PETROLOGY OF THE YAMATO-74442 CHONDRITE

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Abstract: The Yamato-74442 chondrite (LL) consists of high-K lithic fragments, non-recrystallized lithic fragments, recrystallized lithic fragments, chondrules, mineral fragments and matrix. The microporphyritic texture and the chemical compositions of groundmass of the high-K lithic fragments suggest that they were formed by the melting of a rock consisting mainly of olivine, pyroxenes and K-feldspar, and experienced rapid cooling. Non-recrystallized lithic fragments and chondrules have the same chemical composition as the most ferrous chondrules in the Yamato-74191 chondrite (L3). Recrystallized lithic fragments were produced by the heating up to 1000°C of the same materials as the non-recrystallized lithic fragments. Mineral fragments and matrix were formed by disaggregation of the other units.

1. Introduction

The Yamato-74442 meteorite (YANAI *et al.*, 1978) is a brecciated unequilibrated chondrite. The bulk chemical composition (Table 1) indicates that it belongs to the LL group of VAN SCHMUS and WOOD (1967).

Many brecciated chondrites belonging to LL group are known to be composed of some kinds of lithic fragments, and the chemical compositions of these lithic fragments reported up to date are summarized by FODOR and KEIL (1978). However, no detailed study of their petrochemistry has been undertaken. In this paper, detailed petrochemical data of the 74442 chondrite are presented. The chemical composition of lithic fragments is obtained by the same method as that of IKEDA and TAKEDA (1979) employing an X-ray microanalyzer.

2. General Description

The chondrite is a breccia which is composed of lithic fragments, chondrules, mineral fragments and matrix. The lithic fragments are subdivided into three groups: high-K lithic fragments, non-recrystallized lithic fragments and recrystal-

Table 1. Chemical composition of the Yamato-74442 chondrite.

SiO_2	40.47	$H_2O(-)$	0.00
TiO_2	0.23	$H_2O(+)$	0.58
Al_2O_3	3.63	P_2O_5	0.22
FeO	17.89	FeS	4.84
MnO	0.35	Fe	2.48
MgO	24.95	Ni	0.99
CaO	1.98	Co	0.015
Na_2O	0.94	Cr_2O_3	0.82
K_2O	0.23	Total	100.615

Analyst: H. HARAMURA.

lized lithic fragments, The chondrules and the fragmented chondrule-like objects rarely occur in the 74442 chondrite. The mineral fragments include silicate mineral fragments and opaque mineral fragments. The matrix consists of fine-grained substances less than several microns in diameter.

3. High-K Lithic Fragments

The high-K lithic fragments are angular and show a porphyritic texture. Their size ranges from several tens of microns to about one millimeter in diameter. The lithic fragments are composed of euhedral microphenocrysts of olivine and groundmass. The volume ratios of the groundmass to the microphenocrysts are usually larger than 1. The groundmass is often black to brown devitrified glass, whereas some lithic fragments have transparent brown glass. Small opaque minerals are rarely observed in the groundmass of some lithic fragments, and small needle-like olivine is sometimes observed as quenched crystals.

The chemical composition of microphenocrystic olivine is homogeneous and Fo_{71-73}. The chemical composition of high-K lithic fragments and their groundmass is tabulated in Tables 2 and 3, respectively. Their chemical composition is normalized in such a way that the total weight percent is recalculated to 100 wt.%, and the normalized wt.% of each oxide is plotted against their SiO_2 wt.% in Fig. 1. The data of the high-K lithic fragments in Bhola, Vishnupur and Siena chondrites (FODOR and KEIL, 1978) are plotted together for comparison. The K_2O contents of the groundmass of high-K lithic fragments are very high (2.7 to 5.5 normalized wt.%), whereas the Na_2O contents are not so high. In Fig. 2, the atomic ratios of Ca, Mg and Fe of the groundmass are plotted with the data of coexisting olivine. Although the partition coefficient ($K_d=X_{Fe}^{Ol}X_{Mg}^{Liq}/X_{Mg}^{Ol}X_{Fe}^{Liq}$) of Mg-Fe between silicate melt and coexisting olivine is about 0.3 in high temperature range (ROEDDER and EMSLIE, 1970), K_d between the microphenocrystic olivine and the groundmass of the high-K lithic fragments is close to unity. This means that the phenocrystic olivine grew from the melt corresponding to the groundmass in an unequilibrium condition. The wt.% ratios of SiO_2, MgO and FeO of the microphenocrystic olivine, the groundmass and the bulk lithic fragments are shown in Fig. 3. The chemical composition of groundmass is not plotted in the olivine liquidus field. Then, the microphenocrystic olivine might have grown rapidly in an under-cooling condition.

The atomic ratios of Al, (K+Na) and Ca of high-K lithic fragments and their groundmass are shown in Fig. 4. Their chemical composition is plotted near the line connecting (K+Na)Al and Ca. Therefore, the (K+Na) contents in the groundmass are combined with Al to form alkali feldspar component. The molecular ratios of (Mg+Fe)O, SiO_2 and $(K+Na)O_{0.5}$ of the groundmass and bulk lithic fragments are plotted in Fig. 5, where it is shown that their crystalli-

Table 2. Chemical composition of high-K lithic fragments.

	58	56	106	132	144	52	101	123
SiO_2	40.05	42.87	42.94	43.75	44.17	48.36	45.96	46.48
Al_2O_3	1.69	2.10	1.66	2.07	2.30	2.36	2.42	2.21
TiO_2	0.15	0.22	0.16	0.09	0.22	0.11	0.23	0.11
MgO	29.70	26.51	28.48	26.08	27.08	22.82	23.26	24.81
FeO	23.07	20.10	22.59	21.88	20.87	17.36	19.31	18.47
MnO						0.32		0.48
CaO	0.96	2.50	1.70	2.40	1.22	4.05	2.67	2.81
Na_2O	0.34	0.22	0.22	0.48	0.59	0.53	0.20	0.37
K_2O	0.94	1.35	1.36	1.02	1.13	1.11	1.95	1.44
Cr_2O_3	0.57	0.99	0.76	0.56	0.27		1.16	0.91
Total	97.47	96.86	99.87	98.33	97.85	97.02	97.16	98.09

	2	21	3	53	8	5	61	44
SiO_2	48.95	47.36	48.71	47.43	48.96	47.69	49.33	49.68
Al_2O_3	2.35	2.48	2.40	2.64	2.60	2.71	2.76	3.18
TiO_2	0.11	0.12	0.24	0.12	0.05	0.22	0.07	0.03
MgO	24.75	24.23	24.73	23.33	23.54	24.17	22.95	19.96
FeO	18.03	18.62	17.86	19.59	17.19	18.68	17.43	16.79
MnO	0.26	0.46	0.34	0.34	0.34	0.35	0.34	0.30
CaO	2.41	2.25	2.95	2.83	2.81	2.51	3.48	3.73
Na_2O	0.33	0.29	0.38	0.64	0.34	0.22	0.62	0.62
K_2O	1.95	1.67	1.44	1.50	1.97	2.14	1.32	1.70
Cr_2O_3				0.76			1.06	1.09
Total	99.14	97.48	99.05	99.18	97.80	98.69	99.36	97.08

Table 3. Chemical composition of the groundmass of high-K lithic fragments.

	106–8	106–4	106–6	106–7	106–2	101–1	101–2	5–6	5–2	5–4	3–4
SiO_2	47.66	48.84	48.89	49.13	50.15	48.54	50.69	52.09	52.86	52.91	51.91
Al_2O_3	4.69	4.75	5.13	4.82	4.66	4.29	5.15	5.79	5.87	6.63	6.85
TiO_2		0.09	0.40		0.06			0.31	0.39	0.46	0.45
MgO	21.03	18.23	15.05	19.70	16.58	20.56	17.40	13.75	10.55	12.01	11.12
FeO	16.18	15.36	13.15	15.95	16.20	15.49	15.16	11.17	9.57	8.90	13.04
MnO		0.25	0.15		0.30			0.25	0.29	0.27	0.28
CaO	5.13	7.54	9.08	6.02	5.93	3.70	5.59	5.92	10.12	7.62	9.76
Na_2O	0.60	0.55	0.57	0.98	0.80	0.47	0.48	0.66	0.71	0.67	0.66
K_2O	3.25	3.00	3.28	2.92	2.76	3.36	3.87	4.56	4.59	4.91	5.13
Cr_2O_3	1.57	1.17	1.19	1.54	2.47	1.10	0.89	1.59	1.23	1.61	0.30
NiO	0.01			0.05		0.17	0.13	0.09	0.19	0.22	0.00
Total	100.12	99.80	96.90	101.11	99.90	97.68	99.37	96.18	96.37	96.20	99.49

	3–6	3–2	123–1	123–2	60–2	8–14	53–2	21–15	21–14	21–13	
SiO_2	54.75	54.93	52.09	55.86	57.94	58.82	59.95	60.59	62.60	63.30	
Al_2O_3	7.04	6.33	5.85	6.21	6.86	7.74	8.10	7.91	8.43	7.94	
TiO_2	0.33	0.33				0.38		0.41	0.55	0.53	
MgO	14.42	10.62	15.34	14.35	9.19	11.03	7.75	8.59	6.23	6.33	
FeO	11.87	10.30	12.05	10.11	8.07	9.46	8.70	8.46	6.20	5.75	
MnO	0.23	0.24				0.22		0.21	0.20	0.22	
CaO	4.85	8.54	6.26	6.88	9.12	4.47	9.68	7.68	10.37	10.29	
Na_2O	0.76	0.73	1.09	1.25	1.60	0.62	1.60	0.86	1.33	1.09	
K_2O	4.62	5.37	3.74	3.79	3.01	5.33	4.00	5.14	4.63	4.78	
Cr_2O_3	0.33	0.30	0.86	1.01	1.81		0.66				
NiO	0.27	0.06	0.01	0.07	0.04		0.09				
Total	99.47	97.77	97.28	99.53	97.64	98.07	100.53	99.86	100.53	100.22	

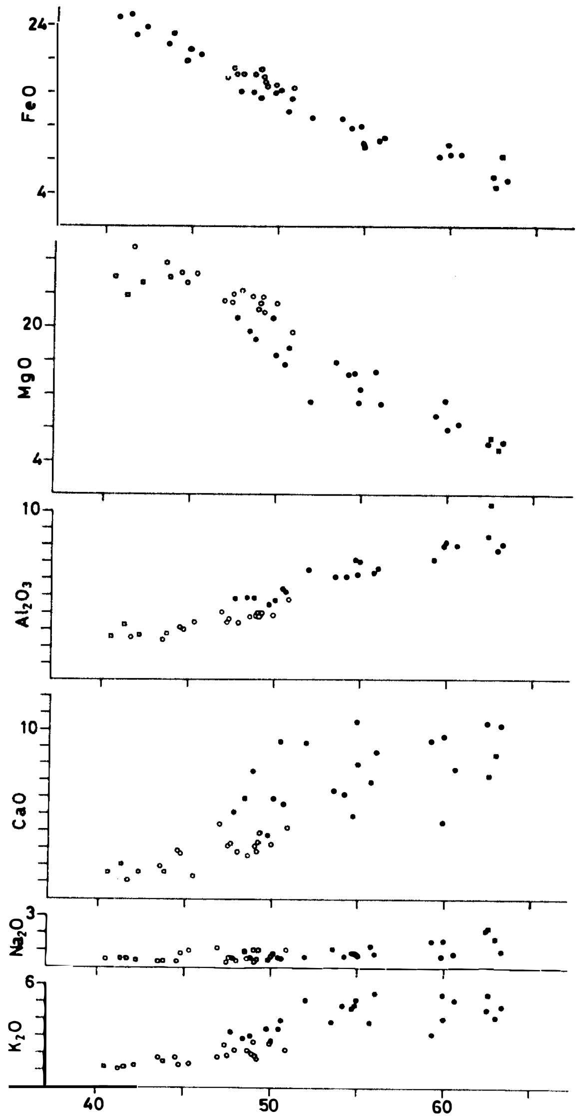

Fig. 1. Normalized weight percents of each oxide of high-K lithic fragments (open circle) in the 74442 chondrite and their groundmass (solid circle) are plotted against their SiO_2 wt. %. The high-K lithic fragments in some meteorites (FODOR and KEIL, 1978) and their groundmass are shown by open square and closed square, respectively.

zation temperature is lower than about 1800°C.

The origin of high-K lithic fragments is not known, but the magma whose composition is equal to the bulk composition of the high-K lithic fragments may be produced by the melting of a rock which is composed mainly of olivine, pyroxenes and K-feldspar. This magma must have experienced an under-cooling

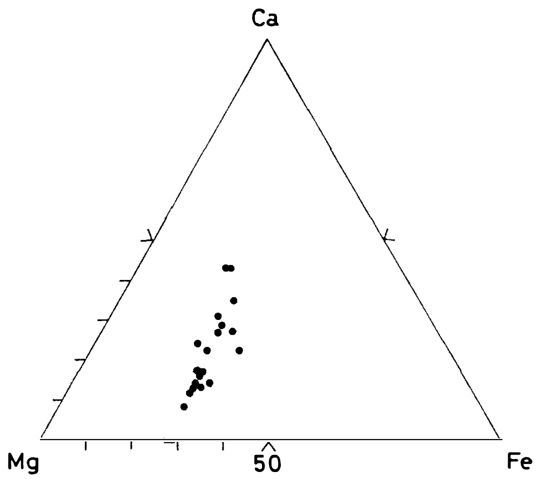

Fig. 2. The atomic ratios of Ca, Mg and Fe of the groundmass (closed circle) of high-K lithic fragments in the 74442 chondrite and olivines (closed rectangular) in those fragments are shown.

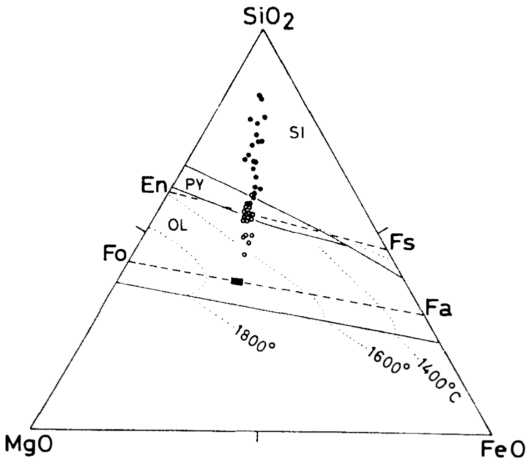

Fig. 3. The wt. % ratios of SiO_2, MgO and FeO of high-K lithic fragments (open circle), their groundmass (closed circle) and coexisting olivines (closed rectangular) in the 74442 chondrite are shown. The solid curves are the liquidus phase boundaries of SiO_2-MgO-FeO system quoted from LEVIN et al. (1964). SI, PY and OL denote silicate mineral, pyroxene and olivine liquidus fields, respectively.

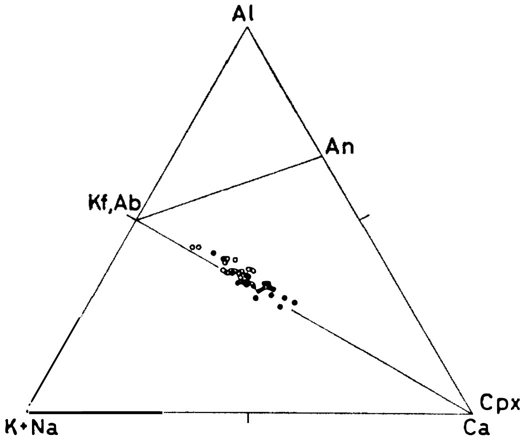

Fig. 4. The atomic ratios of Al, (K+Na) and Ca of high-K lithic fragments (open square) and their groundmass (solid square) are plotted. Kf: K-feldspar, Ab: albite, An: anorthite and Cpx: Ca-rich clinopyroxene.

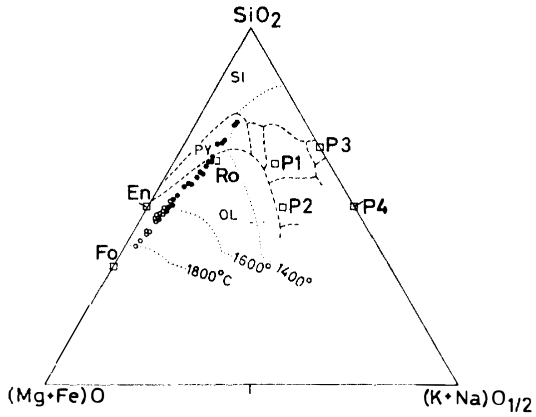

Fig. 5. The molecular ratios of SiO_2, (Mg+Fe) O and (K+Na) $O_{0.5}$ of high-K lithic fragments (open circle) and their groundmass (closed circle) are shown. The dash curves are the liquidus phase boundaries of SiO_2-MgO-K_2O system (ROEDDER, 1951). SI, PY and OL: the same as those in Fig. 3. En: enstatite, Fo: forsterite, Ro: roedderite, P1: $K_2MgSi_5O_{12}$, P2: $K_2MgSi_3O_8$, P3: $K_2Si_4O_9$ and P4: $K_2Si_2O_5$.

condition to crystallize microphenocrystic olivine. The "volcanic rock" thus formed was fragmented into blocks and formed the breccia of the Yamato-74442 chondrite with other units by some impact events.

4. Non-recrystallized Lithic Fragments

Many lithic fragments which have porphyritic texture, radial-pyroxene texture,

Table 4. Chemical composition of non-recrystallized lithic fragments.

	55	46	26	119	Groundmass of 119	140	137	137′	141	Groundmass of 141
SiO_2	56.49	41.35	50.16	45.52	62.36	43.93	40.08	52.49	44.64	55.42
Al_2O_3	2.53	4.50	3.56	2.72	7.50	6.71	2.14	1.16	1.53	4.71
TiO_2	0.40	0.20	0.29	0.21		0.52	0.13	0.11	0.08	
MgO	25.10	27.31	24.79	23.45	6.44	20.71	25.79	22.40	28.13	14.90
FeO	9.39	21.66	12.10	17.96	7.27	20.68	24.93	14.66	18.62	5.44
MnO		0.24						0.42	0.44	
CaO	2.92	0.58	2.34	3.00	7.50	1.82	2.61	4.00	2.62	12.30
Na_2O	1.02	2.27	1.92	1.45	4.00	2.19	0.93	0.62	0.92	2.46
K_2O	0.20	0.14	0.38	0.25	0.08	0.11	0.14	0.13	0.09	0.30
Cr_2O_3	1.02	0.99	1.02	1.96	0.85	0.34	1.02	0.71	0.76	1.16
Total	99.07	99.24	96.56	96.52	96.00	97.01	97.77	96.70	97.83	96.69

	105	108	135	130	50	22	42	57′	Groundmass of 122	Groundmass of 122
SiO_2	55.42	43.12	53.27	41.56	54.41	55.63	39.21	59.56	55.92	55.92
Al_2O_3	3.81	1.98	1.89	2.17	4.31	1.50	0.86	19.17	5.45	5.47
TiO_2					0.37	0.16	0.49	0.78		
MgO	17.79	29.69	23.45	26.87	16.30	24.78	32.00	0.11	12.01	11.68
FeO	8.87	19.39	13.10	23.38	8.77	11.98	22.80	1.43	3.96	3.91
MnO						0.47		0.03		
CaO	7.53	2.19	5.06	2.44	8.06	3.27	0.66	3.47	15.43	15.33
Na_2O	2.09	0.97	0.71	1.06	2.00	0.80	0.25	8.44	2.50	2.58
K_2O	0.29	0.38	0.06	0.10	0.91	0.10	0.26	0.31	0.21	0.22
Cr_2O_3	1.18	1.41	0.91	0.94	0.94	0.94	0.35	1.95	1.11	1.15
Total	96.98	99.13	98.45	98.52	96.07	99.63	96.88	95.25	96.59	96.26

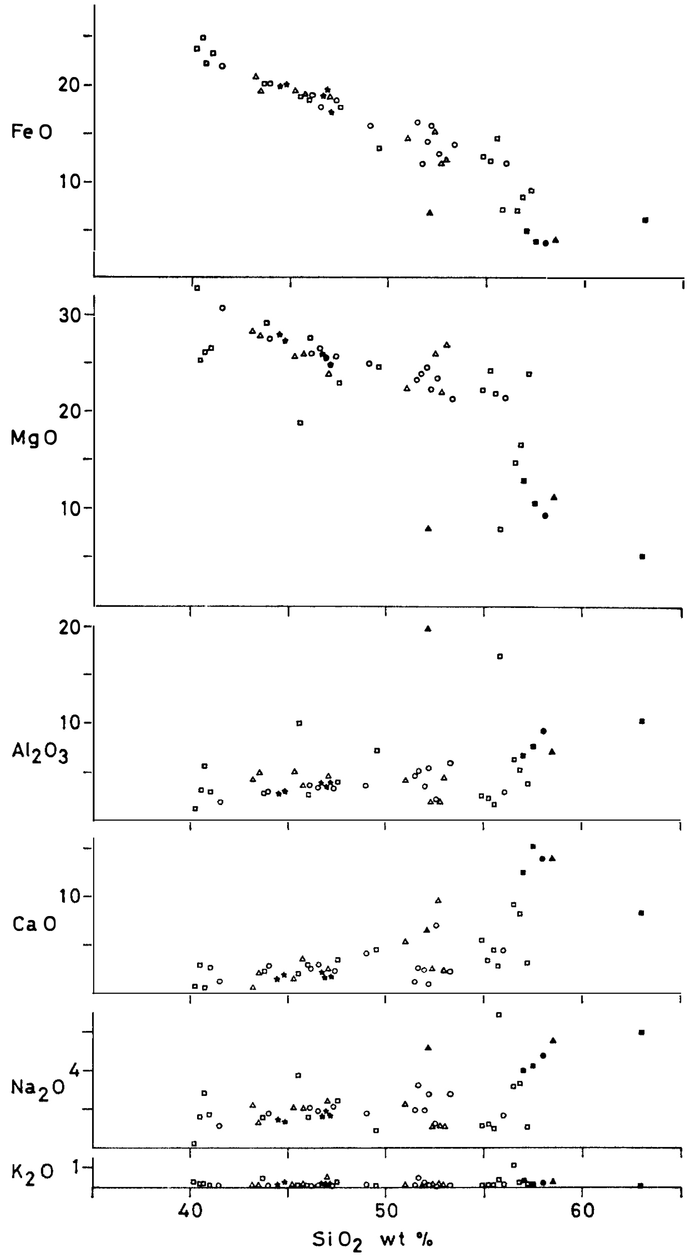

Fig. 6. Normalized weight percents of each oxide of lithic fragments, chondrules and matrix in the 74442 chondrite are plotted against their SiO_2 wt. %. Open and closed circles: recrystallized lithic fragments and their groundmass respectively, open and closed squares: non-recrystallized lithic fragments and their groundmass respectively, open and closed triangles: chondrules and their groundmass respectively, solid star: matrix.

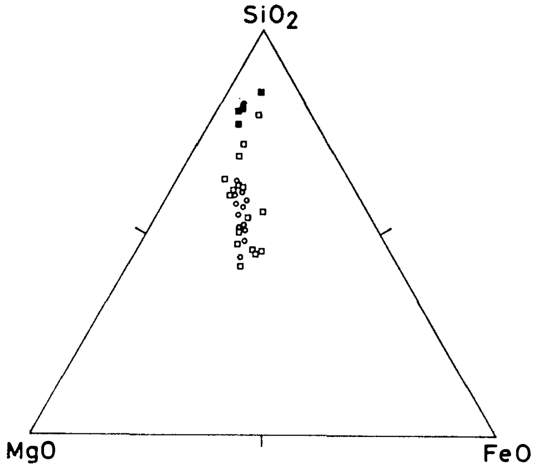

Fig. 7. The wt. % ratios of SiO_2, MgO and FeO of non-recrystallized and recrystallized lithic fragments are plotted. Symbols are the same as those in Fig. 6.

barred-olivine texture, etc. are observed in the 74442 chondrite. The groundmass of these lithic fragments is composed of devitrified glass or very fine-grained substances. In addition, some lithic fragments which are glassy or massive aggregate of very fine-grained substances are observed. These fragments are classified as non-recrystallized lithic fragments.

The constituent minerals of the lithic fragments are mainly olivine and orthopyroxene. The chemical composition of olivine is fairly constant among non-recrystallized lithic fragments and Fo_{71-73}. However, the ranges of chemical zoning with respect to the Mg-Fe ratio of pyroxene are different among the lithic fragments. For example, orthopyroxenes in a non-recrystallized lithic fragment ranging from $En_{93}Wo_{0.5}$ to $En_{77}Wo_{1.0}$, and those in another lithic fragment ranging from $En_{88}Wo_{0.3}$ to $En_{71}Wo_{0.1}$.

The chemical composition of the bulk lithic fragments and their groundmass are tabulated in Table 4 and shown in Figs. 6, 7 and 8.

5. Recrystallized Lithic Fragments

Many lithic fragments which seem to have suffered recrystallization at various degrees occur in the 74442 chondrite. In moderately recrystallized lithic fragments, the groundmass is composed of aggregates of microlites or crystallites. The phenocrystic olivines and pyroxenes are homogeneous and show the same chemical composition as those in strongly recrystallized lithic fragments. In strongly recrystallized lithic fragments, the original texture is obscure so that their groundmass can not be clearly distinguished. The constituent minerals of the strongly recrystallized lithic fragments are olivine, orthopyroxene, Ca-rich clinopyroxene,

Table 5. Chemical composition of recrystallized lithic fragments.

	45	19	17	14	16	11	11′
SiO_2	45.96	51.03	45.83	44.20	40.28	49.28	50.54
Al_2O_3	2.33	2.49	2.37	2.63	1.42	3.79	3.69
TiO_2	0.29	0.15		0.07	0.14	0.26	0.13
MgO	27.78	25.33	27.10	28.13	32.39	23.91	23.33
FeO	18.28	14.53	19.20	19.84	22.90	16.01	16.36
MnO			0.31	0.36	0.45	0.30	0.37
CaO	2.75	2.20	2.27	2.10	1.19	1.23	1.12
Na_2O	1.16	1.16	1.33	1.29	0.70	1.79	1.68
K_2O	0.11	0.26	0.05	0.05	0.06	0.12	0.14
Cr_2O_3	0.45	1.09					
Total	99.11	98.24	98.46	98.67	99.53	96.69	97.35

	9	153	143	48	131-1	Groundmass of 147
SiO_2	50.26	42.95	54.35	47.25	52.47	56.76
Al_2O_3	4.18	2.07	2.14	2.45	1.60	6.41
TiO_2	0.19		0.13	0.15		
MgO	22.78	28.16	22.75	25.46	24.70	10.88
FeO	14.56	20.48	12.30	15.82	13.35	3.97
MnO	0.37	0.38				
CaO	1.88	2.61	3.94	3.65	6.44	13.52
Na_2O	1.65	1.09	1.04	1.06	0.74	3.29
K_2O	0.14	0.05	0.12	0.13	0.04	0.23
Cr_2O_3			0.64	0.21	0.62	1.01
Total	96.01	97.79	97.41	96.18	99.98	96.07

plagioclase, opaque minerals and rarely Ca-phosphate. Their chemical compositions are homogeneous, and olivines are Fo_{71-73}, orthopyroxenes and clinopyroxenes are $En_{74-76}Wo_{1.5-2.5}$ and $En_{46-47}Wo_{43-45}$, respectively, and plagioclase are $An_{9-12}Or_{2.5-4.0}$. According to the two-pyroxene geothermometer of WOOD and BANNO (1973), the recrystallization temperature is about 900° to 1000°C. In a certain strongly recrystallized lithic fragment, many olivine grains show preferred orientation, and this may be due to the recrystallization under a certain stress field.

The chemical compositions of recrystallized lithic fragments and their groundmass are shown in Table 5 and Figs. 6, 7 and 8.

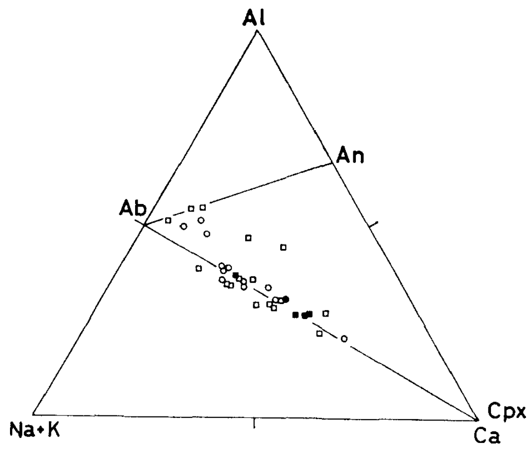

Fig. 8. The atomic ratios of Al, (Na+K) and Ca of non-recrystallized and recrystallized lithic fragments are plotted. Symbols are the same as those in Fig. 6.

6. Chondrules

Chondrules are rare in the 74442 chondrite. Some chondrules have the same texture and chemical composition of constituent minerals as recrystallized lithic fragments. Then, these chondrules may have been derived from the mechanical fragmentation and abrasion of recrystallized lithic fragments. However, the other chondrules did not suffer recrystallization, and they show porphyritic texture, barred-olivine texture, opaque mineral-rimmed texture and so on. These chondrules may have an origin different from the above-stated fragmentation. The chemical compositions of their constituent minerals are the same as those in non-recrystallized lithic fragments. The chemical composition of chondrules is shown in Table 6 and Figs. 6, 9 and 10.

7. Mineral Fragments

Silicate mineral fragments are mainly olivine and pyroxene. Their chemical compositions are the same as those in non-recrystallized or recrystallized lithic fragments. Then, these silicate mineral fragments may be due to disaggregation of those lithic fragments.

Opaque mineral fragments are composed of troilite and/or Fe-Ni metal. Some opaque mineral fragments include minute silicate grains and rarely Ca-phosphate. These silicate grains are olivine, pyroxenes and plagioclase, and often have roundish shapes. The chemical compositions of olivine, orthopyroxene and clinopyroxene in opaque mineral fragments are Fo_{71-72}, $En_{74-77}Wo_{1.0-1.5}$, and $En_{45-46}Wo_{45-46}$ respectively. According to the two-pyroxene geothermometer of WOOD and BANNO

Table 6. Chemical composition of chondrules.

	18	102	Groundmass of 102	Groundmass of 102	110	Groundmass of 110
SiO_2	51.37	44.23	55.89	57.68	48.63	49.83
Al_2O_3	1.35	2.52	5.96	5.05	5.08	14.00
TiO_2	0.06	0.13	0.07	0.07	0.11	0.55
MgO	26.61	26.63	11.85	12.58	28.27	12.38
FeO	15.60	19.23	4.57	4.15	12.86	9.40
MnO	0.37				0.42	0.29
CaO	2.26	2.93	14.00	13.25	2.83	5.46
Na_2O	0.67	1.22	2.75	2.75	1.26	2.76
K_2O	0.03	0.06	0.16	0.22	0.06	0.14
Cr_2O_3			1.23	0.69		1.37
Total	98.32	96.95	96.48	96.44	99.52	96.18
	139	**134**	**13**	**6**	**7**	**52′**
SiO_2	43.12	42.17	52.85	49.66	45.67	39.59
Al_2O_3	2.37	2.93	1.47	2.75	3.19	3.22
TiO_2	0.12	0.02	0.05	0.12	0.11	0.11
MgO	27.88	29.75	22.33	22.75	25.05	28.67
FeO	19.40	21.60	11.58	14.58	19.30	21.00
MnO	0.39	0.39	0.46	0.38	0.53	0.31
CaO	1.34	0.48	7.94	4.62	2.30	2.05
Na_2O	1.12	1.42	0.78	1.34	1.51	0.98
K_2O	0.08	0.04	0.09	0.07	0.41	0.25
Cr_2O_3	0.70	0.18				
Total	96.52	98.98	97.55	96.27	98.06	96.18

(1973), some pairs of orthopyroxene and coexisting Ca-rich clinopyroxene in opaque mineral fragments give 900° to 1000°C.

8. Matrix

Matrix is defined here as an aggregate of very fine-grained substances smaller than several microns in diameter. This definition is arbitrary, and the grain size of matrix ranges continuously up to the grain size of mineral fragments. The chemical composition of matrix is tabulated in Table 7 and shown in Fig. 6.

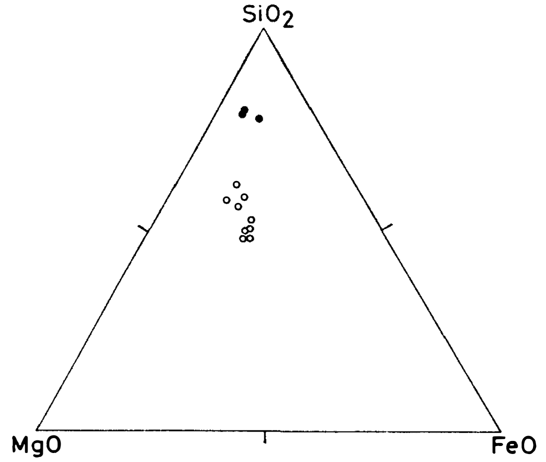

Fig. 9. The wt. % ratios of SiO_2, MgO and FeO of chondrules (open circle) and their groundmass (solid circle) are shown.

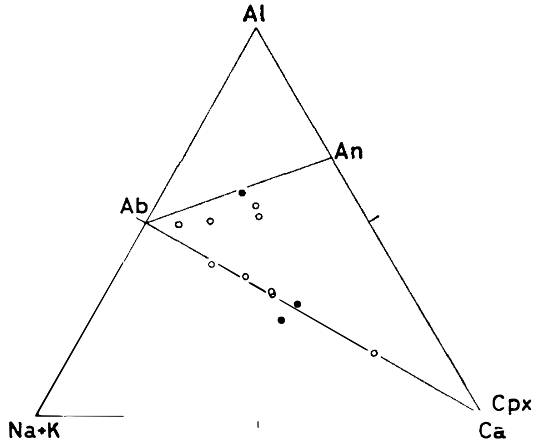

Fig. 10. The atomic ratios of Al, (Na+K) and Ca of the chondrules (open circle) and their groundmass (closed circle) are shown.

9. Discussion

The chemical composition of non-recrystallized lithic fragments is similar to that of recrystallized lithic fragments as shown in Figs. 6, 7 and 8. Then, the original rocks of the recrystallized lithic fragments may be materials similar to the non-recrystallized lithic fragments. The chemical composition of chondrules is also similar to those of non-recrystallized lithic fragments. In addition, the chemical composition of matrix is again similar to non-recrystallized lithic fragments, recrystallized lithic fragments and chondrules except the fact that the com-

Table 7. Chemical composition of matrix.

	Mat-4	Mat-5	Mat-8	Mat-7	Mat-3
SiO_2	44.42	44.38	45.17	46.48	45.94
Al_2O_3	2.09	2.09	2.58	2.50	2.69
TiO_2	0.13			0.01	0.01
MgO	29.16	28.86	26.38	26.62	26.13
FeO	20.66	21.00	18.94	20.00	17.80
MnO	0.41	0.44	0.39	0.41	0.35
CaO	1.44	1.80	1.85	1.58	1.86
Na_2O	0.90	0.82	1.02	1.09	1.08
K_2O	0.14	0.24	0.17	0.14	0.14
Cr_2O_3	0.55	0.42			1.96
Total	99.90	100.05	96.50	98.83	97.96

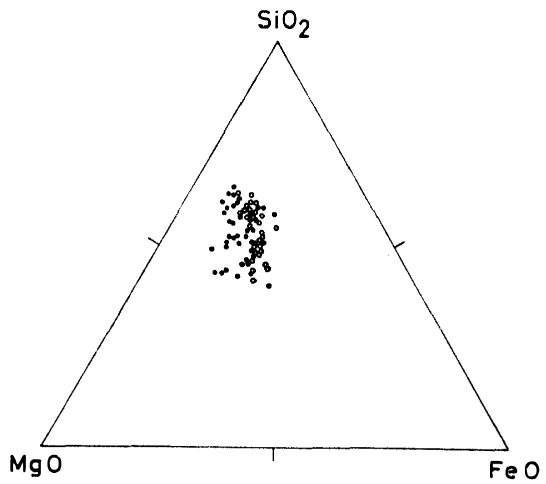

Fig. 11. The wt.% ratios of SiO_2, MgO and FeO of the chondrules in the Yamato-74191 chondrite (IKEDA and TAKEDA, 1979) are plotted together with those of non-recrystallized lithic fragments, recrystallized lithic fragments and chondrules in the Yamato-74442 chondrite. Closed circle: the 74191 chondrite, and open circle: the 74442 chondrite.

position of the matrix is relatively uniform as shown in Fig. 6. Therefore, the non-recrystallized lithic fragments, recrystallized lithic fragments, chondrules and the matrix may have been derived from the same material.

Fig. 11 shows that the chemical compositions of non-recrystallized lithic fragments, recrystallized lithic fragments and chondrules of the Yamato-74442 chondrite are the same as that of the most ferrous chondrules in the Yamato-74191 chondrite of L3 (IKEDA and TAKEDA, 1979). In addition, the chemical compositions of olivines in non-recrystallized lithic fragments and chondrules in the 74442 chondrite show the constant Mg-Fe ratio in spite of the wide Mg-Fe ratios of pyroxenes, and olivines of the most ferrous chondrules in the 74191 chondrite also show the constant Mg-Fe ratio in spite of the wide ratios of pyroxenes. Therefore, it is concluded that non-recrystallized lithic fragments and chondrules in the 74442 chondrite (LL-group) may have been formed by the accretion of the materials similar to the most ferrous chondrules of L-group chondrite (Yamato-74191). Recrystallized lithic fragments of the 74442 chondrite may have been formed by the heating of the non-recrystallized lithic fragments and chondrules in a parental body up to 1000°C. The matrix and the silicate mineral fragments are considered to be produced by crashing of non-recrystallized lithic fragments, recrystallized lithic fragments and chondrules by impact on the parental body.

The high-K lithic fragments of the 74442 chondrite have high ratios of K_2O to Na_2O which are quite different from the other units in the chondrite. However, the Mg-Fe ratios of olivines in the high-K lithic fragments are quite the same as those in the other units. Then, the magma which resulted in the high-K lithic fragments may have been produced by the melting of K-feldspar-bearing rocks in the same oxidation condition as the recrystallization producing the recrystallized lithic fragments.

In summary, the parental body of the 74442 chondrite was formed by accretion of the ferrous chondrules such as those in a L-group unequilibrated chondrite together with opaque minerals and K-feldspar-bearing substances. The temperature of the interior of the parental body increased and recrystallization and melting took place in the inner part. There might have been volcanic activity on the surface of the parental body. The surface and interior materials were fragmented and mingled by some impact events to form the breccia of the Yamato-74442 chondrite.

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References

FODOR, R. V. and KEIL, K. (1978): Catalog of lithic fragments in LL-group chondrites. Spec. Publ., Inst. Meteoritics, Univ. New Mexico, **19**.

IKEDA, Y. and TAKEDA, H. (1979): Petrology of the Yamato-74191 chondrite. Mem. Natl Inst. Polar Res., Spec. Issue, **12**, 38–58.

LEWIN, E. M., ROBBINS, C. R. and MCMURDIE, H. F. (1964): Phase Diagrams for Ceramists. Ed. and pub. by the American Ceramic Society.

ROEDDER, E. W. (1951): The system K_2O–MgO–SiO_2, Part 1. Am. J. Sci., **249**, 81–130.

ROEDDER, P. L. and EMSLIE, R. F. (1970): Olivine-liquid equilibrium. Contr. Mineral. Petrol.,

29, 275–289.

VAN SCHMUS, W. R. and WOOD, J. A. (1967): The chemical-petrologic classification for the chondritic meteorites. Geochim. Cosmochim. Acta, **31**, 747–765.

YANAI, K., MIYAMOTO, M. and TAKEDA, H. (1978): A classification for the Yamato-74 chondrites based on the chemical compositions of their olivines and pyroxenes. Mem. Natl Inst. Polar Res., Spec. Issue, **8**, 110–120.

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