島根大学地球資源環境学研究報告　19, 151～166 ページ（2000 年 12 月）
Geoscience Rept. Shimane Univ., 19, p.151～166（2000）

Major and trace element chemistry of the garnets within the Sambagawa pelitic schists in the Asemigawa area, central Shikoku, Japan

Mihoko Sonobe and Akira Takasu

Abstract

Garnets within the Sambagawa pelitic schists show distinct major and trace element zoning. The chemical compositions of the major (Mn, Fe, Mg and Ca) and trace (Na, Ti, Cr, V, Sc, Y, Er and Yb) elements in the garnets were determined using an electron probe microanalyzer (EPMA).

The pelitic schists analyzed were collected from the garnet zone, through the albite–biotite zone, up to the oligoclase–biotite zone. The cores of garnets in the garnet zone are higher in Mn/(Mn+Fe+Mg) than that in the albite– and oligoclase–biotite zones. In the albite– and oligoclase–biotite zones, the maximum Mn/(Mn+Fe+Mg) at the cores of the garnets are almost the same. Mg/(Mn+Fe+Mg) at the outermost rims of the garnets increases with increasing metamorphic grade. The maximum Mg/(Mn+Fe+Mg) value is 0.07 for the garnet zone, 0.08 for the albite–biotite zone (lower), 0.11 for the albite–biotite zone (upper), and 0.16 for the oligoclase–biotite zone.

In the garnets within the pelitic schists in the Asemigawa area, the maximum abundances of Na, Y, Er and Yb contents generally occur in the core, and their contents decrease towards the rim. There are, however, extremely high–trace element (Na, Y, Er and Yb) zones in the mantle of the garnets. In some garnets, the trace element contents in these zones are more than ten times higher than that of the surrounding mantle.

Key words; garnet, trace elements; Na, Ti, Cr, V, Sc, Y, Er, Yb, REE, Sambagawa metamorphic belt.

Introduction

Garnets in the low to medium grade metamorphic rocks usually show distinct chemical zoning. Various kinds of major element (Mn, Fe, Mg and Ca) zoning in the garnets have been described in the Sambagawa schists from the Asemigawa area (e.g. Itaya, 1978; Asada and Takasu, 1996; Takasu et al., 1997). The present authors have revealed that the garnets in this area contain small amount of Na, Ti, P, Sc, V, Cr, Y, Er, Yb and Lu (Sonobe and Takasu, 1999). Trace element contents decreases from the core to the rim, and then the contents of Na, Y, Er and Yb distinctly increase at the narrow zone in the mantle. The narrow zone shows an euhedral shape (Sonobe and Takasu, 1999, 2000).

This paper provides new EPMA data of the major and trace element compositions of the garnets within the Sambagawa pelitic schists in the Asemigawa area.

Geological setting

The Sambagawa metamorphic belt belongs to the high–pressure type of metamorphic belt. The Sambagawa belt in central Shikoku consists of two tectonostratigraphic units, i. e. the Oboke nappe complex and the structually overlying Besshi nappe complex (Takasu and Dallmeyer, 1990). The Oboke nappe complex is composed mainly of weakly metamorphosed psammitic schists with small amounts of pelitic and conglomeratic schists. The Besshi nappe complex is composed mainly of pelitic schists with minor amounts of basic schists, siliceous schists and psammitic schists.

The Sambagawa schists in central Shikoku have been devided into four mimeral zones, cholorite, garnet, albite–biotite and oligoclase–biotite zones in ascending order of metamorphic grade (Fig.1; Higashino, 1975, 1990; Enami, 1983). The highest grade zone, i.e. the oligoclase–biotite zone is located in the structurally middle part, and the metamorphic grade decreases towards both structurally higher and lower levels. In the Asemigawa area, therefore, from structurally lower to higher levels, the cholorite, garnet, albite–biotite (lower), oligoclase–biotite and albite–biotite (upper) zones occur (Fig.1).

Analytical method

The chemical compositions of the major and trace elements for the garnets were determined by a wave dispersive type electron probe microanalyzer (EPMA:JEOL JXA－8800 M) equipped with the Research Center for Coastal Lagoon Environments, Shimane University. The accelerating voltage, specimen current and beam diameter were 15 kV, 2.0×10^{-8} A and 3~5μm for the major element analysis, respectively. For the trace element analysis, the major elements and Na were first analysed with the analytical conditions as follows; the accelerating voltage: 15 kV, specimen current: 5.5×10^{-8} A, and beam diameter: 5μm. Then, the analysis of Ti, Cr, V, Sc, Y, Er and Yb was made with the analytical conditions as follows; accelerating voltage: 25 kV, specimen current: 1.0×10^{-7} A, and beam diameter: 5μm. Counting duration was for 150 seconds at

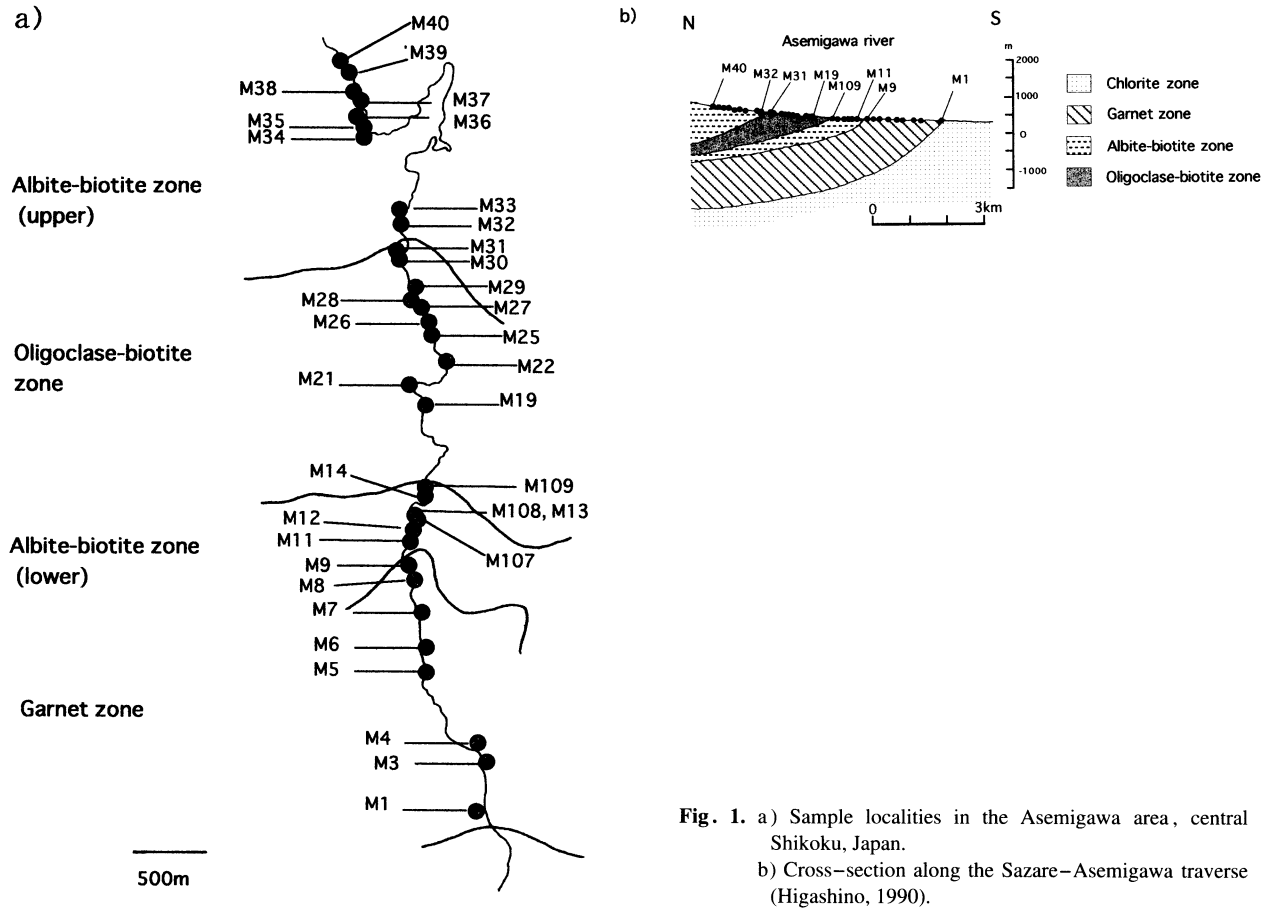

Fig. 1. a) Sample localities in the Asemigawa area, central Shikoku, Japan.
b) Cross-section along the Sazare-Asemigawa traverse (Higashino, 1990).

the peak position, and for 75 seconds at the background positions for the analyses of Na, Cr, V, Sc, Y, Er and Yb, and for 90 seconds at the peak position, and for 45 seconds at the background positions for the Ti analysis. The collection methods were after Bence and Albee (1968) for the major and Na analysis, and ZAF for the other trace element analysis.

Chemistry of the major and trace elements of the garnets in the Sambagawa pelitic schists

1. Major element chemistry

The analytical results for major element compositions are shown in Tables 1-4, and the chemical compositions of garnets are plotted in Mn-Fe-Mg and Mn-(Fe+Mg)-Ca diagrams (Figs. 2 and 3).

The Mn content of the Sambagawa garnets usually decreases and the Mg content increases from the core to the rim. The most garnets show the maximum Mn/(Mn+Fe+Mg) at the core.

In the garnet zone, Mn/(Mn+Fe+Mg) in garnet core is 0.59~0.86 and that in the rim is 0.03~0.15. Mg/(Mn+Fe+Mg) in the outermost rim is 0.03~0.07.

In the albite-biotite zone (lower), Mn/(Mn+Fe+Mg) in the core ranges from 0.27 to 0.64, and that in the rim ranges from 0.01 to 0.07. Mg/(Mn+Fe+Mg) in the rim ranges from 0.05 to 0.08.

In the albite-biotite zone (upper), Mn/(Mn+Fe+Mg) in the core ranges from 0.37 to 0.59 and that in the rim ranges from 0.01 to 0.02. Mg/(Mn+Fe+Mg) in the rim ranges from 0.10 to 0.11 .

In the oligoclase-biotie zone, Mn/(Mn+Fe+Mg) in the core ranges from 0.34 to 0.62 and that in the rim ranges from 0.01 to 0.04. Mg/(Mn+Fe+Mg) in the rim ranges from 0.11 to 0.16.

Ca/(Mn+Fe+Mg+Ca) in the Sambagawa garnets usually shows the maximum value in the mantle parts, which ranges from 0.13 to 0.35 in the garnet zone, from 0.12 to 0.40 in albite-biotite zone (lower), from 0.11 to 0.37 in the albite-biotite zone (upper) and from 0.12 to 0.38 in the oligoclase-biotite zone.

The core of the garnet in the garnet zone is higher in Mn/(Mn+Fe+Mg) than that in the albite- and oligoclase-biotite zones (Fig. 2). In the albite- and oligoclase-biotite zones, the maximum Mn/(Mn+Fe+Mg) at the core of the garnets is almost the same. Mg/(Mn+Fe+Mg) at the outermost rim of the garnets increases with increasing metamorphic grade, and Mg/(Mn+Fe+Mg) value is 0.07 for the garnet zone, 0.08 for the albite-biotite zone (lower), 0.11 for the albite-biotite zone (upper), and 0.16 for the oligoclase-biotite

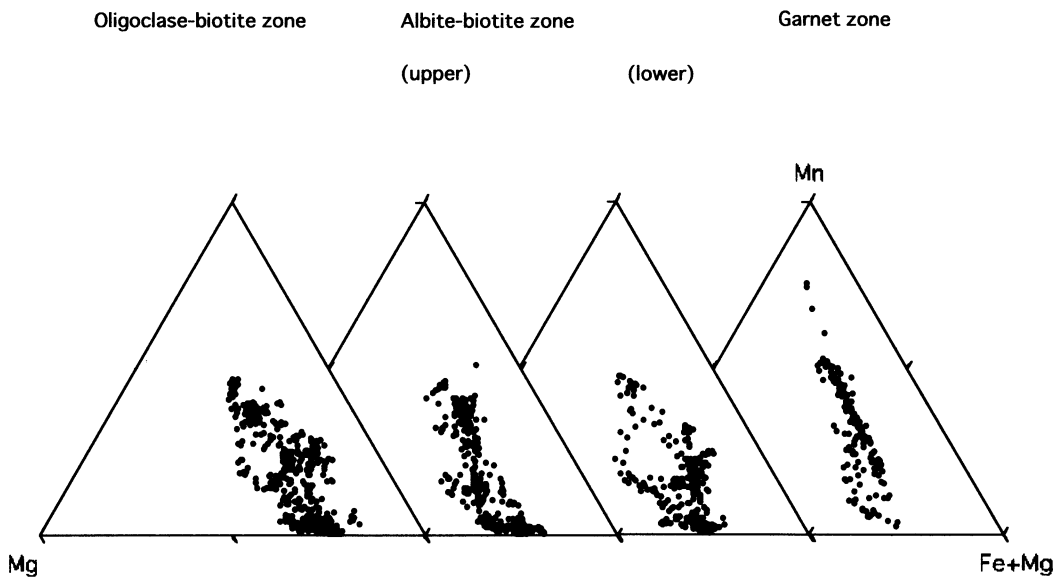

Fig. 3. Chemical composition of the garnets in Mn–(Fe+Mg)–Ca diagram.

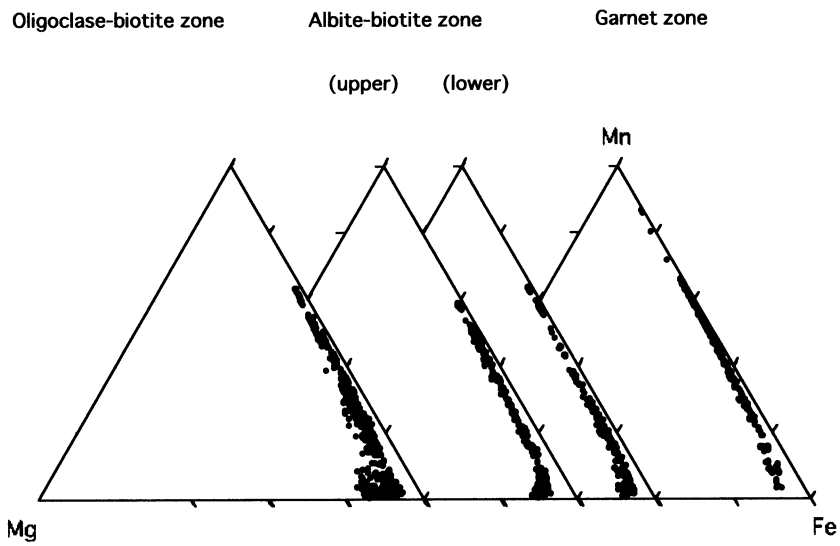

Fig. 2. Chemical composition of the garnets in Mn–Fe–Mg diagram.

zone. In the Mn–Fe–Mg diagram (Fig.2), the compositional trend of garnets in the albite–biotite zone (upper) is located at Mg–rich side compared with that in the albite–biotite zone (lower).

2. Trace element chemistry

Ti, Na, Y, Er and Yb contents are high in the core of the garnets , and they decrease toward the rim. The maximum contents of TiO_2, Na_2O, Y_2O_3, Er_2O_3 and Yb_2O_3 in the core are 0.08 wt%, 0.11 wt%, 0.30 wt%, 0.07 wt% and 0.07 wt% in the albite–biotite zone (lower), 0.18 wt%, 0.17 wt% , 0.50 wt%, 0.12 wt% and 0.27 wt% (4 sample) in the albite–biotite zone (upper) and 0.28 wt%, 0.14 wt%, 0.44 wt%, 0.09 wt% and 0.19 wt% (4 sample) in the oligoclase–biotite zone, respectively. There are narrow bands with extremely high Na, Y, Er and Yb in the mantle parts of the garnets, and the maximum contents of Na_2O and Y_2O_3 in these bands are 0.05~0.06 wt% and 0.05~0.08 wt% in the albite–biotite zone (lower), 0.03~0.09 wt% and 0.02~0.29 wt% in the albite–biotite zone (upper) and 0.04~0.12 wt% and 0.07~0.45 wt% in the oligoclase–biotite zone, respectively.

References

Asada, A, and Takasu, A., 1996, Unusual compositional texture of garnets from the Asemi gawa area in the Sambagawa metamorphic belt, central Shikoku, Japan. Abstract, 103rd Annual Meet. Geol. Soc. Japan, 411. **

Banno, S., Sakai, C. and Higashino, T., 1986, Pressure–temperature trajectory of the Sanbagawa metamorphism deduced from garnet zoning.

Lithos, 19, 51-63.
Bence, A. E. and Albee, A. L., 1968, Empirical correction factors for the electron microanalysis of silicates and oxides. Jour. Geol., 76, 382~403.
Enami, M., 1983, Petrology of pelitic schists in the oligoclase-biotite zone of the Sanbagawa metamorphic terrain, Japan: phase equilibria in the highest grade zone of a high-pressure intermediate type of metamorphic belt. J. metamorphic Geol., 1, 141-161.
Higashino, T., 1975, Biotite zone of the Sanbagawa metamorphic terrain in the Shiragayama area, central Shikoku, Japan. Jour. Geol. Soc. Japan, 81, 653-670.*
Higashino, T., 1990, The higher grade metamorphic zonation of the Sambagawa metamorphic belt in central Shikoku, Japan. J. metamorphic Geol., 8, 413-423.
Itaya, T., 1978, Notes on petrography and rock-forming mineralogy (5) Reverse zoned garnet in Sanbagawa pelitic schists in central Shikoku, Japan. J. Japan. Assoc. Min. Petr. Econ. Geol., 73, 393-396.
Takasu, A. and Dallmeyer, R. D., 1990, $^{40}Ar/^{39}Ar$ mineral age constraints for the tectonothermal evolution of the Sambagawa metamorphic belt, central Shikoku, Japan: a Cretaceous accretionary prism. Tectonophysics, 185, 111-139.
Takasu, A., Asada, A, and Fujita, Y., 1997, Graphic structure-like textures within the garnets in the Sambagawa pelitic schists exposed in central Shikoku, Japan. Abstract, 104th Annual Meet. Geol. Soc. Japan, 213.**

* In Japanese with English abstract.
** In Japanese.

(Received: 15 Nov. 2000, Accepted: 1 Dec. 2000)

（要　旨）

薗部美穂子・高須　晃，2001，四国中央部汗見川地域三波川泥質片岩中のざくろ石の主要元素および微量元素化学組成，島根大学地球資源環境学研究報告，19，151-166

四国中央部汗見川地域の三波川変成岩中のざくろ石には，主要元素と微量元素に関する累帯構造が存在する。汗見川地域の泥質片岩中のざくろ石の主要元素(Mn，Fe，Mg，Ca)，および微量元素（Na，Ti，Cr，V，Sc，Y，Er，Yb）の化学組成を示した．

ざくろ石の最外縁部の Mg /(Mn＋Fe＋Mg) は、変成度の上昇に伴って増加する．また曹長石黒雲母帯のざくろ石は，構造上位の方が下位のものよりも，Mn 成分が同じときの Mg /(Mn＋Fe＋Mg) が高い傾向がみられた．

ざくろ石の核部は，一般に Na，Ti，Cr，V，Sc，Y，Er，Yb の微量元素濃度が高い．またマントルに高い濃度の Na，Y，Er，Yb を含む細い帯が存在する．

Table1. Major element compositions of garnets from the garnet zone in the Asemigawa area.

sample no.	M3									M4								
	im	im	im	im	im	im	rim	←	core	im	im	im	im	im	im	im	im	im
point no.	1	2	6	8	9	10	12	13	14	18	19	20	21	22	23	27	38	39
SiO2	36.88	36.61	36.02	37.01	37.03	36.40	37.16	36.84	37.09	37.54	37.54	36.87	36.74	36.65	36.63	36.17	36.65	37.01
TiO2	0.09	0.17	0.17	0.02	0.07	0.20	0.09	0.09	0.09	0.10	0.08	0.07	0.14	0.11	0.19	0.17	0.10	0.18
Al2O3	20.39	20.59	20.53	20.71	20.57	20.38	20.54	20.59	20.55	20.71	21.01	20.71	20.37	20.43	20.47	20.34	20.07	19.77
FeO※	21.82	13.92	11.46	27.58	18.46	11.89	26.39	21.56	20.86	26.03	23.80	18.87	17.65	16.27	14.79	11.98	16.35	14.19
MnO	10.73	20.09	23.67	4.95	13.99	22.85	5.07	10.77	11.80	4.87	6.61	14.67	16.20	18.48	19.97	22.90	18.46	21.27
MgO	0.41	0.14	0.13	0.66	0.25	0.16	0.57	0.38	0.36	0.61	0.47	0.28	0.25	0.24	0.20	0.12	0.22	0.21
CaO	9.29	8.98	7.77	9.01	9.87	8.05	9.50	9.38	9.49	10.30	10.36	7.80	7.67	7.01	7.20	7.53	7.34	6.96
Total	99.60	100.50	99.75	99.94	100.24	99.94	99.32	99.62	100.23	100.16	99.86	99.26	99.02	99.20	99.45	99.20	99.20	99.59
Element O=12																		
Si	2.991	2.960	2.944	2.989	2.985	2.964	3.008	2.986	2.991	3.009	3.008	2.999	3.002	2.996	2.988	2.967	3.002	3.023
Ti	0.006	0.010	0.010	0.001	0.004	0.012	0.006	0.006	0.005	0.006	0.005	0.004	0.008	0.007	0.012	0.011	0.006	0.011
Al	1.949	1.962	1.978	1.971	1.955	1.957	1.960	1.967	1.953	1.957	1.984	1.985	1.962	1.969	1.968	1.967	1.938	1.903
Fe	1.480	0.941	0.783	1.863	1.245	0.810	1.787	1.462	1.407	1.745	1.595	1.283	1.206	1.112	1.009	0.822	1.120	0.969
Mn	0.737	1.376	1.639	0.338	0.956	1.577	0.348	0.740	0.806	0.331	0.449	1.011	1.122	1.280	1.380	1.591	1.281	1.472
Mg	0.049	0.017	0.016	0.080	0.030	0.020	0.069	0.046	0.043	0.072	0.056	0.034	0.031	0.030	0.024	0.015	0.027	0.025
Ca	0.807	0.778	0.681	0.780	0.852	0.702	0.824	0.815	0.820	0.884	0.890	0.679	0.672	0.614	0.629	0.662	0.645	0.609
Total	8.018	8.045	8.052	8.022	8.027	8.042	8.002	8.020	8.026	8.004	7.986	7.995	8.002	8.007	8.011	8.034	8.019	8.013

sample no.						M6												
	im	im	im	im	im	rim						←						core
point no.	51	52	53	54	55	2	3	5	6	7	8	9	10	11	12	13	14	15
SiO2	37.64	37.17	36.71	37.00	36.87	37.23	37.51	37.34	37.23	37.38	37.32	37.06	36.73	36.82	36.75	36.56	36.74	36.57
TiO2	0.21	0.08	0.06	0.06	0.12	0.02	0.08	0.10	0.05	0.10	0.08	0.07	0.08	0.14	0.07	0.19	0.30	0.13
Al2O3	20.76	20.13	19.90	20.03	19.94	20.84	20.78	20.67	20.83	21.11	20.69	21.00	20.64	20.77	20.49	20.55	20.29	20.37
FeO※	12.90	20.74	21.02	19.92	17.68	29.52	29.39	28.51	26.48	26.68	25.37	22.44	20.43	19.35	17.47	14.31	15.17	14.79
MnO	22.40	11.28	13.20	13.54	17.09	1.11	1.10	1.80	2.84	2.55	3.22	7.35	12.16	15.50	18.71	20.98	20.34	21.38
MgO	0.18	0.30	0.32	0.27	0.30	1.20	1.35	1.11	1.06	1.06	0.94	0.68	0.50	0.37	0.30	0.19	0.22	0.24
CaO	6.79	9.48	8.21	8.73	7.29	9.20	9.25	9.72	10.55	11.17	11.54	11.09	8.58	7.19	6.17	7.35	6.93	6.28
Total	100.89	99.18	99.41	99.54	99.30	99.12	99.46	99.26	99.04	100.04	99.27	99.73	99.18	100.19	100.01	100.18	100.03	99.84
Element O=12																		
Si	3.018	3.022	3.002	3.011	3.015	3.004	3.014	3.009	3.001	2.985	3.003	2.979	2.989	2.982	2.992	2.971	2.989	2.986
Ti	0.013	0.005	0.004	0.004	0.008	0.001	0.005	0.006	0.003	0.006	0.005	0.004	0.005	0.009	0.004	0.012	0.019	0.008
Al	1.962	1.929	1.919	1.922	1.921	1.983	1.968	1.964	1.980	1.987	1.962	1.990	1.980	1.983	1.967	1.968	1.945	1.960
Fe	0.865	1.410	1.437	1.356	1.209	1.992	1.975	1.922	1.785	1.782	1.707	1.509	1.391	1.310	1.190	0.972	1.032	1.010
Mn	1.521	0.777	0.914	0.933	1.184	0.076	0.075	0.123	0.194	0.172	0.220	0.501	0.838	1.063	1.290	1.444	1.402	1.479
Mg	0.022	0.037	0.040	0.033	0.037	0.145	0.162	0.134	0.127	0.126	0.113	0.081	0.061	0.045	0.036	0.024	0.027	0.029
Ca	0.584	0.826	0.719	0.761	0.639	0.796	0.796	0.839	0.912	0.956	0.995	0.955	0.748	0.624	0.538	0.640	0.604	0.550
Total	7.985	8.005	8.034	8.020	8.012	7.996	7.995	7.996	8.002	8.014	8.004	8.019	8.013	8.015	8.017	8.030	8.017	8.020

sample no.																		
	rim					←				core	rim				←			
point no.	22	23	24	25	26	27	28	29	30	32	33	34	35	37	38	39	40	41
SiO2	37.33	37.39	37.26	37.36	37.03	36.89	36.79	36.55	36.36	36.46	37.24	37.30	37.39	37.26	37.02	36.83	36.78	36.62
TiO2	0.07	0.09	0.11	0.07	0.11	0.08	0.11	0.14	0.30	0.17	0.10	0.11	0.10	0.09	0.09	0.07	0.13	0.15
Al2O3	20.67	20.89	20.70	20.83	20.57	20.45	20.39	20.43	20.35	20.35	20.64	20.81	20.61	20.80	20.80	20.63	20.64	20.16
FeO※	28.14	26.81	26.15	24.02	20.99	21.14	19.54	17.36	14.78	15.65	27.37	26.42	25.26	21.83	22.15	20.49	19.69	17.96
MnO	1.82	2.78	2.42	4.74	9.32	11.09	14.90	17.48	20.29	19.59	2.56	2.30	3.40	7.26	8.87	11.77	14.84	17.63
MgO	1.05	1.13	1.06	0.86	0.65	0.52	0.36	0.31	0.23	0.29	1.00	1.08	0.90	0.62	0.63	0.50	0.39	0.32
CaO	9.94	10.64	11.43	11.54	10.53	9.28	7.47	7.01	6.89	6.41	10.22	11.33	11.52	11.47	9.78	8.71	7.23	6.76
Total	99.11	99.81	99.19	99.50	99.22	99.49	99.63	99.38	99.24	99.04	99.21	99.41	99.27	99.39	99.38	99.06	99.74	99.65
Element O=12																		
Si	3.013	2.996	2.999	2.999	2.996	2.993	2.996	2.988	2.979	2.991	3.006	2.996	3.009	2.999	2.993	2.997	2.989	2.993
Ti	0.004	0.005	0.007	0.004	0.007	0.005	0.007	0.008	0.018	0.010	0.006	0.006	0.006	0.006	0.006	0.004	0.008	0.010
Al	1.967	1.972	1.964	1.971	1.962	1.956	1.957	1.968	1.965	1.968	1.964	1.970	1.955	1.973	1.982	1.979	1.977	1.942
Fe	1.899	1.797	1.760	1.613	1.420	1.435	1.331	1.187	1.013	1.074	1.848	1.775	1.700	1.470	1.498	1.395	1.338	1.227
Mn	0.124	0.188	0.165	0.323	0.639	0.762	1.028	1.211	1.408	1.361	0.175	0.157	0.232	0.495	0.607	0.811	1.022	1.221
Mg	0.126	0.135	0.127	0.103	0.079	0.063	0.044	0.037	0.028	0.036	0.120	0.129	0.108	0.075	0.076	0.061	0.048	0.039
Ca	0.860	0.913	0.986	0.993	0.913	0.807	0.652	0.614	0.605	0.564	0.884	0.975	0.993	0.989	0.848	0.759	0.630	0.592
Total	7.993	8.006	8.007	8.006	8.015	8.021	8.015	8.013	8.017	8.004	8.002	8.008	8.002	8.006	8.009	8.006	8.011	8.023

sample no.							M7											
	core	rim		←			core	rim		←		core	rim					←
point no.	43	45	46	48	50	51	52	1	2	5	6	7	8	10	12	13	15	16
SiO2	36.68	37.20	37.36	36.73	36.67	36.31	36.61	37.17	36.88	36.64	35.51	36.64	37.11	36.90	37.27	37.30	36.78	37.00
TiO2	0.32	0.06	0.10	0.13	0.10	0.18	0.13	0.04	0.08	0.66	6.45	0.28	0.08	0.12	0.13	0.11	0.18	0.21
Al2O3	20.34	20.78	20.60	20.47	20.66	20.09	20.41	20.41	20.50	20.09	17.21	20.25	20.37	20.60	20.22	20.48	20.35	20.37
FeO	15.73	24.30	21.92	20.25	16.61	16.54	15.75	26.62	23.24	17.40	13.11	16.22	25.44	25.22	24.84	23.49	21.09	20.52
MnO	19.81	4.20	7.07	14.00	18.44	18.73	19.22	6.90	10.78	17.54	16.49	19.58	9.10	9.12	9.78	11.09	13.30	14.58
MgO	0.24	0.84	0.63	0.40	0.25	0.23	0.25	0.62	0.48	0.28	0.21	0.22	0.48	0.54	0.44	0.45	0.36	0.35
CaO	6.65	11.99	11.49	7.38	6.85	6.85	6.89	8.22	7.46	7.36	10.51	6.79	7.64	7.77	7.33	7.32	7.39	7.39
Total	99.84	99.44	99.22	99.46	99.64	99.03	99.27	100.06	99.49	99.99	99.55	100.06	100.30	100.28	100.08	100.27	99.50	100.48
Element O=12																		
Si	2.989	2.991	3.011	2.994	2.988	2.987	2.994	3.006	3.002	2.981	2.885	2.984	3.003	2.985	3.019	3.013	2.998	2.993
Ti	0.020	0.004	0.006	0.008	0.006	0.011	0.008	0.003	0.005	0.041	0.394	0.017	0.005	0.007	0.008	0.007	0.011	0.013
Al	1.953	1.969	1.957	1.966	1.984	1.948	1.968	1.945	1.966	1.927	1.649	1.944	1.943	1.964	1.931	1.950	1.955	1.942
FeO※	1.072	1.634	1.477	1.381	1.132	1.138	1.077	1.800	1.582	1.184	0.891	1.105	1.722	1.706	1.683	1.587	1.438	1.388
Mn	1.367	0.286	0.483	0.967	1.273	1.305	1.332	0.472	0.743	1.208	1.135	1.351	0.624	0.625	0.671	0.759	0.919	0.999
Mg	0.030	0.101	0.075	0.049	0.031	0.028	0.031	0.075	0.058	0.034	0.025	0.027	0.058	0.065	0.053	0.054	0.044	0.042
Ca	0.581	1.033	0.992	0.645	0.598	0.604	0.604	0.713	0.650	0.641	0.915	0.592	0.662	0.674	0.637	0.634	0.645	0.640
Total	8.011	8.017	8.001	8.008	8.011	8.021	8.013	8.013	8.006	8.015	7.893	8.021	8.016	8.025	8.003	8.004	8.010	8.019

※Total Fe as FeO ※im: intermediate parts between core and rim

Table1. (Continued).

sample no.																			
				core	rim		←	core	rim							←			
point no.	17	18	21	22	24	28	30	31	33	35	36	37	38	39	40	41	42	43
SiO2	37.12	36.98	36.79	36.74	37.22	36.80	36.83	36.75	37.29	37.46	37.34	37.15	37.08	37.11	37.14	36.88	36.95	36.98
TiO2	0.18	0.21	0.18	0.10	0.09	0.13	0.18	0.16	0.08	0.08	0.09	0.12	0.14	0.15	0.15	0.16	0.14	0.15
Al2O3	20.29	20.19	20.09	20.03	20.44	20.26	20.06	19.96	20.25	20.09	20.23	20.08	20.09	19.91	20.21	20.14	19.80	19.81
FeO※	19.47	18.64	16.33	14.95	20.17	16.26	15.25	14.39	25.20	24.12	23.72	22.09	20.67	20.58	19.54	19.61	19.19	18.85
MnO	15.23	16.61	19.07	21.06	14.63	19.21	20.97	21.81	8.05	9.73	10.25	12.31	13.54	14.47	14.78	15.64	16.17	16.43
MgO	0.27	0.28	0.22	0.18	0.32	0.24	0.22	0.19	0.53	0.43	0.43	0.40	0.35	0.30	0.33	0.28	0.31	0.25
CaO	7.53	7.47	6.92	6.71	7.35	7.13	6.94	6.41	8.52	8.12	7.98	7.90	7.49	7.55	7.69	7.43	7.17	7.34
Total	100.15	100.48	99.67	99.83	100.30	100.10	100.48	99.68	100.02	100.08	100.12	100.13	99.39	100.11	99.92	100.16	99.83	99.84
Element O=12																		
Si	3.008	2.996	3.004	3.001	3.010	2.993	2.992	3.006	3.016	3.030	3.020	3.012	3.022	3.015	3.013	2.997	3.015	3.016
Ti	0.011	0.013	0.011	0.006	0.005	0.008	0.011	0.010	0.005	0.005	0.006	0.008	0.008	0.009	0.009	0.010	0.009	0.009
Al	1.938	1.928	1.933	1.929	1.948	1.942	1.921	1.924	1.930	1.915	1.929	1.919	1.931	1.907	1.933	1.929	1.904	1.904
Fe	1.320	1.263	1.115	1.022	1.364	1.106	1.036	0.985	1.704	1.632	1.605	1.498	1.409	1.399	1.326	1.333	1.309	1.286
Mn	1.045	1.140	1.319	1.458	1.002	1.324	1.443	1.511	0.551	0.667	0.702	0.845	0.935	0.996	1.016	1.076	1.118	1.135
Mg	0.033	0.034	0.027	0.022	0.039	0.030	0.027	0.024	0.064	0.051	0.051	0.048	0.042	0.037	0.040	0.035	0.037	0.030
Ca	0.654	0.648	0.605	0.587	0.637	0.621	0.604	0.562	0.738	0.704	0.692	0.687	0.654	0.657	0.668	0.647	0.627	0.641
Total	8.009	8.022	8.014	8.025	8.006	8.024	8.035	8.021	8.008	8.004	8.005	8.016	8.002	8.020	8.005	8.027	8.018	8.021

sample no.																			
				core	rim			←			core	rim						←	
point no.	44	45	46	47	48	50	51	52	53	54	55	56	57	60	61	62	64	65
SiO2	36.76	36.97	36.59	36.76	37.26	37.30	37.17	36.90	37.00	36.83	36.68	37.33	36.79	37.06	36.98	36.90	36.49	36.70
TiO2	0.14	0.18	0.14	0.17	0.07	0.11	0.10	0.16	0.18	0.17	0.16	0.04	0.11	0.10	0.14	0.18	0.17	0.20
Al2O3	19.91	19.91	20.26	19.77	19.95	20.32	19.98	19.78	19.82	20.03	19.98	19.96	20.12	19.94	20.13	20.04	19.82	19.91
FeO※	18.40	18.47	17.66	17.36	24.93	22.17	21.37	20.69	19.85	19.36	19.24	26.16	25.41	21.46	19.72	18.36	16.46	16.25
MnO	16.78	17.09	17.80	17.72	8.83	11.70	12.93	14.20	14.97	15.38	15.46	7.02	9.32	14.64	15.38	16.95	19.33	19.10
MgO	0.29	0.28	0.26	0.22	0.50	0.45	0.41	0.34	0.32	0.32	0.31	0.59	0.50	0.37	0.30	0.28	0.23	0.21
CaO	7.27	7.40	7.20	7.19	8.38	8.03	7.61	7.31	7.53	8.12	7.86	8.30	7.45	6.86	7.36	7.20	7.24	7.48
Total	99.61	100.39	100.02	99.25	99.98	100.13	99.66	99.40	99.75	100.26	99.71	99.46	99.71	100.47	100.07	99.98	99.76	99.88
Element O=12																		
Si	3.005	3.003	2.982	3.014	3.021	3.015	3.024	3.019	3.017	2.991	2.994	3.034	2.999	3.009	3.005	3.004	2.988	2.996
Ti	0.008	0.011	0.009	0.011	0.004	0.007	0.006	0.010	0.011	0.011	0.010	0.003	0.007	0.006	0.009	0.011	0.011	0.013
Al	1.918	1.906	1.946	1.911	1.907	1.936	1.917	1.907	1.904	1.918	1.922	1.912	1.933	1.908	1.928	1.923	1.913	1.915
Fe	1.258	1.255	1.203	1.191	1.690	1.499	1.454	1.415	1.353	1.315	1.313	1.778	1.733	1.457	1.340	1.250	1.128	1.109
Mn	1.162	1.176	1.229	1.231	0.607	0.801	0.891	0.984	1.034	1.058	1.069	0.483	0.643	1.007	1.059	1.169	1.341	1.321
Mg	0.035	0.034	0.032	0.027	0.060	0.054	0.049	0.042	0.039	0.039	0.037	0.071	0.061	0.044	0.037	0.034	0.028	0.026
Ca	0.637	0.644	0.629	0.632	0.728	0.696	0.664	0.640	0.658	0.706	0.687	0.723	0.651	0.597	0.641	0.628	0.635	0.654
Total	8.023	8.027	8.030	8.017	8.018	8.008	8.005	8.017	8.015	8.037	8.033	8.004	8.027	8.028	8.018	8.020	8.043	8.033

sample no.		M8																	
	core	rim			←		core	rim			←			core	rim		←	
point no.	66	1	2	3	4	5	7	8	9	10	11	12	13	14	15	16	17	18
SiO2	36.59	37.48	37.28	37.01	37.09	37.57	37.57	36.92	37.25	37.20	37.29	36.57	36.53	36.41	37.12	37.23	36.83	36.38
TiO2	0.17	0.04	0.08	0.12	0.09	0.07	0.07	0.06	0.07	0.05	0.03	0.12	0.14	0.17	0.06	0.09	0.04	0.15
Al2O3	20.10	20.48	20.63	20.41	20.65	20.51	20.30	20.52	20.50	20.44	20.69	20.18	20.40	20.10	20.27	20.59	20.48	20.26
FeO※	15.93	28.95	28.47	24.68	22.04	20.56	18.18	29.04	28.64	27.00	21.82	17.28	15.24	14.25	29.43	25.79	18.63	18.51
MnO	19.69	2.60	3.11	6.51	8.43	8.47	11.38	2.71	2.80	4.88	8.64	16.62	20.50	20.69	2.89	6.11	15.14	16.53
MgO	0.22	0.79	0.77	0.61	0.54	0.46	0.41	0.88	0.82	0.74	0.48	0.30	0.22	0.26	0.82	0.61	0.40	0.37
CaO	7.52	8.75	9.55	9.79	10.94	11.98	11.44	9.16	9.82	9.39	10.33	7.89	6.96	7.03	8.73	9.48	8.79	7.25
Total	100.29	99.11	99.94	99.16	99.87	99.68	99.45	99.33	99.95	99.74	99.36	99.04	100.06	99.00	99.35	99.97	100.36	99.54
Element O=12																		
Si	2.978	3.035	3.002	3.004	2.987	3.017	3.027	2.995	3.001	3.006	3.011	2.996	2.976	2.992	3.013	3.001	2.978	2.976
Ti	0.010	0.002	0.005	0.007	0.006	0.004	0.004	0.004	0.005	0.003	0.002	0.008	0.009	0.010	0.004	0.005	0.003	0.009
Al	1.929	1.955	1.958	1.953	1.961	1.941	1.928	1.962	1.947	1.947	1.969	1.948	1.959	1.947	1.940	1.957	1.952	1.954
Fe	1.084	1.960	1.917	1.675	1.484	1.381	1.225	1.970	1.930	1.824	1.473	1.184	1.038	0.979	1.998	1.739	1.260	1.266
Mn	1.358	0.178	0.212	0.448	0.575	0.576	0.777	0.186	0.191	0.334	0.591	1.153	1.415	1.440	0.199	0.417	1.037	1.145
Mg	0.027	0.095	0.093	0.073	0.065	0.055	0.049	0.106	0.098	0.089	0.058	0.037	0.026	0.031	0.100	0.073	0.048	0.046
Ca	0.656	0.759	0.824	0.851	0.944	1.031	0.988	0.796	0.847	0.813	0.894	0.692	0.608	0.619	0.759	0.819	0.761	0.635
Total	8.041	7.984	8.011	8.010	8.022	8.004	7.999	8.018	8.018	8.016	7.998	8.018	8.031	8.017	8.012	8.011	8.039	8.032

sample no.							
		core	rim		←		core
point no.	19	20	21	22	23	24	25
SiO2	36.25	36.29	37.15	37.30	36.83	36.61	36.64
TiO2	0.22	0.18	0.06	0.10	0.14	0.17	0.13
Al2O3	20.47	20.30	20.41	20.52	20.14	20.30	20.30
FeO※	16.70	14.66	26.20	19.04	17.33	16.02	15.28
MnO	18.86	21.19	5.01	11.60	17.09	18.95	19.48
MgO	0.32	0.22	0.67	0.41	0.25	0.23	0.23
CaO	6.74	6.72	9.70	10.46	7.43	7.42	7.39
Total	99.61	99.63	99.29	99.46	99.28	99.77	99.53
Element O=12							
Si	2.965	2.972	3.010	3.012	3.010	2.985	2.992
Ti	0.013	0.011	0.004	0.006	0.009	0.011	0.008
Al	1.974	1.960	1.950	1.953	1.940	1.951	1.954
Fe	1.142	1.004	1.776	1.286	1.184	1.092	1.044
Mn	1.307	1.470	0.344	0.793	1.183	1.309	1.347
Mg	0.039	0.027	0.081	0.049	0.031	0.028	0.029
Ca	0.591	0.590	0.842	0.905	0.651	0.648	0.646
Total	8.031	8.034	8.006	8.004	8.007	8.024	8.019

※Total Fe as FeO ※im: intermediate parts between core and rim

Table2. Major element compositions of the garnets from the albite-biotite zone (lower) in the Asemigawa area .

sample no.	M12																	
	rim					←					core	rim						←
point no.	2	4	5	6	7	9	10	11	12	13	15	16	17	18	19	20	21	22
SiO2	37.19	37.31	37.03	36.93	36.76	37.02	36.77	36.54	36.47	36.47	36.63	37.20	37.33	37.76	37.43	37.20	37.26	36.82
TiO2	0.11	0.12	0.12	0.12	0.14	0.11	0.09	0.08	0.10	0.08	0.14	0.08	0.09	0.04	0.11	0.10	0.14	0.11
Al2O3	20.40	20.48	20.34	20.43	20.36	20.29	20.49	20.30	20.40	20.42	20.24	20.52	20.70	20.46	20.58	20.43	20.48	20.48
FeO※	29.96	24.81	25.44	26.30	25.80	25.52	27.65	28.32	27.36	26.16	26.28	31.85	28.89	27.10	25.90	24.37	24.80	25.38
MnO	0.66	7.42	7.29	6.51	6.82	6.89	5.27	5.29	6.69	8.82	9.48	0.75	0.97	1.38	4.92	7.15	7.35	6.68
MgO	1.09	0.75	0.70	0.73	0.68	0.67	0.63	0.63	0.54	0.55	0.55	1.16	0.84	0.85	0.81	0.77	0.74	0.70
CaO	9.73	9.03	8.76	8.92	8.84	8.92	8.36	7.96	7.50	6.80	6.20	8.33	10.96	12.14	9.84	9.59	9.19	9.05
Total	99.15	99.90	99.67	99.94	99.39	99.41	99.25	99.12	99.06	99.30	99.51	99.90	99.78	99.72	99.60	99.61	99.96	99.22
Element O=12																		
Si	3.008	3.007	3.000	2.988	2.988	3.004	2.992	2.987	2.985	2.983	2.993	3.000	2.999	3.023	3.014	3.004	3.002	2.991
Ti	0.007	0.007	0.007	0.007	0.008	0.007	0.005	0.005	0.006	0.005	0.008	0.005	0.006	0.002	0.006	0.006	0.009	0.007
Al	1.945	1.946	1.942	1.948	1.951	1.940	1.965	1.956	1.968	1.969	1.949	1.951	1.960	1.931	1.953	1.945	1.945	1.961
Fe	2.027	1.672	1.723	1.780	1.754	1.732	1.882	1.936	1.873	1.790	1.796	2.148	1.941	1.814	1.744	1.646	1.671	1.725
Mn	0.046	0.507	0.500	0.446	0.470	0.474	0.363	0.367	0.464	0.611	0.656	0.051	0.066	0.094	0.336	0.489	0.502	0.460
Mg	0.132	0.090	0.084	0.088	0.082	0.081	0.076	0.076	0.066	0.067	0.067	0.140	0.100	0.102	0.097	0.093	0.089	0.085
Ca	0.843	0.780	0.760	0.773	0.770	0.776	0.729	0.697	0.658	0.596	0.543	0.720	0.943	1.042	0.849	0.829	0.794	0.788
Total	8.008	8.009	8.017	8.030	8.024	8.012	8.013	8.024	8.019	8.021	8.013	8.015	8.014	8.007	7.999	8.012	8.012	8.017

sample no.																		
					core	rim					←				core	rim		
point no.	23	24	25	28	29	30	33	34	35	36	37	38	39	40	42	43	46	49
SiO2	36.90	36.95	36.90	36.68	36.15	37.54	37.49	37.60	37.23	37.50	37.73	37.62	37.31	37.25	37.00	37.66	37.30	37.21
TiO2	0.11	0.06	0.06	0.09	2.24	0.05	0.11	0.05	0.10	0.07	0.04	0.11	0.13	0.10	0.09	0.09	0.08	0.14
Al2O3	20.48	20.43	20.25	20.27	19.94	20.55	20.54	20.57	20.41	20.71	20.74	20.55	20.42	20.46	20.65	20.68	20.58	20.65
FeO※	25.52	25.39	27.47	27.43	25.66	30.92	31.08	29.76	27.52	26.62	26.39	24.07	24.88	25.13	26.06	27.38	26.03	25.53
MnO	7.15	7.34	5.61	7.25	8.22	0.21	0.82	0.64	3.99	1.45	3.50	6.32	6.27	6.11	6.44	2.02	1.66	6.59
MgO	0.65	0.66	0.68	0.56	0.55	1.56	1.05	0.96	0.59	0.86	0.78	0.78	0.78	0.72	0.75	0.73	0.75	0.78
CaO	8.88	8.52	8.16	7.32	6.63	9.00	9.07	10.34	10.13	12.45	11.20	9.85	9.59	9.91	9.45	11.19	12.82	9.31
Total	99.69	99.34	99.13	99.60	99.38	99.82	100.15	99.91	99.97	99.67	100.38	99.29	99.37	99.68	100.43	99.75	99.22	100.20
Element O=12																		
Si	2.990	3.001	3.007	2.990	2.945	3.012	3.010	3.015	3.002	3.002	3.010	3.030	3.014	3.004	2.977	3.018	3.000	2.991
Ti	0.007	0.004	0.004	0.005	0.137	0.003	0.006	0.003	0.006	0.004	0.003	0.006	0.008	0.006	0.005	0.005	0.005	0.008
Al	1.956	1.956	1.945	1.948	1.915	1.944	1.943	1.944	1.940	1.954	1.951	1.951	1.945	1.945	1.958	1.953	1.951	1.957
Fe	1.730	1.725	1.872	1.870	1.748	2.075	2.087	1.995	1.855	1.782	1.761	1.622	1.681	1.695	1.753	1.835	1.751	1.716
Mn	0.491	0.505	0.387	0.501	0.567	0.014	0.056	0.043	0.272	0.098	0.236	0.431	0.429	0.417	0.439	0.137	0.113	0.449
Mg	0.079	0.080	0.083	0.068	0.066	0.187	0.125	0.114	0.070	0.103	0.093	0.094	0.093	0.087	0.090	0.087	0.090	0.093
Ca	0.771	0.742	0.712	0.640	0.579	0.774	0.780	0.889	0.875	1.068	0.957	0.851	0.830	0.856	0.814	0.960	1.105	0.802
Total	8.023	8.012	8.010	8.021	7.957	8.009	8.008	8.003	8.020	8.011	8.010	7.985	8.000	8.010	8.036	7.996	8.015	8.016

sample no.										M13								
			←						core	rim					←			
point no.	50	54	55	56	58	63	64	65	66	2	3	4	5	6	7	8	9	10
SiO2	37.48	37.78	37.18	37.46	37.35	37.05	36.79	37.19	37.48	37.30	37.54	37.74	37.47	37.70	37.51	37.54	37.91	37.76
TiO2	0.10	0.15	0.12	0.08	0.10	0.12	0.04	0.13	0.09	0.10	0.05	0.10	0.09	0.07	0.10	0.10	0.08	0.13
Al2O3	20.50	20.51	20.49	20.52	20.56	20.49	20.50	20.24	20.34	20.60	20.34	20.08	20.34	20.22	20.17	20.47	20.61	20.33
FeO※	25.39	24.13	27.67	28.66	28.19	26.82	27.14	26.19	25.86	30.30	30.95	29.00	29.74	30.34	30.43	29.08	27.81	25.48
MnO	6.76	6.38	6.15	5.02	4.69	7.49	8.06	7.94	8.55	0.63	1.22	2.05	2.08	2.17	2.18	1.69	2.44	4.57
MgO	0.74	0.58	0.61	0.69	0.58	0.52	0.59	0.53	0.54	0.85	0.80	0.66	0.68	0.72	0.74	0.68	0.63	0.50
CaO	9.46	10.69	7.83	7.95	8.56	7.86	6.71	7.48	7.47	9.54	9.30	10.03	9.87	8.98	8.84	10.60	11.00	11.07
Total	100.43	100.22	100.04	100.37	100.04	100.35	99.83	99.71	100.33	99.32	100.19	99.66	100.26	100.20	99.96	100.15	100.48	99.84
Element O=12																		
Si	3.007	3.022	3.006	3.014	3.009	2.992	2.992	3.018	3.022	3.013	3.019	3.042	3.012	3.032	3.025	3.012	3.023	3.032
Ti	0.006	0.009	0.007	0.005	0.006	0.007	0.002	0.008	0.006	0.006	0.003	0.006	0.005	0.004	0.006	0.006	0.005	0.008
Al	1.939	1.934	1.953	1.946	1.953	1.951	1.966	1.936	1.933	1.961	1.928	1.908	1.927	1.917	1.918	1.936	1.937	1.924
Fe	1.704	1.614	1.871	1.929	1.900	1.812	1.846	1.778	1.745	2.047	2.081	1.955	2.000	2.040	2.053	1.952	1.855	1.711
Mn	0.460	0.433	0.421	0.342	0.320	0.512	0.555	0.546	0.584	0.043	0.083	0.140	0.141	0.148	0.149	0.115	0.165	0.311
Mg	0.088	0.069	0.073	0.082	0.070	0.063	0.071	0.064	0.065	0.103	0.096	0.080	0.082	0.086	0.089	0.082	0.075	0.060
Ca	0.813	0.916	0.678	0.686	0.739	0.681	0.585	0.651	0.646	0.826	0.801	0.866	0.850	0.774	0.764	0.911	0.940	0.952
Total	8.016	7.995	8.009	8.005	7.997	8.018	8.018	8.000	8.000	7.999	8.012	7.997	8.018	8.001	8.004	8.013	8.001	7.997

sample no.																		
				core	rim											←		
point no.	11	12	13	16	26	27	29	30	31	32	33	34	35	37	38	39	40	41
SiO2	38.00	37.26	37.12	36.93	37.76	37.62	37.31	37.44	37.76	37.62	37.36	37.80	37.90	37.60	37.59	37.65	37.47	37.56
TiO2	0.09	0.09	0.13	0.27	0.10	0.09	0.07	0.07	0.12	0.10	0.13	0.15	0.07	0.05	0.12	0.12	0.14	0.11
Al2O3	20.32	20.11	19.95	20.08	20.33	20.45	20.05	20.16	20.15	20.10	20.14	20.14	20.27	20.04	20.11	20.28	20.02	20.10
FeO※	20.53	16.01	14.31	14.82	30.05	31.37	29.81	29.72	29.15	27.73	27.12	24.17	23.57	23.73	23.62	23.23	22.36	22.28
MnO	6.91	16.34	19.12	19.46	0.56	0.54	1.98	2.23	2.32	2.06	3.58	5.59	5.83	6.17	6.01	6.05	6.63	6.97
MgO	0.29	0.29	0.25	0.22	0.90	0.89	0.73	0.69	0.70	0.60	0.54	0.41	0.41	0.44	0.37	0.41	0.39	0.34
CaO	13.86	9.66	9.22	8.40	9.75	9.47	9.25	9.42	9.91	11.44	11.21	12.02	12.02	11.90	12.26	12.60	12.48	12.54
Total	100.01	99.76	100.09	100.18	99.45	100.43	99.18	99.73	100.10	99.64	100.08	100.27	100.06	99.92	100.08	100.34	99.49	99.89
Element O=12																		
Si	3.031	3.015	3.006	2.994	3.041	3.015	3.030	3.025	3.034	3.028	3.008	3.026	3.035	3.024	3.018	3.011	3.020	3.018
Ti	0.005	0.006	0.008	0.016	0.006	0.005	0.004	0.004	0.007	0.006	0.008	0.009	0.004	0.003	0.007	0.007	0.009	0.007
Al	1.911	1.918	1.904	1.919	1.929	1.932	1.919	1.920	1.908	1.907	1.910	1.900	1.913	1.899	1.903	1.912	1.902	1.904
Fe	1.370	1.084	0.969	1.005	2.024	2.102	2.024	2.008	1.959	1.867	1.825	1.618	1.578	1.596	1.586	1.554	1.507	1.497
Mn	0.467	1.120	1.312	1.336	0.038	0.037	0.136	0.153	0.158	0.141	0.244	0.379	0.395	0.420	0.409	0.410	0.453	0.475
Mg	0.035	0.035	0.030	0.026	0.108	0.106	0.088	0.083	0.084	0.072	0.065	0.049	0.049	0.053	0.045	0.049	0.047	0.040
Ca	1.185	0.837	0.801	0.729	0.842	0.813	0.805	0.816	0.853	0.986	0.967	1.031	1.031	1.025	1.054	1.079	1.078	1.080
Total	8.003	8.014	8.030	8.025	7.988	8.010	8.006	8.009	8.003	8.007	8.027	8.013	8.004	8.020	8.022	8.022	8.015	8.021

※Total Fe as FeO ※im: intermediate parts between core and rim

Table2. (Continued).

sample no.		core	rim							←							core	rim
point no.	44	45	46	47	48	51	52	53	54	55	56	57	58	59	60	62	64	65
SiO2	37.79	38.01	37.33	37.47	37.48	37.40	37.21	37.55	37.53	37.57	36.81	36.60	37.26	36.68	36.65	36.87	37.85	37.76
TiO2	0.12	0.06	0.10	0.10	0.12	0.07	0.12	0.09	0.09	0.14	0.13	0.17	0.20	0.19	0.12	0.17	0.17	0.12
Al2O3	20.51	20.22	19.84	19.89	20.19	19.81	20.21	19.91	20.08	20.03	20.01	20.04	19.86	19.88	20.04	20.05	19.50	20.11
FeO※	18.53	20.79	29.76	30.24	30.37	21.85	18.87	17.15	16.04	15.71	15.13	13.93	13.72	14.53	15.56	19.00	24.26	30.52
MnO	9.70	7.77	1.71	1.89	2.14	6.65	8.30	10.24	13.69	16.68	18.85	19.52	20.58	20.06	19.76	16.17	9.96	0.69
MgO	0.28	0.29	0.73	0.69	0.69	0.34	0.28	0.29	0.26	0.26	0.26	0.23	0.23	0.21	0.23	0.46	0.63	0.83
CaO	13.43	13.28	10.20	9.50	9.41	13.09	14.24	13.85	11.89	9.92	8.80	8.72	8.27	7.88	7.37	6.83	7.11	9.57
Total	100.35	100.42	99.67	99.77	100.41	99.20	99.22	99.06	99.59	100.29	99.98	99.20	100.11	99.43	99.73	99.55	99.47	99.59
Element O=12																		
Si	3.012	3.030	3.021	3.030	3.014	3.024	2.999	3.029	3.025	3.024	2.991	2.992	3.019	2.999	2.992	3.008	3.074	3.044
Ti	0.007	0.004	0.006	0.006	0.007	0.004	0.007	0.005	0.005	0.009	0.008	0.011	0.012	0.012	0.007	0.011	0.010	0.007
Al	1.926	1.900	1.893	1.896	1.914	1.889	1.920	1.893	1.907	1.901	1.916	1.931	1.897	1.916	1.929	1.928	1.866	1.911
Fe	1.235	1.386	2.014	2.045	2.043	1.478	1.272	1.157	1.081	1.058	1.028	0.952	0.929	0.993	1.062	1.296	1.648	2.057
Mn	0.655	0.525	0.117	0.130	0.146	0.456	0.566	0.700	0.935	1.137	1.298	1.352	1.412	1.389	1.366	1.118	0.685	0.047
Mg	0.033	0.034	0.088	0.083	0.083	0.041	0.033	0.034	0.032	0.031	0.032	0.028	0.028	0.026	0.029	0.056	0.076	0.100
Ca	1.147	1.134	0.884	0.823	0.811	1.134	1.230	1.197	1.027	0.855	0.766	0.764	0.718	0.691	0.644	0.597	0.618	0.826
Total	8.015	8.014	8.023	8.011	8.017	8.025	8.028	8.015	8.012	8.014	8.038	8.029	8.016	8.026	8.029	8.013	7.978	7.991

sample no.													M14					
						←							core	rim			←	
point no.	66	68	69	71	72	73	74	76	77	75	79	80	81	40	41	42	43	44
SiO2	37.78	37.51	37.39	37.56	37.81	37.53	37.16	37.23	36.79	37.02	37.82	37.22	36.92	36.91	36.61	36.94	36.58	36.50
TiO2	0.05	0.10	0.07	0.09	0.12	0.10	0.12	0.12	0.13	0.13	0.18	0.18	0.16	0.12	0.11	0.13	0.03	0.06
Al2O3	20.31	20.27	20.35	20.35	20.27	20.11	19.93	20.26	19.78	20.14	19.52	20.06	20.02	20.62	20.53	20.65	20.55	20.50
FeO※	30.02	30.55	29.28	24.43	19.80	18.04	17.41	19.23	21.33	16.73	22.02	19.58	24.72	25.72	24.48	23.49	23.34	22.45
MnO	1.11	1.88	1.66	5.39	7.30	11.42	14.63	14.80	13.20	16.68	12.28	14.97	10.02	10.14	12.07	12.70	13.59	14.07
MgO	0.73	0.71	0.73	0.43	0.31	0.33	0.34	0.39	0.53	0.27	0.60	0.38	0.70	0.52	0.46	0.48	0.45	0.50
CaO	10.06	9.42	10.65	12.00	14.16	12.47	10.33	8.34	7.46	9.64	7.05	7.63	7.08	6.43	6.09	5.95	5.59	5.46
Total	100.05	100.44	100.12	100.25	99.78	99.98	99.90	100.35	99.22	100.61	99.47	100.01	99.61	100.44	100.35	100.35	100.13	99.53
Element O=12																		
Si	3.032	3.013	3.005	3.009	3.023	3.014	3.007	3.006	3.011	2.986	3.069	3.017	3.007	2.988	2.976	2.992	2.990	2.985
Ti	0.003	0.006	0.004	0.006	0.007	0.006	0.007	0.007	0.008	0.008	0.011	0.011	0.010	0.007	0.007	0.008	0.002	0.004
Al	1.921	1.920	1.928	1.922	1.911	1.904	1.902	1.928	1.908	1.915	1.867	1.916	1.922	1.968	1.967	1.972	1.973	1.976
Fe	2.015	2.052	1.968	1.637	1.324	1.212	1.178	1.298	1.460	1.129	1.495	1.327	1.684	1.741	1.664	1.591	1.591	1.535
Mn	0.076	0.128	0.113	0.366	0.494	0.777	1.003	1.012	0.915	1.140	0.844	1.028	0.691	0.686	0.831	0.871	0.938	0.974
Mg	0.087	0.086	0.087	0.051	0.037	0.039	0.041	0.048	0.065	0.033	0.073	0.046	0.085	0.062	0.056	0.058	0.055	0.061
Ca	0.865	0.811	0.917	1.030	1.214	1.073	0.895	0.722	0.654	0.833	0.613	0.663	0.618	0.557	0.530	0.517	0.488	0.478
Total	7.998	8.015	8.023	8.020	8.010	8.025	8.033	8.020	8.020	8.043	7.972	8.008	8.017	8.009	8.030	8.009	8.038	8.013

sample no.			
			core
point no.	45	46	47
SiO2	36.52	36.74	36.36
TiO2	0.07	0.08	0.07
Al2O3	20.52	20.44	20.44
FeO※	22.59	22.90	23.01
MnO	13.93	14.02	13.93
MgO	0.51	0.52	0.51
CaO	5.40	5.26	5.19
Total	99.55	99.96	99.51
Element O=12			
Si	2.986	2.993	2.980
Ti	0.005	0.005	0.004
Al	1.977	1.963	1.974
Fe	1.545	1.561	1.577
Mn	0.965	0.967	0.967
Mg	0.062	0.063	0.063
Ca	0.473	0.460	0.456
Total	8.011	8.011	8.021

※Total Fe as FeO ※im: intermediate parts between core and rim

Table3. Major element compositions of the garnets from the albite-biotite zone (upper) in the Asemigawa area.

sample no	M34								M35									
	im	im	im	im	im	im	im	im	rim						←			
point no.	13	14	15	28	41	43	46	47	1	2	3	4	5	7	10	11	12	13
SiO2	36.94	36.81	37.14	37.15	36.93	37.30	37.10	37.38	37.85	37.98	37.72	37.78	37.96	37.80	37.74	37.58	37.72	37.63
TiO2	0.11	0.13	0.14	0.14	0.10	0.08	0.16	0.11	0.07	0.06	0.07	0.06	0.04	0.12	0.13	0.17	0.14	0.14
Al2O3	20.73	20.77	20.69	20.65	20.66	20.50	20.49	20.63	20.65	20.78	20.75	20.87	20.76	20.77	20.50	20.50	20.29	20.38
FeO※	21.79	22.99	22.91	30.22	30.82	30.45	30.52	30.24	30.88	31.30	31.38	30.50	30.52	27.46	24.35	23.78	22.86	22.10
MnO	8.83	7.62	7.08	1.23	0.72	0.96	1.09	1.07	0.34	0.30	0.37	0.69	1.00	1.61	6.47	7.31	8.87	10.33
MgO	0.69	0.62	0.66	1.38	1.65	1.29	1.33	1.49	2.06	2.10	1.85	1.70	1.68	1.02	0.74	0.71	0.60	0.61
CaO	9.91	10.52	10.64	8.32	8.29	8.54	8.58	8.22	8.06	7.66	7.78	8.03	8.29	11.39	10.13	10.15	9.74	9.07
Total	99.00	99.45	99.26	99.09	99.16	99.12	99.26	99.14	99.91	100.19	99.92	99.61	100.24	100.16	100.06	100.18	100.22	100.26
Element O=12																		
Si	2.993	2.976	2.999	3.005	2.988	3.016	3.002	3.017	3.025	3.027	3.019	3.026	3.026	3.012	3.024	3.013	3.027	3.023
Ti	0.007	0.008	0.008	0.008	0.006	0.005	0.010	0.007	0.004	0.004	0.005	0.003	0.003	0.007	0.008	0.010	0.009	0.008
Al	1.980	1.979	1.969	1.969	1.970	1.954	1.954	1.963	1.945	1.952	1.958	1.970	1.951	1.950	1.936	1.936	1.919	1.929
Fe	1.477	1.554	1.547	2.045	2.086	2.060	2.065	2.041	2.064	2.086	2.101	2.043	2.035	1.830	1.632	1.594	1.535	1.485
Mn	0.606	0.522	0.484	0.084	0.049	0.066	0.075	0.073	0.023	0.020	0.025	0.047	0.068	0.109	0.439	0.496	0.603	0.703
Mg	0.083	0.075	0.080	0.166	0.199	0.156	0.160	0.179	0.246	0.250	0.221	0.203	0.199	0.122	0.088	0.084	0.072	0.073
Ca	0.860	0.911	0.920	0.721	0.718	0.740	0.744	0.711	0.691	0.654	0.668	0.689	0.708	0.972	0.869	0.871	0.837	0.781
Total	8.006	8.023	8.007	7.998	8.017	7.996	8.008	7.991	7.996	7.992	7.996	7.981	7.990	8.002	7.996	8.005	8.001	8.003

Table3. (Continued)

sample no.												M36					M38	
				core	rim				←			core	im	im	im	im	rim	
point no.	14	16	18	19	33	34	36	37	38	39	40	41	1	3	4	10	1	2
SiO2	37.00	37.52	37.02	37.07	37.82	37.91	37.50	37.65	37.55	37.65	37.19	37.20	37.51	37.07	36.72	37.55	37.87	37.40
TiO2	0.12	0.15	0.11	0.17	0.04	0.05	0.10	0.08	0.10	0.13	0.15	0.13	0.03	0.01	0.17	0.04	0.00	0.07
Al2O3	20.60	20.25	20.51	20.43	20.61	20.72	20.78	20.49	20.36	20.51	20.43	20.31	20.56	20.55	20.19	20.42	20.87	20.72
FeO※	20.42	18.90	18.64	18.83	30.41	30.96	27.64	24.93	24.42	23.27	23.01	22.64	25.95	18.60	17.77	29.06	29.73	31.05
MnO	12.58	15.91	16.57	16.47	0.58	0.36	2.79	6.17	6.26	7.55	8.20	8.16	4.09	13.27	16.31	0.56	0.61	0.34
MgO	0.56	0.51	0.55	0.58	1.95	2.03	1.17	0.84	0.74	0.71	0.69	0.77	0.57	0.42	0.40	1.06	1.93	1.92
CaO	8.54	7.18	6.95	6.85	7.91	7.69	9.78	9.59	10.11	9.99	9.85	9.80	10.87	9.26	7.58	10.54	8.45	8.13
Total	99.82	100.42	100.35	100.40	99.31	99.72	99.77	99.75	99.54	99.81	99.51	99.01	99.57	99.18	99.14	99.25	99.45	99.62
Element O=12																		
Si	2.992	3.024	2.993	2.995	3.036	3.033	3.007	3.026	3.026	3.023	3.004	3.016	3.018	3.007	2.999	3.025	3.030	3.004
Ti	0.007	0.009	0.007	0.010	0.003	0.003	0.006	0.005	0.006	0.008	0.009	0.008	0.002	0.001	0.010	0.003	0.000	0.004
Al	1.963	1.924	1.955	1.945	1.950	1.954	1.964	1.942	1.934	1.942	1.946	1.941	1.950	1.965	1.944	1.938	1.968	1.961
Fe	1.381	1.274	1.261	1.273	2.042	2.072	1.854	1.676	1.646	1.563	1.555	1.535	1.746	1.262	1.213	1.958	1.989	2.086
Mn	0.862	1.086	1.135	1.127	0.039	0.025	0.190	0.420	0.427	0.514	0.561	0.560	0.279	0.912	1.129	0.039	0.041	0.023
Mg	0.067	0.061	0.066	0.070	0.233	0.242	0.140	0.101	0.088	0.085	0.083	0.093	0.068	0.051	0.048	0.128	0.230	0.229
Ca	0.740	0.620	0.602	0.593	0.680	0.659	0.840	0.826	0.873	0.859	0.853	0.852	0.937	0.805	0.663	0.910	0.725	0.700
Total	8.013	7.999	8.017	8.014	7.983	7.987	8.001	7.995	8.000	7.994	8.010	8.005	7.999	8.003	8.007	8.000	7.981	8.008

sample no.															M40			
	←			core	rim		←	core	rim			←		core	rim			
point no.	5	6	7	8	9	10	11	12	25	26	27	28	29	30	1	2	3	4
SiO2	37.62	37.58	37.17	37.34	37.50	37.62	37.61	37.24	37.64	37.12	37.51	36.89	37.06	36.59	37.53	37.50	37.68	37.20
TiO2	0.11	0.11	0.06	0.04	0.10	0.04	0.07	0.03	0.10	0.10	0.07	0.19	0.16	0.15	0.08	0.07	0.06	0.12
Al2O3	20.75	20.60	20.62	20.52	20.66	20.68	20.82	20.50	20.90	20.82	20.84	20.42	20.42	20.63	20.98	20.81	20.79	20.64
FeO※	24.21	20.14	18.15	18.02	29.03	26.70	21.66	20.05	29.75	26.84	20.92	17.82	17.19	17.73	30.65	30.95	31.12	30.59
MnO	3.74	8.01	14.58	15.80	1.24	2.20	7.14	11.75	1.38	1.86	7.82	16.62	17.19	18.10	0.67	0.61	0.82	1.05
MgO	0.83	0.48	0.45	0.46	1.57	0.97	0.62	0.81	1.54	1.06	0.51	0.40	0.38	0.35	1.81	1.78	1.61	1.51
CaO	12.22	12.37	9.07	7.45	8.92	10.91	11.98	8.99	8.66	11.58	12.64	7.76	8.03	6.69	8.14	8.10	8.41	8.23
Total	99.47	99.29	100.10	99.62	99.02	99.12	99.91	99.37	99.97	99.38	100.31	100.10	100.43	100.23	99.85	99.82	100.50	99.34
Element O=12																		
Si	3.013	3.019	2.997	3.023	3.021	3.023	3.005	3.011	3.009	2.984	2.992	2.990	2.993	2.971	3.004	3.007	3.007	3.003
Ti	0.007	0.007	0.004	0.002	0.006	0.003	0.004	0.002	0.006	0.006	0.004	0.012	0.010	0.009	0.005	0.004	0.004	0.007
Al	1.959	1.951	1.960	1.958	1.961	1.959	1.961	1.954	1.969	1.973	1.960	1.950	1.944	1.974	1.979	1.967	1.956	1.964
Fe	1.621	1.353	1.224	1.220	1.956	1.795	1.448	1.356	1.989	1.804	1.395	1.208	1.161	1.203	2.052	2.076	2.077	2.066
Mn	0.254	0.545	0.996	1.084	0.085	0.150	0.484	0.805	0.094	0.127	0.528	1.141	1.176	1.244	0.046	0.042	0.055	0.072
Mg	0.099	0.057	0.054	0.055	0.188	0.116	0.074	0.097	0.184	0.128	0.061	0.048	0.046	0.042	0.216	0.213	0.192	0.181
Ca	1.049	1.065	0.784	0.646	0.770	0.939	1.026	0.779	0.742	0.998	1.080	0.674	0.695	0.581	0.698	0.696	0.719	0.712
Total	8.001	7.996	8.018	7.989	7.987	7.983	8.002	8.003	7.992	8.019	8.021	8.022	8.023	8.025	7.999	8.003	8.009	8.006

sample no.																		
					←						core	rim				←		
point no.	5	6	7	8	9	10	11	12	13	14	15	17	19	20	21	22	23	25
SiO2	37.21	37.26	37.39	37.55	37.28	37.42	37.06	36.64	36.29	36.34	36.48	37.39	37.10	36.87	37.10	37.26	37.11	36.83
TiO2	0.10	0.08	0.17	0.10	0.15	0.12	0.12	0.28	0.22	0.17	0.15	0.07	0.09	0.08	0.16	0.10	0.08	0.18
Al2O3	20.57	20.74	20.62	20.69	20.71	20.76	20.90	20.50	20.43	20.40	20.52	20.85	20.80	20.68	20.63	20.65	20.66	20.47
FeO※	30.94	30.51	30.59	29.35	27.84	23.85	16.79	13.52	13.63	14.05	14.22	30.46	30.65	30.11	29.46	26.87	20.82	14.85
MnO	2.13	2.11	2.01	2.10	1.88	5.66	13.66	18.97	19.42	20.52	20.81	0.63	1.09	2.01	2.05	1.74	7.63	17.67
MgO	1.30	1.34	1.16	1.19	0.96	0.66	0.40	0.30	0.32	0.26	0.26	1.67	1.40	1.25	1.12	0.91	0.53	0.35
CaO	7.81	8.13	8.19	9.15	10.57	11.62	10.43	9.29	8.98	8.09	7.54	8.37	8.47	8.07	8.53	11.64	12.62	9.33
Total	100.06	100.18	100.12	100.13	99.39	100.09	99.37	99.50	99.29	99.82	99.99	99.44	99.59	99.05	99.06	99.16	99.45	99.67
Element O=12																		
Si	2.997	2.992	3.005	3.009	3.001	2.995	2.991	2.975	2.962	2.962	2.968	3.006	2.991	2.992	3.006	3.001	2.987	2.985
Ti	0.006	0.005	0.010	0.006	0.009	0.008	0.007	0.017	0.013	0.010	0.009	0.004	0.005	0.005	0.010	0.006	0.005	0.011
Al	1.953	1.964	1.953	1.954	1.964	1.958	1.988	1.963	1.966	1.960	1.968	1.976	1.977	1.978	1.970	1.960	1.960	1.955
Fe	2.084	2.049	2.056	1.967	1.874	1.597	1.133	0.918	0.931	0.958	0.968	2.048	2.066	2.044	1.996	1.810	1.402	1.006
Mn	0.145	0.144	0.137	0.143	0.128	0.384	0.934	1.305	1.343	1.417	1.434	0.043	0.074	0.138	0.141	0.119	0.520	1.213
Mg	0.156	0.160	0.139	0.142	0.116	0.079	0.049	0.037	0.038	0.031	0.032	0.200	0.168	0.151	0.135	0.109	0.063	0.042
Ca	0.674	0.700	0.705	0.786	0.912	0.996	0.902	0.808	0.786	0.707	0.657	0.721	0.732	0.702	0.740	1.004	1.089	0.810
Total	8.016	8.014	8.006	8.006	8.003	8.016	8.004	8.023	8.039	8.045	8.036	7.999	8.014	8.009	7.998	8.010	8.026	8.022

sample no.		core	rim	im	im	im	im	im
point no.	26	27	28	31	32	33	34	36
SiO2	36.42	36.70	37.51	37.40	36.82	36.67	36.36	36.59
TiO2	0.21	0.18	0.09	0.17	0.14	0.15	0.17	0.12
Al2O3	20.55	20.35	20.86	20.49	20.92	20.49	20.27	20.60
FeO※	14.52	14.33	30.27	27.14	16.26	13.82	14.31	14.79
MnO	19.94	20.85	1.41	1.76	15.76	20.02	20.16	19.89
MgO	0.31	0.26	1.37	1.00	0.39	0.29	0.32	0.27
CaO	8.00	7.78	8.07	11.33	9.44	8.18	7.97	7.91
Total	99.94	100.44	99.57	99.27	99.72	99.62	99.55	100.16
Element O=12								
Si	2.961	2.974	3.015	3.010	2.975	2.981	2.970	2.968
Ti	0.013	0.011	0.006	0.010	0.008	0.009	0.010	0.007
Al	1.969	1.944	1.976	1.943	1.992	1.964	1.952	1.970
Fe	0.987	0.971	2.034	1.826	1.099	0.939	0.978	1.003
Mn	1.373	1.432	0.096	0.120	1.079	1.378	1.395	1.367
Mg	0.037	0.031	0.164	0.120	0.047	0.035	0.038	0.033
Ca	0.697	0.676	0.695	0.977	0.817	0.713	0.697	0.688
Total	8.037	8.039	7.985	8.006	8.017	8.020	8.040	8.035

※Total Fe as FeO ※im: intermediate parts between core and rim

Table4. Major element compositions of the garnets from the oligoclase-biotite zone in the Asemigawa area.

sample no.	M19-A																	
	rim				←					core	im	im	im	im	rim	im	im	im
point no.	71	72	73	74	75	76	77	78	79	80	8	9	10	12	13	14	15	16
SiO2	37.48	37.32	37.38	37.00	37.34	37.04	37.01	36.97	37.03	36.72	37.00	36.77	36.62	36.87	37.39	37.48	37.45	37.38
TiO2	0.10	0.09	0.10	0.13	0.09	0.05	0.06	0.09	0.02	0.02	0.08	0.07	0.08	0.04	0.05	0.05	0.05	0.08
Al2O3	20.72	20.39	20.59	20.33	20.21	20.31	20.20	20.34	20.30	20.43	20.18	20.23	20.11	20.21	20.49	20.66	20.34	20.54
FeO※	28.61	27.22	26.45	25.48	24.58	24.17	24.11	24.06	23.73	23.31	25.33	24.85	24.81	24.22	28.15	27.64	26.53	27.99
MnO	2.81	4.73	5.10	9.37	10.50	11.48	12.08	12.44	12.41	12.71	10.34	11.73	12.36	12.42	3.60	4.80	6.54	7.22
MgO	2.06	1.38	1.36	1.17	1.06	0.94	0.98	1.01	0.98	0.97	0.56	0.55	0.59	0.58	1.43	1.17	1.08	1.17
CaO	7.85	8.34	8.54	6.61	5.51	5.29	4.98	4.67	5.17	5.32	6.20	5.50	4.81	5.39	8.19	8.33	7.53	6.11
Total	99.63	99.46	99.52	100.08	99.29	99.28	99.42	99.58	99.63	99.47	99.69	99.71	99.38	99.73	99.28	100.13	99.51	100.47
Element O=12																		
Si	3.007	3.013	3.010	2.994	3.037	3.021	3.019	3.012	3.015	2.995	3.014	3.004	3.004	3.009	3.018	3.010	3.029	3.009
Ti	0.006	0.005	0.006	0.008	0.006	0.003	0.004	0.006	0.001	0.001	0.005	0.004	0.005	0.002	0.003	0.003	0.003	0.005
Al	1.959	1.941	1.954	1.939	1.938	1.952	1.943	1.953	1.948	1.965	1.937	1.949	1.944	1.944	1.949	1.955	1.939	1.949
Fe	1.919	1.838	1.781	1.724	1.672	1.649	1.645	1.640	1.615	1.590	1.726	1.698	1.702	1.653	1.901	1.856	1.795	1.885
Mn	0.191	0.323	0.348	0.642	0.724	0.793	0.835	0.859	0.856	0.878	0.713	0.812	0.859	0.859	0.246	0.326	0.448	0.492
Mg	0.246	0.167	0.164	0.141	0.129	0.114	0.119	0.123	0.118	0.117	0.068	0.068	0.072	0.070	0.172	0.140	0.130	0.140
Ca	0.675	0.721	0.737	0.573	0.480	0.463	0.435	0.408	0.451	0.465	0.541	0.482	0.423	0.471	0.708	0.717	0.652	0.527
Total	8.003	8.008	8.000	8.021	7.984	7.995	7.998	8.000	8.003	8.012	8.005	8.016	8.009	8.009	7.997	8.007	7.996	8.007

sample no.										M19-B				M21				
	core	rim				←				core	im	im	im	rim				←
point no.	17	20	21	22	23	24	25	26	27	29	2	10	13	2	3	4	6	7
SiO2	37.22	37.63	38.01	37.63	37.61	37.31	37.12	37.17	37.02	37.05	37.49	37.25	36.89	37.46	37.36	37.62	37.37	37.32
TiO2	0.01	0.07	0.09	0.10	0.10	0.05	0.06	0.07	0.08	0.05	0.01	0.14	0.11	0.14	0.10	0.14	0.10	0.07
Al2O3	20.21	20.87	20.75	20.72	20.94	20.86	20.31	20.58	20.33	20.58	20.60	20.57	20.52	20.42	20.28	20.48	20.40	20.43
FeO※	27.75	30.42	28.72	28.79	28.14	25.77	25.99	25.78	25.55	24.30	28.51	27.57	24.82	30.21	31.07	30.84	29.82	26.58
MnO	7.15	1.89	1.80	2.23	3.16	6.62	9.03	9.97	10.16	9.57	3.34	3.66	10.56	0.50	0.54	0.55	1.36	4.30
MgO	1.19	2.88	2.36	2.06	1.95	1.63	1.51	1.55	1.57	1.42	1.06	1.54	0.87	1.57	1.42	1.36	1.40	0.83
CaO	5.51	5.71	7.75	8.00	8.58	7.87	5.59	5.25	4.67	6.51	8.96	8.36	5.24	9.18	8.68	9.05	9.20	9.90
Total	99.03	99.46	99.48	99.53	100.49	100.11	99.62	100.38	99.38	99.48	99.96	99.08	99.02	99.48	99.44	100.04	99.65	99.41
Element O=12																		
Si	3.035	3.015	3.035	3.015	2.994	2.992	3.012	2.997	3.012	3.001	3.013	3.008	3.012	3.015	3.016	3.016	3.009	3.013
Ti	0.001	0.004	0.006	0.006	0.006	0.003	0.004	0.004	0.005	0.003	0.000	0.008	0.007	0.008	0.006	0.008	0.006	0.004
Al	1.942	1.971	1.953	1.958	1.965	1.972	1.942	1.956	1.950	1.964	1.952	1.958	1.975	1.937	1.930	1.935	1.936	1.944
Fe	1.892	2.038	1.918	1.929	1.874	1.728	1.763	1.738	1.738	1.646	1.916	1.862	1.695	2.033	2.098	2.067	2.008	1.795
Mn	0.494	0.128	0.122	0.151	0.213	0.450	0.621	0.681	0.700	0.657	0.227	0.250	0.730	0.034	0.037	0.038	0.092	0.294
Mg	0.145	0.343	0.281	0.247	0.231	0.195	0.183	0.187	0.190	0.172	0.126	0.186	0.106	0.188	0.171	0.163	0.168	0.100
Ca	0.482	0.490	0.664	0.687	0.732	0.676	0.486	0.453	0.407	0.565	0.772	0.724	0.458	0.792	0.751	0.777	0.794	0.856
Total	7.989	7.989	7.977	7.993	8.016	8.016	8.010	8.016	8.001	8.008	8.006	7.997	7.984	8.007	8.009	8.004	8.013	8.006

sample no.																		
				core	rim										←			
point no.	8	9	10	11	12	13	14	17	19	20	21	22	23	24	27	28	29	30
SiO2	37.34	37.33	37.33	37.33	37.59	37.32	37.63	37.75	37.33	37.61	37.30	37.49	37.22	37.47	37.59	37.19	37.01	37.13
TiO2	0.10	0.02	0.07	0.05	0.06	0.11	0.08	0.11	0.12	0.13	0.14	0.06	0.08	0.10	0.10	0.09	0.10	0.10
Al2O3	20.51	20.44	20.63	20.48	20.85	20.65	20.70	20.42	20.43	20.46	20.28	20.30	20.37	20.49	20.39	20.40	20.42	20.38
FeO※	24.65	24.43	24.95	24.98	30.75	30.53	30.20	30.82	30.31	30.78	30.65	30.51	30.30	29.31	27.77	26.97	26.74	22.85
MnO	6.91	7.48	6.10	5.78	0.54	0.63	0.55	0.58	0.57	0.72	0.72	0.72	1.06	1.43	3.84	4.31	4.57	6.95
MgO	0.72	0.99	1.20	1.16	1.58	1.44	1.47	1.29	1.17	1.21	1.19	1.06	1.00	0.89	0.83	0.80	0.83	0.49
CaO	9.73	9.41	9.51	9.49	8.83	9.20	9.57	9.51	9.48	9.34	9.28	9.88	9.86	10.38	9.55	9.74	10.27	11.39
Total	99.96	100.09	99.80	99.27	100.19	99.88	100.20	100.48	99.41	100.24	99.55	100.02	99.88	100.07	100.07	99.50	99.94	99.28
Element O=12																		
Si	3.005	3.002	3.000	3.012	3.004	2.996	3.006	3.017	3.012	3.012	3.011	3.014	2.999	3.007	3.019	3.006	2.984	3.002
Ti	0.006	0.001	0.004	0.003	0.004	0.007	0.005	0.007	0.008	0.008	0.009	0.004	0.005	0.006	0.006	0.006	0.006	0.006
Al	1.946	1.937	1.954	1.947	1.964	1.954	1.949	1.924	1.942	1.932	1.930	1.924	1.934	1.937	1.930	1.944	1.940	1.942
Fe	1.660	1.643	1.677	1.685	2.055	2.050	2.018	2.060	2.045	2.062	2.069	2.051	2.042	1.967	1.865	1.823	1.803	1.545
Mn	0.471	0.510	0.415	0.395	0.036	0.043	0.037	0.040	0.039	0.049	0.049	0.049	0.072	0.097	0.261	0.295	0.312	0.476
Mg	0.087	0.119	0.144	0.139	0.188	0.173	0.175	0.154	0.141	0.144	0.143	0.127	0.120	0.106	0.100	0.096	0.100	0.059
Ca	0.840	0.811	0.819	0.821	0.756	0.791	0.819	0.815	0.820	0.802	0.802	0.851	0.851	0.893	0.822	0.844	0.888	0.987
Total	8.014	8.023	8.013	8.002	8.007	8.013	8.009	8.015	8.007	8.007	8.013	8.019	8.023	8.013	8.003	8.013	8.033	8.016

sample no.											M22							
					←						core	rim				←		
point no.	31	32	33	34	35	37	38	39	40	41	42	1	3	4	5	7	8	9
SiO2	37.46	37.39	37.07	36.97	36.72	36.79	36.51	36.78	36.51	36.70	36.85	37.49	37.42	37.37	37.14	36.90	37.04	36.82
TiO2	0.10	0.09	0.06	0.13	0.16	0.16	0.20	0.20	0.15	0.19	0.21	0.09	0.13	0.06	0.07	0.12	0.13	0.15
Al2O3	20.28	20.53	20.22	20.41	20.34	20.04	20.13	20.08	20.36	20.16	20.13	21.11	20.75	20.83	20.67	20.53	20.54	20.39
FeO※	23.06	22.37	20.06	19.69	18.78	17.51	17.20	17.21	16.92	16.94	16.57	30.97	28.32	26.45	22.70	22.98	22.85	22.44
MnO	7.10	7.91	11.66	13.28	13.69	15.43	15.42	15.22	15.50	15.28	15.96	0.46	0.95	2.69	7.14	10.32	11.17	10.86
MgO	0.50	0.50	0.41	0.40	0.40	0.34	0.40	0.39	0.39	0.38	0.34	2.61	1.05	0.74	0.49	0.46	0.41	0.37
CaO	11.50	11.12	10.20	10.10	9.79	9.67	9.55	9.66	9.64	10.03	10.11	7.40	11.25	11.86	11.06	8.31	8.31	8.19
Total	100.00	99.90	99.69	100.99	99.87	99.94	99.40	99.54	99.47	99.67	100.18	100.13	99.86	99.99	99.28	99.61	100.45	99.22
Element O=12																		
Si	3.010	3.004	3.002	2.969	2.976	2.986	2.977	2.989	2.971	2.980	2.981	2.987	2.996	2.991	2.999	2.994	2.989	3.000
Ti	0.006	0.005	0.004	0.008	0.010	0.010	0.012	0.012	0.009	0.011	0.013	0.005	0.008	0.004	0.004	0.007	0.008	0.009
Al	1.920	1.945	1.930	1.932	1.943	1.917	1.935	1.924	1.952	1.930	1.919	1.983	1.958	1.965	1.968	1.963	1.953	1.959
Fe	1.550	1.504	1.358	1.322	1.273	1.189	1.173	1.170	1.151	1.151	1.121	2.064	1.896	1.771	1.533	1.559	1.542	1.529
Mn	0.483	0.538	0.800	0.904	0.940	1.061	1.065	1.048	1.068	1.051	1.093	0.031	0.065	0.182	0.489	0.709	0.763	0.750
Mg	0.060	0.060	0.050	0.048	0.048	0.042	0.048	0.048	0.047	0.046	0.041	0.310	0.125	0.088	0.060	0.055	0.049	0.045
Ca	0.990	0.957	0.885	0.869	0.850	0.841	0.834	0.841	0.840	0.872	0.876	0.632	0.965	1.017	0.957	0.723	0.719	0.715
Total	8.018	8.013	8.027	8.053	8.040	8.043	8.043	8.031	8.039	8.042	8.044	8.012	8.012	8.019	8.008	8.011	8.023	8.007

※Total Fe as FeO ※im: intermediate parts between core and rim

Table4. (Continued).

sample no.							M25											
			core	im	im	im	rim					←				core	im	rim
point no.	10	12	13	21	22	24	2	4	5	6	7	10	11	12	13	14	15	18
SiO2	36.65	36.65	36.85	37.21	36.87	36.62	37.51	37.11	37.42	37.78	37.58	37.09	36.79	36.74	36.89	36.88	36.73	37.17
TiO2	0.13	0.13	0.08	0.07	0.14	0.17	0.12	0.12	0.12	0.07	0.11	0.22	0.14	0.21	0.19	0.17	0.24	0.10
Al2O3	20.43	20.13	20.30	20.64	20.53	20.17	20.86	20.73	20.80	20.82	20.69	20.57	20.48	20.40	20.75	20.90	20.62	20.84
FeO※	22.21	22.11	22.55	27.61	23.87	22.58	29.79	29.79	28.76	27.49	27.22	15.33	15.20	14.53	15.04	14.72	16.28	30.20
MnO	11.14	12.44	12.39	1.13	8.65	11.01	0.22	0.94	1.02	1.21	1.17	16.35	17.55	17.73	17.79	17.56	16.38	0.27
MgO	0.38	0.35	0.35	1.49	0.96	0.63	2.27	1.75	1.41	1.22	1.05	0.54	0.43	0.43	0.44	0.43	0.57	2.13
CaO	8.32	7.36	6.60	11.16	8.46	7.87	8.63	8.91	9.94	11.20	11.73	9.92	9.14	9.80	9.25	9.12	8.77	8.30
Total	99.27	99.17	99.13	99.31	99.49	99.06	99.41	99.34	99.46	99.79	99.55	100.03	99.73	99.83	100.34	99.76	99.59	99.00
Element O=12																		
Si	2.989	3.000	3.013	2.991	2.988	2.993	3.004	2.989	3.004	3.015	3.009	2.987	2.980	2.975	2.971	2.978	2.976	2.992
Ti	0.008	0.008	0.005	0.004	0.008	0.011	0.007	0.007	0.007	0.004	0.007	0.013	0.009	0.013	0.011	0.010	0.015	0.006
Al	1.964	1.942	1.957	1.955	1.961	1.943	1.969	1.968	1.968	1.958	1.953	1.953	1.956	1.946	1.970	1.990	1.969	1.977
Fe	1.515	1.514	1.542	1.856	1.618	1.543	1.995	2.007	1.931	1.834	1.823	1.033	1.030	0.984	1.013	0.994	1.103	2.034
Mn	0.769	0.863	0.858	0.077	0.594	0.762	0.015	0.064	0.069	0.082	0.080	1.115	1.204	1.216	1.214	1.201	1.124	0.018
Mg	0.047	0.043	0.043	0.178	0.117	0.077	0.271	0.210	0.169	0.146	0.125	0.065	0.052	0.052	0.053	0.052	0.069	0.256
Ca	0.727	0.645	0.578	0.961	0.735	0.690	0.741	0.769	0.855	0.958	1.007	0.856	0.793	0.850	0.798	0.789	0.761	0.716
Total	8.019	8.014	7.997	8.022	8.021	8.019	8.001	8.013	8.003	7.997	8.004	8.022	8.023	8.035	8.030	8.013	8.016	7.999

sample no.									M28									
				←					core	rim						←		
point no.	20	21	22	26	27	28	29	30	31	2	3	4	5	8	9	11	12	13
SiO2	37.18	37.32	37.26	37.11	37.69	37.32	36.84	37.01	37.25	37.73	37.86	37.67	37.53	37.73	37.72	37.45	37.63	37.78
TiO2	0.12	0.10	0.11	0.14	0.13	0.11	0.10	0.16	0.17	0.05	0.07	0.10	0.08	0.10	0.11	0.09	0.14	0.13
Al2O3	20.69	20.52	20.76	20.65	20.75	20.93	20.79	20.61	20.79	20.26	20.55	20.37	20.25	20.15	20.04	20.07	20.03	19.89
FeO※	30.21	31.14	30.05	30.44	28.47	27.55	25.16	18.03	15.47	30.55	30.11	30.03	30.59	29.65	29.92	30.45	30.37	30.44
MnO	0.32	0.41	1.01	0.99	1.06	1.05	4.71	12.37	15.00	0.56	0.58	0.60	0.69	0.83	0.76	1.02	1.02	1.04
MgO	1.97	1.91	1.80	1.29	1.16	0.99	0.75	0.60	0.54	2.02	2.05	2.08	2.05	1.83	1.66	1.79	1.66	1.63
CaO	8.63	7.78	8.23	9.28	10.64	11.34	11.18	10.92	10.81	8.40	8.44	8.57	8.15	8.91	8.86	8.24	8.30	8.39
Total	99.11	99.19	99.21	99.90	99.90	99.30	99.52	99.69	100.03	99.56	99.66	99.43	99.33	99.20	99.07	99.11	99.15	99.29
Element O=12																		
Si	2.996	3.012	3.001	2.984	3.012	2.997	2.972	2.982	2.988	3.030	3.028	3.023	3.023	3.037	3.044	3.028	3.039	3.048
Ti	0.007	0.006	0.006	0.008	0.008	0.007	0.006	0.010	0.010	0.003	0.005	0.006	0.005	0.006	0.007	0.005	0.009	0.008
Al	1.965	1.952	1.970	1.957	1.955	1.981	1.977	1.957	1.966	1.917	1.938	1.927	1.922	1.912	1.906	1.913	1.906	1.892
Fe	2.036	2.102	2.024	2.047	1.903	1.850	1.697	1.215	1.038	2.051	2.014	2.016	2.061	1.996	2.019	2.060	2.051	2.054
Mn	0.022	0.028	0.069	0.068	0.072	0.072	0.322	0.845	1.019	0.038	0.039	0.041	0.047	0.057	0.052	0.070	0.070	0.071
Mg	0.236	0.230	0.216	0.155	0.138	0.119	0.090	0.072	0.064	0.242	0.245	0.249	0.246	0.219	0.200	0.215	0.199	0.196
Ca	0.745	0.673	0.710	0.799	0.911	0.976	0.966	0.943	0.930	0.722	0.723	0.737	0.704	0.769	0.766	0.714	0.718	0.725
Total	8.008	8.003	7.997	8.018	7.998	8.001	8.029	8.024	8.015	8.003	7.992	8.000	8.008	7.994	7.993	8.005	7.992	7.995

sample no.	M28																	
					←													
point no.	2	3	4	5	8	9	11	12	13	31	32	33	34	35	37	38	39	40
SiO2	37.73	37.86	37.67	37.53	37.73	37.72	37.45	37.63	37.78	37.26	37.51	37.07	37.25	37.11	36.87	36.97	36.90	36.63
TiO2	0.05	0.07	0.10	0.08	0.10	0.11	0.09	0.14	0.13	0.09	0.15	0.17	0.18	0.21	0.18	0.24	0.22	0.22
Al2O3	20.26	20.55	20.37	20.25	20.15	20.04	20.07	20.03	19.89	19.89	19.92	19.75	19.87	19.69	19.51	19.92	19.93	19.81
FeO※	30.55	30.11	30.03	30.59	29.65	29.92	30.45	30.37	30.44	19.50	17.22	14.62	14.42	13.75	13.00	12.97	12.80	12.75
MnO	0.56	0.58	0.60	0.69	0.83	0.76	1.02	1.02	1.04	9.14	12.85	15.95	16.57	17.89	18.83	19.15	19.50	19.82
MgO	2.02	2.05	2.08	2.05	1.83	1.66	1.79	1.66	1.63	0.42	0.45	0.38	0.40	0.37	0.37	0.37	0.33	0.33
CaO	8.40	8.44	8.57	8.15	8.91	8.86	8.24	8.30	8.39	12.73	12.04	11.10	10.86	10.94	10.47	9.98	10.19	9.95
Total	99.56	99.66	99.43	99.33	99.20	99.07	99.11	99.15	99.29	99.03	100.13	99.04	99.55	99.95	99.23	99.61	99.86	99.50
Element O=12																		
Si	3.030	3.028	3.023	3.023	3.037	3.044	3.028	3.039	3.048	3.016	3.013	3.015	3.015	3.001	3.007	3.000	2.991	2.985
Ti	0.003	0.005	0.006	0.005	0.006	0.007	0.005	0.009	0.008	0.006	0.009	0.010	0.011	0.013	0.011	0.015	0.013	0.013
Al	1.917	1.938	1.927	1.922	1.912	1.906	1.913	1.906	1.892	1.898	1.887	1.893	1.895	1.877	1.875	1.905	1.904	1.903
Fe	2.051	2.014	2.016	2.061	1.996	2.019	2.060	2.051	2.054	1.320	1.157	0.995	0.976	0.930	0.886	0.880	0.868	0.869
Mn	0.038	0.039	0.041	0.047	0.057	0.052	0.070	0.070	0.071	0.627	0.874	1.099	1.136	1.226	1.301	1.316	1.339	1.368
Mg	0.242	0.245	0.249	0.246	0.219	0.200	0.215	0.199	0.196	0.051	0.054	0.046	0.049	0.044	0.045	0.045	0.040	0.040
Ca	0.722	0.723	0.737	0.704	0.769	0.766	0.714	0.718	0.725	1.105	1.036	0.967	0.942	0.948	0.915	0.867	0.885	0.869
Total	8.003	7.992	8.000	8.008	7.994	7.993	8.005	7.992	7.995	8.022	8.030	8.024	8.022	8.038	8.041	8.029	8.039	8.047

sample no.		
		core
point no.	41	43
SiO2	36.68	36.90
TiO2	0.26	0.22
Al2O3	19.48	19.76
FeO※	12.57	12.28
MnO	19.71	20.24
MgO	0.35	0.30
CaO	10.00	9.64
Total	99.06	99.34
Element O=12		
Si	3.001	3.005
Ti	0.016	0.013
Al	1.878	1.897
Fe	0.860	0.836
Mn	1.366	1.397
Mg	0.043	0.037
Ca	0.877	0.841
Total	8.040	8.026

※Total Fe as FeO ※im: intermediate parts between core and rim

Table5. Major and trace element compositions of the garnets from the albite-biotite zone (lower)

	M14						M107										
	core			→		rim	rim					←					core
Element	1	3	5	6	7	9	3	4	5	7	8	9	10	11	12	13	14
SiO2	36.64	36.81	37.52	37.70	37.46	37.23	36.35	36.30	36.63	36.64	36.50	36.72	36.53	36.63	36.61	36.59	36.76
TiO2	0.08	0.08	0.07	0.04	0.09	0.03	0.084	0.004	0.10	0.08	0.08	0.10	0.12	0.08	0.07	0.07	0.08
Al2O3	20.12	20.04	20.16	20.01	20.18	19.83	20.39	20.48	20.43	20.52	20.31	20.52	20.41	20.49	20.37	20.59	20.36
FeO※	22.81	23.17	30.03	29.49	31.27	32.27	31.30	31.19	30.14	26.88	24.09	24.73	24.93	27.62	26.70	26.47	26.68
MnO	14.03	13.77	3.28	2.67	1.22	1.32	0.48	0.90	1.26	2.60	9.21	8.76	8.21	7.18	7.84	8.10	8.71
MgO	0.52	0.55	0.68	0.83	1.26	1.40	1.18	1.06	0.89	0.66	0.47	0.47	0.45	0.42	0.41	0.47	0.46
CaO	5.43	5.58	9.12	9.24	8.84	7.16	8.76	8.82	9.05	11.12	7.68	7.92	7.89	6.94	7.01	6.50	5.73
Na2O	0.112	0.057	0.022	0.018	0.022	0.035	0.01	0.01	0.012	0.012	0.032	0.026	0.038	0.015	0.037	0.064	0.098
Cr2O3							0.005	0.000	0.000	0.005	0.005	0.001	0.005	0.005	0.002	0.004	0.002
V2O3							0.007	0.010	0.012	0.009	0.006	0.006	0.003	0.011	0.005	0.004	0.007
Sc2O3							0.011	0.009	0.005	0.015	0.020	0.018	0.015	0.013	0.020	0.023	0.022
Y2O3	0.299	0.249	0.020	0.003	0.061	0.072	0.015	0.023	0.013	0.019	0.068	0.061	0.076	0.016	0.069	0.148	0.202
Er2O3	0.068	0.045	0.020	0.016	0.019	0.021	0.015	0.023	0.015	0.015	0.022	0.022	0.019	0.018	0.024	0.053	0.072
Yb2O3	0.043	0.021	0.003	0.001	0.000	0.001	0.002	0.001	0.000	0.001	0.006	0.011	0.010	0.000	0.020	0.051	0.066
Total	100.15	100.37	100.93	100.02	100.42	99.37	98.61	98.83	98.56	98.57	98.49	99.36	98.70	99.43	99.19	99.14	99.25
Element O=12																	
Si	2.993	2.999	3.011	3.038	3.010	3.028	2.974	2.968	2.993	2.984	2.999	2.992	2.994	2.992	2.997	2.995	3.011
Ti	0.005	0.005	0.004	0.002	0.005	0.002	0.005	0.000	0.006	0.005	0.005	0.006	0.007	0.005	0.004	0.004	0.005
Al	1.937	1.924	1.907	1.900	1.911	1.901	1.966	1.974	1.967	1.970	1.967	1.971	1.972	1.973	1.966	1.986	1.966
Fe	1.558	1.579	2.016	1.987	2.101	2.195	2.142	2.133	2.059	1.831	1.656	1.685	1.709	1.887	1.828	1.812	1.827
Mn	0.971	0.950	0.223	0.182	0.083	0.091	0.033	0.062	0.087	0.179	0.641	0.605	0.570	0.497	0.544	0.562	0.604
Mg	0.063	0.067	0.081	0.100	0.151	0.170	0.144	0.129	0.108	0.080	0.058	0.057	0.055	0.051	0.050	0.057	0.056
Ca	0.475	0.487	0.784	0.798	0.761	0.624	0.768	0.773	0.792	0.970	0.676	0.691	0.693	0.607	0.615	0.570	0.503
Na	0.018	0.009	0.003	0.003	0.003	0.006	0.002	0.001	0.002	0.002	0.005	0.004	0.006	0.002	0.006	0.010	0.016
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
V	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Sc	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002
Y	0.013	0.011	0.001	0.000	0.003	0.003	0.001	0.001	0.001	0.001	0.003	0.003	0.003	0.001	0.003	0.006	0.009
Er	0.002	0.001	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.001	0.001	0.000	0.000	0.001	0.001	0.002
Yb	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002
Total	8.035	8.032	8.032	8.011	8.029	8.020	8.037	8.044	8.017	8.025	8.012	8.016	8.013	8.017	8.016	8.007	8.002

※ Total Fe as FeO ※im: intermediate parts between core and rim

Table6. Major and trace element compositions of the garnets from the albite-biotite zone (upper).

sample no.	M33				M34								M36				
	core	→		rim	core			→				rim			rim		
point no.	1	2	3	5	2	3	4	6	7	8	9	10	1	5	21	22	24
SiO2	36.82	36.31	36.99	37.67	36.97	36.99	37.22	37.53	37.54	37.71	36.83	36.74	37.17	37.77	37.97	37.72	37.99
TiO2	0.13	0.15	0.19	0.11	0.15	0.23	0.16	0.12	0.09	0.07	0.12	0.06	0.21	0.11	0.09	0.13	0.08
Al2O3	20.35	20.10	20.07	20.58	20.40	20.24	20.37	20.70	20.52	20.25	20.40	20.31	19.98	20.32	20.84	20.91	20.76
FeO※	18.31	18.34	18.14	31.30	17.77	17.98	17.31	27.18	29.48	31.19	30.89	30.92	17.84	31.80	29.67	27.53	23.38
MnO	18.36	17.46	18.07	1.03	16.64	16.41	15.02	4.76	1.34	0.85	0.37	0.25	17.12	1.04	0.54	2.62	6.33
MgO	0.31	0.34	0.31	1.50	0.29	0.28	0.37	0.81	0.96	1.51	2.01	2.04	0.30	1.55	1.26	0.67	0.51
CaO	5.55	5.83	6.03	8.61	7.26	8.33	9.96	9.60	10.22	8.27	7.96	8.24	7.89	7.79	10.01	11.31	11.61
Na2O	0.156	0.156	0.096	0.031	0.091	0.027	0.028	0.034	0.022	0.031	0.012	0.026	0.031	0.044	0.022	0.029	0.025
Cr2O3	0.007	0.004	0.007	0.006	0.006	0.005	0.005	0.006	0.007	0.004	0.007	0.008	0.006	0.00	0.008	0.009	0.007
V2O3	0.009	0.008	0.010	0.008	0.007	0.013	0.014	0.015	0.007	0.005	0.007	0.007	0.011	0.01	0.006	0.007	0.003
Sc2O3	0.012	0.017	0.010	0.016	0.018	0.030	0.011	0.010	0.011	0.007	0.006	0.002	0.048	0.02			
Y2O3	0.489	0.476	0.495	0.054	0.180	0.077	0.136	0.045	0.046	0.018	0.038	0.000	0.098	0.09	0.015	0.035	0.052
Er2O3	0.119	0.099	0.093	0.021	0.072	0.030	0.031	0.026	0.027	0.017	0.024	0.016	0.031	0.03	0.020	0.019	0.022
Yb2O3	0.272	0.215	0.112	0.000	0.200	0.028	0.028	0.010	0.004	0.006	0.002	0.000	0.048	0.01	0.002	0.004	0.016
Total	100.89	99.50	100.62	100.94	100.05	100.67	100.66	100.85	100.27	99.94	98.67	98.61	100.78	100.57	100.45	100.99	100.79
Element O=12																	
Si	2.989	2.985	3.004	3.003	3.002	2.988	2.991	2.998	3.008	3.030	2.993	2.990	3.003	3.023	3.020	2.997	3.019
Ti	0.008	0.009	0.011	0.007	0.009	0.014	0.010	0.007	0.005	0.004	0.007	0.003	0.013	0.007	0.005	0.008	0.005
Al	1.947	1.948	1.921	1.934	1.952	1.927	1.930	1.949	1.938	1.918	1.954	1.948	1.903	1.917	1.954	1.958	1.944
Fe	1.243	1.261	1.232	2.087	1.207	1.215	1.163	1.816	1.976	2.096	2.100	2.104	1.205	2.129	1.974	1.829	1.554
Mn	1.262	1.216	1.243	0.070	1.144	1.123	1.022	0.322	0.091	0.058	0.025	0.017	1.172	0.071	0.036	0.176	0.426
Mg	0.037	0.042	0.038	0.178	0.035	0.034	0.044	0.096	0.115	0.181	0.243	0.247	0.036	0.185	0.149	0.079	0.060
Ca	0.483	0.514	0.525	0.735	0.632	0.721	0.858	0.822	0.877	0.712	0.693	0.718	0.683	0.668	0.853	0.963	0.989
Na	0.025	0.025	0.015	0.005	0.014	0.004	0.004	0.005	0.003	0.005	0.002	0.004	0.005	0.007	0.003	0.004	0.004
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.001	0.000
V	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Sc	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.003	0.001			
Y	0.021	0.021	0.021	0.002	0.008	0.003	0.006	0.002	0.002	0.001	0.002	0.000	0.004	0.004	0.001	0.001	0.002
Er	0.003	0.003	0.002	0.001	0.002	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.000	0.000	0.001
Yb	0.007	0.005	0.003	0.000	0.005	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Total	8.026	8.029	8.017	8.023	8.012	8.033	8.032	8.020	8.017	8.007	8.022	8.034	8.030	8.012	7.998	8.017	8.004

※ Total Fe as FeO ※im: intermediate parts between core and rim

Table6. (Continued)

sample no.	M37																
										rim		rim					
point no.	25	26	27	31	32	33	34	35	36	37	5	2	7	8	10	11	12
SiO2	37.27	37.24	37.23	36.97	36.84	37.07	37.58	37.50	37.64	37.49	37.47	38.74	38.51	37.86	38.38	38.24	37.84
TiO2	0.10	0.18	0.16	0.18	0.16	0.18	0.09	0.18	0.11	0.10	0.11	0.10	0.14	0.12	0.11	0.12	0.17
Al2O3	20.44	20.48	20.49	20.34	20.45	20.40	20.37	20.16	20.54	20.60	20.71	21.37	21.00	20.85	20.75	20.77	20.52
FeO※	18.25	17.71	17.52	17.33	17.71	18.52	22.32	25.75	29.12	30.84	23.68	29.71	27.47	27.01	22.76	18.17	16.18
MnO	14.86	16.99	17.98	17.82	17.34	15.81	6.25	4.58	0.59	0.53	5.89	0.31	1.50	1.84	4.77	12.73	17.50
MgO	0.37	0.38	0.49	0.46	0.39	0.44	0.47	0.47	1.09	1.40	0.48	1.70	0.84	0.79	0.48	0.39	0.25
CaO	8.40	7.43	6.78	6.96	7.36	7.81	12.57	11.11	10.87	8.87	12.43	8.93	11.18	10.95	12.41	9.61	7.50
Na2O	0.068	0.047	0.062	0.052	0.048	0.043	0.035	0.028	0.018	0.020	0.026	0.020	0.019	0.022	0.021	0.041	0.035
Cr2O3	0.004	0.007	0.002	0.004	0.005	0.004	0.008	0.006	0.009	0.007	0.006	0.008	0.011	0.006	0.014	0.011	0.012
V2O3	0.008	0.005	0.004	0.006	0.009	0.008	0.007	0.008	0.007	0.006	0.008	0.007	0.009	0.010	0.014	0.011	0.018
Sc2O3																	
Y2O3	0.275	0.178	0.170	0.179	0.175	0.290	0.067	0.024	0.000	0.010	0.037	0.000	0.000	0.012	0.018	0.186	0.235
Er2O3	0.047	0.047	0.040	0.043	0.042	0.057	0.027	0.020	0.012	0.016	0.017	0.018	0.014	0.014	0.022	0.037	0.037
Yb2O3	0.038	0.045	0.051	0.055	0.046	0.033	0.020	0.001	0.001	0.001	0.011	0.000	0.000	0.007	0.014	0.033	0.044
Total	100.13	100.74	100.98	100.40	100.58	100.67	99.81	99.84	100.01	99.89	100.87	100.92	100.69	99.49	99.76	100.34	100.34
Element O=12																	
Si	3.010	3.000	2.997	2.994	2.981	2.991	3.015	3.020	3.013	3.011	2.985	3.045	3.043	3.031	3.055	3.049	3.042
Ti	0.006	0.011	0.010	0.011	0.010	0.011	0.005	0.011	0.007	0.006	0.006	0.006	0.008	0.007	0.006	0.007	0.010
Al	1.946	1.945	1.944	1.942	1.951	1.940	1.926	1.914	1.938	1.950	1.945	1.980	1.956	1.968	1.947	1.952	1.944
Fe	1.233	1.193	1.180	1.174	1.199	1.250	1.498	1.734	1.949	2.071	1.578	1.953	1.815	1.809	1.515	1.212	1.088
Mn	1.017	1.160	1.226	1.223	1.189	1.081	0.425	0.312	0.040	0.036	0.397	0.021	0.100	0.125	0.322	0.860	1.192
Mg	0.045	0.046	0.059	0.055	0.047	0.053	0.056	0.056	0.130	0.167	0.057	0.199	0.099	0.094	0.057	0.046	0.030
Ca	0.727	0.641	0.585	0.604	0.638	0.675	1.081	0.959	0.932	0.763	1.061	0.752	0.946	0.939	1.058	0.821	0.646
Na	0.011	0.007	0.010	0.008	0.008	0.007	0.005	0.004	0.003	0.003	0.004	0.003	0.003	0.003	0.003	0.006	0.005
Cr	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.001
V	0.001	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.001
Sc																	
Y	0.012	0.008	0.007	0.008	0.008	0.012	0.003	0.001	0.000	0.000	0.002	0.000	0.000	0.001	0.001	0.008	0.010
Er	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001
Yb	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
Total	8.009	8.014	8.021	8.022	8.032	8.023	8.017	8.013	8.013	8.009	8.037	7.960	7.972	7.979	7.966	7.965	7.971

sample no.	M40																
									rim	core		→				rim	
point no.	13	14	15	16	17	18	20	21	23	1	-2	7	8	9	10	11	12
SiO2	37.61	37.83	38.00	38.04	38.14	38.44	38.36	38.27	38.15	37.18	37.23	37.63	37.23	37.35	37.70	37.06	36.84
TiO2	0.15	0.16	0.15	0.08	0.11	0.12	0.12	0.11	0.10	0.18	0.17	0.13	0.11	0.09	0.09	0.16	0.22
Al2O3	20.62	20.41	20.43	20.43	20.62	20.71	20.68	20.82	20.79	20.54	20.59	20.58	20.45	20.36	20.71	20.24	20.36
FeO※	16.34	16.24	17.10	21.32	24.52	27.52	30.11	30.13	29.82	14.63	13.18	30.80	31.21	30.78	31.51	17.06	14.06
MnO	17.31	17.16	15.41	5.50	3.48	1.10	1.16	1.17	0.24	20.38	18.70	2.08	2.05	1.18	0.66	14.42	19.88
MgO	0.25	0.25	0.30	0.50	0.50	0.90	1.30	1.34	1.73	0.28	0.32	1.12	1.29	1.40	1.69	0.38	0.31
CaO	7.58	7.63	8.33	12.81	12.21	10.91	8.40	8.44	8.53	7.77	10.34	8.50	8.02	8.71	8.17	10.37	8.67
Na2O	0.033	0.041	0.038	0.024	0.021	0.022	0.035	0.043	0.029	0.031	0.033	0.022	0.042	0.017	0.017	0.023	0.029
Cr2O3	0.015	0.011	0.010	0.013	0.003	0.003	0.010	0.009	0.009	0.009	0.010	0.001	0.009	0.009	0.009	0.007	0.010
V2O3	0.018	0.017	0.010	0.011	0.010	0.006	0.008	0.005	0.009	0.010	0.019	0.009	0.008	0.004	0.007	0.017	0.021
Sc2O3										0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.007
Y2O3	0.087	0.221	0.193	0.021	0.016	0.001	0.068	0.104	0.004	0.218	0.162	0.037	0.193	0.041	0.015	0.075	0.158
Er2O3	0.030	0.043	0.029	0.016	0.014	0.016	0.013	0.025	0.016	0.045	0.026	0.018	0.038	0.018	0.024	0.017	0.023
Yb2O3	0.038	0.045	0.031	0.019	0.000	0.000	0.004	0.000	0.000	0.088	0.014	0.002	0.016	0.000	0.000	0.009	0.008
Total	100.08	100.06	100.03	98.78	99.64	99.75	100.27	100.47	99.43	101.37	100.80	100.94	100.67	99.97	100.61	99.85	100.59
Element O=12																	
Si	3.031	3.048	3.054	3.056	3.046	3.061	3.055	3.043	3.049	2.984	2.983	3.006	2.991	3.007	3.008	2.996	2.976
Ti	0.009	0.010	0.009	0.005	0.006	0.007	0.007	0.007	0.006	0.011	0.010	0.008	0.006	0.005	0.005	0.010	0.013
Al	1.959	1.938	1.935	1.935	1.941	1.944	1.941	1.951	1.959	1.943	1.945	1.938	1.936	1.932	1.948	1.929	1.938
Fe	1.101	1.094	1.149	1.433	1.638	1.833	2.005	2.004	1.993	0.982	0.883	2.058	2.097	2.072	2.103	1.153	0.950
Mn	1.182	1.171	1.049	0.374	0.235	0.074	0.078	0.079	0.016	1.386	1.269	0.141	0.139	0.080	0.045	0.987	1.360
Mg	0.030	0.030	0.036	0.060	0.059	0.107	0.154	0.159	0.206	0.033	0.038	0.133	0.154	0.168	0.201	0.046	0.037
Ca	0.655	0.659	0.717	1.103	1.045	0.931	0.717	0.719	0.731	0.668	0.888	0.728	0.690	0.751	0.698	0.898	0.750
Na	0.005	0.006	0.006	0.004	0.003	0.003	0.005	0.007	0.004	0.005	0.005	0.003	0.007	0.003	0.003	0.004	0.005
Cr	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.000	0.001
V	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.001	0.001
Sc										0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.000
Y	0.004	0.009	0.008	0.001	0.001	0.000	0.003	0.004	0.000	0.009	0.007	0.002	0.008	0.002	0.001	0.003	0.007
Er	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.001	0.000	0.001	0.000	0.001
Yb	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	7.979	7.970	7.967	7.972	7.977	7.961	7.968	7.975	7.967	8.028	8.032	8.018	8.032	8.022	8.013	8.029	8.039

※ Total Fe as FeO ※im: intermediate parts between core and rim

Table6. (Continued)

sample no.				M44						
		im	im	core	→		rim	im	im	im
point no.	13	55	56	8	9	10	13	1	2	3
SiO2	36.97	38.31	38.13	35.90	36.79	36.92	37.21	37.09	36.95	36.87
TiO2	0.11	0.26	0.17	0.09	0.14	0.14	0.11	0.52	0.15	0.17
Al2O3	20.23	20.69	20.77	19.64	20.17	20.25	20.14	19.95	19.89	20.00
FeO※	31.28	13.92	13.81	16.55	18.94	18.41	30.17	19.04	17.46	18.00
MnO	2.03	18.68	18.76	22.52	14.96	16.08	1.13	16.44	16.89	16.26
MgO	1.25	0.28	0.26	0.25	0.32	0.27	1.24	0.47	0.28	0.35
CaO	8.10	8.41	8.26	3.87	8.08	7.73	8.60	7.00	8.07	8.29
Na2O	0.065	0.031	0.033	0.026	0.025	0.024	0.020	0.047	0.025	0.027
Cr2O3	0.011	0.009	0.007	0.007	0.016	0.012	0.006	0.008	0.009	0.012
V2O3	0.012	0.014	0.013	0.011	0.011	0.010	0.009	0.012	0.012	0.013
Sc2O3	0.012			0.011	0.025	0.029	0.019	0.016	0.030	0.019
Y2O3	0.173	0.221	0.246	0.182	0.168	0.168	0.092	0.156	0.154	0.132
Er2O3	0.041	0.034	0.039	0.052	0.032	0.025	0.032	0.050	0.035	0.027
Yb2O3	0.014	0.020	0.044	0.183	0.018	0.015	0.004	0.163	0.023	0.018
Total	100.30	100.88	100.54	99.29	99.70	100.09	98.79	100.96	99.98	100.19
Element O=12										
Si	2.986	3.050	3.046	2.983	2.996	2.998	3.025	2.995	3.006	2.994
Ti	0.007	0.016	0.010	0.005	0.009	0.009	0.007	0.031	0.009	0.010
Al	1.926	1.941	1.956	1.924	1.936	1.938	1.930	1.899	1.907	1.914
Fe	2.113	0.927	0.923	1.150	1.290	1.250	2.051	1.286	1.188	1.222
Mn	0.139	1.260	1.270	1.585	1.032	1.106	0.078	1.125	1.164	1.118
Mg	0.150	0.033	0.031	0.031	0.039	0.033	0.150	0.057	0.034	0.042
Ca	0.701	0.717	0.707	0.345	0.705	0.672	0.749	0.606	0.703	0.721
Na	0.010	0.005	0.005	0.004	0.004	0.004	0.003	0.007	0.004	0.004
Cr	0.001	0.001	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.001
V	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sc	0.001			0.001	0.002	0.002	0.001	0.001	0.002	0.001
Y	0.007	0.009	0.010	0.008	0.007	0.007	0.004	0.007	0.007	0.006
Er	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Yb	0.000	0.000	0.001	0.005	0.000	0.000	0.000	0.004	0.001	0.000
Total	8.044	7.960	7.961	8.044	8.023	8.021	8.001	8.020	8.027	8.036

Table7. Major and trace element compositions of the garnets from the oligoclase-biotite zone.

sample no.	M25																	
	rim									←							core	
point no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19
SiO2	38.16	38.37	38.27	38.21	38.31	38.23	38.07	38.11	38.15	37.94	37.88	37.73	37.69	37.76	37.55	37.79	37.87	37.89
TiO2	0.12	0.13	0.10	0.15	0.13	0.13	0.11	0.09	0.19	0.17	0.18	0.16	0.23	0.22	0.19	0.19	0.19	0.20
Al2O3	20.80	20.69	20.70	20.83	20.83	20.54	20.75	20.64	20.54	20.65	20.44	20.4	20.28	20.56	20.42	20.52	20.45	20.51
FeO※	30.80	30.53	30.88	30.17	30.05	27.15	25.16	22.49	15.64	15.39	14.93	14.91	14.91	15.63	15.38	15.61	14.91	15.2
MnO	0.37	0.29	0.73	0.97	0.96	1.05	4.42	6.29	14.59	16.23	16.66	17.25	17.46	17.59	17.55	16.07	17.72	16.15
MgO	2.37	2.04	1.75	1.61	1.54	1.20	1.05	0.63	0.58	0.47	0.46	0.41	0.41	0.35	0.37	0.58	0.44	0.49
CaO	7.82	8.50	8.17	8.87	9.04	11.77	10.77	12.00	10.79	9.75	9.69	9.59	9.26	8.64	8.72	9.33	9.17	10.05
Na2O	0.030	0.027	0.057	0.029	0.033	0.022	0.039	0.022	0.016	0.028	0.030	0.029	0.028	0.029	0.030	0.037	0.032	0.024
Cr2O3	0.010	0.011	0.015	0.012	0.012	0.008	0.009	0.011	0.007	0.009	0.007	0.008	0.010	0.014	0.010	0.010	0.013	0.008
V2O3	0.008	0.004	0.008	0.007	0.010	0.011	0.011	0.012	0.011	0.016	0.021	0.018	0.020	0.015	0.012	0.017	0.015	0.014
Sc2O3																		
Y2O3	0.006	0.000	0.152	0.056	0.013	0.014	0.050	0.036	0.005	0.057	0.145	0.131	0.113	0.142	0.135	0.121	0.118	0.035
Er2O3	0.009	0.018	0.029	0.024	0.017	0.013	0.013	0.024	0.013	0.017	0.030	0.023	0.020	0.020	0.026	0.022	0.026	0.015
Yb2O3	0.003	0.000	0.018	0.005	0.000	0.000	0.000	0.010	0.000	0.002	0.010	0.010	0.005	0.013	0.010	0.010	0.013	0.004
Total	100.50	100.61	100.88	100.94	100.94	100.13	100.45	100.37	100.54	100.73	100.48	100.67	100.44	100.98	100.40	100.31	100.96	100.59
Element O=12																		
Si	3.026	3.039	3.035	3.026	3.032	3.038	3.026	3.031	3.035	3.025	3.030	3.020	3.024	3.018	3.018	3.026	3.023	3.025
Ti	0.007	0.008	0.006	0.009	0.008	0.008	0.007	0.006	0.012	0.010	0.011	0.010	0.014	0.013	0.011	0.012	0.011	0.012
Al	1.944	1.932	1.935	1.944	1.943	1.924	1.944	1.935	1.926	1.940	1.927	1.925	1.918	1.937	1.935	1.937	1.924	1.930
Fe	2.043	2.023	2.048	1.998	1.989	1.804	1.672	1.496	1.041	1.026	0.999	0.998	1.001	1.045	1.034	1.045	0.995	1.015
Mn	0.025	0.019	0.049	0.065	0.064	0.071	0.298	0.424	0.983	1.096	1.129	1.170	1.187	1.191	1.195	1.090	1.198	1.092
Mg	0.280	0.241	0.207	0.190	0.182	0.142	0.124	0.075	0.069	0.056	0.055	0.049	0.049	0.042	0.044	0.069	0.052	0.058
Ca	0.665	0.721	0.694	0.753	0.767	1.002	0.917	1.023	0.920	0.833	0.830	0.823	0.796	0.740	0.751	0.801	0.784	0.860
Na	0.005	0.004	0.009	0.004	0.005	0.003	0.006	0.003	0.002	0.004	0.005	0.005	0.004	0.004	0.005	0.006	0.005	0.004
Cr	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001
V	0.001	0.000	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sc																		
Y	0.000	0.000	0.006	0.002	0.001	0.001	0.002	0.002	0.000	0.002	0.006	0.006	0.005	0.006	0.006	0.005	0.005	0.001
Er	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
Yb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	7.996	7.988	7.992	7.993	7.991	7.994	7.997	7.996	7.990	7.995	7.994	8.006	8.001	7.998	8.001	7.993	8.002	7.999

※ Total Fe as FeO ※im: intermediate parts between core and rim

Table7. (Continued)

sample no.							M28											
		→					rim	core	im	im	core						im	im	
point no.	20	21	22	23	27	28	29	16	17	25	2	3	4	5	6	7	8	9
SiO2	38.04	38.23	38.18	38.41	38.18	38.46	38.28	38.09	38.02	38.55	36.76	37.52	37.36	37.51	37.36	37.16	37.05	37.37
TiO2	0.20	0.11	0.12	0.13	0.10	0.10	0.09	0.28	0.24	0.11	0.24	0.15	0.11	0.13	0.14	0.09	0.09	0.10
Al2O3	20.57	20.4	20.35	20.66	20.82	20.82	20.53	20.44	20.75	20.85	20.51	20.78	20.79	20.79	20.64	20.81	20.57	20.71
FeO※	15.42	20.8	25.86	27.76	30.36	29.65	30.83	11.52	12.32	29.96	12.46	19.33	25.41	27.25	29.92	30.56	30.92	31.01
MnO	15.13	7.7	4.09	0.97	0.26	0.99	0.9	20.48	18.95	1.30	20.95	8.41	5.23	1.90	2.05	2.24	2.24	2.12
MgO	0.59	0.56	0.75	0.98	2.36	1.99	1.79	0.29	0.36	1.65	0.28	0.43	0.76	0.96	1.30	1.36	1.41	1.40
CaO	10.43	12.48	11.13	11.93	8.12	8.57	8.03	9.17	9.73	8.31	8.90	13.70	11.09	11.97	8.96	7.73	7.96	7.95
Na2O	0.016	0.024	0.035	0.024	0.019	0.039	0.044	0.040	0.022	0.017	0.041	0.013	0.022	0.015	0.026	0.110	0.106	0.026
Cr2O3	0.009	0.013	0.011	0.011	0.000	0.015	0.016	0.013	0.015	0.020	0.018	0.019	0.020	0.010	0.017	0.020	0.017	0.000
V2O3	0.009	0.015	0.012	0.005	0.007	0.009	0.007	0.015	0.018	0.005	0.016	0.019	0.013	0.011	0.009	0.008	0.006	0.005
Sc2O3																		
Y2O3	0.009	0.032	0.047	0.011	0.000	0.137	0.130	0.264	0.138	0.018	0.225	0.009	0.025	0.002	0.029	0.342	0.317	0.019
Er2O3	0.007	0.020	0.018	0.015	0.017	0.024	0.033	0.058	0.022	0.022	0.049	0.015	0.024	0.013	0.020	0.076	0.074	0.016
Yb2O3	0.000	0.010	0.000	0.006	0.001	0.006	0.015	0.098	0.020	0.004	0.078	0.010	0.012	0.010	0.000	0.075	0.077	0.001
Total	100.43	100.39	100.61	100.91	100.24	100.81	100.70	100.76	100.60	100.81	100.53	100.40	100.86	100.57	100.47	100.58	100.84	100.73
Element O=12																		
Si	3.032	3.040	3.039	3.035	3.031	3.039	3.042	3.040	3.030	3.049	2.969	2.988	2.980	2.987	2.993	2.983	2.975	2.992
Ti	0.012	0.007	0.007	0.008	0.006	0.006	0.005	0.017	0.014	0.006	0.015	0.009	0.006	0.008	0.008	0.005	0.006	0.006
Al	1.932	1.912	1.909	1.924	1.948	1.939	1.923	1.923	1.949	1.944	1.952	1.950	1.955	1.952	1.949	1.969	1.947	1.954
Fe	1.028	1.383	1.721	1.834	2.015	1.960	2.049	0.769	0.821	1.982	0.842	1.287	1.695	1.815	2.004	2.052	2.076	2.076
Mn	1.021	0.519	0.276	0.065	0.017	0.066	0.061	1.385	1.279	0.087	1.433	0.567	0.353	0.128	0.139	0.152	0.152	0.144
Mg	0.070	0.066	0.089	0.115	0.279	0.234	0.212	0.034	0.043	0.194	0.034	0.051	0.090	0.114	0.155	0.163	0.169	0.167
Ca	0.891	1.063	0.949	1.010	0.691	0.726	0.684	0.784	0.831	0.704	0.770	1.169	0.948	1.021	0.769	0.665	0.685	0.682
Na	0.002	0.004	0.005	0.004	0.003	0.006	0.007	0.006	0.003	0.003	0.006	0.002	0.003	0.002	0.004	0.017	0.017	0.004
Cr	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
V	0.001	0.001	0.001	0.000	0.000	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
Sc																		
Y	0.000	0.001	0.002	0.000	0.000	0.006	0.005	0.011	0.006	0.001	0.010	0.000	0.001	0.000	0.001	0.015	0.014	0.001
Er	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.001	0.002	0.002	0.000
Yb	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.002	0.002	0.000
Total	7.990	7.997	8.000	7.997	7.991	7.984	7.990	7.976	7.979	7.972	8.036	8.027	8.036	8.029	8.025	8.026	8.045	8.026

						M29						M30					M31		
						core	im	rim	core	im	rim	core	core	im	im	core	im	im	
	10	4	5	6	7	1	2	5	2.1	2.2	2.6	1	2	3	4	1	2	4
SiO2	37.42	37.19	37.06	37.71	37.70	36.68	37.15	37.49	37.11	37.19	37.65	35.90	36.22	36.74	37.12	36.78	36.91	37.51
TiO2	0.17	0.79	0.24	0.21	0.15	0.26	0.10	0.10	0.19	0.12	0.11	0.17	0.14	0.10	0.10	0.21	0.09	0.11
Al2O3	20.75	19.61	19.95	20.28	20.05	19.88	19.86	20.07	19.67	19.82	20.18	20.01	19.89	20.21	20.49	19.90	20.34	20.42
FeO※	15.71	12.87	13.13	14.15	18.48	17.59	18.93	31.79	17.53	18.24	31.63	18.25	18.30	21.87	31.29	16.67	20.95	30.54
MnO	14.61	20.25	19.54	18.19	10.35	17.25	13.71	0.99	17.23	14.69	0.94	17.20	16.78	11.42	0.98	16.84	13.01	1.04
MgO	0.39	0.36	0.34	0.37	0.44	0.25	0.31	1.31	0.24	0.30	1.35	0.29	0.28	0.49	1.45	0.22	0.39	1.37
CaO	11.76	9.71	10.27	10.73	13.10	7.63	9.26	8.18	8.07	8.86	8.19	6.35	6.00	8.24	7.85	9.01	8.08	8.45
Na2O	0.022	0.028	0.023	0.015	0.015	0.039	0.059	0.036	0.026	0.064	0.024	0.109	0.144	0.037	0.044	0.029	0.064	0.035
Cr2O3	0.020					0.010	0.012	0.011	0.009	0.007	0.008	0.007	0.007	0.010	0.007	0.001	0.007	0.009
V2O3	0.019					0.015	0.013	0.006	0.013	0.010	0.008	0.010	0.009	0.012	0.007	0.011	0.012	0.007
Sc2O3						0.020	0.016	0.008	0.029	0.025	0.011	0.021	0.023	0.015	0.012	0.018	0.014	0.014
Y2O3	0.020	0.161	0.066	0.024	0.160	0.123	0.258	0.114	0.131	0.334	0.124	0.403	0.433	0.181	0.165	0.076	0.295	0.119
Er2O3	0.007	0.033	0.021	0.015	0.030	0.033	0.064	0.025	0.040	0.067	0.028	0.093	0.106	0.034	0.025	0.014	0.061	0.034
Yb2O3	0.010	0.025	0.005	0.007	0.034	0.034	0.094	0.011	0.046	0.068	0.008	0.190	0.262	0.018	0.001	0.004	0.054	0.006
Total	100.90	101.03	100.65	101.70	100.51	99.82	99.84	100.14	100.33	99.80	100.27	99.00	98.59	99.38	99.54	99.79	100.27	99.66
Element O=12																		
Si	2.982	2.990	2.987	2.998	3.013	2.994	3.017	3.021	3.014	3.022	3.025	2.969	3.000	2.996	3.001	2.995	2.991	3.021
Ti	0.010	0.048	0.015	0.013	0.009	0.016	0.006	0.006	0.011	0.007	0.007	0.011	0.008	0.006	0.006	0.013	0.005	0.006
Al	1.949	1.858	1.895	1.901	1.889	1.913	1.901	1.906	1.883	1.898	1.911	1.950	1.942	1.943	1.953	1.910	1.943	1.939
Fe	1.047	0.865	0.885	0.941	1.235	1.201	1.286	2.142	1.191	1.239	2.125	1.262	1.268	1.492	2.116	1.135	1.420	2.057
Mn	0.986	1.379	1.334	1.225	0.701	1.193	0.943	0.068	1.185	1.011	0.064	1.205	1.177	0.789	0.067	1.161	0.893	0.071
Mg	0.046	0.043	0.041	0.044	0.052	0.030	0.037	0.157	0.029	0.036	0.162	0.036	0.035	0.060	0.175	0.027	0.047	0.164
Ca	1.004	0.836	0.887	0.914	1.122	0.667	0.806	0.706	0.702	0.771	0.705	0.563	0.532	0.720	0.680	0.786	0.702	0.729
Na	0.003	0.004	0.004	0.002	0.002	0.006	0.009	0.006	0.004	0.010	0.004	0.017	0.023	0.006	0.007	0.005	0.010	0.005
Cr	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.001
V	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.000
Sc						0.001	0.001	0.001	0.002	0.002	0.001	0.002	0.002	0.001	0.001	0.001	0.001	0.001
Y	0.001	0.007	0.003	0.001	0.007	0.005	0.011	0.005	0.006	0.014	0.005	0.018	0.019	0.008	0.007	0.003	0.013	0.005
Er	0.000	0.001	0.001	0.000	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.002	0.003	0.001	0.001	0.000	0.002	0.001
Yb	0.000	0.001	0.000	0.000	0.001	0.001	0.002	0.000	0.001	0.002	0.000	0.005	0.007	0.000	0.000	0.000	0.001	0.000
Total	8.033	8.032	8.051	8.039	8.031	8.031	8.023	8.019	8.030	8.016	8.011	8.040	8.017	8.023	8.015	8.037	8.028	8.002

※ Total Fe as FeO ※im: intermediate parts between core and rim

Table7. (Continued)

sample no.							
	im	im	im	core	→		rim
point no.	2.2	2.3	2.4	1	2	3	4
SiO2	38.37	38.27	38.21	36.49	36.83	36.82	37.27
TiO2	0.13	0.10	0.15	0.26	0.19	0.17	0.10
Al2O3	20.69	20.70	20.83	19.96	20.01	20.04	20.38
FeO※	30.53	30.88	30.17	15.98	21.33	21.31	30.64
MnO	0.29	0.73	0.97	19.60	12.30	12.12	1.00
MgO	2.04	1.75	1.61	0.22	0.47	0.45	1.40
CaO	8.50	8.17	8.87	7.10	8.35	8.59	8.42
Na2O	0.031	0.042	0.036	0.066	0.031	0.042	0.036
Cr2O3	0.011	0.011	0.007	0.007	0.011	0.011	0.007
V2O3	0.021	0.019	0.007	0.014	0.021	0.019	0.007
Sc2O3	0.021	0.019	0.012	0.018	0.021	0.019	0.012
Y2O3	0.104	0.092	0.090	0.339	0.104	0.092	0.090
Er2O3	0.025	0.020	0.013	0.063	0.025	0.020	0.013
Yb2O3	0.023	0.009	0.008	0.053	0.023	0.009	0.008
Total	100.78	100.81	100.98	100.17	99.72	99.71	99.38
Element O=12							
Si	3.036	3.036	3.025	2.979	2.998	2.996	3.013
Ti	0.008	0.006	0.009	0.016	0.012	0.010	0.006
Al	1.930	1.935	1.944	1.921	1.920	1.922	1.942
Fe	2.021	2.049	1.998	1.091	1.452	1.450	2.071
Mn	0.019	0.049	0.065	1.355	0.848	0.835	0.068
Mg	0.240	0.207	0.190	0.027	0.057	0.055	0.169
Ca	0.721	0.694	0.752	0.621	0.728	0.749	0.729
Na	0.005	0.006	0.006	0.010	0.005	0.007	0.006
Cr	0.001	0.001	0.000	0.000	0.001	0.001	0.000
V	0.001	0.001	0.000	0.001	0.001	0.001	0.000
Sc	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Y	0.004	0.004	0.004	0.015	0.005	0.004	0.004
Er	0.001	0.000	0.000	0.002	0.001	0.001	0.000
Yb	0.001	0.000	0.000	0.001	0.001	0.000	0.000
Total	7.989	7.990	7.994	8.040	8.029	8.032	8.010

※ Total Fe as FeO ※im: intermediate parts between core and rim