A CLASSIFICATION OF SEVERAL YAMATO-75 CHONDRITES

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***Abstract*:** The Yamato-75108 to -75257 chondrites are considered to be originally one meteorite which was broken into many fragments (Matsumoto, 1978; Matsumoto *et al.*, 1979). Electron microprobe studies have been made on the olivine and orthopyroxene in ten chondrites (Yamato-75109, -75110, -75111, -75112, -75113, -75114, -75115, -75129, -75131 and -75139) out of these fragments. Textural characters of chondrules, matrix, igneous glass and secondary feldspar, and the mean composition, mean deviation, and percent mean deviation of olivines and orthopyroxenes are given. As a result, the chondrites are tentatively classified as L group and petrologic type 4–5. Accordingly, these chondrites were possibly one meteorite originally.

1. Introduction

As a part of preliminary examination of Yamato meteorites collected during a period from 1975 to 1976 (Matsumoto, 1978), electron microprobe analyses of olivine and pyroxene in ten chondrites have been carried out. The first purpose of this study is to compile a catalog of the Yamato meteorites, which will be used as a guidebook in processing allocation and distribution of the meteorites for investigators in various fields. The second purpose is to explore the possibility that the Yamato-75108 to -75257 chondrites represent broken fragments of one original meteorite. As many of these meteorites have been preserved at low temperatures under an exceptionally clean environment, we had to select a method of investigation that would allow minimal contamination.

For these purposes, thin sections were made from near the surface. In addition, the sample preparation microprobe analyses had to be carried out in an efficient manner. The SiO_2, CaO, MgO and FeO contents of olivine and orthopyroxene in polished thin sections have been determined to obtain histograms of iron contents in the two minerals such as given by Dodd *et al.* (1967). Then the Yamato meteorites have been classified based upon the method by Van Schmus and Wood (1967).

2. Experimental Method

The 150 meteorites (from Yamato-75108 to -75257 chondrites) were found within the limited area of about 10 m $\times$ 50 m, by the 16th Japanese Antarctic Research Expedition, 1974–1976 (JARE-16) (MATSUMOTO, 1978) (Figs. 1 and 2). These concentrated meteorite fragments seem to belong to the same kind in appearance.

In these meteorite fragments, there are two kinds of the fusion crust in appearance. One is a thick and smooth fusion crust that is globular in shape, and dark brownish black in color. The other is a thin fusion crust that is subrounded or subangular in shape with a finely waved surface and a dark brown color.

Among these 150 meteorites, Yamato-75108 and -75110 chondrites are tentatively classified as the petrologic type 4–5 of the moderately equilibrated ordinary chondrites and the chemical group of two chondrites corresponds to L group (MATSUMOTO *et al.*, 1979). Ten meteorite fragments which weigh more than 100 g were selected to examine the possibility of one meteorite shower. Thin sections of about 20 to 40 mm^2 were made and mounted on glass, polished and prepared for the electron microprobe analyses by coating with carbon. In these ten meteorites, Yamato-75110 chondrite was repeatedly analyzed in a thin section of another part of the chondrite.

The quantitative chemical analysis of olivine and orthopyroxene was made with a JEOL JXA-5A electron probe X-ray microanalyzer with a 40° take-off angle. The method was the same as that described by NAKAMURA and KUSHIRO (1970).

Measurement for each thin section was made on about 20 points of both olivine and on orthopyroxene in different chondrules. However, some sections contain small numbers in grains, and some contain very large chondrules. The homogeneity of the composition of minerals was checked by monitoring the intensities of the nine elements (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K) with the scanning technique.

Grains with total weight percents ($CaO + MgO + FeO + SiO_2$) outside the range between 99 and 101 wt% were interpreted as glass or other mineral phases, or ascribed to inaccurate analyses and were rejected. Any analyses in which the Ca, Mg, Fe and Si contents were inappropriate for either olivine or pyroxene were also discarded. Thus, the total number of measurements was generally less than 20 for each sample. Atomic % of calcium, magnesium, and iron in the olivine and pyroxene were calculated. Then the "percent mean deviation" proposed by DODD *et al.* (1967) was also calculated. In this paper, the mean deviation and the "percent mean deviation" are shown with the atomic % of iron, according to the previous work (YANAI *et al.*, 1978).

Though the parameter "percent mean deviation" has been used as an indicator of heterogeneity of olivene and pyroxene (DODD *et al.*, 1967), it is found that the frequency distribution of atomic % of iron is useful.

Fig. 1. Many meteorite fragments (from Yamato-75108 to Yamato-75257) on the south-westsouthern side of Massif A, Yamato Mountains.

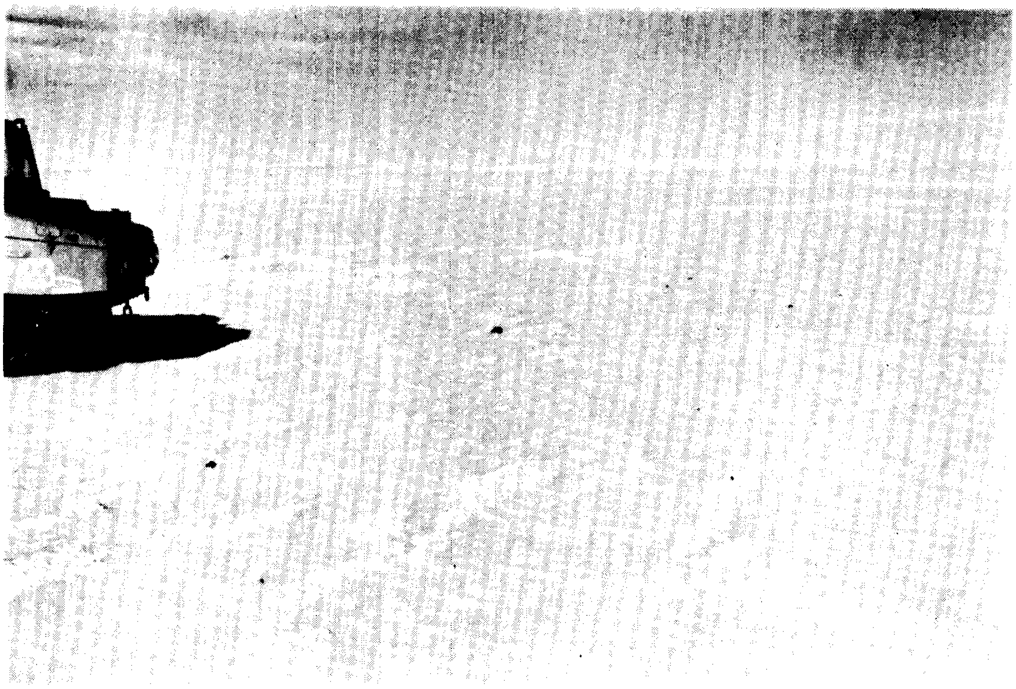

Fig. 2. Many meteorite fragments (from Yamato-75108 to Yamato-75257) on the surface of the bare ice area on the south-westsouthern side of Massif A, Yamato Mountains.

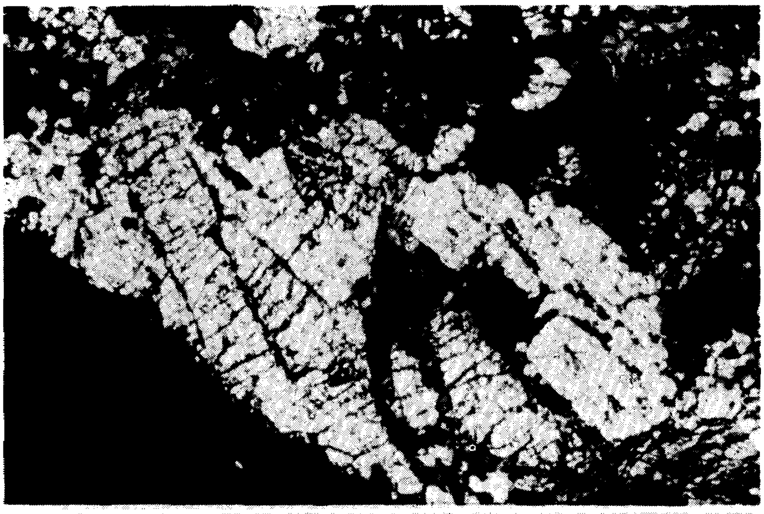

Fig. 3. A relic structure of chondrule consisting of alternate layers of olivine crystals in Yamato-75110 chondrite. The interstices between olivine layers are filled with aggregate of plagioclases and cryptocrystalline materials. Crossed nicols. Long dimension of photograph = 1.3 mm.

Fig. 4. Barred-olivine chondrule composed of alternate layers of olivine crystals in Yamato-75111 chondrite. The interstices between olivine bars are filled with cryptocrystalline materials and devitrified glass. Crossed nicols. Long dimension of photograph = 1.3 mm.

Fig. 5. Radial chondrule consisting of aggregate of fine prismatic orthopyroxene crystals and cryptocrystalline materials in Yamato-75112. Crossed nicols. Long dimension of photograph = 1.3 mm.

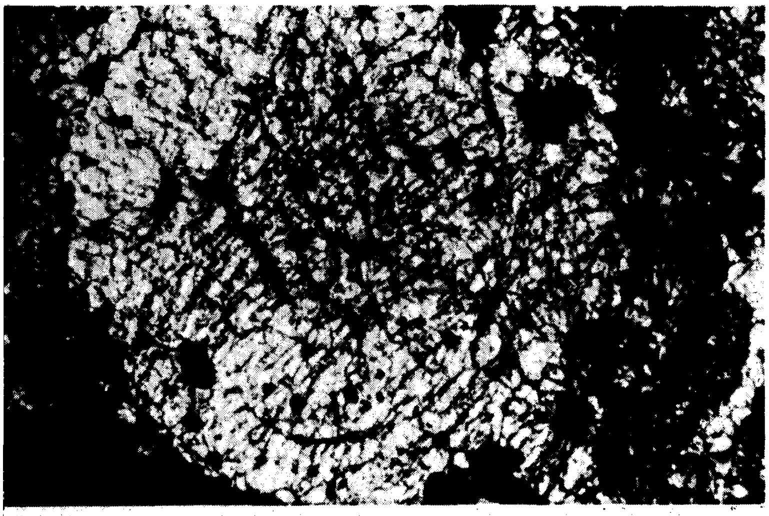

Fig. 6. Concentric and barred-chondrule consisting of prismatic olivine crystals (in the core), fine-grained olivine crystals (in the margine), and weakly recrystallized glass in Yamato-75113 chondrite. Crossed nicols. Long dimension of photograph = 1.3 mm.

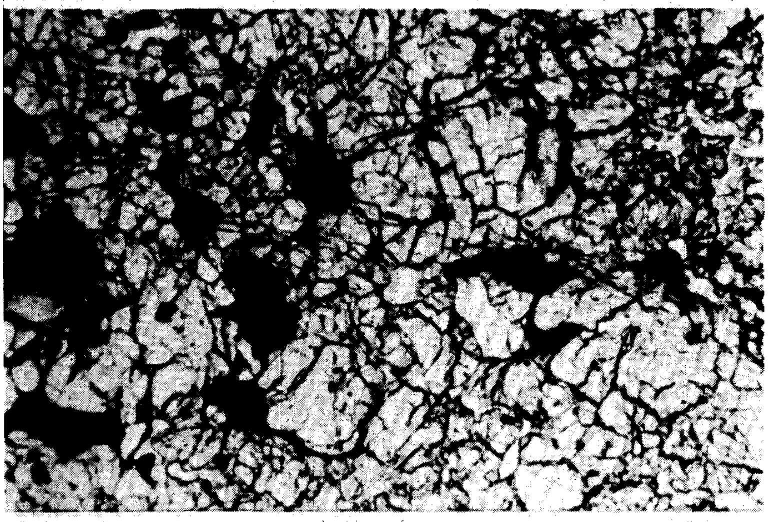

Fig. 7. Concentric and porphyritic-olivine chondrule consisting of fine-grained olivine crystals, microcrystalline aggregate of plagioclase and cryptocrystalline materials in Yamato-75114 chondrite. One nicol. Long dimension of photograph = 1.3 mm.

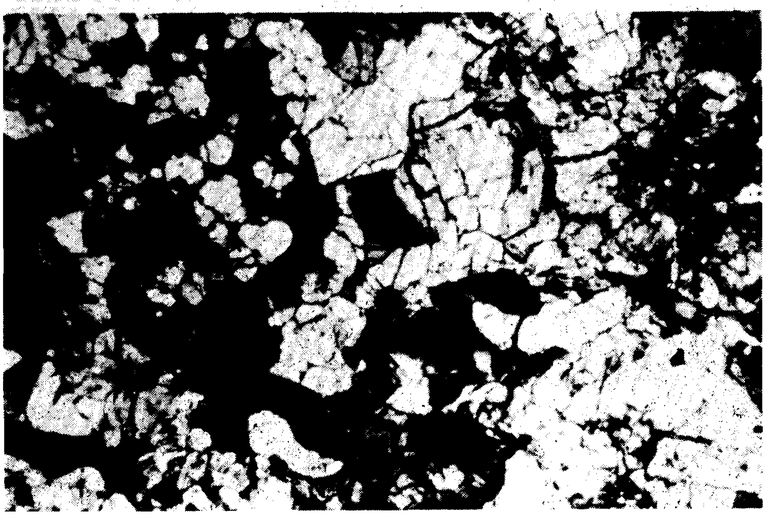

Fig. 8. The same as Fig. 7. Crossed nicols.

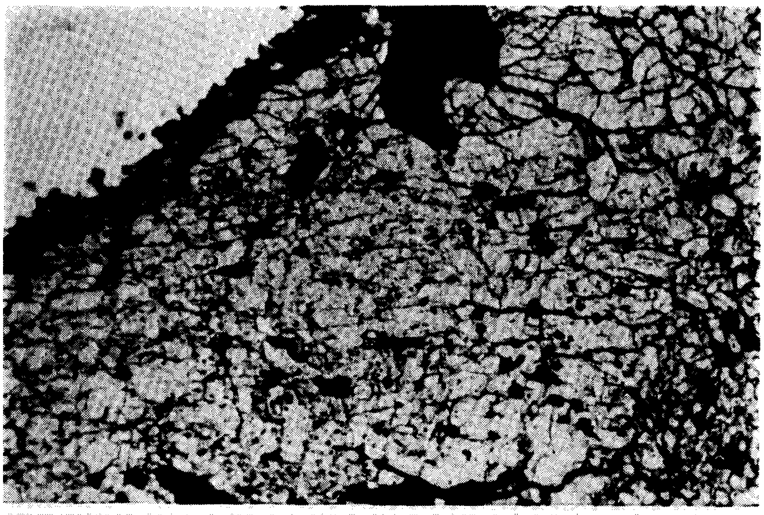

Fig. 9. Barred-orthopyroxene chondrule composed of approximately parallel sets of orthopyroxene crystals and weakly devitrified glass in Yamato-75114 chondrite. One nicols. Long dimension of photograph = 1.3 mm.

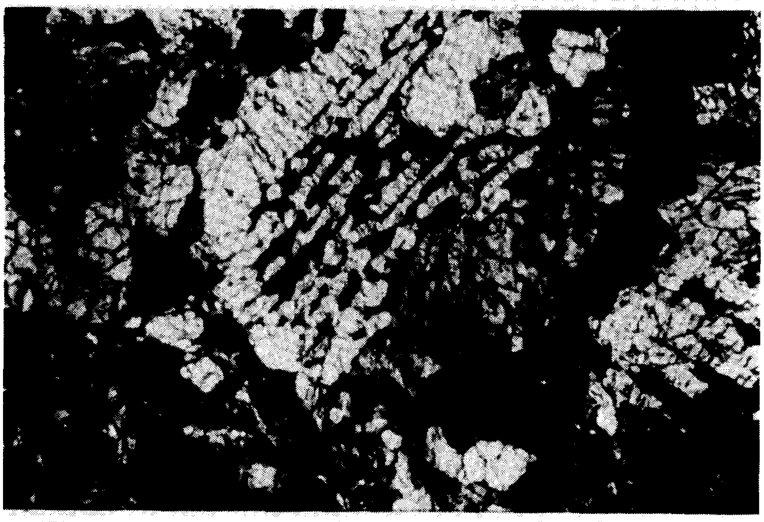

Fig. 10. Barred-olivine chondrule composed of alternate layers of olivine crystals in Yamato-75131 chondrite. The interstices between olivine bars are filled with wholly devitrified glass and cryptocrystalline materials. Crossed nicols. Long dimension of photograph = 1.3 mm.

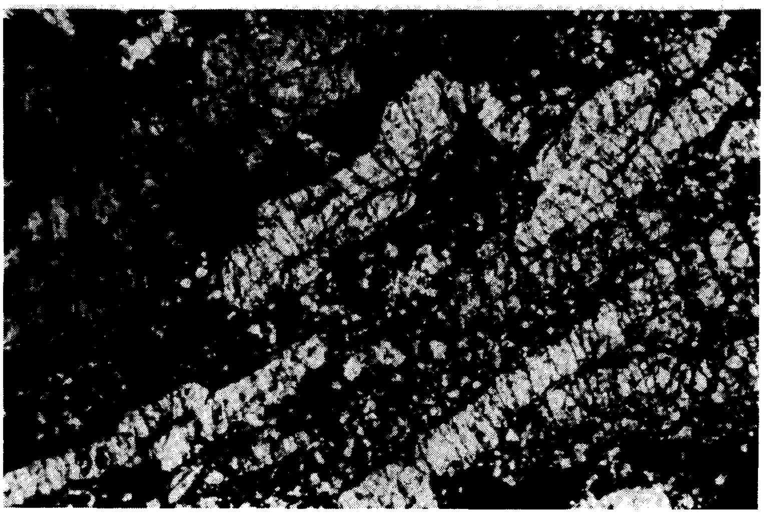

Fig. 11. A part of barred-orthopyroxene chondrule composed of parallel sets of orthopyroxene crystals, microcrystalline and cryptocrystalline materials in Yamato-75131 chondrite. Crossed nicols. Long dimension of photograph = 1.3 mm.

3. Textural Characteristics

These ten chondrites show similar textural characteristics. They belong to L-type chondrite and show texture of considerably weak recrystallization. Some chondrules are easily defined and others are hardly defined. Internal textures of chondrules, such as porphyritic-olivine (Figs. 7 and 8), granular-olivine, barred-olivine (Figs. 4, 6 and 10), porphyritic-orthopyroxene, barred-orthopyroxene (Figs. 3, 9 and 11), radial orthopyroxene (Fig. 5), cryptocrystalline and microcrystalline textures, are well preserved. Some chondrules show the concentric texture (Figs. 6, 7 and 8). Rarely, chondrules which consist of glass or wholly devitrified glass are contained. Matrix of chondrules also consists of glass or weakly devitrified glass or extremely fine material with a small amount of plagioclase. Some chondrules have glassy or poorly recrystallized rims.

Porphyritic-olivine chondrules consist mainly of fine-grained olivine crystals and glassy or cryptocrystalline materials. Olivine of porphyritic chondrules is rarely surrounded by narrow Ca-rich clinopyroxene rims. Barred-olivine chondrules

Table 1. Petrologic type determined by textural characteristics of several Yamato-75 chondrites.

Sample No.	Texture of chondrule	Texture of matrix	Igneous glass	Development of feldspar	Petrologic type
Yamato -75109	Readily delineated	Microcrystalline and weakly recrystallized	Turbid glass	Microcrystalline aggregates	4–5
Yamato -75110	Well defined and readily delineated	ditto	ditto	Microcrystalline aggregates and interstitial grains	4–5
Yamato -75111	ditto	ditto	ditto	ditto	4–5
Yamato -75112	Readily delineated	Microcrystalline	ditto	Microcrystalline aggregates	4–5
Yamato -75113	Well defined and readily delineated	Weakly recrystallized	ditto	Microcrystalline aggregates and interstitial grains	4–5
Yamato -75114	Readily delineated	ditto	ditto	Microcrystalline aggregates	4–5
Yamato -75115	Well defined and readily delineated	ditto	ditto	Microcrystalline aggregates and interstitial grains	4–5
Yamato -75129	ditto	Microcrystalline	ditto	Microcrystalline aggregates	4–5
Yamato -75131	Well defined	Microcrystalline and weakly recrystallized	ditto	ditto	4–5
Yamato -75139	Well defined and readily delineated	Weakly recrystallized	ditto	ditto	4–5

are mainly composed of parallel sets of olivine crystals and glass or weakly devitrified glass. Pophyritic-orthopyroxene chondrules consist mainly of fine-grained orthopyroxene and olivine crystals, and glassy or cryptocrystalline materials. Barred-orthopyroxene chondrules are largely composed of parallel sets of orthopyroxene crystals and glass or devitrified glass. Radial orthopyroxene chondrules consist mainly of very fine prismatic orthopyroxene crystals and glassy or cryptocrystalline materials.

Rarely, secondary feldspar in chondrules and matrix occurs as microcrystalline aggregates. Clear plagioclase does not exist in these ten chondrites either within the chondrules or in the matrix. Metal occurs not only in the matrix, but also within the chondrules.

Table 1 shows petrologic type of the specimens determined by the textural characteristics of chondrules, matrix, igneous glass and secondary feldspar (VAN SCHMUS and WOOD, 1967).

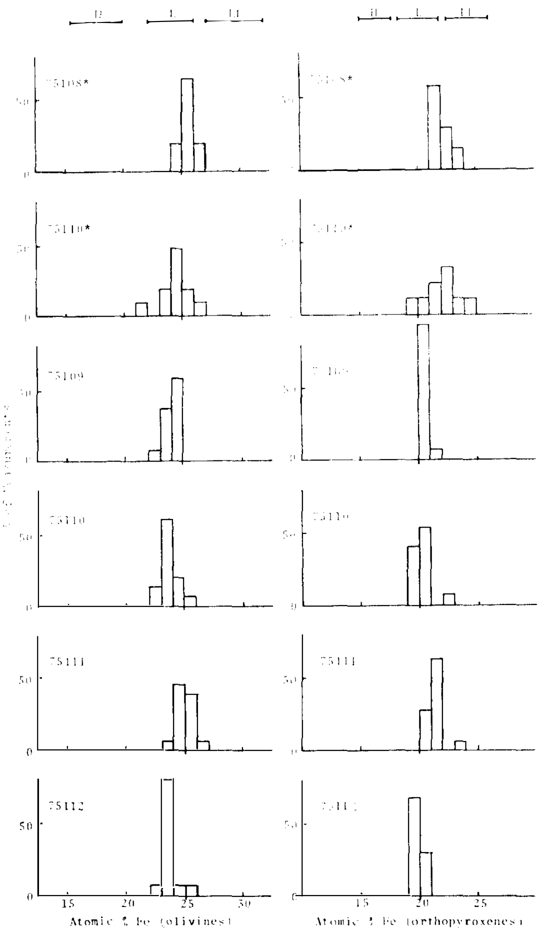

*Fig. 12a. Iron contents of olivines and orthopyroxenes. *MATSUMOTO et al. (1979).*

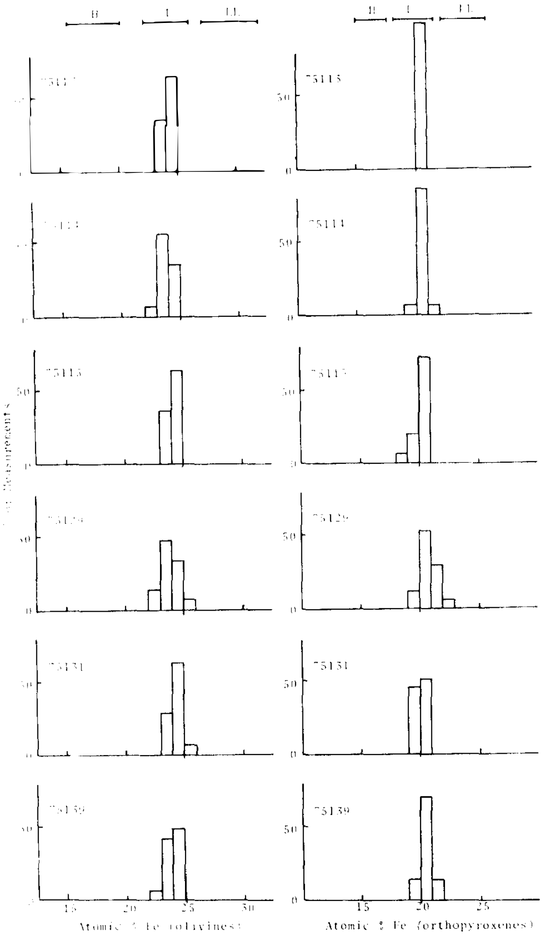

*Fig. 12b. Iron contents of livines and orthopyroxenes. *MATSUMOTO et al. (1979).*

4. Classification of Yamato-75 Chondrites

Histograms of iron contents (atomic percent) of olivine and orthopyroxene for the surveyed samples are given in Figs. 12a and b, and Table 2. In this figure, the

Table 2. Iron contents of olivines and orthopyroxenes in 11 Yamato-75 chondrites.

	Olivine					Orthopyroxene						
Atomic % Fe	22	23	24	25	26	18	19	20	21	22	23	24
Sample No.	Percent of measurements					Percent of measurements						
Yamato-75108*	-	-	18.2	63.6	18.2	-	-	-	57.1	28.6	14.3	-
-75110*	-	18.2	45.5	18.2	9.1	-	11.1	11.1	22.2	33.3	11.1	11.1
-75109	7.1	35.7	57.1	-	-	-	-	92.9	7.1	-	-	-
-75110	13.3	60.0	20.6	6.7	-	-	40.0	53.3	-	6.7	-	-
-75111	-	6.7	46.7	40.0	6.7	-	-	28.6	64.3	7.1	-	-
-75112	6.7	80.0	6.7	6.7	-	-	68.8	31.2	-	-	-	-
-75113	-	35.3	64.7	-	-	-	-	100.0	-	-	-	-
-75114	7.1	57.1	35.7	-	-	-	6.7	86.7	6.7	-	-	-
-75115	-	35.7	64.3	-	-	-	6.7	20.0	73.3	-	-	-
-75129	13.3	46.7	33.3	-	6.7	-	11.8	52.9	29.4	5.9	-	-
-75131	-	28.6	64.3	7.1	-	-	46.7	53.3	-	-	-	-
-75139	-	7.1	42.9	50.0	-	-	14.3	71.4	14.3	-	-	-

* MATSUMOTO *et al.* (1979).

Table 3. Mean compositions of olivines and percent mean deviations of their iron contents in the analyzed Yamato-75 chondrites.

Sample No.	Mean composition			No. of measure-ments	Mean diviation	% mean diviation	Remarks
	Ca	Mg	Fe				
Yamato-75108*	0.00	74.49	25.51	11	0.409	1.61	L 4-5
-75110*	0.00	75.69	24.31	11	0.878	3.61	L 4-5
-75109	0.00	76.09	23.91	14	0.440	1.84	L 4-5
-75110	0.00	76.42	23.58	15	0.546	2.32	L 4-5
-75111	0.00	75.08	24.92	15	0.396	1.59	L 4-5
-75112	0.00	76.44	23.56	15	0.293	1.24	L 4-5
-75113	0.01	75.81	24.18	17	0.269	1.11	L 4-5
-75114	0.00	76.16	23.84	14	0.385	1.62	L 4-5
-75115	0.01	75.77	24.22	14	0.319	1.32	L 4-5
-75129	0.00	75.99	24.01	15	0.479	2.00	L 4-5
-75131	0.00	75.80	24.20	14	0.357	1.48	L 4-5
-75139	0.00	76.08	23.92	14	0.290	1.21	L 4-5

* MATSUMOTO *et al.* (1979).

Table 4. Mean compositions of orthopyroxenes and percent mean deviations of their iron contents in the analyzed Yamato-75 chondrites.

Sample No.	Mean composition			No. of measure-ments	Mean deviation	% mean deviation	Remarks
	Ca	Mg	Fe				
Yamato-75108*	0.21	77.77	22.02	7	0.479	2.17	L4-5
-75110*	0.00	77.96	22.04	9	1.161	5.27	L4-5
-75109	0.81	78.73	20.46	14	0.196	0.96	L4-5
-75110	1.20	78.47	20.33	15	0.453	2.23	L4-5
-75111	0.95	77.72	21.33	14	0.486	2.28	L4-5
-75112	0.81	79.44	19.75	16	0.225	1.14	L4-5
-75113	1.35	78.29	20.36	15	0.171	0.84	L4-5
-75114	0.77	78.71	20.52	15	0.274	1.34	L4-5
-75115	1.13	78.64	20.23	15	0.441	2.18	L4-5
-75129	1.42	77.91	20.67	17	0.555	2.68	L4-5
-75131	0.96	78.95	20.09	15	0.249	1.24	L4-5
-75139	0.93	78.50	20.57	14	0.296	1.44	L4-5

* MATSUMOTO *et al.* (1979).

range of iron contents (atomic %) for the average H6, L6, and LL6 chondrites is shown at the top. The numerals are the sample numbers of the Yamato meteorites studied. The mean compositions (Ca, Mg and Fe), the number of measurements, the mean deviation of iron contents and the percent mean deviations of iron contents in their olivine and orthopyroxene are given in Tables 3 and 4. The data of chondrites in the first and second rows (Yamato-75108 and -75110) are quoted from MATSUMOTO *et al.* (1979).

All of the mean compositions of the olivines and orthopyroxenes fall within the compositional range determined for the equilibrated L chondrites, indicating that all these chondrite belong to L group.

The % M. D. for olivine of Yamato-75110 chondrite is 3.61 (MATSUMOTO *et al.*, 1979) and 2.32 (this paper), and that for orthopyroxene is 5.27 (MATSUMOTO *et al.*, 1978) and 2.23 (this paper). Other chondrites have 1 to 2% M. D. for olivine. However, Yamato-75108, -75111, -75115 and -75129 chondrites contain more than 2% M. D. for orthopyroxene. Yamato-75109, -75112, -75113, -75114, -75131 and -75139 chondrites have less than 2% M. D. for olivine and orthopyroxene. The textural characteristics of chondrules, matrix, igneous glass and secondary feldspar of those chondrites (Table 1), suggest that those chondrites correspond to petrologic type 4–5.

5. Conclusion

A preliminary classification of ten Yamato-75 chondrites (Yamato-75109,

-75110, -75111, -75112, -75113, -75114, -75115, -75129, -75131 and -75139) from East Antarctica was performed, based on the textural characteristics and electron microprobe analyses of olivine and orthopyroxene. These chondrites are ten out of the 150 meteorites which were found in the limited area.

On the basis of the histogram of iron contents of olivine and orthopyroxene, and the microscopical characters, these chondrites are classified as L group and petrologic type 4–5, and they were possibly one meteorite originally.

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