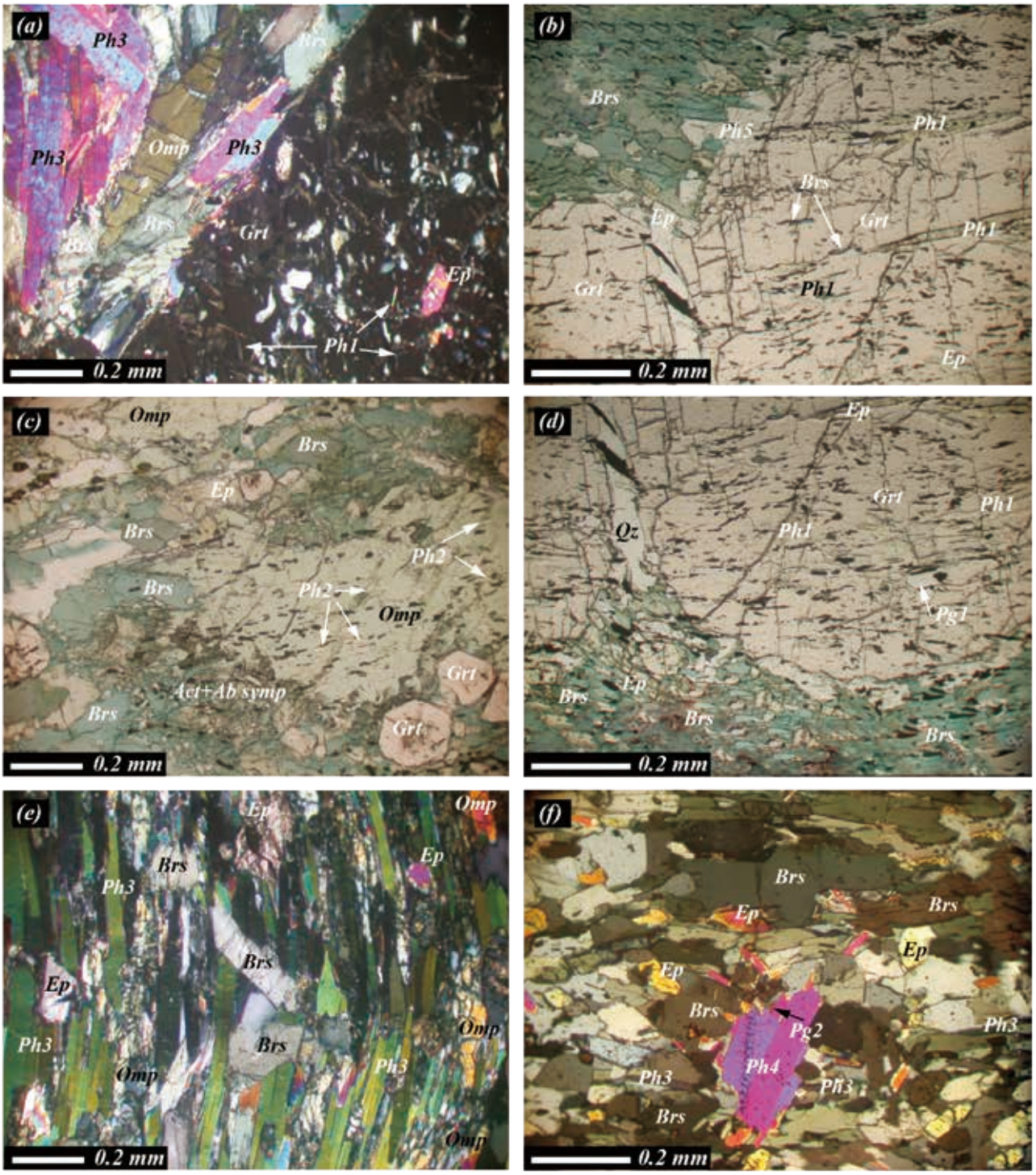

Fig. 2. Photomicrographs showing textural relationships of minerals in the Seba eclogitic basic schists. (a) Porphyroblastic garnet and schistosity-forming omphacite, barroisitic amphibole and phengite (Ph3). Porphyroblastic garnet contains inclusions of phengite (Ph1) and epidote. (b) Porphyroblastic garnets and surrounding matrix minerals (barroisitic amphibole and phengite) (Ph5). The garnets contain inclusions of phengite (Ph1), barroisitic amphibole and epidote. (c) Clinopyroxene (omphacite) in the matrix containing inclusions of phengite (Ph2). (d) Porphyroblastic garnets and matrix minerals including barroisitic amphibole, epidote and quartz. The garnets contain inclusions of phengite (Ph1), paragonite (Pg1) and epidote. (e) Schistosity-forming phengite (Ph3) in the matrix and other matrix minerals (omphacite, barroisitic amphibole and epidote). (f) Matrix paragonite (Pg2), together with randomly oriented phengite (Ph4) and schistosity-forming phengite (Ph3), barroisitic amphibole, and epidote.

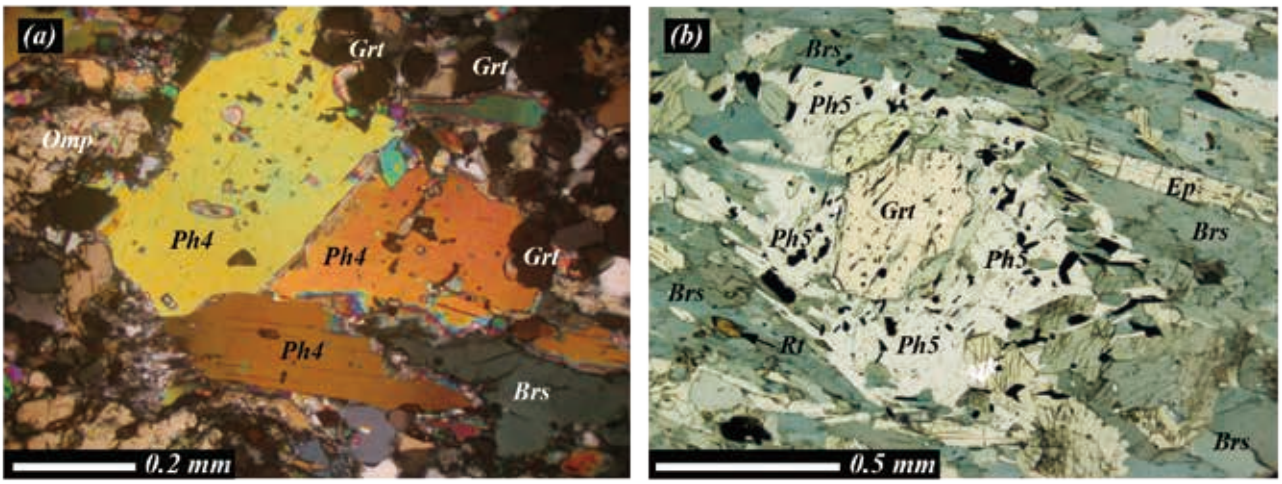

Fig. 3. Photomicrographs showing textural relationships of minerals in the Seba eclogitic basic schists. (a) Coarse-grained randomly oriented phengite (Ph4). (b) Garnet in the matrix, surrounded by phengite (Ph5) and other matrix minerals (barroisitic amphibole, epidote, and rutile).

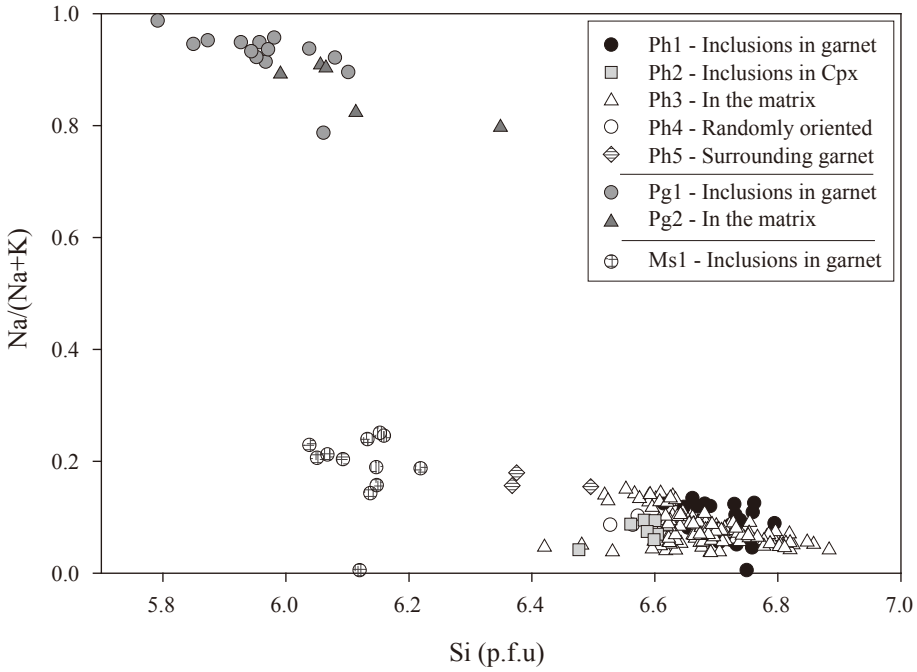

Fig. 4. Chemical composition of white micas from the Seba eclogitic basic schists.

0.12 pfu. Phengite (Ph1) inclusions occurring in the mantles of the porphyroblastic garnets have Si (6.60-6.79 pfu), X_{Na} (0.01-0.14) and Ti (0.02-0.06 pfu), whereas inclusions in the omphacites (Ph2) have slightly lower Si (6.48-6.60 pfu), X_{Na} (0.04-0.09) and Ti (0-0.07 pfu). Phengites in the matrix (Ph3) have wide ranges of Si (6.42-6.88 pfu), X_{Na}(0.04-0.15), Ti (0.03-0.06 pfu) and Ca (0-0.10 pfu) than the phengite (Ph1) inclusions within the garnets. Phengites (Ph3) in the matrix are zoned, with increasing Si (6.64-6.85 pfu) and decreasing X_{Na} (0.09-0.05) from cores to rims. Paragonites (Pg2) in the matrix are relatively richer in Si (5.99-6.35 pfu) and poorer in X_{Na} (0.80-0.91) and Ca (0.02-0.03 pfu) than paragonite (Pg1) inclusions within garnets. Randomly oriented phengites (Ph4) in the matrix have narrow ranges of Si (6.53-6.57 pfu), X_{Na} (0.09-0.10) and Ti (0-0.4 pfu). Phengites (Ph5) surrounding garnets have relatively low Si (6.37-6.50 pfu) and Ti (0-0.2 pfu) contents, and higher X_{Na} (0.16-0.18) contents than any other phengites in the eclogites.

Discussion and Conclusions

The cores of the garnets in the eclogitic basic schists contain inclusions of two differing groups of minerals, i.e. sodic and sodic-calcic amphiboles (e.g. glaucophane, winchite, barroisite, taramite, Mg-taramite), epidote (X_{Ps} 0.24-0.29), paragonite, albite (An < 3), titanite, hematite, chlorite, calcite and quartz. Glaucophane is typically stable in low-temperature and high-pressure metamorphic conditions, whereas muscovite (Ms1) (Si 6.04-6.22 pfu) is stable in relatively high-temperature and low-pressure conditions. These features suggest that glaucophane and muscovite were probably not in equilibrium at the same time. Muscovite inclusions in the cores of the garnets probably represent relict minerals of a precursor stage, and exhibit relatively high-*T*/*P* metamorphic conditions similar to those identified in the Seba pelitic schists by Kabir and Takasu (2009).

Phengite (Ph1) and paragonite (Pg1) inclusions in the porphyroblastic garnets and phengite (Ph2) inclusions in the clinopyroxenes crystallized before or during the garnet growth. These are the product of the prograde to peak metamorphism from the epidote-amphibolite facies to the eclogite facies metamorphic conditions. Phengites (Ph3) in the matrix represent a peak metamorphism of the eclogite facies (Kabir and Takasu, 2010b). The peak metamorphic conditions are defined by the schistosity-forming minerals coexisting with the outermost mantles of the porphyroblastic garnets, i.e. omphacite, barroisitic amphibole, phengite (Si 6.62-6.88 pfu), rutile and quartz (Kabir and Takasu, 2010b). The estimated peak metamorphic conditions of the eclogites are 12-24 kbar and 610-640˚C (Aoya, 2001; Kabir and Takasu, 2010c). Phengites (Ph4) occurring as crystals oriented randomly to the matrix schistosity are similar to omphacites in the R-type eclogites defined by Aoya and Wallis (1999). The R-type eclogites were previously reported as confined only to the area adjacent to the Sebadani metagabbro mass (Aoya and Wallis, 1999), but have now been identified at a locality 1 km distant from the mass (Kabir and Takasu, 2010c). The eclogites in the Sebadani area were affected by deformation of varying degrees, resulting in the formation of a variety of omphacite textural types (e.g. lineated and randomly oriented) (Aoya and Wallis, 1999).

The retrograde stage is defined by the phases replacing the minerals of the peak metamorphic stage. Some phengites (Ph5) surround porphyroblastic garnets together with epidote (X_{Ps} 0.23-0.29), Na-Ca amphibole (e.g. barroisite, Mg-katophorite, Mg-taramite), albite (An < 2), chlorite, and quartz. These are the product of retrograde metamorphism (Kabir and Takasu, 2010b).

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（要　旨）

高須　晃・Kabir, Md. Fazle., 2012 四国中央部三波川変成帯瀬場エクロジャイト質塩基性片岩中の白色雲母（白雲母・フェンジャイト・パラゴナイト）の化学組成．島根大学地球資源環境学研究報告，31, 49-58.

四国中央部別子地域の瀬場エクロジャイト質塩基性片岩は主要構成鉱物としてざくろ石、単斜輝石（オンファス輝石・エジリン - オージャイト），Na-, Na-Ca-, Ca- 角閃石，緑れん石，フェンジャイト，微量成分鉱物としてルチル，チタン石，曹長石，赤鉄鉱，石英を含む．また，緑泥石，パラゴナイト，炭酸塩鉱物を含む場合もある．エクロジャイト中の白色雲母には白雲母（Ms 1），フェンジャイト（Ph 1-5)，およびパラゴナイト（Pg 1-2）があり，それらはさまざまな産状を示す．白雲母（Ms 1）は斑状変晶ざくろ石のコア部の包有物としてのみ産出する．一方，フェンジャイト（Ph 1）とパラゴナイト（Pg 1）は斑状変晶ざくろ石のマントル部の包有物として産出する．Ph 2 は基質中のオンファス輝石中の包有物として産出する．Ph 3 と Pg 2 は基質において定向配列して片理を形成する．粗粒の Ph 4 は片理と斜行して成長することがある．Ph 5 はざくろ石斑状変晶を取り囲んで産する．瀬場谷地域のフェンジャイトは多様な産状を示し，また化学組成の多様性を示す．これは形成された P-T 条件の違いを反映している．ざくろ石のコアに包有される白雲母はおそらく相対的に高い T/P 条件の変成作用時のレリックであると考えられる．

斑状変晶ざくろ石に包有される Ph 1 と Pg 1 及びオンファス輝石中の Ph 2 包有物は緑れん石角閃岩相からエクロジャイト相への昇温変成作用の間に形成された．基質中の Ph 3 はエクロジャイト相のピーク変成作用中の産物であり，斑状変晶ざくろ石のマントル最外縁部，オンファス輝石及びバロワ閃石と平衡にあった．方向性をもたない Ph 4 の存在は瀬場谷地域のエクロジャイトの受けた変形作用に多様性のあることを示す．ざくろ石を取り囲んで産する Ph 5 はエクロジャイト相のピーク変成作用の後の降温変成作用中に形成されたものである．

Table 1. Representative chemical compositions of white micas from the Seba eclogitic basic schists.

Sample	S 9C																		
Analysis	2	19	21	22	23	24	96	53	5	1	2	17	55	108	38	33	34	6	83
Mode	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1	Ph1
SiO_2	48.52	48.16	48.96	49.05	49.04	48.97	49.99	49.69	50.13	50.09	49.20	49.08	49.72	50.65	48.37	50.53	51.06	51.29	49.38
TiO_2	0.27	0.35	0.23	0.23	0.20	0.20	0.19	0.20	0.41	0.41	0.48	0.37	0.27	0.50	0.15	0.33	0.36	0.39	0.26
Al_2O_3	26.81	27.61	27.18	26.87	26.96	27.20	27.07	26.76	26.41	26.45	27.10	25.94	27.60	28.08	22.46	27.39	28.01	27.87	26.56
FeO*	4.14	3.95	3.96	4.11	3.97	4.19	3.72	3.68	5.14	3.87	3.89	4.67	2.54	1.91	7.63	3.28	3.67	2.28	3.40
MnO	0.07	0.08	0.05	0.01	0.02	0.09	0.04	0.07	0.00	0.00	0.00	0.02	0.00	0.03	0.04	0.03	0.03	0.01	0.00
MgO	3.22	2.59	3.10	3.07	3.13	3.08	3.28	3.29	3.23	3.49	3.22	3.41	3.13	3.21	5.10	3.25	3.11	3.01	2.94
CaO	0.02	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.02	0.09	0.05	0.00	0.00	0.03	0.06	0.08	0.17	0.03	0.00
Na_2O	0.91	0.95	0.90	0.92	0.96	1.02	0.94	0.80	0.45	0.46	0.62	0.44	0.66	0.71	0.05	0.33	0.37	0.67	0.97
K_2O	10.21	9.96	9.97	10.12	10.21	9.86	10.00	10.30	10.74	10.32	10.31	11.08	10.38	10.21	10.75	10.16	10.06	10.28	10.07
Total	94.18	93.65	94.35	94.38	94.49	94.59	95.24	94.81	96.53	95.18	94.86	95.00	94.29	95.33	94.61	95.37	96.82	95.83	93.57
Cations on the basis of 12 oxygens																			
Si	6.65	6.61	6.67	6.69	6.68	6.66	6.73	6.73	6.73	6.76	6.67	6.70	6.72	6.74	6.75	6.76	6.73	6.79	6.76
Ti	0.03	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.05	0.04	0.03	0.05	0.02	0.03	0.04	0.04	0.03
Al	4.33	4.47	4.36	4.32	4.33	4.36	4.29	4.27	4.18	4.20	4.33	4.18	4.40	4.40	3.69	4.32	4.35	4.35	4.29
Fe*	0.47	0.45	0.45	0.47	0.45	0.48	0.42	0.42	0.58	0.44	0.44	0.53	0.29	0.21	0.89	0.37	0.40	0.25	0.39
Mn	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.66	0.53	0.63	0.62	0.64	0.62	0.66	0.66	0.65	0.70	0.65	0.69	0.63	0.64	1.06	0.65	0.61	0.59	0.60
Ca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00
Na	0.24	0.25	0.24	0.24	0.25	0.27	0.25	0.21	0.12	0.12	0.16	0.12	0.17	0.18	0.01	0.09	0.09	0.17	0.26
K	1.78	1.74	1.73	1.76	1.77	1.71	1.72	1.78	1.84	1.78	1.78	1.93	1.79	1.73	1.91	1.73	1.69	1.74	1.76
Total	14.17	14.11	14.11	14.13	14.15	14.13	14.09	14.10	14.12	14.05	14.09	14.19	14.03	13.96	14.35	13.96	13.95	13.95	14.08
X_{Na}	0.12	0.13	0.12	0.12	0.13	0.14	0.13	0.11	0.06	0.06	0.08	0.06	0.09	0.10	0.01	0.05	0.05	0.09	0.13

**Total Fe as FeO*

Sample	S 9C																		
Analysis	84	1	2	20	21	1	2	3	4	5	6	7	8	9	10	11	12	13	15
Mode	Ph1	Ph4	Pg2	Ph4	Ph4	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Pg2	Pg2	Pg2	Ph3
SiO_2	49.24	47.95	45.36	48.12	47.94	47.78	47.74	48.01	47.86	47.92	48.22	47.41	47.18	48.01	48.04	46.15	47.91	46.19	48.91
TiO_2	0.29	0.41	0.11	0.41	0.43	0.43	0.41	0.42	0.45	0.40	0.43	0.48	0.47	0.45	0.50	0.13	0.15	0.12	0.33
Al_2O_3	26.67	28.25	38.48	28.85	29.02	27.42	27.79	27.87	27.85	27.78	27.48	28.58	28.41	27.69	28.31	37.63	34.78	36.81	27.93
FeO*	3.08	3.48	1.05	3.47	3.64	3.45	3.37	3.46	3.51	3.61	3.42	3.66	3.51	3.44	3.52	1.07	1.54	1.19	3.38
MnO	0.04	0.03	0.00	0.02	0.00	0.00	0.03	0.00	0.02	0.00	0.02	0.00	0.00	0.03	0.01	0.03	0.00	0.00	0.00
MgO	2.92	2.68	0.09	2.63	2.75	2.58	2.64	2.58	2.56	2.57	2.72	2.27	2.30	2.60	2.48	0.14	0.47	0.28	2.73
CaO	0.00	0.00	0.23	0.00	0.02	0.03	0.01	0.02	0.03	0.02	0.00	0.03	0.02	0.02	0.02	0.17	0.18	0.13	0.03
Na_2O	0.82	0.76	4.34	0.59	0.60	0.96	1.06	1.01	0.98	0.91	1.07	1.09	1.00	1.10	1.09	6.61	5.20	5.99	0.83
K_2O	10.04	9.97	0.65	9.38	9.41	9.84	9.93	9.91	10.02	10.20	10.00	10.07	10.07	9.89	9.90	1.06	2.00	1.93	10.14
Total	93.11	93.53	90.30	93.46	93.81	92.51	92.96	93.27	93.28	93.40	93.36	93.58	92.95	93.23	93.86	92.98	92.22	92.63	94.26
Cations on the basis of 12 oxygens																			
Si	6.76	6.57	6.06	6.56	6.53	6.62	6.59	6.60	6.59	6.60	6.63	6.52	6.52	6.61	6.57	6.06	6.35	6.11	6.65
Ti	0.03	0.04	0.01	0.04	0.04	0.05	0.04	0.04	0.05	0.04	0.04	0.05	0.05	0.05	0.05	0.01	0.01	0.01	0.03
Al	4.31	4.56	6.05	4.64	4.66	4.48	4.52	4.52	4.52	4.51	4.45	4.63	4.63	4.49	4.56	5.83	5.43	5.74	4.47
Fe*	0.35	0.40	0.12	0.40	0.41	0.40	0.39	0.40	0.40	0.42	0.39	0.42	0.41	0.40	0.40	0.12	0.17	0.13	0.38
Mn	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
Mg	0.60	0.55	0.02	0.53	0.56	0.53	0.54	0.53	0.52	0.53	0.56	0.46	0.47	0.53	0.50	0.03	0.09	0.06	0.55
Ca	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.02	0.00
Na	0.22	0.20	1.12	0.16	0.16	0.26	0.28	0.27	0.26	0.24	0.28	0.29	0.27	0.29	0.29	1.68	1.34	1.54	0.22
K	1.76	1.74	0.11	1.63	1.63	1.74	1.75	1.74	1.76	1.79	1.75	1.77	1.78	1.74	1.73	0.18	0.34	0.33	1.76
Total	14.04	14.07	13.52	13.96	14.00	14.09	14.12	14.10	14.11	14.12	14.12	14.14	14.13	14.11	14.11	13.94	13.76	13.94	14.07
X_{Na}	0.11	0.10	0.91	0.09	0.09	0.13	0.14	0.13	0.13	0.12	0.14	0.14	0.13	0.14	0.14	0.90	0.80	0.82	0.11

**Total Fe as FeO*

Sample	S 9C			S 9G															
Analysis	16	17	18	21	22	24	25	26	27	69	73	74	75	76	77	78	83	84	129
Mode	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3
SiO_2	47.90	48.18	48.71	48.69	49.19	48.38	48.39	47.83	48.78	47.67	48.21	48.06	48.12	48.64	48.01	48.08	48.64	49.84	48.30
TiO_2	0.43	0.50	0.45	0.48	0.36	0.52	0.44	0.53	0.44	0.53	0.52	0.52	0.48	0.39	0.51	0.43	0.32	0.30	0.38
Al_2O_3	28.54	28.28	28.28	26.99	26.35	26.72	26.90	26.92	26.86	27.09	27.10	27.03	26.61	26.18	26.48	26.66	26.33	25.10	26.47
FeO*	3.39	3.50	3.33	3.98	3.95	3.72	4.01	4.13	4.11	4.08	4.31	4.01	4.16	3.95	4.03	3.86	4.12	3.80	4.07
MnO	0.00	0.00	0.01	0.00	0.00	0.01	0.04	0.00	0.03	0.02	0.00	0.02	0.07	0.00	0.01	0.06	0.00	0.00	0.05
MgO	2.47	2.52	2.58	2.90	3.01	2.94	2.91	2.73	3.02	2.82	2.80	2.87	2.86	3.09	2.84	2.82	3.02	3.42	2.97
CaO	0.00	0.00	0.00	0.06	0.05	0.00	0.00	0.04	0.06	0.04	0.00	0.05	0.03	0.01	0.01	0.00	0.03	0.03	0.05
Na_2O	1.16	1.03	0.99	0.47	0.51	0.70	0.51	0.69	0.35	0.71	0.73	0.77	0.74	0.65	0.68	0.68	0.60	0.39	0.46
K_2O	9.85	10.04	10.12	10.48	10.51	10.33	10.32	10.12	10.48	9.98	10.11	9.99	9.97	10.14	10.08	10.20	10.22	10.47	10.37
Total	93.74	94.05	94.48	94.06	93.92	93.31	93.52	92.99	94.11	92.93	93.77	93.32	93.04	93.04	92.65	92.79	93.28	93.35	93.10
Cations on the basis of 12 oxygens																			
Si	6.55	6.57	6.61	6.67	6.74	6.67	6.66	6.63	6.68	6.61	6.63	6.63	6.66	6.72	6.67	6.67	6.71	6.86	6.69
Ti	0.04	0.05	0.05	0.05	0.04	0.05	0.05	0.06	0.04	0.06	0.05	0.05	0.05	0.04	0.05	0.04	0.03	0.03	0.04
Al	4.60	4.55	4.52	4.35	4.26	4.34	4.36	4.40	4.33	4.42	4.39	4.39	4.34	4.26	4.34	4.36	4.28	4.07	4.32
Fe*	0.39	0.40	0.38	0.46	0.45	0.43	0.46	0.48	0.47	0.47	0.50	0.46	0.48	0.46	0.47	0.45	0.48	0.44	0.47
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.01
Mg	0.50	0.51	0.52	0.59	0.62	0.61	0.60	0.56	0.62	0.58	0.57	0.59	0.59	0.64	0.59	0.58	0.62	0.70	0.61
Ca	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Na	0.31	0.27	0.26	0.13	0.13	0.19	0.14	0.19	0.09	0.19	0.19	0.20	0.20	0.17	0.18	0.18	0.16	0.10	0.12
K	1.72	1.75	1.75	1.83	1.84	1.82	1.81	1.79	1.83	1.76	1.77	1.76	1.76	1.79	1.79	1.81	1.80	1.84	1.83
Total	14.11	14.11	14.09	14.08	14.08	14.10	14.08	14.10	14.07	14.10	14.10	14.10	14.09	14.08	14.09	14.10	14.09	14.04	14.09
X_{Na}	0.15	0.14	0.13	0.06	0.07	0.09	0.07	0.09	0.05	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.08	0.05	0.06

**Total Fe as FeO*

Table 1. (continued)

Sample	S 9G																			
Analysis	175	176	177	178	204	205	221	222	223	224	225	226	249	250	251	252	253	254	255	
Mode	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	
	Core	→	→	Rim	Core	Rim	Rim	←	←	Core	→	Rim	←	←	←	←	←	←	Core	
SiO_2	47.23	47.14	47.32	47.76	48.56	48.41	48.19	48.28	48.34	49.16	49.14	48.10	49.16	49.59	48.92	48.95	47.97	48.02	48.03	
TiO_2	0.45	0.53	0.50	0.43	0.47	0.49	0.38	0.40	0.48	0.27	0.34	0.41	0.31	0.31	0.26	0.24	0.50	0.53	0.48	
Al_2O_3	26.99	27.11	26.88	26.78	27.73	27.02	26.74	26.37	26.55	25.53	25.46	27.22	24.99	24.52	24.96	25.14	26.64	26.75	27.31	
FeO*	3.94	3.99	4.17	4.05	3.96	3.86	3.86	3.91	4.24	3.93	3.74	3.84	4.01	3.81	4.03	4.03	4.40	4.23	3.86	
MnO	0.00	0.02	0.02	0.00	0.00	0.05	0.00	0.06	0.03	0.06	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.03	
MgO	2.80	2.80	2.79	2.87	2.66	2.83	3.03	2.97	2.86	3.24	3.39	2.86	3.40	3.49	3.31	3.33	2.90	2.81	2.71	
CaO	0.04	0.00	0.02	0.00	0.03	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.04	0.00	0.02	0.01	
Na_2O	0.62	0.70	0.70	0.72	0.54	0.73	0.65	0.63	0.71	0.50	0.43	0.41	0.38	0.32	0.32	0.42	0.69	0.75	0.67	
K_2O	10.16	9.94	10.10	9.99	10.35	10.26	10.07	10.05	10.04	10.56	10.66	10.71	10.52	10.69	10.69	10.30	10.03	10.03	10.18	
Total	92.22	92.22	92.51	92.60	94.29	93.64	92.96	92.66	93.25	93.26	93.17	93.53	92.79	92.72	92.48	92.45	93.12	93.13	93.27	
Cations on the basis of 12 oxygens																				
Si	6.60	6.58	6.60	6.64	6.62	6.65	6.66	6.70	6.68	6.79	6.79	6.63	6.82	6.88	6.82	6.81	6.64	6.64	6.62	
Ti	0.05	0.06	0.05	0.04	0.05	0.05	0.04	0.04	0.05	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.05	0.05	0.05	
Al	4.44	4.46	4.42	4.39	4.46	4.38	4.36	4.31	4.32	4.16	4.15	4.42	4.09	4.01	4.10	4.12	4.35	4.36	4.44	
Fe*	0.46	0.47	0.49	0.47	0.45	0.44	0.45	0.45	0.49	0.45	0.43	0.44	0.47	0.44	0.47	0.47	0.51	0.49	0.45	
Mn	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Mg	0.58	0.58	0.58	0.60	0.54	0.58	0.62	0.61	0.59	0.67	0.70	0.59	0.70	0.72	0.69	0.69	0.60	0.58	0.56	
Ca	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	
Na	0.17	0.19	0.19	0.19	0.14	0.19	0.18	0.17	0.19	0.13	0.11	0.11	0.10	0.09	0.09	0.11	0.18	0.20	0.18	
K	1.81	1.77	1.80	1.77	1.80	1.80	1.78	1.78	1.77	1.86	1.88	1.88	1.86	1.89	1.90	1.83	1.77	1.77	1.79	
Total	14.12	14.11	14.13	14.10	14.07	14.10	14.09	14.08	14.09	14.10	14.09	14.11	14.08	14.07	14.09	14.07	14.10	14.10	14.09	
X_{Na}	0.08	0.10	0.10	0.10	0.07	0.10	0.09	0.09	0.10	0.07	0.06	0.05	0.05	0.04	0.04	0.06	0.09	0.10	0.09	

**Total Fe as FeO*

Sample	S 9G																			
Analysis	256	27	28	29	31	32	33	34	42	43	45	46	47	51	52	53	54	55	56	
Mode	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	
		Rim	←	Core	Rim	Core	Rim	←	←	←	Core	→	Rim							
SiO_2	49.56	47.07	47.96	47.83	49.03	48.77	47.98	48.24	48.23	48.46	48.70	48.32	48.23	48.65	48.30	48.49	48.24	48.04	49.00	
TiO_2	0.37	0.61	0.51	0.59	0.40	0.44	0.39	0.50	0.40	0.40	0.32	0.45	0.53	0.51	0.47	0.49	0.45	0.52	0.34	
Al_2O_3	25.00	28.30	27.12	27.19	26.59	26.52	27.09	26.82	27.34	26.48	26.71	27.00	27.51	27.37	27.61	27.72	27.58	27.28	26.74	
FeO*	3.94	3.98	4.15	4.23	4.11	4.14	4.11	4.15	3.25	4.26	4.16	4.17	3.89	4.05	4.25	3.81	3.79	4.47	4.08	
MnO	0.02	0.04	0.09	0.00	0.06	0.00	0.00	0.03	0.11	0.00	0.05	0.10	0.00	0.09	0.00	0.00	0.02	0.00	0.00	
MgO	3.31	2.91	2.98	2.98	3.29	3.38	3.01	3.14	3.20	3.21	3.14	3.10	3.03	3.24	3.12	3.07	3.08	3.11	3.40	
CaO	0.03	0.02	0.04	0.00	0.02	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.02	0.00	
Na_2O	0.42	0.32	0.52	0.56	0.28	0.27	0.30	0.39	0.31	0.42	0.42	0.43	0.45	0.38	0.34	0.40	0.38	0.41	0.27	
K_2O	10.45	10.58	10.35	10.35	10.21	10.21	10.55	10.23	10.42	10.50	10.51	10.24	10.44	10.11	9.63	9.66	9.60	9.85	10.37	
Total	93.09	93.83	93.73	93.73	94.00	93.75	93.43	93.49	93.28	93.72	94.01	93.81	94.07	94.39	93.70	93.65	93.14	93.70	94.18	
Cations on the basis of 12 oxygens																				
Si	6.85	6.48	6.60	6.59	6.70	6.69	6.62	6.64	6.63	6.67	6.68	6.63	6.60	6.62	6.61	6.62	6.62	6.60	6.69	
Ti	0.04	0.06	0.05	0.06	0.04	0.04	0.04	0.05	0.04	0.04	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.03	
Al	4.07	4.59	4.40	4.41	4.29	4.29	4.40	4.35	4.43	4.30	4.32	4.37	4.44	4.39	4.45	4.46	4.46	4.42	4.30	
Fe*	0.46	0.46	0.48	0.49	0.47	0.47	0.47	0.48	0.37	0.49	0.48	0.48	0.44	0.46	0.49	0.44	0.44	0.51	0.47	
Mn	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	
Mg	0.68	0.60	0.61	0.61	0.67	0.69	0.62	0.64	0.66	0.66	0.64	0.63	0.62	0.66	0.64	0.63	0.63	0.64	0.69	
Ca	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	0.00	0.00	0.00	0.00	0.00	0.00	
Na	0.11	0.08	0.14	0.15	0.07	0.07	0.08	0.10	0.08	0.11	0.11	0.11	0.12	0.10	0.09	0.11	0.10	0.11	0.07	
K	1.84	1.86	1.82	1.82	1.78	1.79	1.86	1.80	1.83	1.84	1.84	1.79	1.82	1.76	1.68	1.68	1.68	1.73	1.81	
Total	14.05	14.13	14.12	14.13	14.04	14.05	14.09	14.07	14.06	14.11	14.10	14.08	14.09	14.05	14.00	13.99	13.98	14.06	14.06	
X_{Na}	0.06	0.04	0.07	0.08	0.04	0.04	0.04	0.05	0.04	0.06	0.06	0.06	0.06	0.05	0.05	0.06	0.06	0.06	0.04	

**Total Fe as FeO*

Sample	S 9G																			
Analysis	57	58	59	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	
Mode	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	
				Rim	←	←	←	←	←	←	←	←	←	←	←	←	Core	→	→	
SiO_2	48.24	48.37	48.22	50.13	49.54	49.02	49.42	49.48	49.28	49.36	49.14	49.23	49.41	49.26	49.19	48.34	48.48	48.75	48.96	
TiO_2	0.46	0.50	0.45	0.40	0.49	0.52	0.54	0.48	0.47	0.39	0.40	0.35	0.41	0.42	0.44	0.51	0.53	0.56	0.50	
Al_2O_3	27.30	27.23	27.58	26.89	26.86	27.31	27.09	27.02	26.50	26.36	26.67	26.57	26.81	26.56	26.12	26.98	27.32	27.65	26.86	
FeO*	3.99	4.04	4.09	3.33	3.81	3.68	3.86	3.96	4.06	4.04	4.20	4.19	4.12	4.22	3.99	3.81	3.82	3.04	3.82	
MnO	0.00	0.05	0.00	0.05	0.00	0.03	0.01	0.01	0.00	0.02	0.00	0.05	0.01	0.02	0.03	0.00	0.00	0.00	0.04	
MgO	3.11	3.16	3.19	2.76	3.12	2.91	2.95	2.94	3.13	3.07	3.11	3.17	3.12	3.12	3.12	2.86	2.92	2.91	3.17	
CaO	0.00	0.00	0.05	0.06	0.04	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.03	0.00	0.00	0.02	0.01	
Na_2O	0.40	0.46	0.31	1.60	0.58	0.70	0.67	0.69	0.62	0.57	0.63	0.59	0.54	0.60	0.61	0.67	0.66	0.55	0.53	
K_2O	10.08	10.14	10.07	10.89	10.84	10.62	10.91	10.82	10.96	10.99	10.92	11.03	10.98	11.06	10.94	10.82	10.74	11.07	10.96	
Total	93.57	93.94	93.97	96.11	95.29	94.78	95.46	95.40	95.03	94.79	95.08	95.18	95.40	95.26	94.46	94.00	94.47	94.54	94.85	
Cations on the basis of 12 oxygens																				
Si	6.62	6.62	6.60	6.73	6.70	6.66	6.68	6.69	6.70	6.73	6.68	6.69	6.69	6.69	6.73	6.64	6.62	6.63	6.66	
Ti	0.05	0.05	0.05	0.04	0.05	0.05	0.06	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.05	
Al	4.42	4.39	4.45	4.25	4.28	4.37	4.31	4.30	4.25	4.23	4.27	4.26	4.28	4.25	4.21	4.37	4.40	4.43	4.31	
Fe*	0.46	0.46	0.47	0.37	0.43	0.42	0.44	0.45	0.46	0.46	0.48	0.48	0.47	0.48	0.46	0.44	0.44	0.35	0.43	
Mn	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Mg	0.64	0.64	0.65	0.55	0.63	0.59	0.59	0.59	0.64	0.62	0.63	0.64	0.63	0.63	0.64	0.58	0.59	0.59	0.64	
Ca	0.00	0.00	0.01	0.01	0.01	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	
Na	0.11	0.12	0.08	0.42	0.15	0.18	0.18	0.18	0.16	0.15	0.16	0.16	0.14	0.16	0.16	0.18	0.18	0.15	0.14	
K	1.77	1.77	1.76	1.86	1.87	1.84	1.88	1.87	1.90	1.91	1.89	1.91	1.90	1.92	1.91	1.90	1.87	1.92	1.90	
Total	14.05	14.07	14.05	14.24	14.12	14.11	14.14	14.13	14.16	14.15	14.17	14.17	14.15	14.17	14.16	14.16	14.15	14.13	14.15	
X_{Na}	0.06	0.06	0.05	0.18	0.08	0.09	0.09	0.09	0.08	0.07	0.08	0.08	0.07	0.08	0.08	0.09	0.09	0.07	0.07	

**Total Fe as FeO*

Table 1. (continued)

Sample	S 9G																			
Analysis	43	44	45	46	47	48	49	50	1	2	3	4	5	6	7	8	9	10	11	
Mode	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	
	→	→	→	→	→	→	→	Rim	Core	→	→	→	→	→	→	→	→	→	→	
SiO_2	48.95	48.64	48.67	49.13	49.09	49.12	49.13	49.07	48.69	48.44	48.54	49.04	49.86	49.80	50.33	49.87	49.64	49.30	48.06	
TiO_2	0.42	0.51	0.49	0.49	0.48	0.42	0.44	0.42	0.54	0.51	0.50	0.52	0.36	0.42	0.38	0.48	0.40	0.43	0.52	
Al_2O_3	26.45	27.20	27.49	27.03	26.69	26.40	26.71	26.67	27.31	27.27	27.04	28.00	26.16	26.04	26.15	26.28	25.64	25.78	26.77	
FeO*	3.89	4.25	3.95	4.08	4.45	4.21	4.09	4.38	4.01	3.96	4.13	3.40	4.08	4.38	3.97	3.84	3.81	4.34	4.15	
MnO	0.05	0.00	0.04	0.06	0.01	0.00	0.00	0.00	0.03	0.02	0.03	0.06	0.03	0.00	0.01	0.00	0.05	0.02	0.01	
MgO	3.16	2.96	2.81	2.93	3.05	3.08	3.11	3.01	2.93	2.97	2.94	2.89	3.37	3.40	3.46	3.48	3.46	3.46	3.01	
CaO	0.05	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.04	0.01	0.00	0.00	0.00	0.01	0.03	0.02	0.00	
Na_2O	0.47	0.70	0.65	0.68	0.64	0.62	0.72	0.62	0.73	0.72	0.78	0.65	0.56	0.50	0.50	0.49	0.53	0.48	0.69	
K_2O	11.19	10.67	10.68	10.71	10.69	10.82	10.75	10.85	10.44	10.40	10.37	10.57	10.77	10.71	10.70	10.74	10.64	10.94	10.58	
Total	94.62	94.93	94.78	95.10	95.10	94.69	94.96	95.03	94.67	94.30	94.36	95.13	95.20	95.26	95.50	95.19	94.20	94.79	93.79	
Cations on the basis of 12 oxygens																				
Si	6.69	6.62	6.62	6.67	6.67	6.70	6.68	6.68	6.62	6.62	6.64	6.62	6.75	6.75	6.78	6.74	6.78	6.73	6.62	
Ti	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.04	0.04	0.05	
Al	4.26	4.36	4.41	4.32	4.28	4.25	4.28	4.28	4.38	4.39	4.36	4.45	4.18	4.16	4.15	4.19	4.13	4.15	4.35	
Fe*	0.44	0.48	0.45	0.46	0.51	0.48	0.47	0.50	0.46	0.45	0.47	0.38	0.46	0.50	0.45	0.43	0.44	0.50	0.48	
Mn	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	
Mg	0.64	0.60	0.57	0.59	0.62	0.63	0.63	0.61	0.59	0.61	0.60	0.58	0.68	0.69	0.70	0.70	0.70	0.70	0.62	
Ca	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Na	0.13	0.19	0.17	0.18	0.17	0.16	0.19	0.16	0.19	0.19	0.21	0.17	0.15	0.13	0.13	0.13	0.14	0.13	0.18	
K	1.95	1.85	1.85	1.85	1.85	1.88	1.86	1.88	1.81	1.81	1.81	1.82	1.86	1.85	1.84	1.85	1.85	1.91	1.86	
Total	14.17	14.16	14.13	14.14	14.15	14.15	14.16	14.16	14.12	14.13	14.14	14.09	14.12	14.12	14.09	14.10	14.10	14.16	14.16	
X_{Na}	0.06	0.09	0.08	0.09	0.08	0.08	0.09	0.08	0.10	0.10	0.10	0.09	0.07	0.07	0.07	0.06	0.07	0.06	0.09	

**Total Fe as FeO*

Sample	S 9G																		
Analysis	12	13	14	15	16	17	18	19	20	21	22	23	24	25	9	10	11	12	51
Mode	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Pg1
	→	→	→	→	→	→	→	→	→	→	→	→	→	Rim					
SiO_2	48.68	50.38	49.10	50.37	49.94	49.76	50.46	49.59	49.37	50.22	49.61	50.20	50.17	50.13	49.73	49.39	49.19	49.52	47.15
TiO_2	0.46	0.38	0.47	0.40	0.38	0.35	0.37	0.36	0.35	0.38	0.35	0.43	0.42	0.35	0.39	0.47	0.51	0.57	0.21
Al_2O_3	26.44	25.57	26.42	26.67	25.72	25.76	25.67	26.35	26.04	25.92	26.19	25.54	25.67	25.43	26.34	26.97	27.35	28.12	39.25
FeO*	4.31	4.31	4.42	4.43	4.33	4.11	4.15	4.20	4.23	3.86	3.79	3.73	4.03	3.94	4.36	4.01	3.91	3.59	1.87
MnO	0.00	0.03	0.00	0.00	0.03	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.05	0.00	0.12
MgO	2.99	3.54	3.22	3.34	3.52	3.47	3.63	3.61	3.32	3.53	3.39	3.49	3.49	3.65	3.42	3.02	3.12	3.08	0.15
CaO	0.00	0.02	0.01	0.02	0.01	0.01	0.02	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.39	0.02	0.04	0.01	0.25
Na_2O	0.61	0.41	0.54	0.55	0.45	0.38	0.41	0.45	0.44	0.42	0.49	0.43	0.37	0.36	0.57	0.85	0.82	0.79	7.14
K_2O	10.69	10.65	10.76	10.66	10.72	10.92	10.92	10.69	10.93	10.98	10.69	10.90	10.96	11.12	10.41	10.59	10.40	10.44	0.47
Total	94.18	95.28	94.94	96.45	95.09	94.75	95.63	95.25	94.69	95.31	94.52	94.74	95.11	95.00	95.60	95.32	95.38	96.12	96.61
Cations on the basis of 12 oxygens																			
Si	6.68	6.81	6.69	6.73	6.78	6.78	6.80	6.71	6.74	6.79	6.75	6.82	6.80	6.81	6.71	6.68	6.64	6.62	5.98
Ti	0.05	0.04	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.02
Al	4.28	4.08	4.24	4.20	4.11	4.13	4.08	4.20	4.19	4.13	4.20	4.09	4.10	4.07	4.19	4.30	4.35	4.43	5.87
Fe*	0.50	0.49	0.50	0.50	0.49	0.47	0.47	0.48	0.48	0.44	0.43	0.42	0.46	0.45	0.49	0.45	0.44	0.40	0.20
Mn	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	0.01	0.00	0.01
Mg	0.61	0.71	0.65	0.67	0.71	0.70	0.73	0.73	0.68	0.71	0.69	0.71	0.71	0.74	0.69	0.61	0.63	0.61	0.03
Ca	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	0.06	0.00	0.01	0.00	0.03
Na	0.16	0.11	0.14	0.14	0.12	0.10	0.11	0.12	0.12	0.11	0.13	0.11	0.10	0.10	0.15	0.22	0.21	0.21	1.76
K	1.87	1.84	1.87	1.82	1.86	1.90	1.88	1.85	1.90	1.89	1.86	1.89	1.90	1.93	1.79	1.83	1.79	1.78	0.08
Total	14.15	14.08	14.15	14.10	14.11	14.12	14.10	14.13	14.14	14.10	14.09	14.09	14.10	14.13	14.12	14.14	14.13	14.10	13.98
X_{Na}	0.08	0.05	0.07	0.07	0.06	0.05	0.05	0.06	0.06	0.05	0.07	0.06	0.05	0.05	0.08	0.11	0.11	0.10	0.96

**Total Fe as FeO*

Sample	S 9G																		
Analysis	6	7	8	9	10	11	12	13	18	34	35	43	44	45	46	47	48	49	15
Mode	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ms1	Ms1	Ms1	Ms1	Ms1	Ms1	Ms1	Ms1	Ms1	Ms1	Ms1
SiO_2	48.13	47.71	47.84	47.78	47.93	47.77	47.77	47.92	45.34	45.22	46.98	47.66	47.92	48.12	44.59	46.63	48.08	46.06	44.03
TiO_2	0.51	0.58	0.52	0.50	0.51	0.50	0.50	0.50	0.11	0.18	0.17	0.21	0.24	0.19	0.29	0.28	0.22	0.21	0.09
Al_2O_3	27.22	27.05	27.16	26.96	27.18	27.15	27.45	27.51	33.59	34.82	36.78	37.47	37.30	37.56	35.79	37.49	35.65	37.26	34.60
FeO*	5.12	5.65	5.27	5.67	5.14	5.10	5.03	5.35	3.57	1.32	0.93	1.12	0.93	0.99	1.13	1.42	2.24	1.59	1.48
MnO	0.04	0.02	0.04	0.02	0.00	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.03	0.04	0.00	0.05	0.03	0.00	0.00
MgO	2.54	2.69	2.46	2.72	2.43	2.36	2.31	2.43	1.02	1.23	0.81	0.65	0.67	0.64	0.89	0.48	1.09	0.68	0.96
CaO	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.14	0.05	0.04	0.04	0.02	0.03	0.05	0.02	0.03	0.03	0.00
Na_2O	0.61	0.55	0.63	0.59	0.63	0.65	0.63	0.57	1.13	1.08	1.35	1.78	1.84	1.89	1.49	1.58	1.37	1.69	1.47
K_2O	10.57	10.63	10.52	10.58	10.51	10.76	10.52	10.61	10.20	8.66	8.69	8.53	8.51	8.51	8.62	8.84	8.93	8.60	8.69
Total	94.75	94.88	94.44	94.81	94.32	94.30	94.23	94.94	95.11	92.56	95.74	97.45	97.47	97.96	92.83	96.77	97.62	96.11	91.32
Cations on the basis of 12 oxygens																			
Si	6.59	6.55	6.58	6.56	6.59	6.58	6.58	6.56	6.14	6.15	6.15	6.13	6.16	6.15	6.05	6.07	6.22	6.04	6.09
Ti	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.01
Al	4.39	4.38	4.40	4.37	4.41	4.41	4.45	4.44	5.36	5.58	5.67	5.68	5.65	5.66	5.72	5.75	5.43	5.76	5.64
Fe*	0.59	0.65	0.61	0.65	0.59	0.59	0.58	0.61	0.40	0.15	0.10	0.12	0.10	0.11	0.13	0.15	0.24	0.17	0.17
Mn	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Mg	0.52	0.55	0.50	0.56	0.50	0.48	0.47	0.50	0.21	0.25	0.16	0.12	0.13	0.12	0.18	0.09	0.21	0.13	0.20
Ca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Na	0.16	0.15	0.17	0.16	0.17	0.17	0.17	0.15	0.30	0.28	0.34	0.44	0.46	0.47	0.39	0.40	0.34	0.43	0.40
K	1.85	1.86	1.85	1.85	1.84	1.89	1.85	1.85	1.76	1.50	1.45	1.40	1.40	1.39	1.49	1.47	1.47	1.44	1.53
Total	14.16	14.20	14.17	14.20	14.15	14.19	14.15	14.17	14.20	13.94	13.89	13.93	13.92	13.92	14.00	13.96	13.95	13.99	14.04
X_{Na}	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.14	0.16	0.19	0.24	0.25	0.25	0.21	0.21	0.19	0.23	0.21

**Total Fe as FeO*

Table 1. (continued)

Sample	S 9R										0605079								
Analysis	46	27	31	87	101	103	104	105	28	29	11	13	19	24	25	25	11	12	13
Mode	Ph5	Ph5	Ph5	Pg2	Ph3	Ph3	Ph3	Ph3	Pg1	Pg1	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3
SiO_2	46.11	46.98	47.91	46.10	48.69	48.75	48.42	48.23	45.51	45.58	48.95	48.78	48.79	48.92	49.26	49.17	46.80	46.84	46.23
TiO_2	0.23	0.23	0.23	0.12	0.32	0.37	0.39	0.38	0.11	0.12	0.35	0.58	0.57	0.60	0.40	0.29	0.09	0.19	0.11
Al_2O_3	30.28	30.66	29.36	38.08	27.80	27.64	27.61	27.99	36.62	37.11	26.15	26.20	25.56	26.39	25.68	26.32	27.85	26.23	28.11
FeO*	4.24	4.34	4.19	1.59	4.21	4.23	4.15	4.13	1.21	1.28	4.68	4.80	5.28	4.43	4.29	4.76	5.65	6.76	5.71
MnO	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.05	0.02	0.05	0.02	0.00	0.00	0.02	0.03	0.00	0.03	0.03
MgO	1.92	1.85	2.26	0.31	2.73	2.67	2.62	2.52	0.11	0.08	3.16	2.93	3.05	2.93	3.19	2.96	2.40	2.86	2.44
CaO	0.02	0.00	0.00	0.24	0.00	0.00	0.00	0.02	0.20	0.26	0.03	0.04	0.00	0.00	0.01	0.00	0.05	0.06	0.06
Na_2O	1.23	1.21	1.18	6.93	0.95	1.00	1.01	1.06	6.22	6.20	0.60	0.60	0.44	0.50	0.49	0.57	0.40	0.31	0.38
K_2O	8.42	9.80	9.71	1.25	9.79	9.88	9.73	9.72	1.09	0.79	10.72	10.53	10.85	10.59	10.64	10.88	11.21	11.22	11.35
Total	92.46	95.06	94.83	94.65	94.49	94.53	93.93	94.06	91.10	91.43	94.70	94.48	94.54	94.35	93.99	94.97	94.45	94.48	94.41
Cations on the basis of 12 oxygens																			
Si	6.37	6.37	6.50	5.99	6.62	6.63	6.62	6.59	6.10	6.08	6.70	6.69	6.71	6.70	6.77	6.71	6.48	6.53	6.42
Ti	0.02	0.02	0.02	0.01	0.03	0.04	0.04	0.04	0.01	0.01	0.04	0.06	0.06	0.06	0.04	0.03	0.01	0.02	0.01
Al	4.93	4.90	4.69	5.83	4.45	4.43	4.45	4.51	5.79	5.83	4.22	4.23	4.14	4.26	4.16	4.23	4.54	4.31	4.60
Fe*	0.49	0.49	0.47	0.17	0.48	0.48	0.47	0.47	0.14	0.14	0.54	0.55	0.61	0.51	0.49	0.54	0.65	0.79	0.66
Mn	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mg	0.39	0.37	0.46	0.06	0.55	0.54	0.53	0.51	0.02	0.01	0.64	0.60	0.63	0.60	0.65	0.60	0.50	0.59	0.51
Ca	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.03	0.04	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Na	0.33	0.32	0.31	1.75	0.25	0.26	0.27	0.28	1.62	1.60	0.16	0.16	0.12	0.13	0.13	0.15	0.11	0.08	0.10
K	1.48	1.69	1.68	0.21	1.70	1.71	1.70	1.69	0.19	0.13	1.87	1.84	1.90	1.85	1.87	1.89	1.98	2.00	2.01
Total	14.04	14.17	14.13	14.06	14.09	14.10	14.09	14.10	13.89	13.86	14.17	14.13	14.16	14.10	14.11	14.17	14.28	14.33	14.32
X_{Na}	0.18	0.16	0.16	0.89	0.13	0.13	0.14	0.14	0.90	0.92	0.08	0.08	0.06	0.07	0.07	0.07	0.05	0.04	0.05

**Total Fe as FeO*

Sample	0605079						SEB M-2												
Analysis	64	65	20	21	46	47	2	50	20	22	23	34	6	1	65	8	9	10	12
Mode	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph2	Ph3	Ph3	Ph2	Ph3	Ph3	Ph1	Ph3	Ph3	Ph3	Ph3
SiO_2	48.18	48.37	48.18	48.07	47.88	48.14	49.50	49.61	49.34	50.80	50.47	49.92	48.81	49.46	48.94	46.90	46.81	46.38	47.94
TiO_2	0.33	0.29	0.42	0.38	0.35	0.30	0.45	0.57	0.66	0.46	0.35	0.62	0.43	0.55	0.59	0.56	0.47	0.46	0.50
Al_2O_3	25.45	26.04	24.41	26.18	26.02	26.34	27.31	27.00	28.67	27.60	28.39	28.81	25.95	27.07	27.14	27.00	28.14	27.99	27.11
FeO*	4.13	4.21	6.17	4.42	4.44	4.35	3.36	3.24	3.29	2.91	2.98	3.06	3.56	3.26	3.56	5.44	5.68	5.75	5.41
MnO	0.03	0.00	0.00	0.00	0.06	0.03	0.01	0.01	0.01	0.03	0.00	0.00	0.04	0.02	0.00	0.03	0.01	0.06	0.04
MgO	3.06	2.97	3.54	2.89	2.78	2.89	3.26	3.45	3.29	3.49	3.45	3.34	3.33	3.15	3.08	2.29	2.06	2.13	2.50
CaO	0.04	0.04	0.70	0.02	0.00	0.06	0.02	0.11	0.09	0.02	0.04	0.04	0.04	0.02	0.09	0.02	0.01	0.03	0.04
Na_2O	0.52	0.60	0.54	0.52	0.54	0.54	0.65	0.64	0.67	0.62	0.68	0.68	0.49	0.69	0.63	0.53	0.57	0.54	0.55
K_2O	10.67	10.68	9.94	10.70	10.71	10.71	10.75	10.17	10.39	10.45	10.46	10.37	10.06	10.74	10.63	10.88	10.77	10.84	11.12
Total	92.40	93.21	93.91	93.18	92.77	93.37	95.32	94.79	96.41	96.38	96.81	96.83	92.69	94.96	94.66	93.65	94.53	94.19	95.19
Cations on the basis of 12 oxygens																			
Si	6.74	6.71	6.70	6.67	6.69	6.67	6.68	6.70	6.56	6.73	6.66	6.59	6.75	6.69	6.65	6.54	6.46	6.44	6.57
Ti	0.03	0.03	0.04	0.04	0.04	0.03	0.05	0.06	0.07	0.05	0.04	0.06	0.04	0.06	0.06	0.06	0.05	0.05	0.05
Al	4.20	4.26	4.00	4.29	4.28	4.30	4.34	4.30	4.49	4.31	4.42	4.48	4.23	4.32	4.35	4.43	4.58	4.58	4.38
Fe*	0.48	0.49	0.72	0.51	0.52	0.50	0.38	0.37	0.37	0.32	0.33	0.34	0.41	0.37	0.41	0.63	0.66	0.67	0.62
Mn	0.00	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	0.00	0.00	0.01	0.00
Mg	0.64	0.61	0.73	0.60	0.58	0.60	0.66	0.69	0.65	0.69	0.68	0.66	0.69	0.64	0.62	0.48	0.42	0.44	0.51
Ca	0.01	0.01	0.10	0.00	0.00	0.01	0.00	0.02	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01
Na	0.14	0.16	0.15	0.14	0.15	0.15	0.17	0.17	0.17	0.16	0.17	0.17	0.13	0.18	0.17	0.14	0.15	0.15	0.15
K	1.91	1.89	1.76	1.90	1.91	1.89	1.85	1.75	1.76	1.77	1.76	1.75	1.77	1.85	1.84	1.94	1.90	1.92	1.95
Total	14.15	14.15	14.21	14.15	14.16	14.16	14.12	14.05	14.09	14.03	14.06	14.06	14.04	14.11	14.11	14.22	14.22	14.26	14.23
X_{Na}	0.07	0.08	0.08	0.07	0.07	0.07	0.08	0.09	0.09	0.08	0.09	0.09	0.07	0.09	0.08	0.07	0.07	0.07	0.07

**Total Fe as FeO*

Sample	SEB M-2																		
Analysis	24	25	27	28	29	30	43	44	45	46	47	48	54	57	58	2	3	4	5
Mode	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3	Ph3
SiO_2	50.02	48.33	48.02	46.49	47.11	47.49	48.14	47.74	47.65	48.27	48.06	49.07	48.06	47.48	47.11	48.13	47.93	47.75	48.33
TiO_2	0.42	0.50	0.43	0.41	0.20	0.54	0.26	0.51	0.47	0.51	0.50	0.56	0.42	0.45	0.53	0.52	0.56	0.51	0.58
Al_2O_3	26.62	27.53	27.37	28.16	28.50	27.13	27.24	27.25	27.38	28.13	27.54	27.66	27.34	28.56	27.33	27.04	27.19	27.17	27.24
FeO*	4.68	4.84	5.10	5.29	5.56	5.33	5.29	5.23	5.36	5.28	5.03	5.14	5.48	6.00	5.12	5.56	5.23	5.07	4.99
MnO	0.06	0.00	0.05	0.00	0.03	0.02	0.05	0.01	0.05	0.01	0.09	0.01	0.02	0.04	0.06	0.05	0.04	0.00	0.12
MgO	3.13	2.53	2.58	2.13	2.20	2.49	2.50	2.49	2.32	2.46	2.51	2.48	2.53	2.13	2.31	2.43	2.44	2.53	2.50
CaO	0.05	0.05	0.01	0.02	0.02	0.07	0.02	0.05	0.06	0.00	0.05	0.07	0.01	0.03	0.00	0.04	0.02	0.00	0.01
Na_2O	0.58	0.54	0.51	0.57	0.57	0.56	0.51	0.56	0.55	0.55	0.56	0.55	0.58	0.65	0.53	0.57	0.65	0.63	0.67
K_2O	10.61	10.73	11.19	10.86	10.85	10.89	10.96	10.68	10.80	10.73	10.61	10.81	11.00	10.77	10.84	10.64	10.66	10.65	10.76
Total	96.16	95.06	95.25	93.94	95.04	94.52	94.97	94.51	94.63	95.94	94.95	96.36	95.43	96.11	93.83	94.98	94.71	94.30	95.19
Cations on the basis of 12 oxygens																			
Si	6.72	6.59	6.57	6.45	6.46	6.55	6.60	6.57	6.56	6.53	6.57	6.61	6.57	6.45	6.54	6.60	6.58	6.58	6.59
Ti	0.04	0.05	0.04	0.04	0.02	0.06	0.03	0.05	0.05	0.05	0.05	0.06	0.04	0.05	0.05	0.05	0.06	0.05	0.06
Al	4.21	4.42	4.41	4.61	4.61	4.41	4.40	4.42	4.44	4.49	4.44	4.39	4.40	4.57	4.47	4.37	4.40	4.41	4.38
Fe*	0.53	0.55	0.58	0.61	0.64	0.61	0.61	0.60	0.62	0.60	0.58	0.58	0.63	0.68	0.59	0.64	0.60	0.58	0.57
Mn	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01
Mg	0.63	0.51	0.53	0.44	0.45	0.51	0.51	0.51	0.48	0.50	0.51	0.50	0.51	0.43	0.48	0.50	0.50	0.52	0.51
Ca	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Na	0.15	0.14	0.14	0.15	0.15	0.15	0.14	0.15	0.15	0.14	0.15	0.14	0.15	0.17	0.14	0.15	0.17	0.17	0.18
K	1.82	1.87	1.95	1.92	1.90	1.92	1.92	1.87	1.90	1.85	1.85	1.86	1.92	1.87	1.92	1.86	1.87	1.87	1.87
Total	14.11	14.15	14.23	14.24	14.24	14.22	14.20	14.18	14.20	14.17	14.16	14.14	14.22	14.23	14.20	14.17	14.18	14.18	14.18
X_{Na}	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.07	0.07	0.08	0.08	0.09

**Total Fe as FeO*