

**Electron microprobe analyses of rock-forming minerals from the
Sanbagawa metamorphic rocks, Shikoku
Part I. Asemi River area**

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Abstract Chemical compositions of rock-forming minerals from the Sanbagawa metamorphic rocks in the Asemi River area, central Shikoku, are tabulated along with their brief descriptions. They include 867 electron microprobe analyses of silicate, oxide and sulfide minerals, and 10 analyses of carbonaceous matter.

Introduction

The Sanbagawa metamorphic belt is of an intermediate high-pressure type terrain, Miyashiro (1961). It extends longitudinally for about 800 km through the central and southwestern portion of the Japanese island arc on the Pacific Ocean side. Through the studies of Miyashiro and Banno (1958), Seki (1958), Iwasaki (1963), Banno (1964), Ernst et al. (1970) and others, the basic petrology of this belt has been established and is best summarized in the textbooks of Miyashiro (1965, 1973). The early petrological studies were mainly based upon conventional wet chemical analyses, and optical and X-ray properties of rock-forming minerals, but Ernst et al. (1970) have used electronprobe analyses. We have been engaged in the petrology of the Sanbagawa metamorphic rocks in the Shikoku region for the last ten years. This research has involved extensive use of the electronprobe microanalyser. Electronprobe microanalysis has revealed that most of the rock-forming minerals with solid solution show chemical heterogeneity, often exhibiting more or less regular zonal structure. This offers us an opportunity to elucidate the metamorphic history more deeply. Some of our works have been published, and others are in progress. Our present view on the phase petrology and its implication to the tectonics of the south western Japan was recently summarized by Banno et al. (1978).

In the literature, full details of the electronprobe microanalysis have not always been

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published, only representative or average compositions were generally reported, or chemical data were summarized in figures. This method of data presentation is neither convenient nor fair, but was necessitated by editorial requirements. Therefore, we have decided to publish a full compilation of chemical data for the Sanbagawa metamorphic rocks collected by us in Shikoku, so that interested persons can examine their own ideas on the Sanbagawa metamorphism, not necessarily following the logic and prejudices of the authors.

This is the first report in a series of papers presently in preparation. It deals with the chemical data in the Asemi River* area in central Shikoku.

Outline of geology and petrography

The Asemi River area is located in Motoyama-cho, Nagaoka-gun, Kochi Prefecture** in central Shikoku, and a part of the Shiragayama*** area of Higashino (1975). It is underlain by the upper two formations of stratigraphy in central Shikoku established by Kojima and his collaborators (Kojima et al., 1956 and others), that is, the Ojoin formation mainly composed of alternating pelitic and psammitic schists with minor intercalated quartz and basic schists, and the Minawa formation composed of basic, pelitic and psammitic schists with a very thin intercalated calcareous bed. The latter formation is further divided into three members, the lower, main and upper members. The localities of the samples containing analyzed minerals, and the traverse map along the Asemi River section are shown in Fig. 1. Intercalated thin beds are not shown. Also, psammitic schists are not distinguished from pelitic schists because of their similar appearance in the intensely recrystallized area and their tendency to alternate in beds varying from a few to several tens of centimeters in thickness. In our definitions of rock-types, the term "siliceous schist" is applied to a rock, which is more siliceous than ordinary pelitic and basic schists, this includes psammitic and quartzitic schists, and so on.

The apparent geologic structure is that of a simple monocline trending approximately E-W and dipping north, minor folding is common. Kawachi (1968) and Hara et al. (1977), who made a detailed structural analysis of the geology of this area, have proposed a large scale recumbent fold or nappe. However, the location and significance of folds, their axial planes and the thrust zone are still in dispute. We have also proposed a large recumbent fold based upon the thermal structure (Banno et al., 1978), but the location of the axial plane differs from that postulated in the earlier works.

On the basis of the mineral assemblage in pelitic schists, this area is divided into three mineral zones, the chlorite, garnet and biotite zones in order of ascending metamorphic grade. The garnet zone is not comparable to the almandine zone of Barrovian-type metamorphism, as the garnet in the garnet zone contains 2-6 wt. % of MnO and 8-11 wt. % of CaO at the rim, and biotite is absent. In basic schists, two isograds are defined in the

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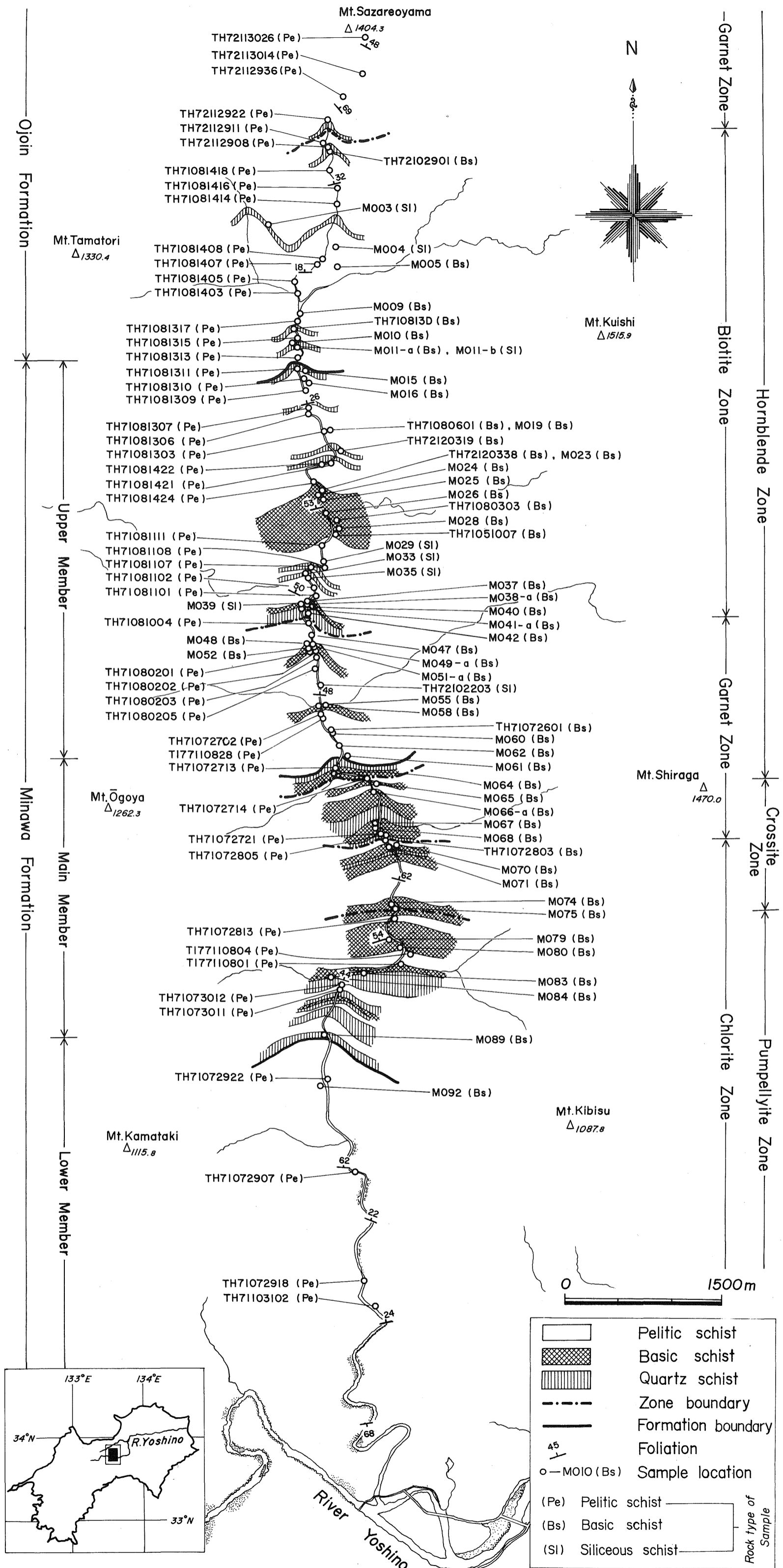


Fig. 1. Traverse map and sample localities along the Asemi River section.

study area. One of these is the transition from crossite-bearing to barroisite (subcalcic hornblende)-bearing assemblages in hematite-bearing basic schists, and the other is that from pumpellyite-bearing to pumpellyite-free assemblages in Fe₂O₃-poor basic schists. The crossite to barroisite isograd is located in the garnet zone, and pumpellyite disappearance isograd in the chlorite zone. In the Asemi River section, not only the metamorphic grade is defined in terms of mineral zones, but it is also confirmed by the sliding equilibrium among silicate minerals that metamorphic temperature in each zone increases from the lower-grade to higher-grade parts. The schematic stability field of diagnostic minerals and the distribution of mineral zones are shown in Fig. 2 and Fig. 1, respectively. The mineral assemblages of the samples containing analyzed minerals are shown in Table 18.

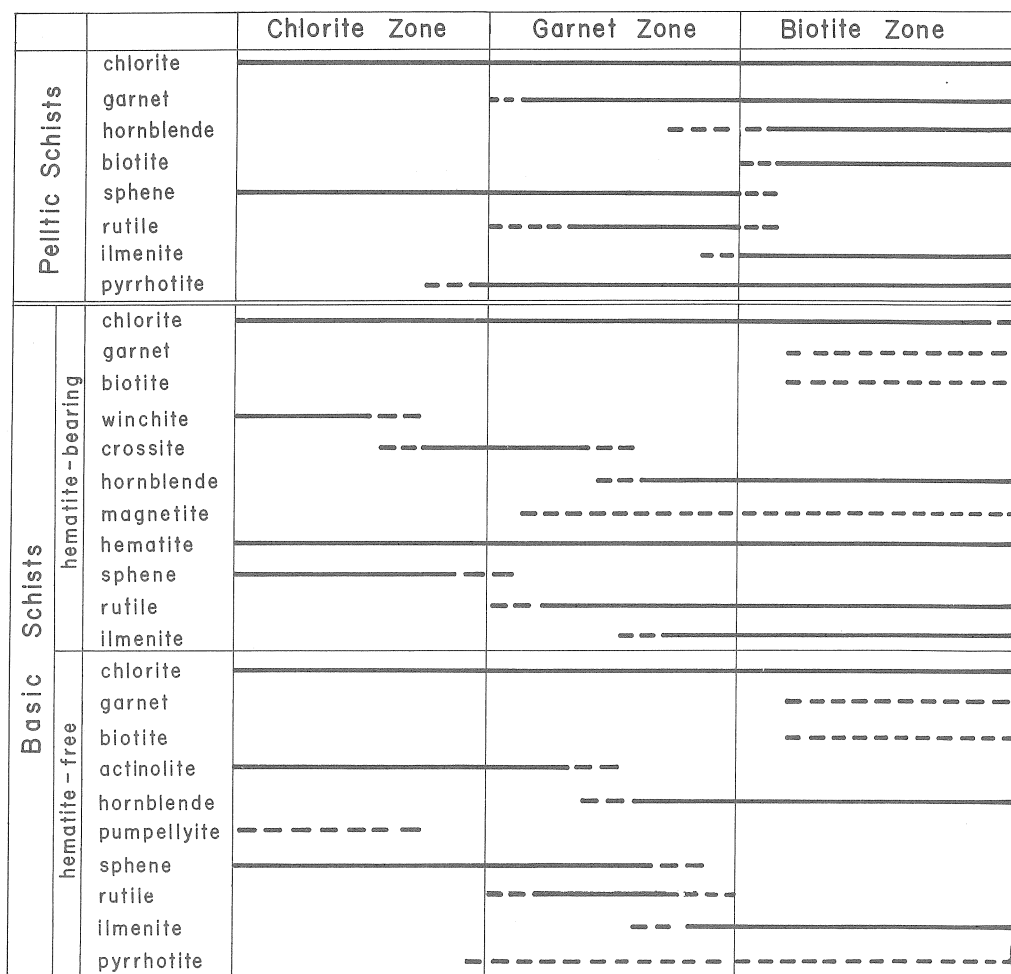


Fig. 2. Schematic stability field of diagnostic minerals. Quartz, albite, muscovite, epidote, calcite, tourmaline, apatite, pyrite, chalcopyrite and carbonaceous matter, which appear throughout the three zones, are not shown in this figure. Among them, quartz, albite, muscovite and epidote always occur in the pelitic and basic schists.

The detailed discussions on the mineral assemblages of the Sanbagawa schists of the Asemi River area have been given in the following papers : Higashino (1975) on silicate minerals in pelitic schists ; Nakajima et al. (1977), Otsuki (1980a), Nakajima (in press) and Otsuki and Banno (in prep.) on silicate minerals in basic schists ; Itaya (1975) on pyrrhotite in pelitic schists ; Itaya and Banno (1980) on titanium-bearing accessories in pelitic schists and Itaya and Otsuki (1978) on those in basic schists ; Itaya (1981) on carbonaceous matter in pelitic schists.

Analytical Procedure

We used two electronprobe microanalysers, Hitachi XMA-5A of the Kanazawa University and J.E.O.L JXA-5A of the University of Tokyo in the determination of chemical analyses of silicate, oxide and sulfide minerals. Correction procedures follow the methods of Bence and Albee (1968) for silicate minerals, Yui and Shoji (1976) for oxide minerals and Itaya (1975) for pyrrhotites. Chemical analyses of carbonaceous matter were determined using Shimazu Organic Microanalyser of Universal type of the Tohoku University by the Pregle method for carbon and hydrogen, and the Unterzaucher method for oxygen.

Iron content is represented as FeO for silicate and oxide minerals, except epidote, pumpellyite, magnetite and hematite. For epidote and pumpellyite, it is represented as Fe_2O_3 , and the amounts of ferrous and ferric iron in magnetite and hematite were estimated by the method of Carmichael (1967) or Rumble (1973).

Brief description of individual minerals

In this chapter, we briefly describe the mode of occurrence and the chemical characteristics of individual minerals listed in Tables 1-17. Analyses were determined on arbitrarily selected points unless otherwise stated. More detailed descriptions were given in the papers referred.

Albite (OTSUKI, 1980b)

Albite occurs as a stable phase in most schists of all the mineral zones in the Asemi River area. It is almost pure albite and not zoned in the chlorite zone. However, it generally forms porphyroblastic aggregates zoned optically and chemically in the garnet and bitote zones. Its An content ranges from nearly 0 to 6 in a conspicuously zoned albite. A preliminary study of the zonal structure of albite porphyroblasts was reported by Otsuki (1980b). The chemical compositions of albities from basic and siliceous schists are listed in Table 1.

Muscovite (HIGASHINO, 1974 ; OTSUKI, 1980 a ; OTSUKI and BANNO, in Pre.)

This phase is phengitic, and its FeO for total Fe and MgO contents are about 1.7-8.3

and 1.6-4.0 wt. %, respectively. Chemical heterogeneity is observed within individual grains. For example, a muscovite grain of specimen TH71080201 shows a variation of 1.7-3.2 wt. % in FeO and 1.6-2.4 wt. % in MgO, but the details of this zonation have not, as yet, been worked out. The chemical compositions of muscovites are listed in Table 2.

Paragonite (OTSUKI, 1980a)

Electron microprobe analysis enabled the recognition of paragonite in one basic schist (MO10). Two analyses from this specimen are listed in Table 3.

Biotite (HIGASHINO, 1975; OTSUKI, 1980a)

In the pelitic schists of the biotite zone, biotite is common and is usually brown colored with $TiO_2 = 0.8-2.7$ wt. %. The brown biotite is almost homogeneous within individual grains, except for a few grains with pale green colored margins, which always make contact with quartz, albite or garnet. The pale green colored margin is very poor in TiO_2 . Occasionally, minute grains of brown biotite occur growing in cracks of garnet and hornblende, or replacing them along with chlorite. Their chemical compositions are similar to those of the brown biotites in the matrix. In the basic schists of the biotite zone, brown biotite occurs but sporadically.

Table 4 includes analyses of the brown biotites in the matrix and, in addition, analyses of two points of the pale green margin and one point of the brown biotite replacing garnet.

Chlorite (HIGASHINO, 1975 ; OTSUKI, 1980a ; OTSUKI and BANNO, in prep.)

Chlorite generally occurs forming the schistosity plane along with muscovite, but some chlorites occur in pressure shadow of garnet or replacing ferromagnesian minerals such as garnet, hornblende and biotite. Chemical heterogeneity, mainly in regard to Fe-Mg substitution, is often distinct among the chlorites with different mode of occurrence and also sometimes within individual grains.

Analyzed points for pelitic schists listed in Table 5 are Mg-rich parts of the schistosity-forming chlorites, which were assumed to represent the composition stable during the prograde metamorphism. On the other hand, analyzed points for the schistosity-forming chlorites in basic and siliceous schists in the table were chosen arbitrarily, as they are rather homogeneous within a grain. Some analyses of chlorite replacing hornblende or garnet in basic schists are also listed.

Stilpnomelane (OTSUKI, 1980a)

Basic schists rarely contain stilpnomelane, but pelitic schists do not. The basic schists, which contain stilpnomelane, are rich in iron as judged from the chemistry of coexisting chlorite. Analyses of stilpnomelanes from three specimens are listed in Table 6.

Amphibole (HIGASHINO, 1974 ; OTSUKI, 1980a ; OTSUKI and BANNO, in prep.)

With advancing metamorphic grade, the species of amphibole changes in the following order ; winchite, crossite and subcalcic hornblende in hematite-bearing basic schists, and actinolite, subcalcic hornblende and calcic hornblende in hematite-free schists. With a few exceptions (e.g. some actinolites), they are chemically zoned, and most of the zoned amphiboles have Al_2O_3 -poor compositions at the marginal part. The composition of the Al_2O_3 -rich core is usually the same from grain to grain, whereas that at the margin is heterogeneous even in the same grain. The aluminous core represents the chemistry during the prograde metamorphism, while the less aluminous margin that during the retrograde metamorphism. The same zonal structure is also observed in amphiboles in siliceous schists. In the pelitic schists, hornblende commonly occurs in the uppermost garnet zone and biotite zone, but its heterogeneity has not been examined in detail. Acicular actinolite occurs in a quartz vein of one pelitic schist of the biotite zone (TH71081303), but this occurrence is exceptional.

The chemical compositions of amphiboles are listed in Table 7. For the amphiboles in the basic and siliceous schists, the analyzed points of the aluminous core are distinguished from those of the less aluminous margin by naming POINT NO of the former "CORE".

Pyroxene (OTSUKI, 1980a)

Metamorphic pyroxene has been found from only one specimen of the lower chlorite zone (MO83) in our study. It is green colored aegirine-augite, grown replacing the rim of relic augite. Analyses of three grains are listed in Table 8.

Pumpellyite (OTSUKI, 1980a ; NAKAJIMA, in press)

In the present area, pumpellyite is stable in the lower-grade part of the chlorite zone, but is sporadic. Pumpellyite was analyzed from only one specimen (MO80), and its composition is listed in Table 9. It occurs as aggregates and is more aluminous than those of the Omoiji -Nagasawa area studied by Nakajima et al. (1977).

Garnet (HIGASHINO, 1975 ; ITAYA, 1978b ; OTSUKI, 1980a)

Garnet usually shows chemical zoning with regard to Mn, Ca, Fe and Mg. Homogeneous garnet occurs in the basic schist (TH71120338), but this occurrence is exceptional. Based upon the Mn distribution, the zonal structure is classified into three types ; normal zoning with a decrease in Mn outwards from the core, reverse zoning with Mn-rich rim around normal zoning and oscillatory zoning with an oscillatory distribution of Mn. Most garnets in the pelitic schists show the normal zoning, although a few garnets show the reverse type. Garnets in the basic schists show all three types of zoning.

Chemical compositions of garnet are listed in Table 10. The analyses for the normally zoned garnets were determined on the rim and rarely on the core, while those for the reversely and oscillatorily zoned garnets on the Mn-poor part, and rarely on the core and the rim. Partial analysis was done on the rim and the Mn-poor part for the reversely

zoned garnets in pelitic schists (Itaya, 1978b), but not listed in Table 10.

Epidote (OTSUKI, 1980a; OTSUKI and BANNO, in prep.)

Epidote is a major constituent of the basic schists, and is also a common but minor constituent of the pelitic schists. Analyses were determined on epidotes from basic and siliceous schists, and are listed in Table 11. Zoning is common, but it has not been studied in detail at the time this compilation is completed.

Ilmenite (ITAYA and OTSUKI, 1978; ITAYA and BANNO, 1980)

Ilmenite occurs as discrete grain, intergrowth with hematite, fine lamellae in hematite, and in composite aggregates. The composite aggregates are made up of ilmenite, and sphene or rutile, or both. Ilmenite is manganoan, and its MnO content is 1-9 wt. % in pelitic and basic schists. The maximum MnO content is 24 wt. %, as observed in a discrete grain in the siliceous schist of the garnet zone (MO52). Ilmenite is homogeneous, when occurring as discrete grains and in hematite-ilmenite intergrowths, but ilmenite in composite aggregates is distinctly heterogeneous even within the same aggregate. Table 12 shows the chemical compositions of ilmenites of various modes of occurrence described above.

Rutile (ITAYA and OTSUKI, 1978; ITAYA and BANNO, 1980)

Rutile is widespread in the garnet and biotite zones, and very often armoured by sphene of retrograde origin. The chemical compositions of this mineral are listed in Table 13. SiO₂, Al₂O₃, MnO and FeO are minor components.

Magnetite (ITAYA and OTSUKI, 1978)

Magnetite is rare in the present area, and usually coexists with hematite. It is euhedral, and is homogeneous. Analyses of magnetite are listed in Table 14. TiO₂, Al₂O₃, MnO and SiO₂ are detected as minor components. Among them, SiO₂ is sometimes as high as 4.62 wt. %, as observed in magnetite of specimen MO38b.

Hematite (ITAYA and OTSUKI, 1978)

Hematite occurs in various forms; as intergrowths with ilmenite or rutile, discrete grains, or as lamellae in ilmenite. Coarse-grained discrete hematite grains are usually zoned with TiO₂ decreasing towards the rim. The composition of the core is constant throughout a single thin section, but that of the rim differs from grain to grain. On the other hand, hematite intergrown with ilmenite is homogeneous, and does not differ from grain to grain. The compositions of the core and rim of the zoned hematite, the core of hematite in hematite-ilmenite intergrowths and hematite lamellae are listed in Table 15.

Pyrrhotite (ITAYA, 1975)

Pyrrhotite is rare in the basic schists, but common in pelitic schists of the higher chlorite zone to the biotite zone. Chemical analyses were determined on pyrrhotites from the pelitic schists. These analyses are homogeneous within one grain. The totals of analyses are generally less than 100 %, suggesting oxidation of them at the earth's surface. The Fe/S ratios of pyrrhotites range from 0.87 to 0.90, though most of them are close to 0.875, the value of Fe_7S_8 . The pyrrhotites with Fe/S ratio of nearly 0.875 are monoclinic, while the pyrrhotites with the higher value of it exhibit the X-ray powder pattern intermediate between monoclinic and hexagonal pyrrhotites. Table 16 shows analyses of pyrrhotites.

Carbonaceous matter (ITAYA, 1981)

Pelitic schists of the Sanbagawa terrain are black colored by the ubiquitous presence of carbonaceous matter, and in the field the name of "black schist" is often used instead of pelitic schist. Carbonaceous matter is amorphous carbon in the lower-grade area of the chlorite zone. The degree of graphitization advances with the grade of metamorphism until the higher-grade part of the biotite zone is reached, where carbonaceous matter close to the well-ordered graphite occurs. Table 17 shows analyses of carbonaceous matter with regard to C, H, O and ash. Atomic ratios of C, H and O are recalculated to 100.0 %.

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Abbreviations used in Tables 1-17 are as follows.

(Tables 1-17) PE=pelitic schist, BS=basic schist, SL=siliceous schist, CHL=chlorite zone, GAR=garnet zone, BIO=biotite zone, TH=Toshio Higashino, MO=Masayuki Otsuki, TI=Tetsumaru Itaya, Ku=Hitach XMA-5A of the Kanazawa University, TU=J.E.O.L JXA-5A of the University of Tokyo, SM=Shimazu Organic Microanalyser of Universal type of the Tohoku University.

(Table 4) (G)=pale green colored margin, (RG)=replacing garnet.

(Table 5) (RH)=replacing hornblende, (RG)=replacing garnet.

(Table 7) (V)=occurring in quartz vein, CORE=aluminous core.

(Table 10) (N)=normally zoned, (R)=reversely zoned, (O)=oscillatorily zoned, (NZ)=not zoned, POOR=Mn-poor part.

(Table 12) (D)=discrete grain, (R)=forming composite aggregate with rutile, (S)=forming composite aggregate with sphene, (RS)=forming composite aggregate with rutile and sphene, (L)=lamellae in hematite.

(Table 15) (D)=discrete grain, (I)=intergrown with ilmenite, (L)=lamellae in ilmenite.

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

SAMPLE NO ROCK TYPE ZONE	TH71081303			TH71081111						TH71081107		
	PE			PE						PE		
	BIO			BIO						BIO		
GRAIN NO	1	2	2	1	2	2	3	3	3	1	2	
POINT NO	1	1	2	1	1	2	1	2	3	1	1	
SI02	46.88	48.47	49.54	50.57	49.14	48.93	49.08	51.57	50.62	48.08	49.57	
TI02	0.46	0.53	0.47	0.12	0.43	0.41	0.12	0.30	0.12	0.40	0.26	
AL203	29.98	29.64	30.19	28.41	31.02	29.89	29.29	28.88	27.81	29.58	27.93	
FE0	3.75	2.32	2.28	3.00	2.58	2.68	3.69	2.94	3.00	4.18	3.35	
MNO	0.04	0.11	0.03	0.06	0.0	0.02	0.0	0.0	0.01	0.06	0.0	
MGO	2.57	2.49	2.52	2.57	1.88	2.04	2.67	2.61	2.86	2.50	2.51	
CA0	0.04	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.0	
NA20	0.45	0.77	0.46	0.08	0.72	0.58	0.15	0.41	0.35	0.10	0.24	
K20	8.96	9.23	8.41	10.29	9.69	9.49	9.97	9.51	9.42	9.40	10.07	
TOTAL	93.13	93.56	93.92	95.10	95.46	94.04	94.97	96.22	94.19	94.31	93.93	
ATOMIC RATIOS (O = 22.0)												
SI	6.420	6.561	6.618	6.760	6.528	6.595	6.596	6.775	6.802	6.512	6.727	
TI	0.047	0.054	0.047	0.012	0.043	0.041	0.012	0.030	0.043	0.041	0.027	
AL	4.839	4.729	4.753	4.476	4.857	4.748	4.639	4.472	4.404	4.722	4.467	
FE	0.429	0.263	0.255	0.335	0.287	0.302	0.415	0.323	0.337	0.473	0.380	
MN	0.005	0.013	0.003	0.007	0.0	0.002	0.0	0.0	0.001	0.007	0.0	
MG	0.525	0.503	0.502	0.512	0.372	0.410	0.535	0.511	0.573	0.505	0.508	
CA	0.006	0.0	0.003	0.0	0.0	0.0	0.0	0.0	0.0	0.001	0.0	
NA	0.119	0.202	0.119	0.021	0.185	0.152	0.039	0.104	0.091	0.026	0.063	
K	1.565	1.594	1.433	1.755	1.642	1.632	1.709	1.594	1.615	1.624	1.743	
ANALYST	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	
SAMPLE NO ROCK TYPE ZONE	TH71081107						TH71080201					
	PE						PE					
	BIO						GAR					
GRAIN NO	2	2	2	2	3	3	3	3	4	1	1	
POINT NO	2	3	4	5	1	2	3	4	1	1	2	
SI02	48.48	49.02	49.89	49.06	49.51	48.92	49.14	48.46	48.78	49.05	48.70	
TI02	0.30	0.38	0.28	0.35	0.29	0.33	0.37	0.24	0.23	0.33	0.31	
AL203	29.24	29.19	29.71	30.44	28.23	29.24	29.16	28.81	28.47	31.30	30.00	
FE0	3.11	3.17	3.36	3.24	3.36	3.12	3.02	3.25	3.92	2.60	3.07	
MNO	0.01	0.0	0.01	0.01	0.01	0.01	0.0	0.01	0.02	0.0	0.0	
MGO	2.34	2.39	2.32	2.32	2.46	2.26	2.35	2.27	2.48	1.70	2.07	
CA0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
NA20	0.32	0.29	0.19	0.31	0.25	0.33	0.26	0.24	0.24	0.53	0.49	
K20	10.04	9.99	9.90	9.83	10.07	9.94	9.74	9.82	9.81	9.32	9.61	
TOTAL	93.84	94.43	95.66	95.56	94.18	94.15	94.04	93.10	93.95	94.83	94.25	
ATOMIC RATIOS (O = 22.0)												
SI	6.587	6.613	6.632	6.533	6.702	6.616	6.637	6.629	6.636	6.536	6.567	
TI	0.031	0.039	0.028	0.035	0.030	0.034	0.038	0.025	0.024	0.033	0.031	
AL	4.682	4.641	4.655	4.777	4.504	4.661	4.642	4.645	4.565	4.916	4.767	
FE	0.353	0.358	0.374	0.361	0.380	0.353	0.341	0.372	0.446	0.290	0.346	
MN	0.001	0.0	0.001	0.001	0.001	0.001	0.0	0.001	0.002	0.0	0.0	
MG	0.474	0.481	0.460	0.461	0.496	0.456	0.473	0.463	0.503	0.338	0.416	
CA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
NA	0.084	0.076	0.049	0.080	0.066	0.087	0.068	0.064	0.063	0.137	0.128	
K	1.740	1.719	1.679	1.670	1.739	1.715	1.678	1.714	1.703	1.584	1.653	
ANALYST	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	

Electron microprobe analyses of rock-forming minerals from the Sanbagawa metamorphic rocks, Shikoku

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

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH71080201																			
	PE GAR																			
	2 1	2 2	2 3	2 4	2 5	2 6	3 1	3 2	3 3	3 4	3 5									
SiO ₂	48.85	51.67	49.14	52.39	49.20	51.39	52.19	52.28	48.82	48.68	48.45									
TiO ₂	0.19	0.27	0.16	0.25	0.27	0.25	0.13	0.24	0.21	0.31	0.29									
Al ₂ O ₃	31.77	29.47	33.28	28.88	31.51	30.44	27.25	28.44	31.69	29.87	30.79									
FeO	1.71	2.82	1.84	3.17	2.34	2.18	2.79	3.04	2.05	2.63	2.11									
MnO	0.02	0.01	0.01	0.0	0.0	0.02	0.0	0.02	0.02	0.0	0.0									
MgO	1.57	2.17	1.66	2.36	1.85	1.72	2.50	2.47	1.72	2.22	1.72									
CaO	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0									
Na ₂ O	0.12	0.14	0.23	0.16	0.51	0.19	0.09	0.07	0.25	0.35	0.53									
K ₂ O	9.21	9.73	9.42	9.52	9.49	9.47	9.34	9.44	9.20	9.28	9.25									
TOTAL	93.46	96.28	95.74	96.73	95.17	95.66	94.29	96.00	93.96	93.34	93.14									
ATOMIC RATIOS (O = 22.0)																				
SI	6.555	6.775	6.450	6.836	6.529	6.746	6.965	6.865	6.534	6.595	6.559									
TI	0.019	0.027	0.016	0.025	0.027	0.025	0.013	0.024	0.021	0.032	0.030									
AL	5.024	4.554	5.148	4.441	4.928	4.709	4.286	4.402	4.998	4.769	4.913									
FE	0.192	0.309	0.202	0.346	0.260	0.239	0.311	0.334	0.229	0.298	0.239									
MN	0.002	0.001	0.001	0.0	0.0	0.002	0.0	0.002	0.002	0.0	0.0									
MG	0.314	0.424	0.325	0.459	0.366	0.337	0.497	0.484	0.343	0.448	0.347									
CA	0.003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0									
NA	0.031	0.036	0.059	0.040	0.131	0.048	0.023	0.018	0.065	0.092	0.139									
K	1.577	1.628	1.577	1.585	1.607	1.586	1.590	1.581	1.571	1.604	1.597									
ANALYST INSTRUMENT	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU									
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH71080201					TH71073012					TH71072922					TH721029Q1				
	PE GAR					PE CHL					PE CHL					BS BIO				
	3 1	1 1	2 1	3 1	3 1	1 1	2 1	3 1	4 1	5 1	M1 3	M1 1								
SiO ₂	48.86	52.43	52.08	51.39	50.33	52.23	52.74	52.39	52.00	47.97	48.97									
TiO ₂	0.22	0.13	0.05	0.12	0.09	0.05	0.07	0.06	0.05	0.43	0.34									
Al ₂ O ₃	30.85	29.66	29.25	29.67	28.25	28.39	27.70	27.80	28.65	28.48	26.32									
FeO	2.36	2.30	2.76	2.71	3.00	2.76	2.46	3.19	2.97	4.47	5.17									
MnO	0.01	0.02	0.04	0.03	0.02	0.0	0.0	0.0	0.07	0.0	0.0									
MgO	1.80	2.34	2.55	2.53	2.73	2.77	2.64	2.82	2.68	2.38	2.61									
CaO	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.02	0.0	0.14	0.13									
Na ₂ O	0.36	0.25	0.15	0.21	0.16	0.20	0.12	0.26	0.20	0.67	0.56									
K ₂ O	9.29	9.83	9.75	10.33	10.34	10.05	10.58	9.48	10.06	9.75	9.82									
TOTAL	93.75	96.96	96.65	96.99	94.92	96.45	96.31	96.02	96.68	94.29	93.92									
ATOMIC RATIOS (O = 22.0)																				
SI	6.573	6.808	6.801	6.719	6.748	6.849	6.931	6.893	6.815	6.545	6.727									
TI	0.022	0.013	0.005	0.012	0.009	0.005	0.007	0.006	0.005	0.044	0.035									
AL	4.891	4.539	4.502	4.572	4.464	4.588	4.290	4.311	4.425	4.580	4.261									
FE	0.266	0.250	0.301	0.296	0.336	0.303	0.270	0.351	0.326	0.510	0.594									
MN	0.001	0.002	0.004	0.003	0.002	0.0	0.0	0.0	0.008	0.0	0.0									
MG	0.361	0.453	0.496	0.493	0.546	0.542	0.517	0.553	0.524	0.484	0.535									
CA	0.0	0.0	0.003	0.0	0.0	0.0	0.0	0.003	0.0	0.020	0.019									
NA	0.094	0.063	0.038	0.053	0.042	0.051	0.031	0.066	0.051	0.177	0.149									
K	1.594	1.628	1.624	1.723	1.769	1.681	1.774	1.591	1.682	1.697	1.721									
ANALYST INSTRUMENT	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU	TH KU	MO KU	MO KU									

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

SAMPLE NO	M004	M005	TH710813D	M011-A	M019	TH71080601	M023	M024	M026	TH71080303	M028
ROCK TYPE	SL	BS	BS	BS	BS	BS	BS	BS	BS	BS	BS
ZONE	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO
GRAIN NO	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1
POINT NO	3	1	1	3	3	3	3	2	4	2	3
SI02	50.18	49.00	47.07	47.25	47.23	47.85	47.03	45.11	47.48	47.09	46.61
TI02	0.29	0.12	0.72	0.57	0.46	N.D.	0.61	0.41	0.68	0.83	0.54
AL203	29.59	30.32	25.57	26.66	31.79	29.70	32.03	29.26	28.40	27.53	27.30
FE0	2.29	1.81	6.44	4.63	2.09	2.39	3.54	5.76	5.39	5.23	4.96
MNO	0.0	0.0	0.05	0.03	0.0	N.D.	0.0	0.02	0.03	0.03	0.02
MGO	2.63	2.66	3.16	2.96	2.33	2.42	1.63	1.85	2.83	2.62	2.67
CA0	0.0	0.02	0.0	0.06	0.01	0.03	0.0	0.08	0.0	0.11	0.09
NA20	0.66	0.55	0.33	0.45	0.81	0.69	1.59	1.12	0.91	0.55	0.43
K20	9.48	10.46	9.76	10.05	9.10	9.78	8.02	9.23	9.47	9.36	9.57
TOTAL	95.12	94.94	93.10	92.66	93.82	92.86	94.45	92.84	95.19	93.35	92.19
ATOMIC RATIOS (O = 22.0)											
SI	6.665	6.554	6.591	6.591	6.368	6.549	6.322	6.313	6.453	6.515	6.529
TI	0.029	0.012	0.076	0.060	0.047	N.D.	0.062	0.043	0.070	0.086	0.057
AL	4.632	4.779	4.220	4.383	5.051	4.790	5.075	4.826	4.549	4.489	4.507
FE	0.254	0.202	0.754	0.540	0.236	0.274	0.398	0.674	0.613	0.605	0.581
MN	0.0	0.0	0.006	0.004	0.0	N.D.	0.0	0.002	0.003	0.004	0.002
MG	0.521	0.530	0.660	0.616	0.468	0.494	0.327	0.386	0.573	0.540	0.558
CA	0.0	0.003	0.0	0.009	0.001	0.004	0.0	0.012	0.0	0.016	0.014
NA	0.170	0.143	0.090	0.122	0.212	0.183	0.414	0.304	0.240	0.148	0.117
K	1.606	1.785	1.744	1.788	1.565	1.708	1.375	1.648	1.642	1.652	1.710
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	KU	TU	TU	KU	TU	KU	TU	TU	TU	TU	TU
SAMPLE NO	M028	M029	M035		M037		M038-A		M042	M048	M051-A
ROCK TYPE	BS	SL	SL		BS		BS		BS	BS	BS
ZONE	BIO	BIO	BIO		BIO		BIO		BIO	GAR	GAR
GRAIN NO	M1	M1	M1	M1	M2	M1	M1	M1	M2	M2	M2
POINT NO	1	1	3	1	2	2	3	4	1	1	3
SI02	47.02	47.12	47.80	48.52	50.97	51.37	51.40	50.93	48.37	48.34	47.85
TI02	0.35	0.18	0.37	0.24	0.41	0.34	0.37	0.34	0.30	0.33	0.24
AL203	25.80	32.50	27.98	26.31	28.70	26.14	28.09	25.72	27.10	26.77	26.49
FE0	6.05	2.27	3.28	3.99	4.77	5.70	4.27	5.97	5.49	4.77	5.16
MNO	0.01	0.03	0.0	0.04	0.05	0.04	0.01	0.04	0.03	0.0	0.0
MGO	2.84	3.36	3.15	3.48	2.47	3.03	2.67	3.22	3.01	2.89	2.69
CA0	0.06	0.0	0.07	0.05	0.06	0.05	0.03	0.04	0.10	0.03	0.05
NA20	0.38	0.13	0.28	0.10	1.06	0.29	0.99	0.30	0.23	0.29	0.24
K20	9.65	8.83	9.50	9.75	9.64	10.74	10.11	10.81	10.65	10.71	10.68
TOTAL	92.16	94.42	92.43	92.48	98.13	97.70	97.94	97.37	95.28	94.19	93.40
ATOMIC RATIOS (O = 22.0)											
SI	6.628	6.296	6.595	6.720	6.665	6.809	6.730	6.795	6.596	6.647	6.649
TI	0.037	0.018	0.038	0.025	0.040	0.034	0.036	0.034	0.031	0.034	0.025
AL	4.286	5.118	4.549	4.295	4.423	4.084	4.335	4.044	4.356	4.338	4.338
FE	0.713	0.254	0.378	0.462	0.522	0.632	0.468	0.666	0.626	0.548	0.600
MN	0.001	0.003	0.0	0.005	0.006	0.004	0.001	0.005	0.003	0.0	0.0
MG	0.597	0.669	0.648	0.719	0.481	0.599	0.521	0.640	0.612	0.592	0.557
CA	0.009	0.0	0.010	0.007	0.008	0.007	0.004	0.006	0.015	0.004	0.007
NA	0.104	0.034	0.075	0.027	0.269	0.075	0.251	0.078	0.061	0.093	0.065
K	1.735	1.505	1.672	1.723	1.608	1.816	1.689	1.840	1.853	1.879	1.893
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	TU	TU	TU	TU	TU	TU	TU	TU	TU	KU	KU

Electron microprobe analyses of rock-forming minerals from the Sanbagawa metamorphic rocks, Shikoku

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

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M051-A		M055		M058		M065		M067		TH71072803		M074		M079	
	BS		BS		BS		BS		BS		BS		BS		BS	
	GAR		GAR		GAR		GAR		GAR		CHL		CHL		CHL	
	M2	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1	M1
	1	2	2	2	1	2	3	3	3	3	1	3	1	3	3	
SI02	48.35	47.31	47.49	47.25	50.83	49.51	49.34	48.44	52.39	52.06	50.39					
TI02	0.23	0.32	0.50	0.32	0.20	0.17	0.24	0.19	0.06	0.12	0.13					
AL203	25.05	25.95	26.39	25.19	26.84	24.15	26.40	26.83	23.94	21.82	23.00					
FEO	7.64	6.58	5.38	6.30	4.60	7.24	4.79	4.68	5.06	8.31	6.41					
MNO	0.03	0.02	0.01	0.01	0.03	0.04	0.0	0.04	0.06	0.02	0.0					
MGO	3.31	2.92	2.81	2.97	2.76	2.96	2.81	2.81	3.66	3.56	4.04					
CAO	0.06	0.08	0.02	0.07	0.0	0.0	0.03	0.07	0.03	0.03	0.24					
NA2O	0.33	0.24	0.57	0.24	0.31	0.16	0.50	0.60	0.09	0.07	0.08					
K2O	9.34	9.38	9.43	9.67	10.59	10.42	9.43	9.75	9.89	9.54	11.24					
TOTAL	94.34	92.80	92.60	92.02	96.16	94.65	93.54	93.41	95.18	95.53	95.53					
ATOMIC RATIOS (O = 22.0)																
SI	6.689	6.623	6.626	6.677	6.800	6.839	6.766	6.677	7.056	7.099	6.906					
TI	0.024	0.034	0.052	0.034	0.020	0.018	0.025	0.020	0.006	0.012	0.013					
AL	4.084	4.282	4.340	4.195	4.232	3.931	4.267	4.359	3.800	3.507	3.715					
FE	0.884	0.770	0.628	0.744	0.515	0.836	0.549	0.539	0.570	0.948	0.735					
MN	0.004	0.002	0.001	0.001	0.003	0.005	0.0	0.005	0.007	0.002	0.0					
MG	0.683	0.609	0.585	0.626	0.550	0.610	0.574	0.577	0.735	0.724	0.825					
CA	0.009	0.012	0.003	0.011	0.0	0.0	0.004	0.010	0.004	0.004	0.035					
NA	0.089	0.065	0.154	0.066	0.080	0.043	0.133	0.160	0.023	0.019	0.021					
K	1.648	1.675	1.679	1.743	1.807	1.836	1.650	1.714	1.699	1.660	1.965					
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO					
INSTRUMENT	KU	KU	TU	TU	KU	KU	TU	TU	TU	TU	KU					

TABLE 3. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF PARAGONITES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M084		SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M010	
	BS			BS	
	CHL			BIO	
	M2	M1		P1	P1
	2		2	3	3
SI02	49.41		SI02	44.77	44.85
TI02	0.07		TI02	0.08	0.03
AL203	23.68		AL203	39.01	39.69
FEO	5.15		FEO	0.43	0.32
MNO	0.03		MNO	0.0	0.0
MGO	3.80		MGO	0.23	0.12
CAO	0.05		CAO	0.17	0.23
NA2O	0.18		NA2O	7.00	7.36
K2O	9.89		K2O	0.86	0.51
TOTAL	92.26		TOTAL	92.55	93.11
ATOMIC RATIOS (O = 22.0)					
SI	6.910		SI	5.903	5.871
TI	0.007		TI	0.008	0.003
AL	3.903		AL	6.062	6.123
FE	0.602		FE	0.047	0.035
MN	0.004		MN	0.0	0.0
MG	0.792		MG	0.045	0.023
CA	0.007		CA	0.024	0.032
NA	0.049		NA	1.790	1.868
K	1.764		K	0.145	0.085
ANALYST	MO		ANALYST	MO	MO
INSTRUMENT	TU		INSTRUMENT	TU	TU

TABLE 4. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF BIOTITES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH71081416		TH71081408		
	PE		PE		3
	BIO		BIO		
	1	1	2	3	
	1	1	1	1	
SI02	37.23	38.21	39.28	38.75	
TI02	1.94	2.66	2.13	2.04	
AL203	16.04	15.62	16.15	16.34	
FEO	19.56	22.53	21.39	21.81	
MNO	0.11	0.12	0.16	0.14	
MGO	9.41	8.19	8.40	8.78	
CAO	0.0	0.0	0.0	0.0	
NA2O	0.14	0.11	0.11	0.09	
K2O	7.80	7.69	8.25	8.32	
TOTAL	92.23	95.13	95.87	96.27	
ATOMIC RATIOS (O = 22.0)					
SI	5.796	5.830	5.910	5.827	
TI	0.227	0.305	0.241	0.231	
AL	2.943	2.809	2.864	2.896	
FE	2.546	2.875	2.691	2.743	
MN	0.015	0.016	0.020	0.018	
MG	2.184	1.863	1.884	1.968	
CA	0.0	0.0	0.0	0.0	
NA	0.042	0.033	0.032	0.026	
K	1.549	1.497	1.583	1.596	
ANALYST	TH	TH	TH	TH	
INSTRUMENT	KU	KU	KU	KU	

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

SAMPLE NO	MO38-A	MO40	MO41-A	MO42	MO47	MO48	MO49-A	MO51-A	MO55	MO58	
ROCK TYPE	BS	BS	BS	BS	BS	BS	BS	BS	BS	BS	
ZONE	BIO	BIO	BIO	BIO	BIO	GAR	GAR	GAR	GAR	GAR	
GRAIN NO	C1	C5	C1	C1	C1	C1	C1	C1	C2	C1	
POINT NO	2	2	2	4	1	1	2	1	2	2	
SI02	26.47	26.32	25.33	25.39	26.21	25.19	26.40	24.99	24.52	26.07	25.17
AL203	20.36	19.14	19.74	18.91	19.77	19.19	19.27	19.62	18.37	19.00	18.77
FE0	18.19	22.66	24.32	26.53	18.67	23.34	25.97	32.05	30.63	25.37	25.58
MNO	0.31	0.49	0.18	0.24	0.34	0.46	0.35	0.41	0.31	N.D.	0.29
MGO	20.76	18.07	16.77	14.96	24.14	17.69	16.68	11.52	11.04	16.34	16.65
TOTAL	86.09	86.68	86.34	86.03	89.13	85.87	88.67	88.59	84.87	86.78	86.46
ATOMIC RATIOS (O = 28.0)											
SI	5.476	5.550	5.412	5.515	5.270	5.401	5.527	5.425	5.543	5.559	5.422
AL	4.964	4.757	4.971	4.841	4.685	4.849	4.755	5.019	4.895	4.775	4.765
FE	3.147	3.996	4.346	4.819	3.139	4.185	4.547	5.818	5.791	4.524	4.608
MN	0.054	0.088	0.033	0.044	0.058	0.084	0.062	0.075	0.059	N.D.	0.053
MG	6.402	5.681	5.342	4.844	7.236	5.655	5.206	3.728	3.721	5.194	5.347
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	TU	KU	TU	TU	TU	TU	KU	KU	KU	KU	TU
SAMPLE NO	MO60-A	TH71072601	MO62	MO61	MO64	MO65	MO66-A	MO67	TH71072803	MO70	
ROCK TYPE	BS	BS	BS	BS	BS	BS	BS	BS	BS	BS	
ZONE	GAR	GAR	GAR	GAR	GAR	GAR	GAR	GAR	CHL	CHL	
GRAIN NO	C1	C1	C1	C1	C1	C1	C1	C2	C1	C2	
POINT NO	1	3	2	1	3	1	2	1	3	1	
SI02	26.90	26.50	24.74	26.36	25.58	25.45	27.56	27.06	26.31	27.63	26.30
AL203	19.79	19.99	19.76	19.84	19.85	20.15	18.66	19.06	19.11	18.76	19.16
FE0	21.70	27.55	28.67	21.73	24.42	26.47	26.17	19.53	19.73	16.15	24.22
MNO	0.56	0.41	0.37	N.D.	0.32	0.32	0.43	0.06	0.16	0.53	0.34
MGO	17.85	14.85	13.14	17.81	15.92	14.74	14.55	20.47	19.64	22.37	16.71
TOTAL	86.80	89.30	86.68	85.74	86.09	87.13	87.37	86.18	84.95	85.44	86.73
ATOMIC RATIOS (O = 28.0)											
SI	5.620	5.543	5.400	5.570	5.481	5.444	5.844	5.624	5.568	5.700	5.582
AL	4.873	4.928	5.083	4.941	5.013	5.080	4.663	4.669	4.766	4.561	4.793
FE	3.792	4.819	5.233	3.840	4.376	4.735	4.641	3.395	3.492	2.786	4.299
MN	0.099	0.073	0.068	N.D.	0.058	0.058	0.077	0.011	0.029	0.093	0.061
MG	5.560	4.631	4.275	5.610	5.085	4.700	4.599	6.343	6.196	6.880	5.287
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	KU	TU	TU	KU	TU	TU	KU	KU	TU	TU	TU
SAMPLE NO	MO71	MO74	MO75	MO79	MO80	MO83	MO84	MO89	MO92		
ROCK TYPE	BS	BS	BS	BS	BS	BS	BS	BS	BS		
ZONE	CHL	CHL	CHL	CHL	CHL	CHL	CHL	CHL	CHL		
GRAIN NO	C1	C1	C2	C1	C2	C1	C3	C3	C3		
POINT NO	2	2	1	1	2	2	2	3	3		
SI02	25.22	27.09	25.82	27.38	27.58	25.59	26.63	26.40	27.16	26.41	
AL203	18.78	17.67	18.86	18.64	20.27	18.14	18.49	17.80	18.47	19.60	
FE0	26.76	24.31	28.54	19.51	15.85	28.58	19.57	20.93	22.22	26.87	
MNO	0.37	0.75	0.41	0.26	0.33	0.34	0.38	0.31	0.80	0.73	
MGO	14.20	15.77	13.43	21.05	23.04	14.07	20.53	20.03	18.69	14.18	
TOTAL	85.33	85.59	87.06	86.84	87.07	86.72	85.60	85.47	87.34	87.79	
ATOMIC RATIOS (O = 28.0)											
SI	5.538	5.840	5.595	5.652	5.561	5.580	5.596	5.605	5.671	5.615	
AL	4.861	4.489	4.817	4.535	4.817	4.662	4.579	4.454	4.545	4.911	
FE	4.915	4.382	5.172	3.368	2.672	5.212	3.439	3.716	3.880	4.778	
MN	0.069	0.137	0.075	0.045	0.056	0.063	0.068	0.056	0.141	0.131	
MG	4.649	5.068	4.338	6.478	6.925	4.574	6.432	6.339	5.818	4.494	
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	
INSTRUMENT	KU	TU	TU	KU	KU	TU	TU	TU	KU	KU	

TABLE 6. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF STILPNOMELANES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M049-A		M051-A		M083	
	BS	BS	BS	BS	CHL	CHL
	GAR	GAR	GAR	GAR	S1	S1
	S1	S1	S1	S1	S1	S1
	2	1	1	1		
SI02	45.06	44.93	46.49			
TI02	0.03	0.02	0.02			
AL203	7.42	5.90	6.20			
FE0	29.18	28.69	27.24			
MNO	0.87	0.80	1.01			
MGO	5.47	4.87	6.68			
CA0	0.50	0.31	0.18			
NA20	0.13	0.21	0.15			
K20	1.04	1.06	2.60			
TOTAL	89.70	86.79	92.57			
ATOMIC RATIOS (SI = 8.0)						
SI	8.000	8.000	8.000			
TI	0.004	0.003	0.003			
AL	1.553	1.238	1.257			
FE	4.333	4.272	3.920			
MN	0.131	0.121	0.147			
MG	1.448	1.293	2.227			
CA	0.095	0.059	0.033			
NA	0.045	0.072	0.050			
K	0.236	0.241	0.571			
ANALYST	MO	MO	MO			
INSTRUMENT	KU	KU	KU			

TABLE 7. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF AMPHIBOLES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH71081315			TH71081303		
	PE	PE	PE	PE	PE	PE
	BIO	BIO	BIO	BIO	BIO	BIO
	1	2	3	1	2	3
	1	1	1	1	1	1
SI02	44.76	46.20	44.59	43.98	44.31	44.33
TI02	0.63	0.58	0.45	0.45	0.38	0.50
AL203	15.16	13.83	14.66	15.78	15.54	15.73
FE0	15.79	15.01	15.87	13.92	13.96	14.33
MNO	0.05	0.06	0.03	0.05	0.08	0.11
MGO	9.04	9.02	8.89	9.57	9.94	9.47
CA0	9.07	8.23	9.00	10.43	10.40	10.00
NA20	3.41	3.61	3.46	2.74	2.68	2.86
K20	0.45	0.33	0.46	0.48	0.46	0.51
TOTAL	98.36	96.87	97.41	97.40	97.75	97.84
ATOMIC RATIOS (O = 23.0)						
SI	6.545	6.798	6.590	6.459	6.481	6.485
TI	0.069	0.064	0.050	0.050	0.042	0.055
AL	2.612	2.399	2.554	2.731	2.679	2.712
FE	1.931	1.847	1.962	1.710	1.707	1.753
MN	0.006	0.007	0.004	0.006	0.010	0.014
MG	1.970	1.979	1.959	2.095	2.167	2.065
CA	1.421	1.298	1.425	1.641	1.630	1.567
NA	0.967	1.030	0.992	0.780	0.760	0.811
K	0.084	0.062	0.087	0.090	0.086	0.095
ANALYST	TH	TH	TH	TH	TH	TH
INSTRUMENT	KU	KU	KU	KU	KU	KU

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

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH71081303					TH72102901			M003			
	PE	BS	BS	BS	BS	AC(V)	BIO	HB2	HB1	SL	HB3	HB1
	BIO	BIO	BIO	BIO	BIO		BIO	BIO	BIO	BIO	BIO	BIO
	4	5	6	7	8	1	CORE	1	1	CORE	3	1
	1	1	1	1	1	1						
SI02	44.90	45.85	44.93	44.55	44.22	55.24	44.64	51.56	43.82	52.86	51.30	
TI02	0.53	0.43	0.43	0.38	0.43	0.0	0.46	0.04	0.42	N.D.	N.D.	
AL203	15.83	14.02	14.93	15.85	15.30	1.30	13.56	4.41	14.17	1.98	4.24	
FE0	13.95	14.01	14.47	13.96	14.07	10.30	18.10	17.94	15.23	14.21	12.98	
MNO	0.07	0.08	0.11	0.20	0.14	0.23	0.13	0.19	0.12	0.45	0.31	
MGO	9.65	10.27	9.77	10.00	9.84	17.04	8.50	12.20	9.37	15.39	15.71	
CA0	9.87	9.82	9.97	10.27	10.12	12.13	9.38	9.70	9.18	13.01	12.44	
NA20	2.97	2.80	2.88	2.66	2.70	0.33	3.57	2.40	3.07	0.43	0.80	
K20	0.50	0.40	0.45	0.42	0.46	0.09	0.38	0.13	0.35	0.06	0.11	
TOTAL	98.27	97.68	97.94	98.29	97.28	96.66	98.72	98.57	95.73	98.39	97.89	
ATOMIC RATIOS (O = 23.0)												
SI	6.517	6.686	6.565	6.473	6.501	7.923	6.598	7.547	6.580	7.655	7.430	
TI	0.058	0.047	0.047	0.042	0.048	0.0	0.051	0.004	0.047	N.D.	N.D.	
AL	2.708	2.410	2.571	2.714	2.651	0.220	2.362	0.761	2.508	0.338	0.724	
FE	1.693	1.709	1.768	1.696	1.730	1.235	2.237	2.196	1.913	1.721	1.572	
MN	0.009	0.010	0.014	0.025	0.017	0.028	0.016	0.024	0.015	0.055	0.038	
MG	2.088	2.233	2.128	2.166	2.157	3.643	1.873	2.662	2.098	3.323	3.392	
CA	1.535	1.534	1.561	1.599	1.594	1.864	1.485	1.521	1.477	2.019	1.930	
NA	0.836	0.792	0.816	0.749	0.770	0.092	1.023	0.681	0.894	0.121	0.225	
K	0.093	0.074	0.084	0.078	0.086	0.016	0.072	0.024	0.067	0.011	0.020	
ANALYST	TH	TH	TH	TH	TH	TH	MO	MO	MO	MO	MO	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	

Electron microprobe analyses of rock-forming minerals from the Sanbagawa metamorphic rocks, Shikoku

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

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M004			M005			TH710813D			M010	
	SL BIO HB2 CORE	HB1 2	HB1 4	BS BIO HB2 CORE	HB1 3	HB1 2	HB1 1	BS BIO HB4 CORE	HB1 4	BS BIO HB1 CORE	HB2 1
SI02	46.66	47.55	53.75	45.40	47.43	53.26	54.70	45.43	47.49	43.10	46.54
TI02	0.30	0.29	0.11	0.39	0.29	0.09	0.03	0.42	0.22	0.42	0.23
AL203	13.22	12.13	4.29	13.10	11.42	3.28	1.60	9.31	6.93	13.52	9.39
FEO	13.45	12.93	11.34	13.17	12.60	10.49	11.02	18.26	17.02	12.76	11.88
MNO	0.08	0.13	0.20	0.12	0.14	0.16	0.16	0.34	0.30	0.17	0.26
MGO	11.30	11.51	15.19	11.31	12.13	16.54	16.17	10.41	11.75	11.36	13.21
CAO	10.11	9.95	12.72	9.80	9.34	11.94	12.64	8.45	8.06	10.31	9.14
NA2O	2.77	2.89	0.91	2.95	2.87	0.60	0.58	3.64	3.57	2.84	3.23
K2O	0.29	0.28	0.25	0.31	0.25	0.05	0.06	0.73	0.35	0.30	0.19
TOTAL	98.18	97.66	98.76	96.55	96.47	96.41	96.96	96.99	95.69	94.78	94.07
ATOMIC RATIOS (O = 23.0)											
SI	6.749	6.891	7.621	6.690	6.941	7.684	7.869	6.871	7.191	6.501	7.000
TI	0.033	0.032	0.012	0.043	0.032	0.010	0.003	0.048	0.025	0.048	0.026
AL	2.254	2.072	0.717	2.275	1.970	0.558	0.271	1.659	1.237	2.404	1.665
FE	1.627	1.567	1.345	1.623	1.542	1.266	1.326	2.310	2.155	1.610	1.494
MN	0.010	0.016	0.024	0.015	0.017	0.020	0.019	0.044	0.038	0.022	0.033
MG	2.437	2.487	3.211	2.485	2.646	3.557	3.468	2.347	2.653	2.555	2.962
CA	1.567	1.545	1.932	1.547	1.464	1.846	1.948	1.369	1.308	1.666	1.473
NA	0.777	0.812	0.250	0.843	0.814	0.168	0.162	1.067	1.048	0.831	0.942
K	0.054	0.052	0.045	0.058	0.047	0.009	0.011	0.141	0.068	0.058	0.036
ANALYST INSTRUMENT	MO KU	MO KU	MO KU	MO TU	MO TU	MO TU	MO TU	MO TU	MO TU	MO TU	MO TU
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M011-A		M015		M016		M019		TH71080601		
	BS BIO HB1 CORE	HB2 2	BS BIO HB3 CORE	HB3 3	BS BIO HB1 CORE	HB1 4	HB1 1	BS BIO HB2 CORE	HB2 1	HB1 2	BS BIO HB3 CORE
SI02	46.64	49.19	44.98	50.23	44.56	47.61	52.41	44.42	51.96	46.31	43.47
TI02	0.31	0.17	0.38	0.22	0.41	0.17	0.05	0.48	0.15	0.28	0.37
AL203	10.25	7.41	13.15	7.78	13.71	7.88	3.24	15.12	4.53	12.23	15.26
FEO	14.45	13.08	16.42	15.58	14.57	14.20	14.68	14.38	14.12	14.03	14.55
MNO	0.21	0.17	0.26	0.21	0.16	0.19	0.17	0.08	0.19	0.09	0.24
MGO	12.27	15.28	10.12	12.30	11.03	12.65	14.80	10.53	14.28	10.87	10.78
CAO	8.96	10.09	9.04	10.42	10.02	10.36	9.94	9.86	11.17	10.25	10.35
NA2O	3.94	2.80	3.53	2.25	3.19	2.50	2.03	2.70	0.61	2.31	2.81
K2O	0.40	0.34	0.34	0.21	0.39	0.18	0.11	0.35	0.10	0.31	0.40
TOTAL	97.43	98.53	98.22	99.18	98.04	95.74	97.43	97.92	97.11	96.68	98.23
ATOMIC RATIOS (O = 23.0)											
SI	6.872	7.100	6.626	7.241	6.536	7.113	7.639	6.487	7.562	6.824	6.369
TI	0.034	0.018	0.042	0.024	0.045	0.019	0.005	0.053	0.016	0.031	0.041
AL	1.780	1.261	2.283	1.322	2.370	1.388	0.557	2.602	0.777	2.124	2.635
FE	1.781	1.579	2.023	1.878	1.787	1.774	1.789	1.756	1.719	1.729	1.783
MN	0.026	0.021	0.032	0.026	0.020	0.024	0.021	0.010	0.023	0.011	0.030
MG	2.695	3.288	2.222	2.643	2.412	2.818	3.216	2.293	3.098	2.388	2.355
CA	1.415	1.560	1.427	1.609	1.575	1.658	1.552	1.543	1.742	1.625	1.625
NA	1.126	0.784	1.008	0.623	0.907	0.724	0.574	0.765	0.172	0.660	0.798
K	0.075	0.063	0.064	0.039	0.073	0.034	0.020	0.065	0.019	0.058	0.075
ANALYST INSTRUMENT	MO KU	MO KU	MO KU	MO KU	MO KU	MO KU	MO KU	MO TU	MO TU	MO TU	MO KU

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

SAMPLE NO	TH71080601		TH72120319		TH72120338			M023		M024		M026	
	ROCK TYPE	BS	BS	BS	BS	BS	BS	BS	BS	BS	BS	BS	BS
ZONE	B10	B10	B10	B10	B10	B10	B10	B10	B10	B10	B10	B10	B10
GRAIN NO	HB3	HB1	HB3	HB2	HB1	HB2	HB1	HB2	HB1	HB2	HB1	HB2	HB1
POINT NO	2	CORE	1	CORE	1	CORE	3	CORE	3	CORE	3	CORE	1
SI02	44.09	45.03	44.61	41.77	42.95	41.44	41.07	42.04	42.63	45.75	46.71		
TI02	0.22	0.59	0.37	0.0	0.88	0.66	0.58	0.44	0.31	0.40	0.31		
AL203	12.24	12.26	10.39	14.02	12.89	15.47	14.91	14.66	11.88	10.61	8.69		
FE0	14.79	18.93	19.31	19.08	19.23	18.14	18.09	17.22	18.96	13.44	12.43		
MNO	0.25	N.D.	N.D.	N.D.	N.D.	0.11	0.06	0.10	0.23	0.26	0.23		
MGO	11.82	8.22	9.24	7.99	8.84	8.19	8.61	8.44	8.81	12.58	14.18		
CA0	11.04	10.29	9.92	9.47	9.55	9.05	9.63	9.53	8.85	9.22	10.19		
NA20	2.22	2.91	2.88	3.12	2.94	2.26	3.16	3.40	3.38	3.51	2.74		
K20	0.32	0.54	0.50	0.78	0.41	0.46	0.41	0.32	0.34	0.49	0.32		
TOTAL	96.99	98.77	97.22	96.23	97.69	95.78	96.52	96.15	95.39	96.26	95.80		
ATOMIC RATIOS (O = 23.0)													
SI	6.562	6.686	6.759	6.411	6.473	6.317	6.255	6.385	6.585	6.803	6.942		
TI	0.025	0.066	0.042	0.0	0.100	0.076	0.066	0.050	0.036	0.045	0.035		
AL	2.147	2.146	1.855	2.536	2.289	2.779	2.676	2.624	2.163	1.860	1.522		
FE	1.841	2.351	2.447	2.449	2.424	2.313	2.304	2.187	2.449	1.671	1.545		
MN	0.032	N.D.	N.D.	N.D.	N.D.	0.014	0.008	0.013	0.030	0.033	0.029		
MG	2.623	1.820	2.087	1.828	1.986	1.861	1.955	1.911	2.029	2.789	3.142		
CA	1.760	1.637	1.610	1.557	1.542	1.478	1.571	1.551	1.465	1.469	1.623		
NA	0.641	0.838	0.846	0.928	0.859	0.668	0.933	1.001	1.012	1.012	0.790		
K	0.061	0.102	0.097	0.153	0.079	0.089	0.080	0.062	0.067	0.093	0.061		
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	KU	KU	KU	KU	KU	TU	TU	TU	TU	TU	TU	TU	TU
SAMPLE NO	TH71080303				M028		TH71051007		M033		M035		
ROCK TYPE	BS		BS		BS		BS		SL		SL		
ZONE	B10		B10		B10		B10		B10		B10		
GRAIN NO	HB5		HB2		HB1		HB1		HB1		HB1		
POINT NO	CORE		3		1		3		2		5		
SI02	42.65	43.20	50.39	41.44	42.13	40.65	43.69	46.97	47.25	51.59	52.38		
TI02	0.57	0.44	0.12	0.56	0.40	N.D.	0.38	0.20	0.19	0.05	0.01		
AL203	11.14	10.43	5.09	12.03	10.98	12.95	14.01	8.30	7.78	2.77	0.67		
FE0	16.89	16.29	15.08	17.94	17.36	18.90	16.35	16.60	15.35	13.22	12.67		
MNO	0.45	0.39	0.37	0.24	0.28	N.D.	0.10	0.18	0.25	0.23	0.20		
MGO	10.12	10.76	12.48	9.03	10.02	8.56	8.84	10.96	11.94	14.91	15.99		
CA0	9.13	9.42	9.69	9.80	10.00	10.52	9.57	10.08	10.69	11.68	12.32		
NA20	3.47	3.24	2.80	3.30	3.06	3.28	3.11	2.28	1.88	0.70	0.16		
K20	0.54	0.49	0.23	0.49	0.48	0.68	0.43	0.30	0.24	0.08	0.03		
TOTAL	94.96	94.66	96.25	94.83	94.71	95.54	96.48	95.87	95.57	95.23	94.43		
ATOMIC RATIOS (O = 23.0)													
SI	6.586	6.667	7.490	6.454	6.549	6.332	6.559	7.085	7.111	7.662	7.826		
TI	0.066	0.051	0.013	0.066	0.047	N.D.	0.043	0.023	0.022	0.006	0.001		
AL	2.028	1.897	0.892	2.208	2.012	2.378	2.479	1.475	1.380	0.485	0.118		
FE	2.181	2.102	1.875	2.337	2.257	2.462	2.053	2.094	1.932	1.642	1.583		
MN	0.059	0.051	0.047	0.032	0.037	N.D.	0.013	0.023	0.032	0.029	0.025		
MG	2.330	2.475	2.766	2.097	2.322	1.988	1.979	2.464	2.679	3.301	3.562		
CA	1.511	1.558	1.543	1.635	1.666	1.756	1.539	1.629	1.724	1.858	1.972		
NA	1.039	0.969	0.807	0.997	0.922	0.991	0.905	0.667	0.549	0.202	0.046		
K	0.106	0.096	0.044	0.097	0.095	0.135	0.082	0.058	0.046	0.015	0.006		
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	TU	TU	TU	TU	TU	KU	TU	TU	TU	TU	TU	TU	TU

Electron microprobe analyses of rock-forming minerals from the Sanbagawa metamorphic rocks, Shikoku

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

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M049-A			M051-A			M055			M058			M062		
	BS CORE 2	GAR CORE 2	HB4 CORE 2	BS CORE 1	GAR CORE 1	HB3 CORE 1	BS CORE 2	GAR CORE 2	HB2 CORE 2	BS CORE 1	GAR CORE 1	HB1 CORE 1	BS CORE 4	GAR CORE 4	AC1 CORE 1
SI02	52.32	49.80	45.48	51.81	45.36	51.77	51.77	45.36	51.77	53.12	47.81	54.21	53.40	47.81	53.40
TI02	0.01	0.04	0.16	0.03	0.35	0.08	0.34	0.08	0.34	0.01	0.27	0.01	0.06	0.01	0.06
AL203	3.26	4.18	8.67	1.18	11.91	4.40	14.13	4.40	14.13	1.19	8.60	0.70	6.82	0.70	6.82
FEO	19.89	21.32	20.44	17.91	17.64	17.92	17.92	17.64	17.92	17.18	16.70	15.42	17.78	16.70	17.78
MNO	0.32	0.35	0.29	0.24	0.22	N.D.	0.13	N.D.	0.13	N.D.	0.14	0.14	0.13	0.14	0.13
MGO	11.31	10.22	8.23	11.64	8.72	11.82	11.82	8.72	11.82	13.08	11.16	13.88	8.96	11.16	8.96
CAO	12.00	11.67	8.27	12.30	8.04	7.78	7.78	8.04	7.78	10.94	7.50	11.44	1.81	7.50	1.81
NA2O	0.99	1.19	0.99	0.50	3.45	3.61	3.61	3.45	3.61	1.49	4.26	0.91	6.25	4.26	0.91
K2O	0.21	0.24	0.33	0.47	0.28	0.35	0.35	0.28	0.35	0.08	0.32	0.06	0.12	0.32	0.06
TOTAL	100.31	99.01	95.02	95.48	96.09	97.50	97.50	96.09	97.50	97.70	96.76	96.77	95.33	96.76	95.33
ATOMIC RATIOS (O = 23.0)															
SI	7.610	7.427	7.055	7.850	6.841	7.635	7.635	6.841	7.635	7.860	7.126	7.964	7.906	7.126	7.906
TI	0.001	0.004	0.019	0.003	0.040	0.009	0.040	0.003	0.009	0.003	0.003	0.001	0.007	0.003	0.007
AL	0.559	0.735	1.585	0.211	2.117	0.765	2.584	0.211	0.765	0.208	1.511	0.121	1.190	0.121	1.190
FE	2.619	2.859	2.652	2.269	2.325	2.210	2.373	2.269	2.210	2.126	2.082	1.895	2.201	2.082	2.201
MN	0.039	0.044	0.058	0.031	0.028	N.D.	0.017	0.028	N.D.	0.017	0.018	0.017	0.016	0.018	0.016
MG	2.452	2.272	1.905	2.629	1.961	2.599	2.599	1.961	2.599	2.885	2.460	3.040	1.977	2.460	1.977
CA	1.870	1.865	1.375	1.997	1.599	1.259	1.471	1.599	1.259	1.751	1.198	1.801	1.287	1.198	1.287
NA	0.279	0.344	0.947	0.088	1.044	1.032	1.116	0.088	1.032	1.116	1.231	0.427	1.794	1.231	0.427
K	0.039	0.046	0.065	0.014	0.054	0.023	0.069	0.014	0.023	0.015	0.061	0.011	0.023	0.061	0.011
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	KU	KU	KU	KU	TU	KU	TU	KU	TU	KU	TU	TU	TU	TU	TU
M060-A															
TH71072601															
BS															
GAR															
HB2															
POINT NO	GL2 CORE 1	GL2 CORE 2	GL2 CORE 3	GL2 CORE 1	GL2 CORE 2	GL2 CORE 3	HB1 CORE 2	HB3 CORE 2	HB1 CORE 2	HB3 CORE 2	AC1 CORE 1	AC1 CORE 1	AC1 CORE 1	AC1 CORE 1	AC1 CORE 1
SI02	49.71	47.10	54.08	51.05	48.35	49.13	49.13	54.81	49.13	48.90	50.34	54.68	54.47	50.34	54.47
TI02	0.06	0.24	0.06	0.08	0.14	0.08	0.08	0.01	0.08	0.01	0.05	0.0	0.01	0.05	0.01
AL203	3.41	8.18	6.38	3.37	7.83	5.67	5.67	1.51	6.07	1.51	4.86	0.32	1.33	4.86	1.33
FEO	17.56	17.71	17.94	18.51	17.54	14.61	14.61	7.04	17.32	7.04	16.21	14.02	12.10	16.21	12.10
MNO	0.20	0.21	0.09	0.22	0.26	0.38	0.38	0.25	0.27	0.25	0.29	0.21	N.D.	0.29	N.D.
HGO	11.09	10.55	8.85	11.22	11.82	13.07	13.07	20.18	11.15	11.15	12.34	16.87	16.56	12.34	16.56
CAO	8.76	6.84	7.68	7.68	8.89	9.01	9.01	12.25	10.27	10.27	10.52	12.84	13.47	10.52	12.84
NA2O	3.37	4.55	6.66	5.15	3.23	2.95	2.95	0.62	1.80	0.62	1.80	0.05	0.34	1.80	0.05
K2O	0.15	0.29	0.06	0.21	0.24	0.24	0.24	0.03	0.15	0.03	0.23	0.01	0.06	0.23	0.01
TOTAL	94.31	95.67	94.86	95.49	98.30	95.05	95.05	96.68	96.11	96.97	96.97	97.00	98.34	96.97	98.34
ATOMIC RATIOS (O = 23.0)															
SI	7.639	7.143	8.025	7.725	7.125	7.384	7.384	7.772	7.356	7.468	7.468	7.969	7.786	7.468	7.786
TI	0.007	0.027	0.007	0.009	0.016	0.009	0.009	0.006	0.009	0.006	0.006	0.0	0.001	0.006	0.001
AL	0.618	1.462	1.116	0.601	1.360	1.004	1.004	0.252	1.076	0.252	0.850	0.055	0.224	0.850	0.224
FE	2.257	2.246	2.226	2.343	2.162	1.836	1.836	0.835	2.179	0.835	2.011	1.709	1.446	2.011	1.446
MN	0.026	0.027	0.011	0.028	0.032	0.048	0.048	0.030	0.034	0.030	0.036	0.026	N.D.	0.036	N.D.
MG	2.385	2.541	1.913	2.551	2.597	2.928	2.928	4.266	2.500	4.266	2.729	3.251	3.529	2.729	3.529
CA	1.442	1.111	1.111	1.245	1.404	1.451	1.451	1.858	1.655	1.858	1.672	2.005	2.063	1.672	2.005
NA	1.004	1.338	1.916	0.924	0.923	0.860	0.860	0.170	0.525	0.170	0.613	0.014	0.094	0.613	0.014
K	0.029	0.056	0.011	0.041	0.045	0.029	0.029	0.005	0.048	0.005	0.044	0.002	0.011	0.044	0.002
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	TU	TU	TU	TU	KU	KU	KU	KU	TU	KU	TU	TU	TU	TU	TU

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

SAMPLE NO ROCK TYPE ZONE	MO61			MO64			MO65			MO66-A		
	BS GAR AC2 CORE	BS GAR AC1 CORE	BS GAR AC2 CORE	BS GAR HB1 CORE	BS GAR HB2 CORE	BS GAR HB2 CORE	BS GAR HB2 CORE	BS GAR HB2 CORE	BS GAR HB2 CORE	BS GAR GL1 CORE	BS GAR GL1 CORE	BS GAR GL1 CORE
SI02	54.65	52.16	49.90	46.18	46.85	50.74	53.22	51.75	53.78	55.11	55.11	55.11
TI02	0.0	0.04	0.04	0.30	0.30	0.04	0.05	0.01	0.03	0.0	0.03	0.0
AL203	0.73	5.15	3.69	11.38	10.32	4.36	0.83	3.44	1.85	7.63	1.85	7.63
FE0	11.71	14.31	14.29	15.90	15.90	15.46	14.12	17.04	16.72	15.73	16.72	15.73
MNO	N.D.	0.27	0.28	0.23	0.26	0.23	0.25	0.13	0.24	N.D.	0.24	N.D.
MGO	16.96	13.69	14.31	10.03	10.05	12.89	14.90	8.15	10.33	12.92	10.33	12.92
CA0	13.64	10.54	11.31	9.42	9.23	11.16	12.50	0.46	9.54	0.64	9.54	0.64
NA20	0.19	1.19	0.34	3.28	2.91	1.27	0.29	6.99	1.78	7.25	1.78	7.25
K20	0.04	0.19	0.10	0.22	0.23	0.16	0.04	0.02	0.10	0.0	0.10	0.0
TOTAL	97.92	97.55	94.26	97.00	96.05	96.31	96.20	97.32	96.96	96.21	96.96	96.21
ATOMIC RATIOS (O = 23.0)												
SI	7.832	7.561	7.530	6.860	7.008	7.535	7.851	8.009	7.912	7.959	7.912	7.959
TI	0.0	0.005	0.005	0.034	0.034	0.004	0.006	0.003	0.003	0.0	0.003	0.0
AL	0.123	0.880	0.856	1.992	1.819	0.763	0.144	1.328	0.607	1.299	0.607	1.299
FE	1.403	1.735	1.803	1.983	1.989	1.920	1.742	2.035	2.432	2.035	2.432	2.035
MN	N.D.	0.033	0.036	0.029	0.033	0.029	0.031	0.016	0.030	N.D.	0.030	N.D.
MG	3.623	2.958	3.219	2.221	2.241	2.854	3.277	1.735	2.305	2.834	2.305	2.834
CA	2.094	1.637	1.829	1.499	1.479	1.776	1.976	0.067	1.504	0.099	1.504	0.099
NA	0.053	0.334	0.099	0.945	0.844	0.366	0.083	1.936	0.833	0.508	0.833	0.508
K	0.007	0.035	0.019	0.042	0.044	0.030	0.008	0.004	0.048	0.019	0.048	0.019
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	KU	TU	TU	TU	TU	TU	TU	KU	KU	KU	KU	KU
TH71072803												
SI02	51.06	56.03	52.54	54.37	56.16	54.61	54.52	52.72	56.77	55.29	56.77	55.29
TI02	0.06	0.06	0.03	0.05	0.0	0.08	0.05	0.01	0.0	0.06	0.0	0.06
AL203	5.21	8.30	2.16	7.55	0.79	2.46	0.99	2.38	1.59	6.46	1.59	6.46
FE0	15.98	14.49	15.77	13.76	9.93	12.34	12.71	14.13	14.39	16.15	14.39	16.15
MNO	N.D.	0.08	0.19	0.12	0.33	0.29	0.28	0.28	0.27	0.21	0.27	0.18
MGO	12.31	9.35	12.73	10.96	17.47	15.79	15.64	13.56	15.36	8.61	15.36	7.27
CA0	6.16	0.82	7.93	1.03	10.64	11.10	12.38	12.49	13.14	1.01	13.14	1.24
NA20	5.10	6.90	2.77	6.84	2.60	0.94	0.56	0.41	6.84	6.67	6.84	6.67
K20	0.0	0.02	0.08	0.03	0.07	0.04	0.05	0.05	0.03	0.01	0.03	0.01
TOTAL	95.88	96.06	94.20	94.71	97.99	97.65	97.18	96.05	98.73	97.12	98.73	97.12
ATOMIC RATIOS (O = 23.0)												
SI	7.592	8.027	7.924	7.921	7.958	7.820	7.892	7.785	7.715	8.106	7.715	8.106
TI	0.007	0.006	0.003	0.005	0.0	0.009	0.005	0.0	0.0	0.007	0.0	0.007
AL	0.913	1.401	0.384	1.296	0.132	0.415	0.169	0.414	0.270	1.266	0.270	1.266
FE	1.867	1.736	1.989	1.677	1.177	1.478	1.539	1.745	1.735	1.939	1.735	1.939
MN	N.D.	0.010	0.024	0.015	0.040	0.035	0.034	0.035	0.033	0.025	0.033	0.022
MG	2.729	1.999	2.862	2.300	3.691	3.371	3.575	2.985	3.302	1.590	3.302	1.590
CA	0.981	0.126	1.281	0.161	1.615	1.703	1.920	1.976	2.030	0.155	2.030	0.155
NA	1.470	1.917	0.810	1.832	0.714	0.261	0.157	1.894	0.123	1.897	0.123	1.897
K	0.0	0.004	0.015	0.006	0.013	0.007	0.009	0.013	0.006	0.002	0.006	0.002
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	KU	TU	TU	TU	TU	TU	TU	KU	KU	TU	TU	TU

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

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M074			M075			M079			M080		
	BS CHL GL2	GL2	GL1	BS CHL AC1	AC1	AC1	BS CHL GL3	GL3	GL5	BS CHL AC1	AC1	AC2
CORE	3	CORE	CORE	CORE	1	CORE	2	1	CORE	1	1	1
SI02	53.07	52.92	55.43	54.66	53.53	54.32	54.44	54.69	53.19	54.59	53.28	
TI02	0.15	0.0	0.04	0.12	0.08	0.08	0.01	0.04	0.03	0.02	0.02	
AL203	3.47	1.14	8.19	3.30	0.67	2.77	1.26	2.27	1.44	1.00	0.63	
FE0	26.64	15.98	16.28	18.00	14.65	15.10	14.09	15.51	8.02	7.77	7.66	
MNO	0.13	0.40	0.24	0.30	0.31	0.22	0.22	0.17	0.23	0.22	0.27	
MGO	4.98	12.89	7.48	11.15	14.52	15.09	16.22	14.25	19.34	19.62	19.19	
CA0	1.44	8.91	0.85	10.45	12.39	5.14	8.75	10.63	13.13	13.33	13.86	
NA20	6.78	1.52	6.74	1.16	0.15	4.42	2.67	1.83	0.59	0.53	0.42	
K20	0.03	0.05	0.01	0.16	0.02	0.13	0.16	0.05	0.05	0.05	0.05	
TOTAL	96.69	93.81	95.26	96.30	96.32	97.27	97.82	99.44	96.02	97.13	95.38	
ATOMIC RATIOS (O = 23.0)												
SI	8.113	8.017	8.078	7.731	7.894	7.865	7.858	7.813	7.676	7.763	7.744	
TI	0.017	0.0	0.004	0.014	0.009	0.009	0.001	0.004	0.003	0.002	0.002	
AL	0.625	0.204	1.407	0.582	0.116	0.473	0.214	0.382	0.245	0.168	0.108	
FE	3.406	2.024	1.984	2.253	1.807	1.829	1.701	1.853	0.968	0.924	0.931	
MN	0.017	0.051	0.030	0.038	0.039	0.027	0.027	0.021	0.028	0.026	0.033	
MG	1.135	2.911	1.625	2.488	3.192	3.257	3.490	3.035	4.161	4.159	4.158	
CA	0.236	1.446	0.133	1.676	1.958	0.797	1.353	1.627	2.030	2.031	2.158	
NA	2.010	0.446	1.904	0.337	0.043	1.241	0.747	0.507	0.165	0.146	0.118	
K	0.006	0.010	0.002	0.031	0.004	0.024	0.029	0.009	0.009	0.009	0.009	
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	
INSTRUMENT	TU	TU	TU	TU	TU	KU	KU	KU	KU	KU	KU	
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M083			M084			M089			M092		
CORE	BS CHL GL1	GL1	GL1	BS CHL GL4	GL1	GL1	GL3	GL6	GL6	GL4	AC3	
CORE	1	4	CORE	2	1	3	CORE	3	1	1	1	
SI02	53.07	52.61	52.47	54.84	52.80	52.51	52.93	51.61	54.42	52.89	52.80	
TI02	0.04	0.01	0.07	0.05	0.03	0.02	0.01	0.07	0.01	0.01	0.01	
AL203	5.61	2.19	2.11	4.06	1.83	1.43	0.66	2.18	0.87	1.09	0.97	
FE0	23.81	21.67	21.27	17.80	15.69	14.49	12.61	18.06	15.58	14.86	14.31	
MNO	0.16	0.20	0.19	0.13	0.19	0.23	0.26	0.62	0.66	0.58	0.66	
MGO	5.48	9.27	12.23	10.11	13.22	14.18	15.20	12.40	14.09	14.87	14.24	
CA0	0.71	5.27	5.36	1.58	5.51	7.64	11.65	9.12	10.89	9.11	12.17	
NA20	6.16	4.93	5.00	6.42	4.19	2.96	0.97	2.51	1.29	2.16	0.97	
K20	0.04	0.06	0.07	0.05	0.04	0.03	0.05	0.16	0.05	0.04	0.06	
TOTAL	95.08	96.21	98.77	95.04	93.50	93.49	94.34	96.73	97.86	95.61	96.19	
ATOMIC RATIOS (O = 23.0)												
SI	8.079	7.977	7.756	8.140	7.997	7.940	7.909	7.728	7.925	7.864	7.830	
TI	0.005	0.001	0.008	0.006	0.003	0.002	0.001	0.008	0.001	0.001	0.001	
AL	1.006	0.391	0.368	0.710	0.327	0.255	0.116	0.385	0.149	0.191	0.170	
FE	3.031	2.748	2.629	2.210	1.987	1.832	1.576	2.262	1.897	1.848	1.775	
MN	0.021	0.026	0.024	0.016	0.024	0.029	0.033	0.079	0.081	0.073	0.083	
MG	1.244	2.095	2.695	2.237	2.985	3.196	3.386	2.768	3.059	3.296	3.148	
CA	0.116	0.856	0.849	0.251	0.894	1.238	1.865	1.463	1.699	1.451	1.934	
NA	1.818	1.449	1.433	1.848	1.230	0.868	0.281	0.729	0.364	0.623	0.279	
K	0.008	0.012	0.013	0.009	0.008	0.006	0.010	0.031	0.009	0.008	0.011	
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	
INSTRUMENT	KU	KU	KU	TU	TU	TU	TU	KU	KU	KU	KU	

Electron microprobe analyses of rock-forming minerals from the
Sanbagawa metamorphic rocks, Shikoku

TABLE 10. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF GARNETES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH71081422				TH71081111						TH71081107	
	PE BIO				PE BIO						PE BIO	
	7(N) RIM	8(N) RIM	9(N) RIM	10(N) RIM	1(N) RIM	2(N) RIM	3(N) RIM	4(N) RIM	5(N) RIM	6(N) RIM	1(N) RIM	
SI02	38.15	37.53	37.94	38.40	37.73	38.21	38.17	37.42	37.77	37.70	37.53	
AL203	20.95	20.67	20.97	20.83	21.49	21.37	21.43	21.47	21.32	21.65	21.09	
FE0	29.96	28.95	30.61	30.12	30.15	30.36	30.39	30.27	30.56	30.87	28.31	
MNO	1.05	1.65	0.77	1.32	0.75	0.86	0.76	0.92	0.68	0.77	0.46	
MGO	2.35	2.34	2.41	2.36	1.49	1.35	1.48	1.61	1.58	1.32	0.76	
CA0	8.04	7.92	7.44	8.08	9.37	9.03	8.79	8.97	9.03	8.49	11.25	
TOTAL	100.50	99.06	100.14	101.11	100.98	101.18	101.02	100.66	100.94	100.80	99.40	
ATOMIC RATIOS (O = 12.0)												
SI	3.024	3.019	3.020	3.029	2.987	3.016	3.015	2.976	2.994	2.992	3.011	
AL	1.957	1.960	1.967	1.937	2.005	1.988	1.995	2.012	1.992	2.025	1.994	
FE	1.986	1.947	2.037	1.987	1.996	2.004	2.008	2.013	2.026	2.049	1.899	
MN	0.070	0.112	0.052	0.088	0.050	0.058	0.051	0.062	0.046	0.052	0.031	
MG	0.278	0.281	0.286	0.278	0.176	0.159	0.174	0.191	0.187	0.156	0.091	
CA	0.683	0.683	0.634	0.683	0.795	0.764	0.744	0.764	0.767	0.722	0.967	
ANALYST	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH71081107				TH71080201				TH71072702			
	PE BIO				PE GAR				PE GAR			
	2(N) RIM	3(N) RIM	4(N) RIM	5(N) RIM	1(N) RIM	2(N) RIM	3(N) RIM	4(N) RIM	1(N) RIM	2(N) RIM	3(N) RIM	
SI02	37.27	37.97	36.55	36.96	37.55	37.39	37.45	37.27	37.18	37.27	37.56	
AL203	21.13	21.18	21.24	21.17	20.91	20.95	21.04	21.09	20.87	20.70	20.91	
FE0	30.76	30.34	29.02	31.45	28.79	27.77	26.14	28.59	29.41	29.34	29.89	
MNO	0.28	0.55	0.88	0.29	2.61	4.14	6.10	3.51	1.91	2.94	1.47	
MGO	1.16	0.93	0.64	1.21	0.80	0.69	0.51	0.73	0.80	0.76	0.90	
CA0	8.84	9.43	10.66	8.57	8.83	8.65	9.17	9.08	9.53	8.73	8.79	
TOTAL	99.44	100.40	98.99	99.65	99.49	99.59	100.41	100.27	99.70	99.74	99.52	
ATOMIC RATIOS (O = 12.0)												
SI	3.000	3.023	2.963	2.979	3.024	3.014	3.002	2.991	2.997	3.009	3.023	
AL	2.005	1.988	2.029	1.985	2.011	1.991	1.988	1.995	1.983	1.969	1.984	
FE	2.071	2.020	1.967	2.120	1.939	1.872	1.752	1.919	1.983	1.981	2.012	
MN	0.019	0.037	0.060	0.020	0.178	0.283	0.414	0.239	0.130	0.201	0.100	
MG	0.139	0.110	0.077	0.145	0.096	0.083	0.061	0.087	0.096	0.091	0.108	
CA	0.763	0.804	0.926	0.740	0.762	0.747	0.788	0.781	0.823	0.755	0.758	
ANALYST	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	

Electron microprobe analyses of rock-forming minerals from the
Sanbagawa metamorphic rocks, Shikoku

TABLE 10. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF GARNETES (CONTINUED)

SAMPLE NO	TH71072714			M003		M004		M010		M019		
	ROCK TYPE	PE		SL	SL	BS	BS	BIO	BIO	BIO	BIO	
ZONE	GAR			BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	
GRAIN NO	1(N)	2(N)	3(N)	G1(N)	G2(N)	G1(N)	G2(N)	G1(N)	G1(N)	G1(N)	G1(N)	
POINT NO	RIM	RIM	RIM	RIM	CORE	RIM	CORE	RIM	CORE	RIM	CORE	
SI02	37.14	37.10	38.56	36.41	36.05	37.90	37.30	36.45	35.86	37.59	37.46	
AL203	21.02	20.94	20.51	22.16	21.89	21.69	20.12	21.13	21.03	20.72	20.42	
FEO	27.66	26.17	25.71	25.28	16.95	26.89	16.76	23.98	18.48	28.56	18.45	
MNO	3.62	3.70	4.54	3.87	14.52	1.86	9.31	4.58	9.40	1.79	11.13	
MGO	0.71	0.61	0.58	1.51	0.60	2.08	0.96	1.62	0.73	1.94	0.70	
CAO	9.59	10.07	9.54	9.97	10.91	10.23	13.83	10.66	12.19	8.70	11.68	
TOTAL	99.74	98.59	99.44	99.20	100.92	100.65	98.28	98.42	97.69	99.30	99.84	
ATOMIC RATIOS (O = 12.0)												
SI	2.992	3.009	3.089	2.926	2.887	2.987	3.018	2.955	2.938	3.019	3.008	
AL	1.996	2.002	1.936	2.098	2.066	2.015	1.919	2.019	2.031	1.961	1.933	
FE	1.863	1.775	1.722	1.699	1.135	1.772	1.134	1.626	1.266	1.918	1.239	
MN	0.247	0.254	0.308	0.263	0.985	0.124	0.638	0.314	0.652	0.122	0.757	
MG	0.085	0.074	0.069	0.181	0.072	0.244	0.116	0.196	0.089	0.232	0.084	
CA	0.828	0.875	0.819	0.858	0.936	0.864	1.199	0.926	1.070	0.749	1.005	
ANALYST	TH	TH	TH	MO	MO	MO	MO	MO	MO	MO	MO	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	TU	TU	TU	TU	
SAMPLE NO	TH71080601			TH72120319				TH72120338		M023	M025	
ROCK TYPE	BS			BS				BS		BS	BS	
ZONE	BIO			BIO				BIO		BIO	BIO	
GRAIN NO	G2(R)	G2(R)	G1(R)	G6(O)	G6(O)	G2(O)	G5(O)	G1(NZ)	G1(N)	G1(N)	G3(O)	
POINT NO	POOR	RIM	CORE	POOR	CORE	RIM	RIM	RIM	RIM	CORE	POOR	
SI02	36.86	37.90	37.30	38.13	37.72	37.95	37.90	37.97	37.81	37.40	36.95	
AL203	21.82	22.35	21.71	21.55	21.32	20.64	21.48	21.42	20.65	20.12	20.21	
FEO	28.95	27.26	20.35	25.81	19.21	26.88	24.98	27.95	31.56	29.62	27.85	
MNO	2.25	3.07	11.33	2.15	12.02	5.42	3.37	3.03	1.14	3.84	1.49	
MGO	2.23	2.10	0.89	1.97	0.45	2.18	2.11	2.38	3.17	1.63	1.62	
CAO	9.42	10.10	10.26	11.81	10.21	7.65	10.47	8.63	5.84	7.65	11.58	
TOTAL	101.53	102.78	101.84	101.42	100.93	100.72	100.31	101.38	100.17	100.26	99.70	
ATOMIC RATIOS (O = 12.0)												
SI	2.913	2.941	2.946	2.984	2.998	3.018	2.994	2.987	3.015	3.012	2.976	
AL	2.033	2.044	2.021	1.987	1.997	1.934	2.000	1.986	1.941	1.910	1.918	
FE	1.914	1.769	1.344	1.689	1.277	1.788	1.651	1.839	2.105	1.995	1.876	
MN	0.151	0.202	0.758	0.142	0.809	0.365	0.226	0.202	0.077	0.262	0.102	
MG	0.263	0.243	0.105	0.230	0.053	0.258	0.249	0.279	0.377	0.196	0.194	
CA	0.798	0.840	0.868	0.990	0.869	0.652	0.886	0.727	0.499	0.660	0.999	
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	TU	TU	TU	

TABLE 10. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF GARNETS (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	MO29			MO33			MO64			
	BS BIO G3(O) RIM	SL G1(R) POOR	G2(N) CORE	BS BIO G2(R) POOR	SL G1(R) CORE	G2(N) RIM	BS GAR G2(N) RIM	SL G1(N) CORE	G2(N) RIM	G1(N) CORE
SI02	37.77	36.88	35.81	37.18	36.95	36.05	37.13	36.95	37.13	36.65
AL203	20.08	20.84	21.03	21.24	20.38	20.38	20.97	20.38	20.97	20.66
FE0	28.44	27.45	19.40	28.02	25.72	25.72	25.50	25.72	25.50	17.97
MNO	1.99	2.77	4.65	11.13	1.24	10.88	5.19	1.24	10.88	9.65
MGO	1.80	1.17	0.45	1.13	0.95	0.56	1.13	0.95	1.13	0.71
CAO	9.89	9.08	10.93	10.66	9.87	4.74	9.17	9.87	9.17	12.48
TOTAL	99.97	99.02	98.35	99.21	99.06	98.33	99.09	98.33	99.09	98.12
ATOMIC RATIOS (O = 12.0)										
SI	3.066	2.976	2.910	2.989	2.992	2.988	2.999	2.988	2.999	2.983
AL	1.896	1.987	1.957	2.012	1.986	1.991	1.996	1.986	1.996	1.982
FE	1.905	1.945	1.353	1.884	1.783	1.783	1.723	1.783	1.723	1.223
MN	0.135	0.191	0.775	0.067	0.085	0.067	0.355	0.067	0.355	0.565
MG	0.215	0.142	0.055	0.135	0.115	0.069	0.136	0.115	0.086	0.136
CA	0.849	0.790	0.962	0.918	0.856	0.421	0.794	0.856	0.794	1.088
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	TU	TU	TU	TU	TU	TU	TU	TU	TU	TU

TABLE 11. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF EPIDOTES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH72102901			MO04			MO05			TH710813D			MO10		
	BS BIO E5	SL BIO E1	E5 E2	SL BIO E3	E2 E1	E2 E1	BS BIO E1	BIO E1	E2 E1	BS BIO E1	BIO E1	E2 E1	BS BIO E1	BIO E1	E2 E1
SI02	37.64	37.64	37.58	39.27	38.68	38.63	37.86	37.86	37.86	37.12	37.12	36.99	36.99	36.99	36.91
AL203	24.63	29.18	28.33	28.75	27.54	29.08	26.40	26.40	26.40	21.64	21.64	21.33	21.33	21.33	29.17
FE203	12.07	13.58	7.40	6.09	7.71	5.65	9.29	9.29	9.29	15.68	16.18	15.68	16.18	16.18	6.21
MNO	0.09	0.14	0.89	0.10	0.13	0.10	0.07	0.07	0.07	0.16	0.16	0.16	0.16	0.16	0.11
CAO	23.79	23.81	23.97	25.22	24.67	23.52	23.61	23.61	23.61	22.84	22.84	22.23	22.23	22.84	23.55
TOTAL	98.22	98.04	98.17	99.43	98.73	96.98	97.23	97.23	97.23	96.41	96.41	97.94	97.94	97.94	95.95
ATOMIC RATIOS (O = 12.5)															
SI	2.978	3.004	2.935	3.005	2.998	3.012	2.991	2.991	2.991	3.015	3.015	2.986	2.986	2.986	2.925
AL	2.296	2.150	2.608	2.593	2.515	2.872	2.458	2.458	2.458	2.049	2.049	2.052	2.052	2.052	2.725
FE	0.719	0.815	0.566	0.551	0.450	0.551	0.552	0.552	0.552	0.960	0.960	0.962	0.962	0.962	0.570
MN	0.006	0.009	0.059	0.006	0.009	0.007	0.005	0.005	0.005	0.012	0.012	0.011	0.011	0.011	0.007
CA	2.016	2.035	2.006	2.068	2.048	1.965	1.969	1.969	1.969	1.941	1.941	1.969	1.969	1.969	2.000
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	TU	TU	TU	TU	TU	TU

TABLE 11. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF EPIDOTES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M010		M011-A		M015		M016		M019		TH71080601	
	BS	B10	BS	B10	BS	B10	BS	B10	BS	B10	BS	B10
	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
	2	1	2	2	2	2	2	2	2	2	1	2
SI02	36.96	37.28	37.06	38.79	38.67	38.36	37.66	38.45	38.33	38.31	38.95	38.95
AL203	26.24	23.70	22.75	24.61	20.53	27.46	23.65	28.92	25.97	28.47	24.48	24.48
FE203	8.97	12.56	14.18	11.98	13.83	8.64	11.86	6.76	10.33	7.19	10.19	10.19
MNO	0.63	0.44	0.53	0.54	0.61	0.11	0.50	0.08	0.19	0.21	0.29	0.29
CAO	22.66	23.54	23.11	23.52	23.62	24.48	23.34	22.59	23.01	22.42	22.70	22.70
TOTAL	95.46	97.52	97.63	99.44	97.26	99.05	97.01	96.80	97.83	96.60	96.61	96.61
ATOMIC RATIOS (O = 12.5)												
SI	2.976	2.983	2.978	3.025	3.117	2.972	3.019	3.005	3.013	3.007	3.096	3.096
AL	2.490	2.235	2.155	2.262	1.950	2.507	2.234	2.664	2.406	2.633	2.293	2.293
FE	0.543	0.756	0.857	0.703	0.839	0.504	0.715	0.398	0.611	0.425	0.610	0.610
MN	0.043	0.030	0.036	0.036	0.042	0.007	0.034	0.005	0.013	0.014	0.020	0.020
CA	1.955	2.018	1.990	1.965	2.040	2.032	2.004	1.892	1.938	1.885	1.933	1.933
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	TU	KU	KU	KU	KU	KU	KU	TU	TU	KU	KU	KU
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH72120319		TH72120338		M023		M024		M026		TH71080303	
	BS	B10	BS	B10	BS	B10	BS	B10	BS	B10	BS	B10
	E5	E5	E3	E3	E1	E1	E1	E1	E2	E2	E1	E1
	2	1	1	2	3	2	2	3	2	2	1	2
SI02	38.32	37.15	37.54	37.41	38.35	38.25	35.89	36.25	36.92	36.64	37.15	37.15
AL203	26.65	24.08	23.01	19.77	25.41	23.26	24.27	23.15	23.90	23.20	24.14	24.14
FE203	9.16	12.57	13.21	15.99	11.28	14.30	12.95	15.50	13.24	12.42	12.64	12.64
MNO	0.04	0.29	N.D.	N.D.	0.30	0.10	0.25	0.26	0.16	0.16	0.29	0.29
CAO	24.19	23.81	23.75	24.02	22.74	22.83	22.35	22.64	23.55	23.49	23.03	23.03
TOTAL	98.36	97.90	97.51	97.19	98.08	98.74	95.71	97.80	97.77	95.91	97.25	97.25
ATOMIC RATIOS (O = 12.5)												
SI	2.993	2.961	3.006	3.045	3.015	3.020	2.923	2.916	2.951	2.981	2.974	2.974
AL	2.453	2.262	2.171	1.897	2.355	2.165	2.330	2.195	2.251	2.225	2.277	2.277
FE	0.538	0.754	0.796	0.667	0.667	0.850	0.794	0.938	0.796	0.761	0.761	0.761
MN	0.003	0.020	N.D.	N.D.	0.020	0.007	0.017	0.018	0.011	0.011	0.020	0.020
CA	2.024	2.033	2.037	2.095	1.916	1.931	1.951	1.951	2.017	2.048	1.975	1.975
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	KU	KU	KU	KU	TU	TU	TU	TU	TU	TU	TU	TU
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH71080303		M028		TH71051007		M029		M033		M037	
	BS	B10	BS	B10	BS	B10	SL	B10	SL	B10	BS	B10
	E2	E1	E2	E4	E1	E2	E1	E2	E1	E2	E2	E2
	3	1	1	2	1	3	2	3	2	2	3	1
SI02	36.41	36.43	36.92	37.26	37.56	37.36	37.43	38.42	37.94	37.86	37.25	37.25
AL203	24.65	26.04	25.17	24.14	22.74	28.76	27.25	29.68	26.42	25.06	23.19	23.19
FE203	14.60	11.69	11.60	11.79	12.76	6.96	7.73	5.78	9.18	11.39	14.27	14.27
MNO	0.61	0.25	0.23	N.D.	N.D.	0.09	0.18	0.15	0.07	0.26	0.20	0.20
CAO	22.36	23.16	22.82	24.12	23.91	23.65	23.05	23.48	22.60	25.08	23.33	23.33
TOTAL	98.63	97.57	96.74	97.31	96.97	96.82	95.64	97.51	96.21	99.65	98.24	98.24
ATOMIC RATIOS (O = 12.5)												
SI	2.892	2.898	2.957	2.979	3.022	2.940	2.988	2.981	3.016	2.958	2.970	2.970
AL	2.308	2.442	2.376	2.275	2.157	2.668	2.563	2.714	2.476	2.308	2.179	2.179
FE	0.873	0.700	0.699	0.709	0.773	0.412	0.464	0.337	0.549	0.670	0.856	0.856
MN	0.041	0.017	0.016	N.D.	N.D.	0.006	0.012	0.010	0.005	0.017	0.014	0.014
CA	1.903	1.974	1.958	2.066	2.061	1.994	1.971	1.952	1.925	2.100	1.993	1.993
ANALYST	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO	MO
INSTRUMENT	TU	TU	TU	KU	KU	TU	TU	TU	TU	TU	TU	TU

TABLE 11. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF EPIDOTES (CONTINUED)

MO66-A				MO67				TH71072803				MO70				MO71				MO74																							
SAMPLE NO	ROCK TYPE	ZONE	GRAIN NO	POINT NO	BS	GAR	E1	E2	E3	MO	TU	CHL	E1	E2	E3	MO	TU	CHL	E1	E2	E3	MO	TU	BS	CHL	E1	E2	E3	MO	TU	BS	CHL	E1	E2	E3								
																																				MO	TU	CHL	E1	E2	E3	MO	TU
SI02			36.60	36.62	36.06		37.21	38.41	38.04	39.26	38.30	37.70	37.69																														
AL203			22.29	23.47	21.54		22.15	22.58	22.58	27.86	24.26	20.94	20.94																														
FE203			15.12	13.82	15.65		14.66	14.56	14.56	9.54	7.98	13.24	15.72																														
MNO			N.D.	0.16	0.38		0.56	0.27	0.14	0.76	0.13	0.44	0.18																														
CAO			23.58	23.20	23.75		23.00	23.84	23.13	23.07	23.95	22.72	22.29																														
TOTAL			97.99	97.27	97.58		97.52	98.47	98.47	100.31	98.77	96.86	96.82																														
ATOMIC RATIOS (O = 12.5)																																											
SI			2.945	2.947	2.934		2.961	2.983	3.022	3.005	3.012	3.055	3.056																														
AL			2.114	2.226	2.141		2.093	2.114	2.093	2.421	2.506	2.249	2.001																														
FE			0.915	0.837	0.958		0.892	0.931	0.870	0.562	0.458	0.802	0.959																														
MN			N.D.	0.011	0.026		0.038	0.052	0.009	0.018	0.009	0.030	0.012																														
CA			2.067	2.000	2.070		1.992	1.946	1.970	1.998	2.018	1.959	1.936																														
ANALYST			MO	MO	MO		MO	MO	MO	MO	MO	MO	MO																														
INSTRUMENT			TU	TU	TU		TU	TU	TU	TU	TU	TU	TU																														
MO75																																											
SI02			38.06	37.78	37.09		36.84	36.14	36.45	36.86	36.12	36.37	37.52																														
AL203			24.68	22.88	21.89		21.59	23.07	21.66	21.04	22.01	19.99	21.46																														
FE203			11.93	12.23	13.84		14.73	12.07	15.96	16.66	14.59	17.17	16.48																														
MNO			0.15	0.15	0.56		0.13	0.04	0.16	0.35	0.51	0.11	0.33																														
CAO			23.68	23.39	23.69		22.15	24.42	23.84	23.44	22.60	22.69	23.46																														
TOTAL			98.20	97.55	98.15		96.00	97.92	98.09	98.35	95.63	96.33	99.25																														
ATOMIC RATIOS (O = 12.5)																																											
SI			3.004	2.968	2.938		2.938	2.912	2.941	2.970	2.994	2.987	2.987																														
AL			2.252	2.158	2.110		2.060	2.191	2.060	2.133	2.133	2.014	2.014																														
FE			0.691	0.733	0.834		0.724	0.853	0.770	0.890	0.890	0.987	0.987																														
MN			0.010	0.010	0.044		0.039	0.003	0.011	0.024	0.036	0.008	0.022																														
CA			2.002	1.996	2.031		1.941	2.095	2.108	2.051	2.024	2.001	2.001																														
ANALYST			MO	MO	MO		MO	MO	MO	MO	MO	MO	MO																														
INSTRUMENT			TU	TU	TU		TU	TU	TU	TU	TU	TU	TU																														
MO89																																											
SI02			35.93	37.66	37.58																																						
AL203			20.74	24.16	20.33																																						
FE203			17.00	13.10	17.44																																						
MNO			0.35	0.15	0.15																																						
CAO			23.28	24.21	23.85																																						
TOTAL			97.30	99.28	99.35																																						
ATOMIC RATIOS (O = 12.5)																																											
SI			2.936	2.963	3.002																																						
AL			1.998	2.240	1.914																																						
FE			1.045	0.776	1.048																																						
MN			0.024	0.010	0.010																																						
CA			2.038	2.041	2.041																																						
ANALYST			MO	MO	MO		MO	MO	MO	MO	MO	MO	MO																														
INSTRUMENT			TU	TU	TU		TU	TU	TU	TU	TU	TU	TU																														

TABLE 12. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF ILMENITES

TH72112922				TH72112911				TH72112908				TH71081418																											
SAMPLE NO	ROCK TYPE	ZONE	GRAIN NO	POINT NO	PE	GAR	E1	E2	E3	MO	TU	CHL	E1	E2	E3	MO	TU	CHL	E1	E2	E3	MO	TU	BS	CHL	E1	E2	E3	MO	TU	BS	CHL	E1	E2	E3				
																																				MO	TU	CHL	E1
SI02			55.04	52.70	52.70		52.70	52.70	52.70	52.70	52.70	52.70	52.70																										
AL203			42.29	42.59	42.59		42.59	42.59	42.59	42.59	42.59	42.59	42.59																										
FE0			3.68																																				

TABLE 12. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF ILMENITES (CONTINUED)

SAMPLE NO	TH71081416		TH71081414		TH71081408		TH71081405					TH71081403
	ROCK TYPE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE	PE
ZONE	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO
GRAIN NO	1(S)	1(D)	1(R)	2(R)	3(R)	1(R)	2(R)	3(R)	4(R)	5(R)	1(D)	
POINT NO	1	1	1	1	1	1	1	1	1	1	1	
SI02	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
TI02	52.71	52.80	52.86	53.04	52.74	52.24	52.07	52.68	52.68	52.68	52.67	
AL203	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
FE0	44.47	44.47	42.93	42.86	42.29	43.50	43.32	43.17	43.56	44.05	46.26	
MNO	2.01	2.04	3.29	3.18	2.94	3.01	3.29	3.42	3.27	2.81	1.52	
TOTAL	99.19	99.31	99.08	99.08	97.97	98.75	98.68	99.27	99.51	99.54	100.45	
ATOMIC RATIOS (O = 3.0)												
SI	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
TI	1.006	1.007	1.009	1.011	1.015	1.003	1.001	1.005	1.004	1.003	0.997	
AL	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	
FE	0.944	0.943	0.911	0.909	0.905	0.929	0.926	0.916	0.923	0.933	0.974	
MN	0.043	0.044	0.071	0.068	0.064	0.065	0.071	0.074	0.070	0.060	0.032	
ANALYST	TI	TI	TI	TI	TI	TI	TI	TI	TI	TI	TI	
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	
SAMPLE NO	TH71081315			TH71081311			TH71081310			TH71081309		
	ROCK TYPE	PE	PE	PE	PE	PE	PE	PE	PE	PE		
ZONE	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO		
GRAIN NO	1(R)	2(D)	3(R)	1(R)	2(R)	3(R)	4(R)	5(R)	6(D)	1(R)		
POINT NO	1	1	1	1	1	1	1	1	1	1		
SI02	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.		
TI02	52.83	52.73	52.72	52.10	51.77	52.43	52.68	52.71	52.70	52.76		
AL203	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.		
FE0	45.49	45.19	45.14	45.18	45.52	46.22	45.73	44.65	45.71	44.74		
MNO	1.60	1.33	1.39	1.57	1.48	1.49	1.67	1.89	1.43	2.51		
TOTAL	99.92	99.25	99.25	98.85	98.77	100.14	100.08	99.25	99.84	99.99		
ATOMIC RATIOS (O = 3.0)												
SI	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.		
TI	1.003	1.006	1.006	1.001	0.997	0.996	1.000	1.006	1.002	1.001		
AL	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.		
FE	0.960	0.959	0.958	0.965	0.975	0.976	0.965	0.948	0.966	0.944		
MN	0.034	0.029	0.030	0.034	0.032	0.032	0.036	0.041	0.031	0.054		
ANALYST	TI	TI	TI	TI	TI	TI	TI	TI	TI	TI		
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU		
SAMPLE NO	TH71081309		TH71081307		TH71081306		TH71081303		TH71081421		TH71081424	
	ROCK TYPE	PE	PE	PE	PE	PE	PE	PE	PE	PE		
ZONE	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO	BIO		
GRAIN NO	2(R)	3(R)	1(R)	2(R)	1(R)	2(R)	1(R)	2(R)	3(R)	1(R)		
POINT NO	1	1	1	1	1	1	1	1	1	1		
SI02	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.		
TI02	52.71	52.72	52.72	52.72	52.69	52.70	52.70	53.07	52.46	52.51		
AL203	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.		
FE0	45.83	45.67	45.00	40.49	42.47	42.44	42.83	40.65	41.36	39.74		
MNO	1.09	1.14	1.57	4.62	3.89	3.62	3.37	5.69	3.93	5.88		
TOTAL	99.63	99.53	99.29	97.83	99.05	98.76	98.90	99.41	97.75	99.09		
ATOMIC RATIOS (O = 3.0)												
SI	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.		
TI	1.003	1.004	1.006	1.016	1.007	1.009	1.008	1.009	1.013	1.006		
AL	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.		
FE	0.970	0.967	0.955	0.868	0.903	0.904	0.911	0.860	0.888	0.862		
MN	0.023	0.024	0.034	0.100	0.084	0.078	0.073	0.122	0.085	0.127		
ANALYST	TI	TI	TI	TI	TI	TI	TI	TI	TI	TI		
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU		

Electron microprobe analyses of rock-forming minerals from the Sanbagawa metamorphic rocks, Shikoku

TABLE 12. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF ILMENITES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M024			M038-B			M040			M052			M055		
	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)
SI02	0.24	0.23	1	1.08	2.35	1	0.16	0.42	1	0.42	1.16	1.53			
TI02	47.80	49.02		49.57	49.20		47.17	50.38		50.38	49.43	47.68			
AL203	0.16	0.11		0.36	0.09		0.09	0.12		0.12	0.52	0.65			
FE0	48.20	48.60		45.26	36.85		45.34	35.64		35.64	44.96	44.96			
MNO	1.81	1.72		3.27	11.03		24.05	11.74		24.05	11.74	4.76			
TOTAL	98.21	98.68		99.34	99.75		97.97	98.23		98.23	98.19	99.58			
ATOMIC RATIOS (O = 3.0)															
SI	0.006	0.006		0.028	0.059		0.004	0.011		0.011	0.030	0.039			
TI	0.942	0.949		0.947	0.920		0.935	0.974		0.974	0.955	0.915			
AL	0.005	0.003		0.011	0.009		0.003	0.004		0.004	0.007	0.020			
FE	1.056	1.047		0.774	1.000		1.000	0.500		0.500	0.766	0.960			
MN	0.040	0.038		0.071	0.235		0.116	0.524		0.524	0.255	0.103			
ANALYST	TI	TI		TI	TI		TI	TI		TI	TI	TI			
INSTRUMENT	KU	KU		KU	KU		KU	KU		KU	KU	KU			

TABLE 13. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF RUTILES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M024			M028			M048			M052		
	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)
SI02	0.17	0.20		0.16	0.57		0.26	1.19		0.19	0.42	
TI02	98.67	99.35		98.57	97.96		97.10	96.46		97.45	96.65	
AL203	0.04	0.05		0.05	0.18		0.21	0.47		0.13	0.25	
FE0	0.50	0.43		0.36	0.75		0.46	0.97		0.75	1.07	
MNO	N.D.	N.D.		N.D.	N.D.		N.D.	0.21		0.0	0.52	
TOTAL	99.64	99.35		100.00	99.11		98.56	99.44		98.52	98.91	
ATOMIC RATIOS (O = 2.0)												
SI	0.002	0.003		0.002	0.008		0.003	0.016		0.003	0.006	
TI	0.994	0.994		0.995	0.985		0.986	0.973		0.992	0.982	
AL	0.001	0.001		0.001	0.003		0.003	0.007		0.002	0.004	
FE	0.006	0.005		0.004	0.008		0.010	0.011		0.008	0.012	
MN	N.D.	N.D.		N.D.	0.003		0.002	0.000		0.0	0.006	
ANALYST	TI	TI		TI	TI		TI	TI		TI	TI	
INSTRUMENT	KU	KU		KU	KU		KU	KU		KU	KU	

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M024			M028			M048			M052		
	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)
SI02	0.45	0.21		0.19	0.36		0.59	0.75		0.75	4.62	
TI02	96.13	97.87		96.96	96.02		96.02	96.02		96.02	96.06	
AL203	0.24	0.16		0.09	0.13		0.13	0.13		0.13	0.13	
FE0	1.21	0.79		0.66	1.13		0.66	1.13		0.66	1.13	
MNO	0.41	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
TOTAL	98.44	98.03		98.11	98.16		98.16	98.67		98.27	101.13	
ATOMIC RATIOS (O = 2.0)												
SI	0.006	0.003		0.007	0.033		0.023	0.014		0.029	0.172	
TI	0.982	0.991		0.990	0.990		0.990	0.990		0.990	0.990	
AL	0.004	0.003		0.001	0.001		0.001	0.001		0.001	0.002	
FE	0.014	0.009		0.009	0.014		0.009	0.014		0.009	0.014	
MN	0.005	0.0		0.002	0.002		0.002	0.002		0.002	0.002	
ANALYST	TI	TI		TI	TI		TI	TI		TI	TI	
INSTRUMENT	KU	KU		KU	KU		KU	KU		KU	KU	

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M065			M024			M028			M038-B		
	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)
SI02	0.21	0.40		0.08	0.08		0.08	0.08		0.08	0.08	
TI02	97.87	96.96		97.10	96.46		97.10	96.46		97.45	96.65	
AL203	0.24	0.09		0.09	0.13		0.13	0.13		0.13	0.13	
FE0	1.21	0.66		0.66	1.13		0.66	1.13		0.66	1.13	
MNO	0.41	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
TOTAL	98.44	98.11		98.16	98.16		98.16	98.67		98.27	101.13	
ATOMIC RATIOS (O = 4.0)												
SI	0.006	0.003		0.007	0.033		0.023	0.014		0.029	0.172	
TI	0.982	0.991		0.990	0.990		0.990	0.990		0.990	0.990	
AL	0.004	0.003		0.001	0.001		0.001	0.001		0.001	0.002	
FE	0.014	0.009		0.009	0.014		0.009	0.014		0.009	0.014	
MN	0.005	0.0		0.002	0.002		0.002	0.002		0.002	0.002	
ANALYST	TI	TI		TI	TI		TI	TI		TI	TI	
INSTRUMENT	KU	KU		KU	KU		KU	KU		KU	KU	

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M065			M024			M028			M038-B		
	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)	SL	BS	1(D)
SI02	0.21	0.40		0.08	0.08		0.08	0.08		0.08	0.08	
TI02	97.87	96.96		97.10	96.46		97.10	96.46		97.45	96.65	
AL203	0.24	0.09		0.09	0.13		0.13	0.13		0.13	0.13	
FE0	1.21	0.66		0.66	1.13		0.66	1.13		0.66	1.13	
MNO	0.41	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
TOTAL	98.44	98.11		98.16	98.16		98.16	98.67		98.27	101.13	
ATOMIC RATIOS (O = 2.0)												
SI	0.006	0.003		0.007	0.033		0.023	0.014		0.029	0.172	
TI	0.982	0.991		0.990	0.990		0.990	0.990		0.990	0.990	
AL	0.004	0.003		0.001	0.001		0.001	0.001		0.001	0.002	
FE	0.014	0.009		0.009	0.014		0.009	0.014		0.009	0.014	
MN	0.005	0.0		0.002	0.002		0.002	0.002		0.002	0.002	
ANALYST	TI	TI		TI	TI		TI	TI		TI	TI	
INSTRUMENT	KU	KU		KU	KU		KU	KU		KU	KU	

TABLE 14. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF MAGNETITES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M040	M048	M052	M055	M058	M065
	BS BIO	BS GAR	SL GAR	BS GAR	BS GAR	BS GAR
	1	1	1	1	1	1
SI02	0.21	1.74	0.39	1.89	0.29	1.88
TI02	0.01	0.02	0.02	0.04	0.0	0.05
FE203	67.48	64.19	67.17	63.45	67.77	64.15
FEO	30.85	33.30	30.98	33.58	31.12	33.75
MNO	0.06	0.01	0.21	0.05	0.03	0.0
TOTAL	98.61	99.26	98.77	99.01	99.21	99.83
ATOMIC RATIOS (O = 4.0)						
SI	0.008	0.067	0.015	0.073	0.011	0.072
TI	0.000	0.001	0.001	0.001	0.0	0.001
FE3+	1.983	1.861	1.968	1.844	1.978	1.848
FE2+	1.007	1.073	1.009	1.084	1.009	1.081
MN	0.002	0.000	0.007	0.002	0.001	0.0
ANALYST	TI	TI	TI	TI	TI	TI
INSTRUMENT	KU	KU	KU	KU	KU	KU

TABLE 15. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF HEMATITES (CONTINUED)

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M011-B	TH72120338			M024	M038-B			M039		
	SL BIO	BS BIO	BS BIO	BS BIO	BS BIO	BS BIO	BS BIO	BS BIO	BS BIO		
	1(D)	1(D)	1(I)	1(I)	2(L)	3(L)	3(L)	1(D)	1(D)	1(D)	
	RIM1	RIM2	CORE	CORE	1	1	2	CORE	RIM1	RIM2	CORE
SI02	1.49	1.43	0.76	0.30	0.27	0.23	0.29	2.28	2.62	4.25	0.31
TI02	8.67	9.19	18.24	16.88	7.00	10.02	10.77	12.61	8.51	6.71	14.26
FE203	78.57	78.33	62.93	67.15	85.59	79.94	77.92	71.09	77.14	78.47	69.87
FEO	9.30	9.48	16.72	15.16	6.49	9.19	10.03	12.10	10.08	11.02	13.04
MNO	0.26	0.45	0.53	0.36	0.13	0.09	0.10	1.91	0.67	0.07	0.10
TOTAL	98.29	98.88	99.18	99.85	99.48	99.47	99.11	99.99	99.02	100.52	97.58
ATOMIC RATIOS (O = 3.0)											
SI	0.040	0.038	0.020	0.008	0.007	0.006	0.008	0.059	0.069	0.109	0.008
TI	0.174	0.183	0.360	0.332	0.139	0.199	0.215	0.246	0.168	0.130	0.287
FE3+	1.574	1.559	1.242	1.321	1.707	1.599	1.554	1.389	1.526	1.521	1.409
FE2+	0.207	0.210	0.367	0.331	0.144	0.203	0.222	0.263	0.222	0.237	0.292
MN	0.006	0.010	0.012	0.008	0.003	0.002	0.002	0.042	0.015	0.002	0.002
ANALYST	TI	TI	TI	TI	TI	TI	TI	TI	TI	TI	TI
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU
SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	M040					M048					
	BS BIO	BS GAR	BS GAR	BS GAR	BS GAR	BS GAR	BS GAR	BS GAR	BS GAR	BS GAR	BS GAR
	1(D)	1(D)	2(D)	3(D)	3(D)	1(D)	1(D)	1(D)	1(D)	2(D)	2(D)
	CORE	RIM	RIM	RIM1	RIM2	CORE	RIM1	RIM2	RIM3	RIM1	RIM2
SI02	0.20	0.19	0.40	0.20	0.59	1.77	1.71	1.78	1.82	1.75	1.90
TI02	13.74	7.52	2.87	4.99	0.69	12.17	2.30	2.36	9.66	3.14	1.88
FE203	72.01	83.97	92.72	88.93	95.67	71.29	91.36	91.19	77.34	89.41	92.64
FEO	11.72	6.85	3.01	4.60	1.23	12.88	4.09	4.16	10.75	4.94	3.94
MNO	0.80	0.07	0.02	0.07	0.07	0.15	N.D.	0.06	0.09	0.0	0.0
TOTAL	98.47	98.60	99.02	98.79	98.25	98.26	99.46	99.55	99.66	99.24	100.36
ATOMIC RATIOS (O = 3.0)											
SI	0.005	0.005	0.011	0.005	0.016	0.047	0.045	0.047	0.048	0.046	0.050
TI	0.275	0.151	0.058	0.100	0.014	0.243	0.046	0.047	0.190	0.063	0.037
FE3+	1.441	1.689	1.864	1.789	1.941	1.422	1.818	1.813	1.524	1.782	1.827
FE2+	0.261	0.153	0.067	0.103	0.028	0.285	0.090	0.092	0.235	0.109	0.086
MN	0.018	0.002	0.000	0.002	0.002	0.003	N.D.	0.001	0.002	0.0	0.0
ANALYST	TI	TI	TI	TI	TI	TI	TI	TI	TI	TI	TI
INSTRUMENT	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU	KU

TABLE 15. CHEMICAL COMPOSITIONS AND ATOMIC RATIOS OF HEMATITES

SAMPLE NO ROCK TYPE ZONE GRAIN NO POINT NO	TH710813D		M011-B
	BS BIO	1(D)	SL BIO
	1(D)	1(D)	1(D)
	CORE	RIM	CORE
SI02	0.11	0.17	1.48
TI02	12.43	10.65	10.48
FE203	73.26	76.93	76.04
FEO	10.95	9.65	9.75
MNO	0.24	0.05	1.40
TOTAL	96.99	97.45	99.15
ATOMIC RATIOS (O = 3.0)			
SI	0.003	0.005	0.039
TI	0.253	0.216	0.208
FE3+	1.490	1.560	1.507
FE2+	0.248	0.218	0.215
MN	0.005	0.001	0.031
ANALYST	TI	TI	TI
INSTRUMENT	KU	KU	KU

Table 18 • Mineral assemblages and correlations between Sample Nos used in this paper and those given in the referred papers. All minerals present in the samples are listed in the table but not all of them were in equilibrium during the prograde metamorphism. Chemical compositions of the minerals marked with ● or star (e.g. st*) 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, St = stilpnomelane, Ch = chlorite, Am = amphibole, Hb = hornblende, Ac = actinolite, Px = pyroxene, Pu = pumpellyite, Ga = garnet, Ep = epidote, Al = allanite, Cc = calcite, To = tourmaline, Ap = apatite, Sp = sphene, Il = ilmenite, Ru = rutile, Mt = magnetite, Hm = hematite, Po = pyrrhotite, Py = pyrite, Cp = chalcopyrite, Bo = bornite, Cv = covellite, Cm = carbonaceous matter, ○, ● = present, - = absent, / = not determined.

Electron microprobe analyses of rock-forming minerals from the
Sanbagawa metamorphic rocks, Shikoku

TH71081004	Pe	Gar	o	o	o	-	o	-	o	o	-	o	o	o	●	o	-	o	-	o			92		92	
TH71080201	Pe	Gar	o	o	●	-	●	-	●	o	-	-	o	o	●	o	o	o	o	o		8	95		95	
TH71080202	Pe	Gar	o	o	o	-	o	-	o	o	-	o	o	o	-	-	●	o	o	o			96			
TH71080203	Pe	Gar	o	o	o	-	o	-	o	o	-	o	o	o	-	o	-	o	-	●	Al		97			A52
TH71080205	Pe	Gar	o	o	o	-	o	-	o	o	-	o	o	o	-	o	●	o	o	o			99		99	
TH71072702	Pe	Gar	o	o	o	-	●	-	●	o	-	o	o	o	-	o	o	-	-	o	Al	7	101			
TI77110828	Pe	Gar	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	●			106			A50
TH71072713	Pe	Gar	o	o	o	-	o	-	o	o	-	o	o	o	-	o	●	o	o	o			107			
TH71072714	Pe	Gar	o	o	o	-	o	-	●	o	-	o	o	o	-	-	o	o	o	o		6	108			
TH71072721	Pe	Gar	o	o	o	-	●	-	-	o	o	o	o	o	o	o	o	-	o	o		5	109			
TH71072805	Pe	Gar	o	o	o	-	o	-	o	o	o	o	o	o	-	o	●	o	o	o						
TH71072813	Pe	Chl	o	o	o	-	●	-	-	o	o	o	o	o	-	-	●	o	-	o		4	113			
TI77110804	Pe	Chl	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	●						A28
TI77110801	Pe	Chl	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	●						A26
TH71073012	Pe	Chl	o	o	●	-	●	-	-	o	-	o	o	o	-	-	o	o	o	o		3	114			
TH71073011	Pe	Chl	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	●						A25
TH71072922	Pe	Chl	o	o	●	-	●	-	-	o	-	o	o	o	-	-	o	o	o	o		2	115			
TH71072907	Pe	Chl	o	o	o	-	o	-	-	o	o	o	o	o	-	-	o	o	●	o			126			A14
TH71072918	Pe	Chl	o	o	o	-	●	-	-	o	o	o	o	o	-	-	o	o	o	o		1	130			
TH71103102	Pe	Chl	o	o	o	-	o	-	-	o	o	o	o	o	-	-	o	o	●	o			132			A11

Electron microprobe analyses of rock-forming minerals from the Sanbagawa metamorphic rocks, Shikoku

M047	Bs	Gar	o	-	-	-	●	●	-	●	-	-	o	o	o	o	-	-	-	-	-	Stx St*	48	M055	48
M048	Bs	Gar	o	o	●	-	●	●	-	●	-	o	o	o	-	●	●	●	-	-	-				
M049-a	Bs	Gar	o	o	o	-	●	●	-	●	-	-	o	o	-	o	-	-	-	-	-				
M051-a	Bs	Gar	o	o	●	-	●	●	-	●	-	-	o	o	-	-	-	-	-	-	-				
M052	S1	Gar	o	o	o	-	o	-	o	o	o	o	o	o	●	●	●	●	-	-	o				
TH72102203	S1	Gar	/	/	/	/	/	/	/	/	/	/	o	●	●	-	●	●	-	-	-				
M055	Bs	Gar	o	o	●	-	●	●	-	●	o	-	o	o	●	-	o	-	-	-	o				
M058	Bs	Gar	o	o	●	-	●	●	-	●	o	-	o	o	-	●	●	●	-	-	-				
TH71072601	Bs	Gar	o	o	-	-	●	●	-	●	-	-	-	o	-	-	-	-	o	-	-				
M060-a	Bs	Gar	o	o	o	-	●	●	-	●	o	-	o	o	-	o	-	-	-	-	-				
M062	Bs	Gar	o	o	o	-	●	●	-	●	o	-	o	o	-	-	-	-	-	-	-				
M061	Bs	Gar	o	o	o	-	●	●	-	●	-	-	-	o	-	-	-	-	o	-	o				
M064	Bs	Gar	o	o	o	-	●	●	●	●	o	-	o	o	-	o	-	-	o	-	o				
M065	Bs	Gar	o	o	●	-	●	●	-	●	o	o	o	o	-	●	●	●	-	-	o				
M066-a	Bs	Gar	o	o	o	-	●	●	-	●	o	o	-	o	-	-	-	o	-	-	o				
M067	Bs	Gar	o	o	●	-	●	●	-	●	o	-	o	o	-	-	-	o	-	-	o				
M068	S1	Gar	o	●	o	-	o	o	-	o	-	-	o	o	-	o	-	o	-	-	-				
TH71072803	Bs	Chl	o	o	●	-	●	●	-	●	o	o	o	o	-	o	-	o	-	-	-	Pu*,Bo St*,Bo,Px* Bo,Cv			TH45
M070	Bs	Chl	o	o	o	-	●	●	-	●	o	-	-	o	-	-	-	-	o	o	o				
M071	Bs	Chl	o	o	o	-	●	●	-	●	o	-	-	o	-	-	-	-	o	o	o				
M074	Bs	Chl	o	o	●	-	●	●	-	●	-	-	o	o	-	-	-	-	o	-	o				
M075	Bs	Chl	o	o	-	-	●	●	-	●	-	-	-	o	-	-	-	-	-	o	o				
M079	Bs	Chl	o	o	●	-	●	●	-	●	o	-	o	o	-	-	-	-	o	-	-				
M080	Bs	Chl	o	o	o	-	●	●	-	●	o	-	-	o	-	-	-	-	-	-	-				
M083	Bs	Chl	o	o	-	-	●	●	-	●	-	-	o	o	-	-	-	-	o	-	o				
M084	Bs	Chl	o	●	●	-	●	●	-	●	o	o	o	o	-	-	-	-	o	-	-				
M089	Bs	Chl	o	o	o	-	●	●	-	●	o	-	-	o	-	-	-	-	o	-	o				
M092	Bs	Chl	o	o	o	-	●	●	-	●	-	-	o	o	-	-	-	-	-	-	-				