

Electron Microprobe Analyses of Rock-forming Minerals from the Sanbagawa Metamorphic Rocks, Shikoku Part II. Sazare, Kotu and Bessi Areas

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Electron Microprobe Analyses of Rock-forming Minerals from the Sanbagawa Metamorphic Rocks, Shikoku Part II. Sazare, Kotu and Bessi Areas

Toshio HIGASHINO*, Chihiro SAKAI**, Hisayuki KURATA***,
Masaki ENAMI****, Hiroshi HOSOTANI*****, Makiko ENAMI*****
and Shohei BANNO**

Department of Earth Sciences, Faculty of Science, Kanazawa University

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Abstract Chemical compositions of rock-forming minerals from the Sanbagawa metamorphic rocks in the Sazare and Bessi areas in central Shikoku, and the Kotu area in eastern Shikoku, are tabulated. They include 330 electron microprobe analyses of plagioclase, muscovite, paragonite, biotite, chlorite, amphibole, pyroxene, garnet and epidote.

Introduction

This is the second report of "*Electron microprobe analyses of rock-forming minerals from the Sanbagawa metamorphic rocks, Shikoku*". It deals with the chemical data of plagioclase, muscovite, paragonite, biotite, chlorite, amphibole, garnet, pyroxene, and epidote in the Sazare¹⁾ and Bessi²⁾ areas in central Shikoku, and the Kotu³⁾ area in eastern Shikoku, which are presented in Tables 1-9. Chemical analyses were made using two electronprobe microanalyzers, Hitachi XMA-5A of the Kanazawa University and J.E.O.L JXA-5A of the Nagoya University. Mineral assemblages of the samples containing the analyzed minerals are shown in Table 10.

* Hakusan Nature Conservation Center, Yoshinodani-mura, Ishikawa 920-23

** Department of Geology and Mineralogy, University of Kyoto, Kyoto 606

*** Japan Electric Engineering Co. Ltd.(Nippon Denko K.K.), Anan, Tokushima 779-13

**** Department of Earth Sciences, Nagoya University, Nagoya 464

***** Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forestry and Fisheries,
Tokyo 100

***** formerly Hiramura, Nishizato-cho 5-55, Meito-ku, Nagoya 465

1) 佐々連, 2) 別子, 3) 高越

Sanbagawa, Bessi and Kotu have to be spelled Sambagawa, Besshi and Kotsu, respectively, to be consistent with the spelling of Shikoku instead of Sikoku. The localities of geologically famous areas are, however, spelled following the papers widely read in international geological world (cf. Miyashiro, 1973).
Reprint requests to S. Banno.

Sazare area

The Sazare area is located in Iyo-Mishima city, Ehime Prefecture¹⁾ (Fig. 1), being north of the Asemi River area, whose chemical mineralogy were described in Part I of this series of papers (Higashino *et al.*, 1982). According to the conventional stratigraphy of the Sanbagawa schists in central Shikoku, this area is underlain by the Minawa and Ojoin formations. The structural analysis of the geology of the area has been made by Oyagi (1964), Kawachi (1968) and Hara *et al.* (1977) in detail. In Fig. 1, the sample localities and the traverse map along the Saruta River are shown. The schists trend roughly E-W with moderately dipping, and are gently folded with approximate E-W axis of syncline (Tomisato syncline). Most of the samples are collected along the Saruta and Dozan Rivers, and the other near the Sazare mine.

Metamorphic zonal mapping of the area has been done by Kurata and Banno (1974) and Banno *et al.* (1978) on the basis of the mineral assemblage in pelitic schists. Zones A, B and C of Kurata and Banno (1974) approximately correspond to the chlorite, garnet and biotite zones²⁾ of Banno *et al.* (1978), respectively. Pelitic schists near the Fujiwara mass (metamorphosed peridotite-gabbro complex), which belong to the garnet zone according to Banno *et al.* (1978), contain sometimes biotite and have the chemistry of the rock-forming minerals transitional between the garnet and biotite zones of the Asemi River area (Enami, 1980), but we regard them to belong to the garnet zone in this report.

Chemical compositions of muscovite, biotite, chlorite, amphibole, garnet and epidote from the pelitic schists, muscovite, chlorite, amphibole and pyroxene from the siliceous schists, and plagioclase, muscovite, chlorite, amphibole, garnet and epidote from the basic schists are listed in Table 1-9. Modes of occurrence and chemical characteristics of the minerals are the same as those in the Asemi River area described by Higashino *et al.* (1982), except for amphiboles from the siliceous schists, 2160 and 2162, which are nearly homogeneous.

Analyses of chlorite from the pelitic schists were made on the varieties forming the schistosity plane and in the pseudomorphs after garnet, the latter being distinguished from the former by marking their GRAIN NO with "(PG)". The schistosity-forming chlorites generally exhibit chemical heterogeneity mainly with regard to Fe-Mg substitution in the high-grade area. In such a case, Mg-rich and sometimes Fe-rich parts were analyzed, and they are marked with "A" and "B" in their POINT NO, respectively. Most of the zoned garnets and amphiboles were analyzed on the rim, and sometimes the core and the intermediate part of the grain. The analysis of some amphiboles was done on the arbitrarily selected points. The analyses of the rim, core and intermediate part of them are distinguished from the other analyses by marking their POINT NO with "RIM",

1) 愛媛県伊予三島市

2) Recently, Enami (1982) has subdivided the biotite zone into albite-biotite and oligoclase-biotite zones based upon the chemistry of plagioclase in the Bessi area. According to his definition, the biotite zone in the Sazare area is the albite-biotite zone, for plagioclase in the area is albite so far as we have examined.

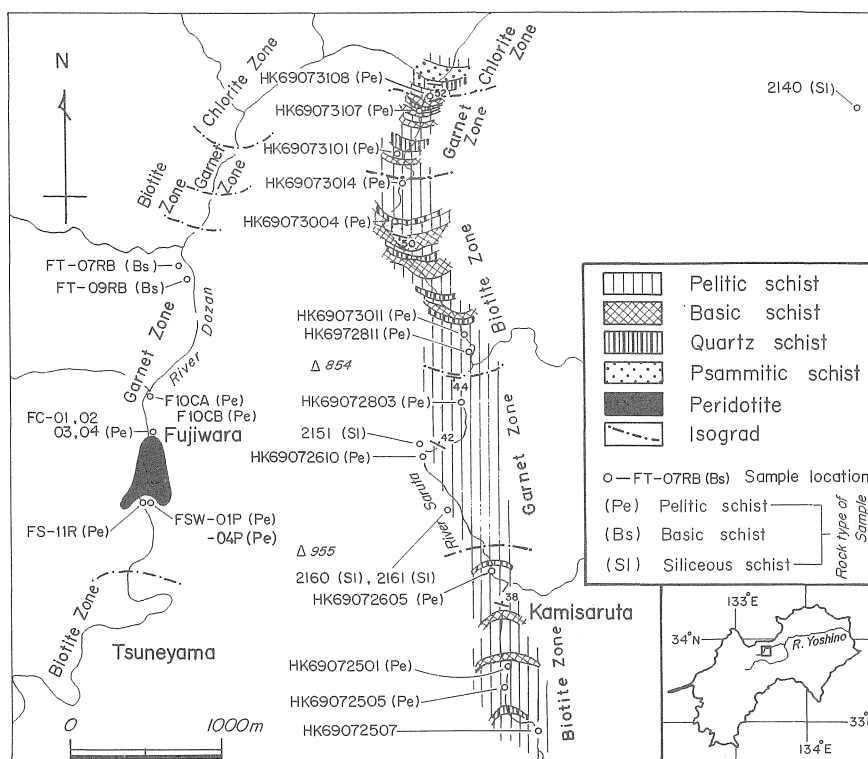


Fig. 1 Traverse map and sample locations of the Sazare area.

"CORE" and "INTER", respectively. Analyzed points of the other minerals are chosen arbitrarily.

Our discussions on the mineralogy and petrology of the Sanbagawa schists of the area have been given in Banno and Kurata (1972), Kurata (1972) and Kurata and Banno (1974) for the pelitic schists along the Saruta River, Enami (1980) for the pelitic and basic schists around the Fujiwara mass, and Hiramura (1977) for the siliceous schists.

Kotu area

The Kotu area is located in Yamakawa-cho, Oe-gun, Tokushima Prefecture¹⁾, and a part of the Kotu-Bizan district described by Iwasaki (1963). The Sanbagawa schists of the Kotu area and its surroundings are divided into five formations, the Nonowaki, Shozanji, Kashidaira, Kotu and Kawata formations in ascending order of stratigraphy; the lower part of the Nonowaki formation, and the higher part of that formation and the remaining formations are correlated with the Koboke and Minawa formations in central Shikoku, respectively (Iwasaki et al., 1968). The samples in this report were collected along the Okunoidani River and its tributary (Fig. 2), where the Kotu formation, mainly composed of basic schists (notably glaucophane schists) with subordinate siliceous schists, and minor

1) 徳島県麻植郡山川町

pelitic schists and ultrabasic rocks, is distributed.

Iwasaki (1963) and Iwasaki *et al.* (1968) have performed the metamorphic zonal mapping of the Kotu area and its surroundings. The study area belongs to zone II of Iwasaki *et al.* (1968), which is characterized by the appearance of garnet in pelitic schists and absence of pumpellyite in basic schists, corresponding to the garnet zone in central Shikoku. In this report, the chemical data of basic epidote-glaucophane schists are mainly described along with those of two siliceous epidote-glaucophane schists.

Muscovite, paragonite, chlorite, amphibole (alkali amphibole and calcic amphibole), garnet and epidote are analyzed. Although the zoning with alkali amphibole core and actinolite rim is not uncommon, alkali amphibole itself is not distinctly zoned. For most of alkali amphiboles in the basic schists, the average compositions of 3 to 7 grains are tabulated, and their POINT NO are marked with "*". Epidote is often slightly zoned with Al-rich core and Fe-rich rim, but the core is relatively homogeneous. The analyses of epidotes in the basic schists were made on the aluminous core, and the average compositions of 3 to 5 points are tabulated with the mark "*" in their POINT NO. Zoning is common in garnet and shows decrease of Mn towards the rim. The analyses of garnets from the basic schists are at the rim, but the garnet from the siliceous schists (23102) was on arbitrarily selected point. Muscovite, paragonite and chlorite are rather homogeneous, and their analyzed points are chosen arbitrarily.

The detailed mineral paragenesis of basic epidote-glaucophane schists and paragonite-bearing siliceous schists are given in Hosotani and Banno (in prep.) and Hiramura (1978), respectively.

Bessi area

The Bessi area is located in Bessiyama-mura, Uma-gun, Ehime Prefecture¹⁾, being about 12km to the west of the Sazare area. Analyzed minerals are alkali amphibole and epidote from basic epidote-glaucophane schists in the Minawa formation, one from the garnet zone, and the others from the chlorite zone. The sample localities are shown in Fig.

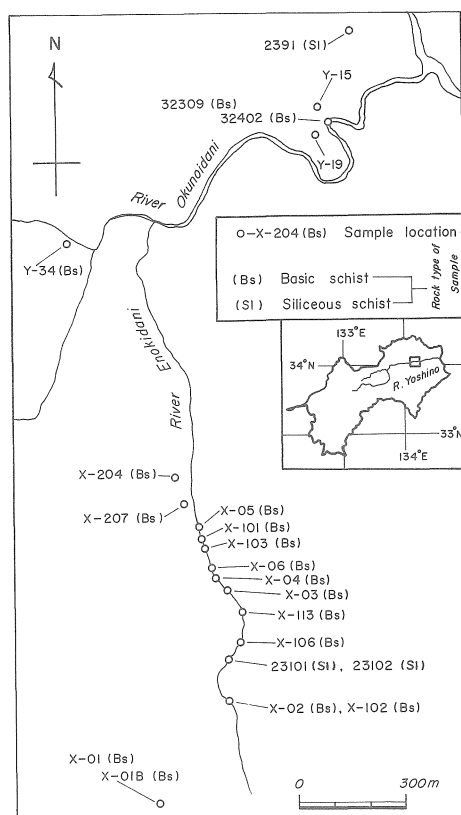


Fig. 2 Map of the Kotu area showing sample locations.

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3. Mode of occurrence, chemical characteristics and analyzed points of the minerals are the same as those from the basic epidote-glaucophane schists in the Kotu area described above, and the average of the point analyses are presented.

The petrology and geology of the area have been worked out by Banno (1964) and Hosotani and Banno (in prep.), and Hide (1961), Hide et al. (1956), Hara et al. (1977) and Takasu and Makino (1980), respectively.

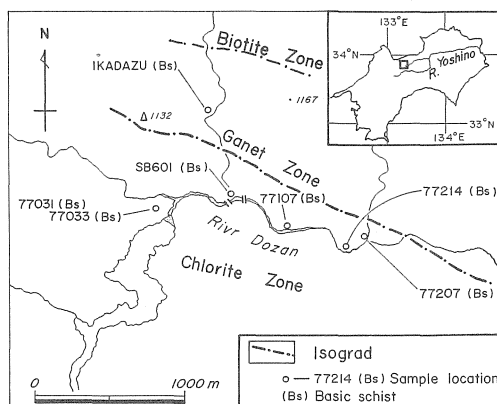


Fig. 3 Map of the Bessi area showing sample locations.

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Abbreviations used in Tables 1-9 are as follows.

(Tables 1-9) PE= pelitic schist, BE= basic schist, SL= siliceous schist, CHL= chlorite zone, GAR= garnet zone, BIO= biotite zone, ME= Masaki Enami, HK= Hisayuki Kurata, HH= Hiroshi Hosotani, MH= Makiko Hiramura, KU= Hitachi XMA-5A of the Kanazawa University, NU= J. E. O. L JXA-5A of the Nagoya University.

(Table 5) PG= occurring in the pseudomorphs after garnet, A= Mg-rich part, B= Fe-rich part.

(Table 6) NA-A= alkali amphibole, CA-A= calcic amphibole, INTER= intermediate part, * = average composition.

(Table 7) N= normal zoning with a decrease in Mn towards the rim, INTER= intermediate part.

(Table 9) * = average composition.

TABLE 1. CHEMICAL COMPOSITION AND ATOMIC RATIO OF PLAGIOCLASE

SAMPLE NO	FT-09RB
ROCK TYPE	BS
ZONE	GAR
GRAIN NO	1
POINT NO	1
SI02	69.14
AL2O3	19.35
CAO	0.68
NA2O	11.61
K2O	0.03
TOTAL	100.81
ATOMIC RATIOS (O = 8.0)	
SI	2.998
AL	0.989
CA	0.032
NA	0.976
K	0.002
ANALYST	ME
INSTRUMENT	NU

TABLE 2. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF MUSCOVITES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	FT-07RB	FT-09RB	F-10CA	FSW-01P		FS-11R		HK69073108	HK69073107	HK69073101	
	BS	BS	PE	PE		PE		PE	PE	PE	
	GAR	GAR	GAR	2	1	2	1	CHL	GAR	GAR	
	1	1	1	2	1	2	1	1	1	1	
	1	1	1	1	1	1	1	1	1	1	
SI02	49.97	49.74	49.38	48.60	50.95	50.16	48.98	49.14	51.00	50.80	50.20
TI02	0.05	0.24	0.07	0.13	0.53	0.41	0.30	0.24	N.D.	N.D.	N.D.
AL2O3	27.29	28.28	29.70	30.02	28.34	28.24	28.89	29.28	29.50	28.90	30.60
FE0	4.04	3.24	2.58	3.19	3.50	3.49	3.19	3.13	2.61	2.28	3.05
MNO	0.01	0.0	0.01	0.02	0.03	0.0	0.0	0.0	0.05	0.05	0.01
MGO	2.36	3.09	2.05	1.96	2.62	2.69	2.36	2.31	2.39	2.47	2.20
CAO	0.21	0.06	0.0	0.0	0.0	0.0	0.0	0.0	N.D.	N.D.	0.31
NA2O	0.12	0.54	0.10	0.20	0.55	0.49	0.76	0.73	N.D.	N.D.	0.58
K2O	10.39	9.79	9.65	9.25	9.84	10.06	9.20	9.52	9.60	10.20	9.18
TOTAL	94.44	94.98	93.54	93.37	96.36	95.54	93.68	94.35	95.15	94.70	96.13
ATOMIC RATIOS (O = 22.0)											
SI	6.780	6.673	6.671	6.593	6.734	6.701	6.640	6.622	6.756	6.780	6.610
TI	0.005	0.024	0.007	0.013	0.053	0.041	0.031	0.024			
AL	4.364	4.472	4.729	4.800	4.414	4.446	4.616	4.651	4.606	4.546	4.749
FE	0.458	0.364	0.291	0.362	0.387	0.390	0.362	0.353	0.289	0.254	0.336
MN	0.001	0.0	0.001	0.002	0.003	0.0	0.0	0.0	0.006	0.006	0.001
MG	0.477	0.618	0.413	0.396	0.516	0.536	0.477	0.464	0.472	0.491	0.432
CA	0.031	0.009	0.0	0.0	0.0	0.0	0.0	0.0			0.044
NA	0.032	0.140	0.026	0.053	0.141	0.127	0.200	0.191			0.148
K	1.799	1.676	1.663	1.601	1.659	1.714	1.591	1.637	1.622	1.737	1.542
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	HK	HK	HK
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	KU	KU	KU

TABLE 2. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF MUSCOVITES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	HK69073014	HK69073004	HK69073011	HK69072811	HK69072803	HK69072610	HK69072605	HK69072501	HK69072507	2140	Y-15
	PE BIO	PE BIO	PE BIO	PE BIO	PE GAR	PE GAR	PE BIO	PE BIO	PE BIO	SL CHL	BS GAR
	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1
SI02	50.90	51.30	49.70	51.30	48.50	49.70	48.60	51.30	48.50	49.36	51.05
TI02	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.0	N.D.	0.09	0.24
AL203	27.50	29.00	29.50	28.60	28.10	27.70	28.30	26.70	28.80	23.94	26.63
FE0	3.63	2.76	2.21	2.84	3.01	3.45	2.83	2.84	2.76	4.19	4.83
MNO	0.0	0.01	0.01	0.01	0.01	0.0	0.01	0.03	0.02	0.05	0.02
MGO	2.54	2.57	2.82	2.84	2.70	2.17	2.50	2.88	2.38	3.95	2.88
CA0	N.D.	N.D.	0.04	N.D.	N.D.	N.D.	0.02	0.02	N.D.	0.0	0.0
NA20	0.55	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.48	N.D.	0.41	0.31
K20	9.37	8.99	8.78	9.89	9.05	9.05	8.89	10.00	8.71	10.76	11.54
TOTAL	94.49	94.63	93.06	95.48	91.37	92.07	91.15	94.25	91.17	92.75	97.50
ATOMIC RATIOS (O = 22.0)											
SI	6.839	6.809	6.697	6.795	6.711	6.823	6.724	6.909	6.696	6.878	6.784
TI								0.0		0.009	0.024
AL	4.354	4.537	4.685	4.465	4.582	4.482	4.614	4.238	4.686	3.932	4.171
FE	0.408	0.306	0.249	0.315	0.348	0.396	0.327	0.320	0.319	0.488	0.537
MN	0.0	0.001	0.001	0.001	0.001	0.0	0.001	0.003	0.002	0.006	0.002
MG	0.509	0.509	0.567	0.561	0.557	0.444	0.516	0.578	0.490	0.821	0.571
CA			0.006				0.003	0.003		0.0	0.0
NA	0.143						0.125			0.111	0.080
K	1.606	1.522	1.509	1.671	1.597	1.585	1.569	1.718	1.534	1.913	1.956
ANALYST	HK	HK	HK	HK	HK	HK	HK	HK	HK	MH	HH
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU

TABLE 3. CHEMICAL COMPOSITION AND ATOMIC RATIO OF PARAGONITE

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	Y-19	X-207	X-106	23102
	BS GAR	BS GAR	BS GAR	SL GAR
	1	1	1	1
	1	1	1	1
SI02	49.88	48.54	50.23	49.71
TI02	0.26	0.19	0.21	0.19
AL203	26.30	27.45	26.08	26.77
FE0	4.33	4.83	3.04	3.58
MNO	0.03	0.0	0.0	0.0
MGO	2.60	3.26	3.41	3.15
CA0	0.03	0.12	0.09	0.0
NA20	0.52	0.39	0.45	0.66
K20	11.28	10.75	10.34	10.35
TOTAL	95.23	95.53	93.85	94.41
ATOMIC RATIOS (O = 22.0)				
SI	6.778	6.586	6.837	6.752
TI	0.027	0.019	0.021	0.019
AL	4.212	4.389	4.184	4.286
FE	0.492	0.548	0.346	0.407
MN	0.003	0.0	0.0	0.0
MG	0.527	0.659	0.692	0.638
CA	0.004	0.017	0.013	0.0
NA	0.137	0.103	0.119	0.174
K	1.955	1.861	1.795	1.794
ANALYST	HH	HH	HH	MH
INSTRUMENT	KU	KU	KU	KU

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	23102
	SL GAR
	1
	1
SI02	47.28
TI02	0.04
AL203	37.58
FE0	1.01
MNO	0.02
MGO	0.14
CA0	0.08
NA20	6.87
K20	1.04
TOTAL	94.06
ATOMIC RATIOS (O = 22.0)	
SI	6.135
TI	0.004
AL	5.747
FE	0.110
MN	0.002
MG	0.027
CA	0.011
NA	1.728
K	0.172
ANALYST	MH
INSTRUMENT	KU

TABLE 4. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF BIOTITES

SAMPLE NO	ROCK TYPE	GRAIN NO	POINT NO	FSM-01P										FSM-04P			
				PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	
SI02		1	1	36.96	36.66	36.78	38.97	37.99	37.27	37.33	36.88	39.02	37.35	36.57			
TI02		1	2	1.35	1.45	1.44	1.22	1.22	1.31	1.23	1.36	1.51	1.56				
AL203		1	1	15.34	15.40	15.13	15.32	15.50	15.13	15.03	16.29	16.10	15.29				
FE0		1	1	23.02	23.76	23.57	20.18	20.98	23.72	23.20	22.34	23.04	22.69				
MNO		1	1	0.18	0.18	0.18	0.15	0.16	0.23	0.19	0.09	0.08	0.05				
MGO		1	1	8.59	8.51	8.61	8.94	8.66	8.68	8.56	8.11	8.03	8.98				
CAO		1	1	0.0	0.0	0.01	0.06	0.03	0.0	0.0	0.33	0.73	0.19				
NA2O		1	1	0.02	0.04	0.03	0.03	0.0	0.03	0.03	0.03	0.05	0.03				
K2O		1	1	8.78	8.67	8.18	7.45	7.66	8.48	8.69	7.63	7.56	7.33				
TOTAL				94.24	94.67	93.93	92.30	92.10	94.85	94.26	93.06	96.12	93.37				
				ATOMIC RATIOS (O = 22.0)													
SI				5.771	5.720	5.762	6.037	5.943	5.788	5.826	5.767	5.891	5.814	5.725			
TI				0.159	0.170	0.170	0.142	0.144	0.153	0.144	0.160	0.171	0.183	0.154			
AL				2.823	2.832	2.794	2.797	2.858	2.769	2.764	3.002	2.864	2.805	3.194			
FE				3.006	3.100	3.088	2.614	2.731	3.081	3.028	2.921	2.909	2.954	2.897			
MN				0.024	0.024	0.024	0.020	0.021	0.030	0.025	0.012	0.010	0.007	0.015			
MG				1.999	1.979	2.011	2.065	2.019	2.009	1.991	1.890	1.807	2.084	1.753			
CA				0.0	0.0	0.002	0.010	0.005	0.0	0.0	0.055	0.118	0.032	0.059			
NA				0.006	0.012	0.009	0.003	0.0	0.009	0.009	0.009	0.015	0.009	0.012			
K				1.749	1.726	1.635	1.472	1.529	1.680	1.730	1.582	1.456	1.436	1.442			
ANALYST				ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME			
INSTRUMENT				NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU			
SAMPLE NO	HK69073011	HK69072507															
ROCK TYPE	PE	PE															
ZONE	BIO	BIO															
GRAIN NO	1	1															
POINT NO	1	1															
SI02				37.80	38.30												
TI02				1.38	1.43												
AL203				15.40	15.50												
FE0				20.80	19.70												
MNO				0.19	N.D.												
MGO				10.40	10.12												
CAO				0.23	N.D.												
NA2O				N.D.	N.D.												
K2O				7.17	6.98												
TOTAL				93.37	92.03												
				ATOMIC RATIOS (O = 22.0)													
SI				5.824	5.927												
TI				0.160	0.166												
AL				2.797	2.827												
FE				2.680	2.549												
MN				0.025													
MG				2.386	2.335												
CA				0.038													
NA																	
K				1.409	1.378												
ANALYST	HK	HK															
INSTRUMENT	KU	KU															

TABLE 5. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF CHLORITES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	FT-07RB		FT-09RB			F-10CA					
	BS		BS			PE					
	GAR		GAR			GAR					
	1	2	1	2	3	1	1	2	2	2	3
	1	1	1	1	1	A1	A2	A1	A2	A3	A
SI02	25.00	25.26	25.21	24.69	24.94	23.35	23.98	23.95	23.86	23.83	24.08
AL203	19.77	19.15	19.26	19.04	19.10	20.24	20.43	20.66	20.63	20.45	20.42
FE0	29.70	31.32	33.97	33.94	33.41	32.48	30.99	32.81	32.68	31.95	32.68
MNO	0.23	0.27	0.38	0.38	0.35	0.41	0.21	0.51	0.59	0.37	0.42
MGO	13.12	12.31	9.95	10.03	9.79	10.18	11.47	9.87	9.38	10.63	9.81
TOTAL	87.82	88.31	88.77	88.08	87.59	86.66	87.08	87.80	87.14	87.23	87.41
ATOMIC RATIOS (O = 28.0)											
SI	5.404	5.477	5.513	5.456	5.521	5.223	5.276	5.280	5.302	5.267	5.327
AL	5.036	4.893	4.964	4.959	4.983	5.336	5.297	5.368	5.403	5.327	5.324
FE	5.369	5.679	6.213	6.273	6.186	6.076	5.702	6.049	6.073	5.905	6.046
MN	0.042	0.050	0.070	0.071	0.066	0.078	0.039	0.095	0.111	0.069	0.079
MG	4.228	3.979	3.244	3.304	3.231	3.395	3.762	3.244	3.107	3.502	3.235
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	F-10CA		F-10CB			FC-01					
	PE		PE			PE					
	GAR		GAR			GAR					
	4	1	2	3	4	4	1	1	1	2	2
	A	A	A	A	A1	A2	A1	A2	A3	A1	A2
SI02	24.80	24.67	24.54	24.75	24.49	24.39	24.91	24.98	24.75	24.84	24.33
AL203	20.71	20.46	20.22	21.00	20.52	20.40	20.22	20.24	20.42	20.18	20.61
FE0	30.44	30.76	31.26	31.17	30.42	32.31	28.96	29.05	29.96	29.06	29.40
MNO	0.28	0.15	0.30	0.23	0.09	0.40	0.15	0.11	0.28	0.14	0.20
MGO	11.50	12.34	11.72	11.89	12.57	10.96	13.18	13.76	12.75	13.47	13.07
TOTAL	87.73	88.38	88.04	89.04	88.09	88.46	87.42	88.14	88.16	87.69	87.61
ATOMIC RATIOS (O = 28.0)											
SI	5.381	5.323	5.339	5.306	5.295	5.313	5.383	5.354	5.335	5.356	5.267
AL	5.296	5.203	5.185	5.306	5.229	5.237	5.150	5.113	5.188	5.128	5.259
FE	5.523	5.551	5.688	5.588	5.500	5.886	5.234	5.207	5.401	5.240	5.323
MN	0.051	0.027	0.055	0.042	0.016	0.074	0.027	0.020	0.051	0.026	0.037
MG	3.720	3.970	3.801	3.800	4.051	3.559	4.246	4.396	4.097	4.330	4.218
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU

TABLE 5. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF CHLORITES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	FC-01		FC-02		FC-03				FC-04								
	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE						
	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR						
	3	1	2	3	1	3	3	4	1	2	3						
A	A	A	A	A	A	A	A	A	A	A							
SI02	25.00	24.87	24.54	24.49	24.78	24.80	24.57	24.75	24.46	24.33	24.67						
AL203	20.24	20.68	20.88	20.51	20.33	20.21	20.17	20.02	20.26	20.05	20.15						
FEO	29.12	29.13	30.32	29.57	29.21	28.72	28.80	28.66	29.98	30.38	29.60						
MNO	0.11	0.10	0.31	0.16	0.18	0.12	0.16	0.12	0.15	0.17	0.11						
MGO	13.84	13.10	12.20	12.81	13.37	13.48	13.32	13.71	12.80	12.60	13.14						
TOTAL	88.31	87.88	88.25	87.54	87.87	87.33	87.02	87.26	87.65	87.53	87.67						
ATOMIC RATIOS (O = 28.0)																	
SI	5.349	5.345	5.294	5.307	5.337	5.360	5.338	5.355	5.308	5.304	5.338						
AL	5.104	5.238	5.309	5.239	5.160	5.148	5.165	5.106	5.182	5.151	5.139						
FE	5.211	5.236	5.470	5.359	5.261	5.191	5.233	5.186	5.441	5.539	5.356						
MN	0.020	0.018	0.057	0.029	0.033	0.022	0.029	0.022	0.028	0.031	0.020						
MG	4.415	4.197	3.923	4.139	4.293	4.344	4.314	4.423	4.141	4.095	4.239						
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME						
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU						
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	FC-04		FSW-01P		FS-11R				HK69073108			HK69073107			HK69073101		
	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE
	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR
	3	1	2	3	1	1	2	2	1	1	1	1	1	1	1	1	1
A2	A	A	A	A1	A2	A1	A2	1	1	1	1	1	1	1	1	1	
SI02	24.37	25.53	25.10	25.20	24.75	24.71	24.89	25.09	26.10	26.10	25.90						
AL203	20.18	19.32	19.54	19.53	19.60	19.62	19.84	19.86	21.10	20.70	21.10						
FEO	30.10	30.18	30.51	30.54	29.45	29.17	29.47	29.42	29.10	28.10	29.70						
MNO	0.15	0.24	0.25	0.25	0.09	0.11	0.08	0.04	0.99	1.19	0.47						
MGO	12.89	12.18	12.41	12.44	13.01	12.94	13.06	13.15	10.50	11.50	12.10						
TOTAL	87.69	87.45	87.81	87.96	86.90	86.55	87.34	87.56	87.79	87.59	89.27						
ATOMIC RATIOS (O = 28.0)																	
SI	5.292	5.549	5.449	5.460	5.404	5.410	5.401	5.424	5.607	5.602	5.478						
AL	5.165	4.949	5.000	4.987	5.043	5.063	5.074	5.060	5.343	5.237	5.260						
FE	5.467	5.486	5.539	5.534	5.377	5.341	5.348	5.318	5.228	5.044	5.254						
MN	0.028	0.044	0.046	0.046	0.017	0.020	0.015	0.007	0.180	0.216	0.084						
MG	4.173	3.947	4.017	4.018	4.234	4.224	4.225	4.238	3.363	3.680	3.815						
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	HK	HK	HK						
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	KU	KU	KU						

TABLE 5. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF CHLORITES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	HK69073101 HK69073014		HK69073004			HK69073011 HK69072811			HK69072803		
	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE
	GAR	BIO	BIO	BIO	BIO	BIO	BIO	GAR	GAR	GAR	GAR
	2(PG)	1	2(PG)	1	1	1	1	1	2(PG)	1	1
	1	1	1	A	B	A	A	B	1	A	B
SI02	25.70	26.40	26.40	29.10	28.50	26.40	28.30	28.00	27.60	26.20	26.10
AL203	21.30	20.50	20.60	19.70	19.70	20.40	20.40	20.30	20.30	20.50	20.50
FEO	30.20	30.50	31.60	25.10	28.30	23.10	25.50	28.40	28.10	27.80	27.50
MNO	0.82	0.22	0.45	0.23	0.40	0.12	0.11	0.22	0.21	0.34	0.30
MGO	11.20	11.90	10.60	16.30	12.80	16.90	17.00	16.00	14.90	13.70	13.90
TOTAL	89.22	89.52	89.65	90.43	89.70	86.92	91.31	92.92	91.11	88.54	88.30
ATOMIC RATIOS (O = 28.0)											
SI	5.464	5.580	5.607	5.883	5.915	5.538	5.683	5.613	5.642	5.532	5.519
AL	5.337	5.107	5.157	4.693	4.819	5.044	4.828	4.796	4.891	5.102	5.109
FE	5.369	5.391	5.613	4.243	4.912	4.052	4.283	4.761	4.804	4.909	4.863
MN	0.148	0.039	0.081	0.039	0.070	0.021	0.019	0.037	0.036	0.061	0.054
MG	3.550	3.750	3.356	4.912	3.960	5.285	5.089	4.782	4.541	4.313	4.382
ANALYST	HK	HK	HK	HK	HK	HK	HK	HK	HK	HK	HK
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU
SAMPLE NO	HK69072610		2160	2161	HK69072605	HK69072501			HK69072505	HK69072507	
ROCK TYPE	PE		SL	SL	PE	PE			PE	PE	
ZONE	GAR		GAR	GAR	BIO	BIO			BIO	BIO	
GRAIN NO	1	1	1	1	1	1	1	2(PG)	1	1	1
POINT NO	A	B	1	1	A	A	B	1	A	A	B
SI02	26.10	25.70	29.98	28.96	26.10	26.50	26.30	25.90	27.80	26.30	26.50
AL203	19.70	19.80	19.54	19.96	20.40	20.80	20.40	20.10	21.10	21.10	21.10
FEO	30.10	30.20	6.72	8.20	25.70	26.30	29.60	31.40	25.20	24.20	25.80
MNO	0.31	0.51	0.15	0.0	0.40	0.09	0.17	0.24	0.07	0.06	0.04
MGO	12.40	11.60	29.77	29.53	15.10	15.40	13.10	11.30	15.00	16.00	15.10
TOTAL	88.61	87.81	86.16	86.65	87.70	89.09	89.57	88.94	89.17	87.66	88.54
ATOMIC RATIOS (O = 28.0)											
SI	5.581	5.562	5.804	5.628	5.511	5.504	5.533	5.551	5.707	5.494	5.520
AL	4.965	5.050	4.458	4.571	5.077	5.092	5.058	5.077	5.105	5.195	5.180
FE	5.383	5.466	1.088	1.333	4.538	4.569	5.208	5.628	4.326	4.228	4.494
MN	0.056	0.093	0.025	0.0	0.072	0.016	0.030	0.044	0.012	0.011	0.007
MG	3.953	3.742	8.592	8.555	4.753	4.769	4.109	3.610	4.590	4.982	4.689
ANALYST	HK	HK	MH	MH	HK	HK	HK	HK	HK	HK	HK
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU

TABLE 6. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF AMPHIBOLES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	FT-07RB					FT-09RB					FSW-01P
	BS					BS					PE
	GAR					GAR					GAR
	1	2	2	3	4	1	2	3	4	4	1
	1	CORE	RIM	1	1	1	1	CORE	RIM	1	
SI02	48.30	52.35	51.50	52.17	53.34	46.22	44.74	51.54	44.90	51.21	50.27
TI02	0.19	0.11	0.09	0.07	0.02	0.25	0.29	0.09	0.28	0.09	0.09
AL203	8.67	2.66	3.27	2.10	1.64	10.66	10.81	3.07	10.94	3.06	4.78
FE0	17.54	17.71	15.82	17.61	15.56	18.91	19.56	19.28	19.62	19.10	17.51
MNO	0.17	0.28	0.15	0.24	0.26	0.22	0.28	0.26	0.28	0.26	0.18
MGO	9.87	11.97	12.81	11.83	13.70	8.21	7.57	10.70	7.61	10.73	11.12
CA0	10.36	11.58	11.77	11.86	12.05	8.92	10.16	11.65	10.20	11.60	11.55
NA20	2.37	0.90	1.07	0.83	0.64	3.45	2.77	0.90	2.73	0.88	1.11
K20	0.34	0.10	0.12	0.09	0.06	0.34	0.46	0.15	0.46	0.15	0.21
TOTAL	97.81	97.66	96.60	96.80	97.27	97.18	96.64	97.64	97.02	97.08	96.82
ATOMIC RATIOS (O = 23.0)											
SI	7.151	7.728	7.637	7.777	7.822	6.947	6.825	7.678	6.820	7.672	7.504
TI	0.021	0.012	0.010	0.008	0.002	0.028	0.033	0.010	0.032	0.010	0.010
AL	1.513	0.463	0.572	0.369	0.283	1.888	1.944	0.539	1.958	0.540	0.841
FE	2.172	2.186	1.962	2.195	1.908	2.377	2.495	2.402	2.492	2.393	2.186
MN	0.021	0.035	0.019	0.030	0.032	0.028	0.036	0.033	0.036	0.033	0.023
MG	2.178	2.634	2.832	2.629	2.995	1.840	1.722	2.376	1.723	2.396	2.474
CA	1.643	1.832	1.870	1.894	1.893	1.436	1.661	1.860	1.660	1.862	1.847
NA	0.680	0.258	0.308	0.240	0.182	1.005	0.819	0.260	0.804	0.256	0.321
K	0.064	0.019	0.023	0.017	0.011	0.065	0.090	0.029	0.089	0.029	0.040
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	FSW-01P				FSW-04P				2151		
	PE				PE				SL		
	GAR				GAR				GAR		
	2	3	1	2	2	3	3	4	5	1	1
	1	1	CORE	RIM	CORE	RIM	1	1	CORE	INTER	
SI02	45.64	46.64	44.85	44.52	51.55	44.27	47.05	44.39	44.10	50.95	54.98
TI02	0.24	0.26	0.29	0.29	0.0	0.30	0.21	0.35	0.34	0.10	0.12
AL203	9.30	9.45	13.78	14.66	2.48	14.08	10.15	14.12	14.03	6.11	3.73
FE0	18.34	18.70	18.55	19.00	19.31	18.53	18.03	18.47	19.40	13.83	16.50
MNO	0.11	0.12	0.04	0.01	0.11	0.02	0.03	0.02	0.13	1.09	1.74
MGO	8.47	8.60	7.13	6.49	10.74	6.95	9.28	6.91	6.42	14.04	11.89
CA0	10.35	10.55	9.10	8.11	11.85	9.03	10.01	8.30	9.27	7.29	2.78
NA20	2.51	2.51	4.01	3.87	0.55	3.59	2.26	3.28	3.34	4.24	5.77
K20	0.45	0.50	0.43	0.45	0.15	0.49	0.34	0.44	0.47	0.34	0.04
TOTAL	95.41	97.33	98.18	97.40	96.74	97.26	97.36	96.28	97.50	97.99	97.55
ATOMIC RATIOS (O = 23.0)											
SI	7.001	7.012	6.673	6.662	7.746	6.645	7.007	6.700	6.634	7.398	7.987
TI	0.028	0.029	0.032	0.033	0.0	0.034	0.024	0.040	0.038	0.011	0.013
AL	1.681	1.674	2.416	2.586	0.439	2.491	1.782	2.512	2.488	1.046	0.639
FE	2.353	2.351	2.308	2.378	2.427	2.326	2.246	2.331	2.441	1.679	2.004
MN	0.014	0.015	0.005	0.001	0.014	0.003	0.004	0.003	0.017	0.134	0.214
MG	1.937	1.927	1.581	1.448	2.406	1.555	2.060	1.555	1.440	3.039	2.575
CA	1.701	1.699	1.451	1.300	1.908	1.452	1.597	1.342	1.494	1.134	0.433
NA	0.746	0.732	1.157	1.123	0.160	1.045	0.653	0.960	0.974	1.194	1.625
K	0.088	0.096	0.082	0.086	0.029	0.094	0.065	0.085	0.090	0.063	0.007
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	ME	MH	MH
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	NU	KU	KU

TABLE 6. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF AMPHIBOLES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	2151	2160	2161	2140			Y-15	32309	32402	Y-19	
	SL	SL	SL	SL			BS	BS	BS	BS	
	GAR	GAR	GAR	CHL			GAR	GAR	GAR	GAR	
	1	1	1	1	1	1	NA-A	NA-A	NA-A	CA-A	1
	RIM	1	1	CORE	INTER	RIM	*	*	*	1	*
SiO ₂	55.21	49.63	49.97	53.33	55.90	56.12	54.70	54.40	55.87	52.69	56.07
TiO ₂	0.01	0.08	0.11	0.06	0.06	0.0	N.D.	N.D.	N.D.	0.02	0.07
Al ₂ O ₃	1.08	8.29	7.97	5.47	4.37	1.27	10.68	8.95	10.17	2.26	9.03
FeO	12.01	8.27	10.05	12.20	11.43	8.62	18.92	16.53	11.84	9.56	15.60
MnO	1.75	0.0	0.0	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.06
MgO	16.47	17.92	15.65	15.66	16.31	19.32	8.76	7.65	11.50	19.46	8.54
CaO	10.14	8.27	7.83	5.17	3.52	8.93	0.71	0.64	1.23	11.19	0.70
Na ₂ O	1.90	4.42	4.57	5.38	5.87	2.70	6.63	7.31	6.83	1.38	6.41
K ₂ O	0.03	0.45	0.45	0.16	0.11	0.12	N.D.	0.03	N.D.	0.0	0.01
TOTAL	98.60	97.33	96.60	97.43	97.57	97.08	100.40	95.51	97.44	96.56	96.49
ATOMIC RATIOS (O = 23.0)											
SI	7.880	7.086	7.227	7.627	7.887	7.931	7.655	7.937	7.802	7.587	8.010
TI	0.001	0.009	0.012	0.006	0.006	0.0	0.0	0.0	0.002	0.002	0.008
AL	0.182	1.395	1.358	0.922	0.727	0.212	1.762	1.539	1.674	0.384	1.520
FE	1.434	0.987	1.215	1.459	1.349	1.019	2.214	2.017	1.383	1.151	1.864
MN	0.212	0.0	0.0								0.007
MG	3.504	3.814	3.374	3.339	3.430	4.070	1.828	1.664	2.394	4.177	1.819
CA	1.551	1.265	1.213	0.792	0.532	1.352	0.106	0.100	0.184	1.726	0.107
NA	0.526	1.223	1.281	1.492	1.606	0.740	1.799	2.068	1.849	0.385	1.775
K	0.005	0.082	0.083	0.029	0.020	0.022	0.006	0.006	0.0	0.0	0.002
ANALYST	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	Y-34	X-204		X-207	X-05	X-101	X-103	X-06	X-04	X-03	
	BS	BS		BS	BS	BS	BS	BS	BS	BS	
	GAR	GAR		GAR	GAR	GAR	GAR	GAR	GAR	GAR	
	NA-A	NA-A	CA-A	NA-A	NA-A	NA-A	NA-A	NA-A	NA-A	NA-A	CA-A
	*	1	*	*	*	*	*	*	*	1	
SiO ₂	56.83	54.59	52.01	54.75	56.85	55.17	54.04	55.33	56.77	57.55	57.32
TiO ₂	N.D.	0.06	0.03	0.02	0.07	0.03	0.01	0.07	0.03	0.0	0.0
Al ₂ O ₃	9.65	10.93	4.00	8.43	8.50	9.27	8.86	9.90	11.50	10.21	1.77
FeO	15.34	12.69	12.76	16.00	14.23	13.35	19.19	12.20	10.07	12.62	12.96
MnO	N.D.	N.D.	N.D.	N.D.	N.D.	0.21	0.09	0.0	0.0	0.08	0.0
MgO	9.01	10.13	13.63	10.31	10.13	10.22	8.22	11.77	11.37	10.36	16.27
CaO	0.53	1.02	9.55	0.81	1.80	0.84	0.68	1.67	0.83	0.85	8.96
Na ₂ O	6.90	6.80	2.39	7.15	6.57	6.72	6.81	6.47	7.20	6.73	2.37
K ₂ O	N.D.	0.02	0.15	N.D.	N.D.	0.02	0.0	0.0	0.0	0.0	0.04
TOTAL	98.26	96.24	94.52	97.47	98.15	95.83	97.90	97.41	97.77	98.40	99.69
ATOMIC RATIOS (O = 23.0)											
SI	7.959	7.750	7.729	7.822	7.966	7.892	7.794	7.756	7.811	7.943	8.000
TI		0.006	0.003	0.002	0.007	0.003	0.001	0.007	0.003	0.0	0.0
AL	1.593	1.829	0.701	1.419	1.404	1.563	1.506	1.636	1.865	1.661	0.291
FE	1.797	1.507	1.586	1.912	1.668	1.597	2.315	1.430	1.159	1.457	1.513
MN						0.025	0.011	0.0	0.0	0.009	0.0
MG	1.881	2.144	3.020	2.196	2.116	2.180	1.767	2.460	2.332	2.132	3.385
CA	0.080	0.155	1.521	0.124	0.270	0.129	0.105	0.251	0.122	0.126	1.340
NA	1.873	1.872	0.689	1.981	1.785	1.864	1.904	1.758	1.921	1.801	0.641
K		0.004	0.028			0.004	0.0	0.0	0.0	0.0	0.007
ANALYST	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU

TABLE 6. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF AMPHIBOLES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	X-113 BS GAR	X-106 BS GAR		23101 SL GAR	23102 SL GAR		X-02 BS GAR					
	NA-A 1	NA-A 1	CA-A 1	NA-A 1	NA-A CORE	NA-A RIM	NA-A51 1	NA-A52 1	NA-A53 1	NA-A54 1	NA-A58 1	
SI02	57.50	56.71	51.67	56.53	55.40	55.57	56.49	55.28	56.68	55.43	56.04	
TI02	0.0	0.0	0.11	0.03	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
AL203	10.83	10.13	2.47	8.92	8.18	8.22	9.22	9.29	9.20	9.54	9.17	
FE0	9.20	11.07	10.13	14.85	15.37	12.30	13.37	13.21	13.08	12.08	13.02	
MNO	0.03	0.05	0.14	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
MGO	11.60	10.79	17.74	9.92	10.22	12.94	10.15	10.14	10.10	10.66	11.05	
CA0	1.75	1.12	11.27	0.76	1.05	2.20	0.94	1.14	1.12	0.81	1.32	
NA20	6.10	7.33	1.21	7.13	6.98	6.55	6.76	6.87	6.93	6.86	6.61	
K20	0.0	0.03	0.08	0.02	0.05	0.04	N.D.	N.D.	N.D.	N.D.	N.D.	
TOTAL	96.99	97.23	94.82	98.16	97.25	97.82	96.93	95.93	97.11	95.38	97.21	
ATOMIC RATIOS (O = 23.0)												
SI	7.923	7.903	7.608	7.937	7.901	7.794	7.964	7.896	7.972	7.907	7.885	
TI	0.0	0.0	0.012	0.003								
AL	1.759	1.664	0.429	1.476	1.375	1.359	1.532	1.564	1.525	1.604	1.521	
FE	1.060	1.290	1.247	1.744	1.833	1.443	1.576	1.578	1.538	1.441	1.532	
MN	0.004	0.006	0.017									
MG	2.383	2.242	3.894	2.076	2.173	2.706	2.133	2.159	2.118	2.267	2.318	
CA	0.255	0.167	1.778	0.114	0.160	0.331	0.142	0.174	0.169	0.124	0.199	
NA	1.630	1.981	0.345	1.941	1.930	1.781	1.848	1.903	1.890	1.897	1.803	
K	0.0	0.005	0.015	0.004	0.009	0.007						
ANALYST	HH	HH	HH	MH	MH	MH	HH	HH	HH	HH	HH	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	X-02 BS GAR									X-102 BS GAR	X-01 BS GAR	
	NA-A59 1	NA-A60 1	NA-A61 1	NA-A62 1	NA-A63 1	NA-A64 1	NA-A65 1	NA-A56 1	CA-A 1	NA-A 1	NA-A 1	
SI02	55.64	54.34	56.71	56.82	56.92	55.67	56.45	55.46	54.39	55.59	55.87	
TI02	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.05	0.03	0.0	
AL203	9.28	9.70	9.40	10.16	9.59	9.60	9.52	7.77	2.39	9.47	8.48	
FE0	13.10	13.04	13.42	13.08	13.93	12.85	12.94	13.26	13.46	14.47	12.47	
MNO	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.10	0.0	
MGO	10.17	9.84	10.40	10.37	10.09	10.70	10.27	11.38	15.95	9.66	11.18	
CA0	0.88	0.87	1.05	1.06	1.03	1.12	1.15	2.52	9.23	0.96	1.17	
NA20	7.03	6.90	7.08	6.84	6.90	6.70	6.77	6.27	2.62	7.43	6.80	
K20	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.03	0.16	0.05	
TOTAL	96.10	94.69	98.06	98.33	98.46	96.64	97.10	96.66	98.12	97.87	96.02	
ATOMIC RATIOS (O = 23.0)												
SI	7.921	7.859	7.917	7.884	7.921	7.870	7.933	7.899	7.791	7.849	7.947	
TI									0.005	0.003	0.0	
AL	1.557	1.653	1.547	1.661	1.573	1.599	1.577	1.304	0.403	1.576	1.422	
FE	1.560	1.577	1.567	1.518	1.621	1.519	1.521	1.579	1.612	1.709	1.483	
MN										0.012	0.0	
MG	2.158	2.122	2.164	2.145	2.093	2.255	2.152	2.416	3.406	2.033	2.371	
CA	0.134	0.135	0.157	0.158	0.154	0.170	0.173	0.385	1.417	0.145	0.178	
NA	1.940	1.935	1.916	1.840	1.862	1.836	1.845	1.731	0.728	2.034	1.875	
K									0.005	0.029	0.009	
ANALYST	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH	HH	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	

TABLE 6. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF AMPHIBOLES (CONTINUED)

SAMPLE NO	IKADAZU	77207	77214	77218	77107	SB601	77031	77033
ROCK TYPE	BS	BS	BS	BS	BS	BS	BS	BS
ZONE	GAR	CHL	CHL	CHL	CHL	CHL	CHL	CHL
GRAIN NO	CA-A	NA-A	NA-A	NA-A	NA-A	NA-A	NA-A	NA-A
POINT NO	1	*	*	*	*	*	*	*
SI02	49.39	55.48	55.13	54.30	54.78	52.58	54.74	54.63
TI02	0.12	0.04	0.03	0.19	0.03	0.47	0.0	N.D.
AL203	7.05	7.06	7.03	7.00	5.65	6.15	4.11	4.52
FE0	16.51	17.68	17.62	17.81	19.20	19.81	20.40	23.36
MNO	0.11	0.10	0.14	0.09	0.10	0.20	0.08	N.D.
MGO	11.91	9.39	9.80	8.42	9.47	9.09	8.75	7.79
CA0	6.84	0.82	1.50	1.34	1.24	2.51	0.95	1.22
NA20	4.46	7.13	6.77	6.78	6.71	5.33	6.46	6.76
K20	0.16	0.02	0.04	0.0	0.08	0.09	0.02	N.D.
TOTAL	96.55	97.72	98.06	95.93	97.26	96.23	95.51	98.28
ATOMIC RATIOS (O = 23.0)								
SI	7.337	7.967	7.906	7.965	7.988	7.805	8.164	8.041
TI	0.013	0.004	0.003	0.021	0.003	0.052	0.0	0.0
AL	1.234	1.195	1.188	1.210	0.971	1.076	0.722	0.784
FE	2.051	2.123	2.113	2.185	2.341	2.459	2.544	2.875
MN	0.014	0.012	0.017	0.011	0.012	0.025	0.010	0.010
MG	2.637	2.010	2.095	1.841	2.059	2.012	1.945	1.709
CA	1.089	0.126	0.230	0.211	0.194	0.399	0.152	0.192
NA	1.285	1.985	1.882	1.928	1.897	1.534	1.868	1.929
K	0.030	0.004	0.007	0.0	0.015	0.017	0.004	0.004
ANALYST	HH	HH	HH	HH	HH	HH	HH	HH
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU

TABLE 7. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF GARNETS

SAMPLE NO	FT-09RB					F-10CA					
	BS	GAR				PE	GAR				
ZONE	1(N)	1(N)	2(N)	3(N)	1(N)	1(N)	2(N)	2(N)	3(N)	3(N)	3(N)
GRAIN NO	1(N)	1(N)	2(N)	3(N)	1(N)	1(N)	2(N)	2(N)	3(N)	3(N)	3(N)
POINT NO	CORE	RIM	RIM	RIM	RIM	CORE	RIM	CORE	RIM1	RIM2	CORE
SI02	36.84	36.77	36.82	36.64	37.29	37.29	37.28	36.47	36.95	37.58	36.57
AL203	20.62	20.39	20.82	20.70	21.04	21.27	20.74	21.06	20.84	20.95	20.81
FE0	23.60	24.66	25.09	24.91	29.79	27.10	29.46	24.91	29.03	27.54	13.27
MNO	6.35	5.50	5.39	5.35	1.29	3.23	1.58	5.00	2.20	2.57	19.57
MGO	0.69	0.69	0.67	0.67	0.82	0.58	1.26	0.48	0.68	0.63	0.16
CA0	11.18	10.61	10.86	10.80	8.65	10.65	8.75	10.62	9.12	10.06	8.31
TOTAL	99.28	98.62	99.65	99.07	98.88	100.12	99.07	98.54	98.82	99.33	98.69
ATOMIC RATIOS (O = 12.0)											
SI	2.982	2.996	2.973	2.975	3.018	2.986	3.013	2.970	3.003	3.024	2.991
AL	1.967	1.958	1.981	1.981	2.007	2.007	1.976	2.022	1.996	1.987	2.006
FE	1.597	1.680	1.694	1.691	2.016	1.815	1.991	1.697	1.973	1.853	0.908
MN	0.435	0.380	0.369	0.368	0.088	0.219	0.108	0.345	0.151	0.175	1.355
MG	0.083	0.084	0.081	0.081	0.099	0.069	0.152	0.058	0.082	0.076	0.020
CA	0.970	0.926	0.939	0.939	0.750	0.914	0.758	0.927	0.794	0.867	0.728
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU

TABLE 7. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF GARNETS (CONTINUED)

SAMPLE NO	FC-03		FC-04		FSW-01P						
	ROCK TYPE	PE	PE								
ZONE	GAR	GAR									
GRAIN NO	3(N)	1(N)	2(N)	2(N)	3(N)	3(N)	1(N)	1(N)	2(N)	3(N)	3(N)
POINT NO	CORE	RIM	RIM	CORE	RIM1	RIM2	CORE	RIM	RIM	CORE	RIM
SI02	36.62	37.05	36.98	36.99	37.11	37.05	36.53	37.38	37.78	36.60	37.52
AL203	20.38	20.49	20.45	20.77	20.68	20.69	20.38	20.82	20.69	20.75	20.90
FE0	17.82	30.48	30.91	24.17	31.29	31.14	12.57	27.87	28.28	13.57	29.47
MNO	15.35	1.47	2.01	9.01	1.76	1.17	21.62	3.17	1.95	20.53	2.23
MGO	0.32	1.00	0.97	0.49	1.01	1.13	0.18	0.86	0.91	0.18	0.94
CAO	9.06	9.13	8.44	9.81	8.89	9.07	7.49	9.31	8.76	8.14	8.99
TOTAL	99.55	99.62	99.76	101.24	100.74	100.25	98.77	99.41	98.37	99.77	100.05
ATOMIC RATIOS (O = 12.0)											
SI	2.982	2.997	2.995	2.963	2.979	2.982	2.998	3.014	3.060	2.975	3.011
AL	1.956	1.954	1.952	1.961	1.957	1.962	1.971	1.979	1.975	1.988	1.976
FE	1.214	2.062	2.094	1.619	2.101	2.096	0.863	1.879	1.915	0.923	1.977
MN	1.059	0.101	0.138	0.611	0.120	0.080	1.503	0.217	0.134	1.414	0.152
MG	0.039	0.121	0.117	0.059	0.121	0.136	0.022	0.103	0.110	0.022	0.112
CA	0.790	0.791	0.732	0.842	0.765	0.782	0.659	0.804	0.760	0.709	0.773
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU

SAMPLE NO	FSW-01P		FSW-04P								
	ROCK TYPE	PE	PE								
ZONE	GAR	GAR									
GRAIN NO	4(N)	1(N)	1(N)	2(N)	2(N)	3(N)	3(N)	3(N)	4(N)	5(N)	5(N)
POINT NO	RIM	RIM	CORE	RIM	INTER	RIM	CORE	INTER	RIM	RIM1	RIM2
SI02	37.14	38.00	37.72	38.44	38.10	37.92	37.29	37.40	37.18	37.01	37.05
AL203	20.74	21.36	21.21	21.42	21.48	21.34	20.89	21.14	20.87	20.99	20.88
FE0	29.23	29.25	13.56	29.55	18.74	30.01	15.80	19.52	28.96	29.66	29.70
MNO	2.57	2.39	18.43	2.11	9.90	2.07	13.84	9.43	2.27	0.88	0.71
MGO	0.89	0.95	0.23	0.96	0.29	0.98	0.23	0.30	0.93	1.02	1.13
CAO	9.02	8.83	10.01	9.17	12.51	8.83	11.59	11.76	8.96	9.25	9.27
TOTAL	99.59	100.78	101.16	101.65	101.02	101.15	99.64	99.55	99.17	98.81	98.74
ATOMIC RATIOS (O = 12.0)											
SI	3.000	3.017	2.999	3.025	3.007	3.007	2.999	3.001	3.007	2.999	3.003
AL	1.974	1.999	1.987	1.986	1.998	1.994	1.980	1.999	1.989	2.004	1.994
FE	1.975	1.942	0.901	1.945	1.237	1.990	1.063	1.310	1.959	2.010	2.013
MN	0.176	0.161	1.241	0.141	0.662	0.139	0.943	0.641	0.155	0.060	0.049
MG	0.107	0.112	0.027	0.113	0.034	0.116	0.028	0.036	0.112	0.123	0.137
CA	0.781	0.751	0.853	0.773	1.058	0.750	0.999	1.011	0.776	0.803	0.805
ANALYST	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME	ME
INSTRUMENT	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU	NU

TABLE 7. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF GARNETS (CONTINUED)

SAMPLE NO	Y-15	Y-34	X-05	X-101	23102
ROCK TYPE	BS	BS	BS	BS	SL
ZONE	GAR	GAR	GAR	GAR	GAR
GRAIN NO	1(N)	1(N)	1(N)	1(N)	1(N)
POINT NO	RIM	RIM	RIM	RIM	1
SI02	37.96	38.22	37.29	37.58	37.39
AL203	20.79	21.51	20.85	20.49	20.11
FE0	26.09	27.65	29.25	27.84	13.20
MNO	3.03	2.88	2.86	3.50	21.26
MGO	0.82	1.08	3.06	2.32	2.27
CA0	12.28	10.03	8.01	7.40	5.46
TOTAL	100.97	101.37	101.32	99.13	99.69
ATOMIC RATIOS (O = 12.0)					
SI	3.008	3.010	2.954	3.026	3.019
AL	1.942	1.996	1.947	1.945	1.914
FE	1.729	1.821	1.938	1.875	0.891
MN	0.203	0.192	0.192	0.239	1.454
MG	0.097	0.127	0.361	0.279	0.273
CA	1.043	0.846	0.680	0.638	0.472
ANALYST	HH	HH	HH	HH	MH
INSTRUMENT	KU	KU	KU	KU	KU

TABLE 8. CHEMICAL COMPOSITION AND ATOMIC RATIO OF PYROXENE

SAMPLE NO	2151
ROCK TYPE	SL
ZONE	GAR
GRAIN NO	
POINT NO	
SI02	53.16
TIO2	0.03
AL203	5.39
FE0	13.57
MNO	0.71
MGO	7.26
CA0	11.76
NA20	7.40
TOTAL	99.28
ATOMIC RATIOS (O = 6.0)	
SI	2.013
TI	0.001
AL	0.241
FE	0.430
MN	0.023
MG	0.410
CA	0.477
NA	0.543
ANALYST	MH
INSTRUMENT	KU

TABLE 9. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF EPIDOTES

SAMPLE NO	FT-07RB	FT-09RB			HK69072803	2160	2161	HK69072605	HK69072501		
ROCK TYPE	BS	BS			PE	SL	SL	PE	PE		
ZONE	GAR	GAR			GAR	GAR	GAR	BIO	BIO		
GRAIN NO	1	2	2	1	2	3	1	1	1		
POINT NO	1	CORE	RIM	1	1	1	1	1	1		
SI02	37.51	37.96	37.95	38.35	38.19	38.10	39.40	37.44	37.16	39.00	39.90
AL203	26.99	27.11	23.70	26.54	27.32	27.34	27.70	23.28	21.81	27.70	26.70
FE203	8.37	7.90	12.04	8.98	6.93	6.85	7.73	13.78	14.36	7.16	8.65
MNO	0.17	0.33	0.05	0.76	0.46	0.46	N.D.	0.29	N.D.	0.40	0.05
CA0	24.30	24.33	23.84	23.60	23.92	23.94	23.00	24.12	23.63	22.70	23.30
TOTAL	97.34	97.63	97.58	98.23	96.82	96.69	97.83	98.91	96.96	96.96	98.60
ATOMIC RATIOS (O = 12.5)											
SI	2.961	2.982	3.022	3.002	3.011	3.008	3.056	2.968	3.008	3.052	3.083
AL	2.511	2.510	2.224	2.449	2.539	2.544	2.532	2.175	2.081	2.555	2.431
FE	0.497	0.467	0.721	0.529	0.411	0.407	0.451	0.822	0.875	0.422	0.503
MN	0.011	0.022	0.003	0.050	0.031	0.031	0.031	0.019	0.019	0.027	0.003
CA	2.055	2.048	2.034	1.979	2.021	2.025	1.912	2.049	2.050	1.904	1.929
ANALYST	ME	ME	ME	ME	ME	ME	HK	MH	MH	HK	HK
INSTRUMENT	NU	NU	NU	NU	NU	NU	KU	KU	KU	KU	KU

Table 10. Mineral assemblages and correlations between sample Nos used in this paper and those given in the referred papers. Chemical compositions of the minerals marked with ● or star (e.g.pa*) are listed in this paper.

Abbreviations: Pe= pelitic schist, Bs= basic schist, Sl= siliceous schist, Chl= chlorite zone, Gar= garnet zone, Bio= biotite zone, Qz= quartz, Ab= albite, Ms= muscovite, Pa= paragonite, Bt= biotite, Ch= chlorite, Am= amphibole, Hb= hornblende, Px= pyroxene, Ga= garnet, Ep= epidote, Pi= piemontite, Al= allanite, Cc= calcite, To= tourmaline, Ap= apatite, Sp= sphene, Il= ilmenite, Ru= rutile, Hm= hematite, Po= pyrrhotite, Py= pyrite, Cp= chalcopyrite, Cv= covellite, Cm= carbonaceous matter, ○, ●= present, - = absent.

(a) Sazare area

Sample No.	Rock type	Mineral zone	Qz	Ab	Ms	Bi	Ch	Hb	Ga	Ep	Cc	To	Ap	Sp	CM	others	Banno & Kurata (1972)	Kurata (1972)	Kurata & Banno (1974)	Enami (1980)
FT-07RB	Bs	Gar	o	o	●	-	●	●	-	●	o	-	-	o	-	Py,Cp,Cv				
FT-09RB	Bs	Gar	o	●	●	-	●	●	●	●	-	-	-	o	-	Po,Py,Cp				FT-09R
F-10CA	Pe	Gar	o	o	●	-	●	-	●	o	-	o	o	o	o					F-10C
F-10CB	Pe	Gar	o	o	o	-	●	-	●	o	-	o	o	o	o					
FC-01	Pe	Gar	o	o	o	-	●	-	●	o	-	o	o	o	o					FC-01
FC-02	Pe	Gar	o	o	o	-	●	-	●	o	-	o	o	o	o					
FC-03	Pe	Gar	o	o	o	-	●	-	●	o	-	o	o	o	o					
FC-04	Pe	Gar	o	o	o	-	●	-	●	o	-	o	o	o	o	Al				
FSW-01P	Pe	Gar	o	o	●	●	●	●	●	o	-	o	o	o	o					FSW-01P
FSW-04P	Pe	Gar	o	o	o	●	o	●	●	o	-	o	o	o	o					
FS-11R	Pe	Gar	o	o	●	-	●	-	●	o	-	o	o	o	o					
HK69073108	Pe	Chl	o	o	●	-	●	-	-	o	o	o	o	o	o			1	1	
HK69073107	Pe	Gar	o	o	●	-	●	-	●	o	o	o	o	o	o		2	2	2	
HK69073101	Pe	Gar	o	o	●	-	●	-	●	o	o	o	o	o	o		4		4	
HK69073014	Pe	Bio	o	o	●	-	●	-	●	-	-	o	o	o	o			5	5	
HK69073004	Pe	Bio	o	o	●	-	●	-	●	-	-	o	o	o	o		7		7	
HK69073011	Pe	Bio	o	o	●	-	●	o	●	-	-	o	o	o	o		11	11	11	
HK69072811	Pe	Bio	o	o	●	-	●	-	●	o	-	o	o	o	o		13		13	
HK69072803	Pe	Gar	o	o	●	-	●	-	●	●	o	o	o	o	o					17
2151	Sl	Gar	o	o	o	-	-	●	o	o	o	o	o	o	-	*Px,Pi,Hm				
HK69072610	Pe	Gar	o	o	●	-	●	-	-	o	-	o	o	-	o					19
2160	Sl	Gar	o	o	o	-	●	●	-	●	o	-	-	-	-	Hm				
2161	Sl	Gar	o	o	o	-	●	●	-	●	o	-	-	o	-	Hm				
HK69072605	Pe	Bio	o	o	●	-	●	-	●	●	-	o	o	-	o					22
HK69072501	Pe	Bio	o	o	●	-	●	-	●	●	o	o	o	o	o		25	25	25	
HK69072505	Pe	Bio	o	o	o	o	●	-	●	o	o	o	o	o	o		26		26	
HK69072507	Pe	Bio	o	o	●	●	●	-	●	-	-	o	o	-	o		27		27	
2140	Sl	Gar	o	o	●	-	o	●	-	●	o	-	o	o	-	Hm				

(b) Kotu area

Sample No.	Rock type	Mineral zone	Qz	Ab	Ms	Ch	Am	Ga	Ep	Cc	Sp	Ru	Op	others	Hosotani & Banno (in prep.)
Y-15	Bs	Gar	○	○	●	●	●	○	-	-	-	-	○		Y-15
32309	Bs	Gar	○	○	○	○	●	-	●	-	○	-	○		
32402	Bs	Gar	○	○	○	○	●	-	●	-	○	-	○		
Y-19	Bs	Gar	○	○	●	○	●	-	●	-	-	○	○	Hm	
Y-34	Bs	Gar	○	○	○	●	●	●	○	-	-	-	○	Py	Y-34
X-204	Bs	Gar	○	○	○	●	●	-	○	-	○	-	○	Py	X-204
X-207	Bs	Gar	○	○	●	●	●	-	○	○	-	○	○	Hm	
X-05	Bs	Gar	○	○	○	●	●	●	●	-	-	○	○		X-05
X-101	Bs	Gar	○	○	○	○	●	●	●	-	-	○	○		X-101
X-103	Bs	Gar	○	○	○	-	●	○	●	-	-	○	○	Hm, Il	X-103
X-06	Bs	Gar	○	○	○	●	●	-	●	○	○	○	○		X-06
X-04	Bs	Gar	○	○	○	●	●	-	●	-	-	○	○		X-04
X-03	Bs	Gar	○	○	○	●	●	-	●	-	-	○	○		X-03
X-113	Bs	Gar	○	○	○	○	●	-	●	-	○	○	○	Py	X-113
X-106	Bs	Gar	○	○	●	●	●	-	○	-	-	○	○		X-106
23101	Sl	Gar	○	○	○	●	●	○	○	-	○	○	○	To, Ap, Hm	
23102	Sl	Gar	○	○	●	○	●	●	●	-	○	○	○	Pa, To, Hm	
X-02	Bs	Gar	○	○	○	●	●	-	●	-	○	○	○		X-02
X-102	Bs	Gar	○	○	○	●	●	○	●	-	○	○	○	Hm	X-102
X-01	Bs	Gar	○	○	○	●	●	-	●	○	-	○	○	Hm	X-01
X-01B	Bs	Gar	○	○	○	●	●	-	●	○	-	○	○	Hm	X-01B
32502	Bs	Gar	○	○	○	○	●	-	●	-	-	○	○		32502
32503	Bs	Gar	○	○	○	●	●	-	○	-	-	○	○		32503

(c) Bessi area

Sample No.	Rock type	Mineral zone	Qz	Ab	Ms	Ch	Am	Ep	Cc	Sp	Ru	Hm
IKADAZU	Bs	Gar	○	○	○	●	●	○	-	-	○	○
77207	Bs	Ch1	○	○	○	○	●	○	-	-	-	○
77214	Bs	Ch1	○	○	○	○	●	○	-	○	-	○
77218	Bs	Ch1	○	○	○	○	●	○	○	-	-	○
77107	Bs	Ch1	○	○	○	○	●	○	○	○	-	○
SB601	Bs	Ch1	○	○	○	○	●	○	○	-	-	○
77031	Bs	Ch1	○	○	○	●	●	○	-	○	-	○
77033	Bs	Ch1	○	○	○	○	●	○	-	-	-	○