CLASSIFICATION OF SEVERAL YAMATO-75 CHONDRITES (IV)

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***Abstract*:** An electron microprobe analyzer was used to determine the chemical compositions of olivines and orthopyroxenes in six chondrites, *i.e.* Yamato-75119, 91, -75124,91, -75125,91, -75126,91, -75128,92 and -75133,93. These chondrites are classified on the basis of textural characteristics of chondrules, matrix, plagioclase and igneous glass, and on the compositions of olivines and orthopyroxenes. The statistical analyses of the experimental results show that the chondrites Yamato-75119,91, -75125,91, -75126,91 and -75128,92 are tentatively assigned to L4$\sim$5 [*i.e.* L4(67%), (67%), (83%) and (83%), respectively], and that the chondrites Yamato-75124,91 and -75133,93 are assigned to L5$\sim$4[*i.e.* L5(67%)] and LL4$\sim$5 [*i.e.* L4(67%)], respectively. These chondrites, except the chondrites Yamato-75133,93, were possibly one single meteorite originally which was broken into many fragments during passage through the atmosphere, together with seventeen chondrites previously reported. The chondrite Yamato-75133,93 is possibly a different fragment from the above seventeen chondrites. Another sample of the chondrite Yamato-75102,74 tentatively classified as L6$\sim$5 chondrite from different sampling area, is determined to be of L4$\sim$5 [*i.e.* L4 (67%)] chondrite based on the same analytical method as the above six chondrites. The chemical compositions of plagioclases in these seven chondrites show some variation in oligoclase compositions.

1. Introduction

As a part of the preliminary examination of 150 meteorites (*i.e.* from Yamato-75108 to -75257 chondrites) found within a limited narrow area of about 10$\times$50 m by the 16th Japanese Antarctic Research Expedition 1974–1976 (JARE-16) (MATSUMOTO, 1978), twelve specimens of Yamato-75108 to -75115, -75129, -75131 and -75139 chondrites (*) and six specimens with subnumber were tentatively classified as the petrologic type 4$\sim$5 or 5$\sim$4, and the chemical group of these twelve chondrites belongs to the L group (MATSUMOTO *et al.*, 1979; MATSUMOTO and HAYASHI, 1980; MIÚRA and MATSUMOTO, 1981).

The first purpose of a series of these classification studies is to compile a catalog on the Yamato meteorites, which catalog will be used as a guidebook in processing allocation and distribution of the meteorites for many investigators in various fields. The second purpose is to discuss how many chondritic meteorites Yamato-75108 to -75257 are possibly related to determine fragments of one single original meteorite.

* Yamato-75110 was briefly reported twice by electron microprobe analyzers for different areas within the Yamato-75110 chondrite by MATSUMOTO *et al.* (1979) and MATSUMOTO and HAYASHI (1980).

The third purpose is to obtain the compositional variation of tiny crystals of plagioclase in types 4 to 5 chondrites.

By using an electron microprobe analyzer, SiO_2, Al_2O_3, FeO, MnO, MgO, CaO and Cr_2O_3 contents in olivine and orthopyroxene have been determined to obtain the histograms of iron contents in the two minerals, using the analytical method proposed by DODD *et al.* (1967).

For the determination of petrologic subdivision of these chondritic meteorites, VAN SCHMUS and WOOD (1967)'s classification was used. Because there are ambiguous descriptions in their classification, especially between type 4 to 6, statistical treatment of the subdivision is introduced in this study mainly for unbiassed description of the petrologic subdivision.

Plagioclase feldspars with almost definite An and Or contents, which might be assigned to type 5, are present. However, the petrological subdivisions obtained from electron microprobe analyses of olivine and orthopyroxene are restricted to type 4~5 or 5~4 in the Yamato-75 chondrites, as reported by MIÚRA and MATSUMOTO (1981). Detailed investigations of plagioclase compositions in the Yamato-75 chondrites are required to explain the discrepancy between type descriptions.

2. Experimental Method

The samples used in this study are six meteorite fragments of Yamato-75 chondrites (*i.e.* Yamato-75119,91, -75124,91, -75125,91, -75126,91, -75128,92 and -75133,93 chondrites) which weighed 40 to 82 g. The additional sample is the one meteorite of Yamato-75102,74 chondrite which was briefly reported by YANAI *et al.* (1978) and MATSUMOTO *et al.* (1979).

Compositional data were obtained on the carbon-coated, polished thin sections of about 25 to 120 mm^2 area in using JXA-50A electron microprobe at the Department of Mineralogical Sciences, Yamaguchi University by the senior author. The instrument was operated at 15 kV and 2.0×10^{-8}A specimen current. The quantitative chemical analyses of constituent minerals were conducted with the method of BENCE and ALBEE (1968) and ALBEE and RAY (1970), by using the correction factors for 35° take-off angle (JAX-50A probe). This calculation system of Bence and Albee's method was checked with the standard specimens of plagioclase which were reported by the senior author (*cf.* MIÚRA, 1978; MIÚRA and TOMISAKA, 1978).

Measurements for each thin section were made on about 30 points on the different areas of both olivine and orthopyroxene. The grain size of chondrules is, however, remarkably variable from section to section. The composition of the minerals was checked by monitoring the peak-intensities of ten elements (*i.e.* Na, K, Mg, Fe, Si, Mn, Al, Ca, Ti, Cr) with the scanning technique. Grains with total weight percents ($SiO_2 + Al_2O_3 + FeO + MnO + MgO + CaO$) outside the range between 99 and 101 wt% were ascribed to inaccurate analyses and were rejected. Any analyses in which Si, Fe, Mg and Ca contents were inappropriate for either olivine or orthopyroxene were also discarded. Thus, the total number of measurements was about 30 for each sample. Atomic % of magnesium, calcium and iron in olivine and orthopyroxene were calculated with the minicomputer, followed by calculation of the "percent mean deviation" proposed by DODD *et al.* (1967). In this paper, the mean deviation and "percent mean deviation" are shown for the atomic percent of iron, as for the previous works by YANAI *et al.* (1978) and MIÚRA and MATSUMOTO (1981).

Plagioclase fragments are also found in each specimen, most with tiny grains of about 25×50 μm (in Yamato-75119,91 and -75124,91), 50×50 μm (Yamato-75119, 91, -75124,91 and -75102,74) or 50×100 μm (in fusion crust of Yamato-75124,91). Almost all fragments of plagioclase, however, are too tiny to get total weight percents inside the range between 99 and 101 wt%. Higher values of total weight percents up to 110 wt% are considered to coexist with another minerals. Because Or and An contents are determined from K, Na and Ca, however, Or and An contents of these fragments are considered to be reliable even in the tiny crystals. The Or-Ab-An percentages of each analyzed grain, therefore, were automatically obtained by the minicomputer

3. Textural Characteristics

Under the polarized and reflection microscopes, various shapes of chondrules are observed in each thin section. That is, some chondrules are clearly defined in their shapes and others are poorly difined within one thin section. Yamato-75119,91 shows barred-olivine (Figs. 1, 2 and 3), and barred-hypersthene chondrules; Yamato-75124,91, porphyritic-olivine and hypersthene chondrules (Figs. 4 and 5); Yamato-75125,91, barred-olivine (Fig. 6), microradiated-olivine (Fig. 7), barred ortho- and clinopyroxenes (Figs. 8 and 9), and radial-olivine (Fig. 10) chondrules; Yamato-75126,91, barred ortho- and clinopyroxenes (Fig. 11), and microradiated- and barred-olivines (Figs. 12 and 13, respectively) chondrules; Yamato-75128,92, herringbone pattern-olivine (Fig. 14), porphyritic-olivine (Figs. 15 and 16), barred-olivine, and barred-orthopyroxene chondrules; Yamato-75133,93, barred-olivine (Fig. 17), and porphyritic-olivine (Figs. 18 and 19), and microradiated-olivine chondrules; Yamato-75102,74, microradiated-orthopyroxene, microradiated-olivine (Fig. 20), barred-olivine, porphyritic-olivine (Fig. 21) chondrules. Cryptocrystalline and microcrystalline textures are also preserved. Some chondrules show several concentric textures (Figs. 10, 11 and 13). Some chondrules contain glass or wholly devitrified glass or

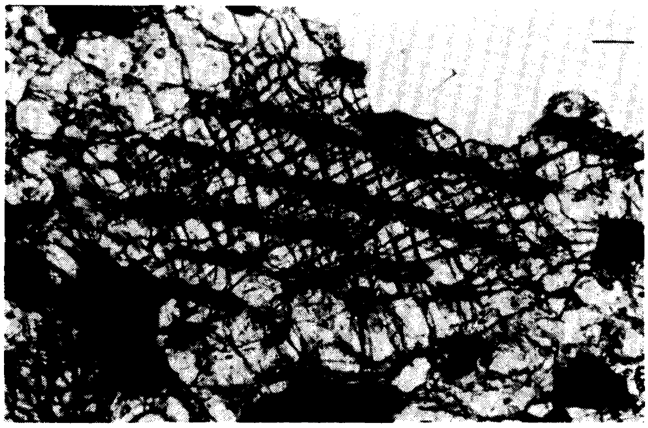

Fig. 1. Barred-olivine chondrule composed of alternate layers of porphyritic-olivine crystals in Yamato-75119,91. The interstices between olivine bars are filled with cryptocrystalline materials and devitrified glass. One nicol. Scale bar 100 μm.

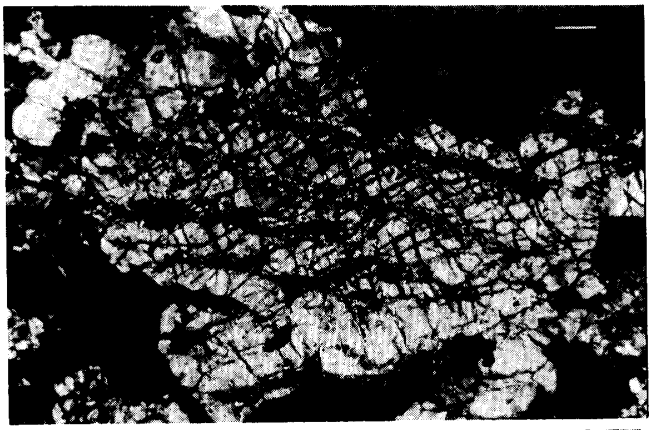

Fig. 2. The photograph with crossed nicols of the same area as in Fig. 1. Yamato-75119,91. Scale bar 100 μm.

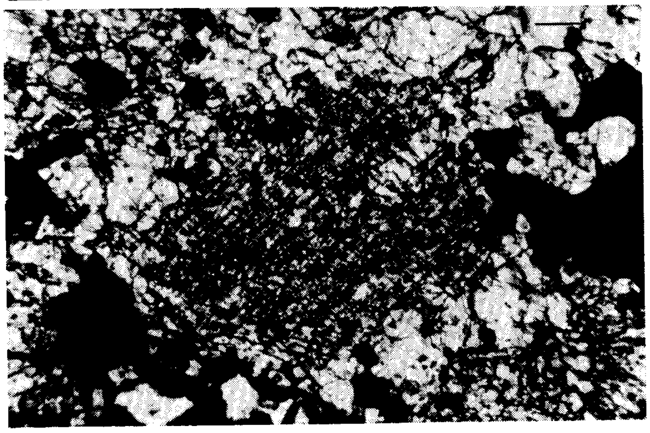

Fig. 3. Weakly recrystallized barred-olivine chondrule in Yamato-75119,91. One nicol. Scale bar 100 μm.

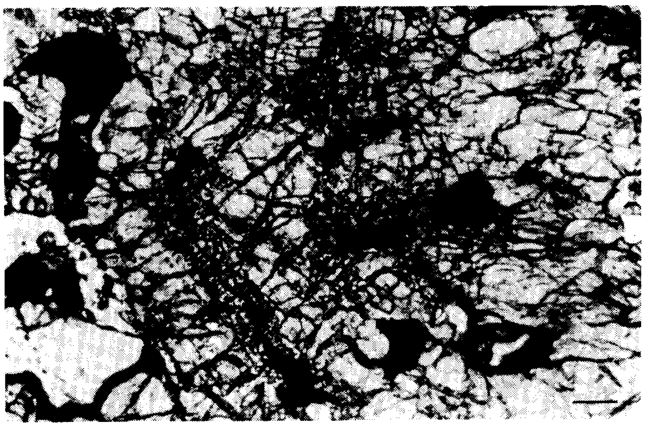

Fig. 4. Porphyritic-olivine and hypersthene chondrule in Yamato-75124,91. The interstices between the porphyritic crystals are filled with cryptocrystalline materials and devitrified glass. One nicol. Scale bar 100 μm.

Fig. 5. Photograph with crossed nicols of the same area as in Fig. 4. Yamato-75124,91. Scale bar 100 μm.

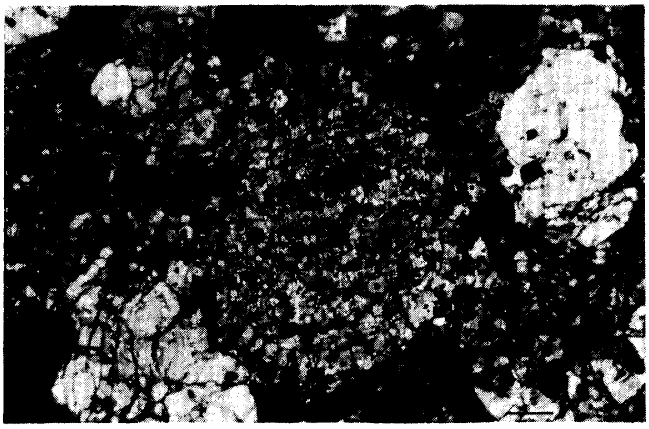

Fig. 6. Barred-olivine chondrule with olivine rim of about 500 × 600 μm composed mainly of medium olivine crystals and plagioclase ($Ab_{67.7}An_{24.6}Or_{7.7}$) in the matrix of Yamato-75125,91. Crossed nicols. Scale bar 100 μm.

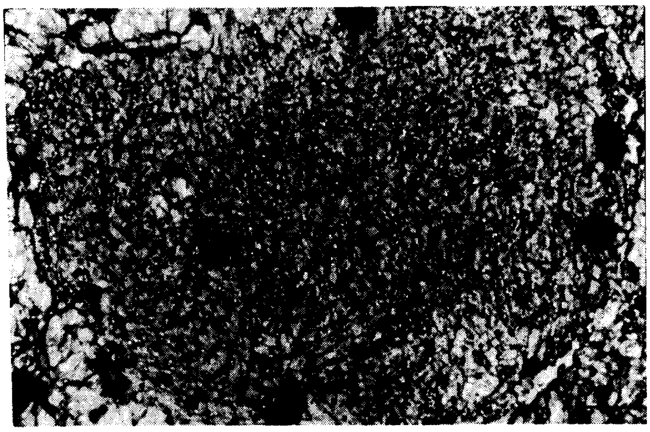

Fig. 7. Microradiated-olivine chondrule with concentric features in Yamato-75125,91. One nicol. Scale bar 100 μm.

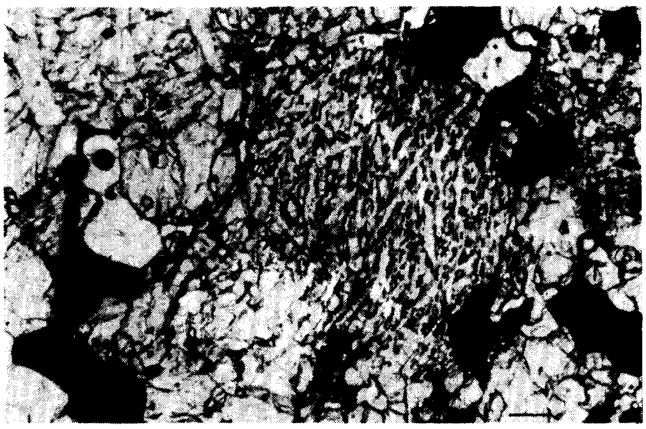

Fig. 8. Barred-orthopyroxene chondrule composed of patchy sets of orthopyroxene crystals with clinopyroxene and plagiocalse ($Ab_{72.7}An_{23.6}Or_{3.7}$) in the matrix of Yamato-75125,91. One nicol. Scale bar 100 μm.

Fig. 9. Photograph with crossed nicols of the same area as in Fig. 8. Yamato-75125,91. Scale bar 100 μm.

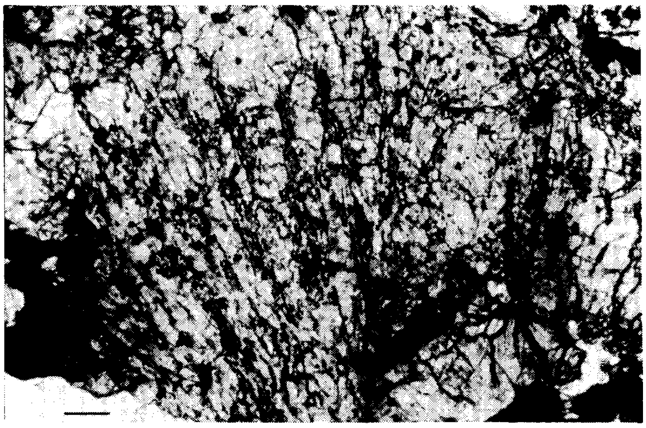

Fig. 10. Radial-olivine chondrule with concentric feature in Yamato-75125,91. Crossed nicols. Scale bar 100 μm.

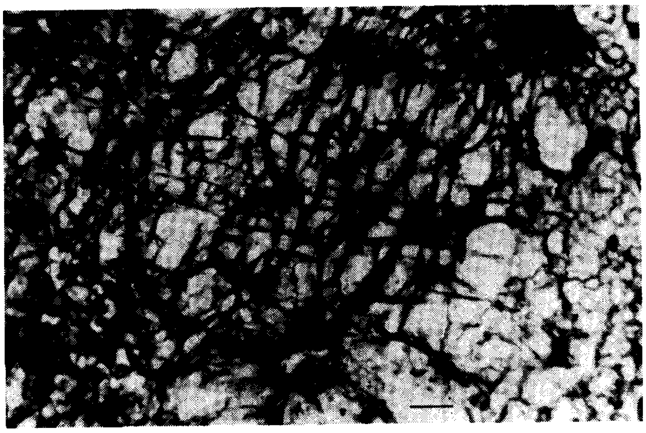

Fig. 11. Porphyritic-orthopyroxene chondrule with the rim and clinopyroxene in the matrix of Yamato-75126,91. One nicol. Scale bar 100 μm.

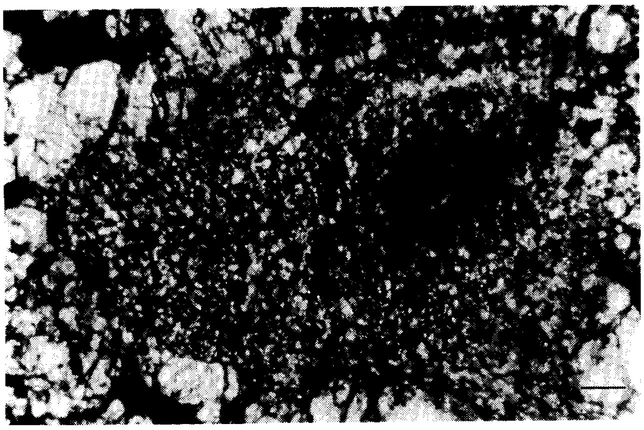

Fig. 12. Microradiated-olivine chondrule with concentric feature in Yamato-75126,91. One nicol. Scale bar 100 μm.

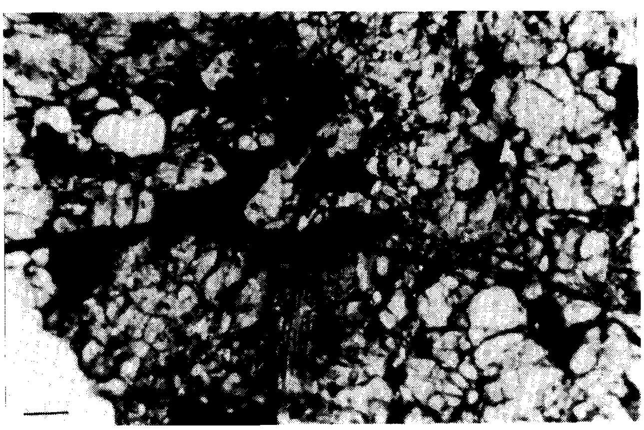

Fig. 13. Barred-olivine chondrule with slightly concentric feature in a glassy matrix in Yamato-75126,91. One nicol. Scale bar 100 μm.

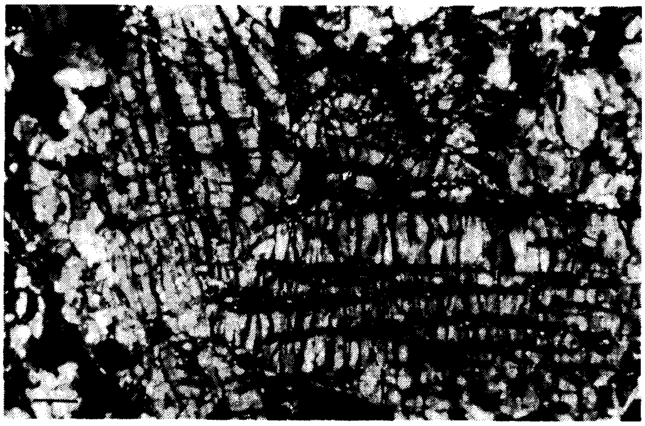

Fig. 14. A couple of barred-olivine chondrules forming a herring-bone pattern composed of irregularly alternate layers of olivine crystals, and glasses of clinopyroxene and plagioclase in the matrix of Yamato-75128,92. Crossed nicols. Scale bar 100 μm.

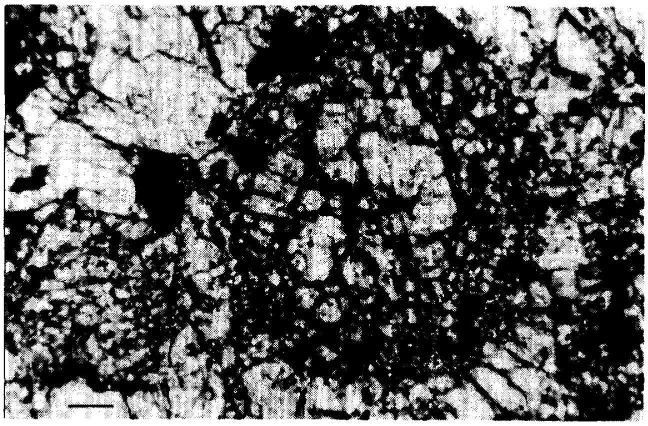

Fig. 15. Porphyritic-olivine chondrule with olivine rim in Yamato-75128,92. Interstices between the olivine crystals are filled with cryptocrystalline materials and devitrified glass. One nicol. Scale bar 100 μm.

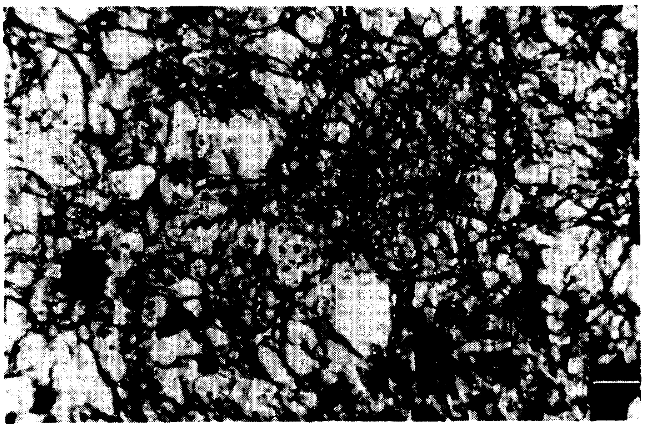

Fig. 16. Porphyritic-olivine chondrule composed of microcrystalline olivine in core and porphyritic olivine in rim with cryptocrystalline materials and devitrified glass in the matrix of Yamato-75128,92. One nicol. Scale bar 100 μm.

Fig. 17. Barred-olivine chondrule composed of alternate layers of olivine crystals with porphyritic olivine in rim of Yamato-75133,93. The interstices between olivines bars are filled with cryptocrystalline materials and devitrified glass. One nicol. Scale bar 100 μm.

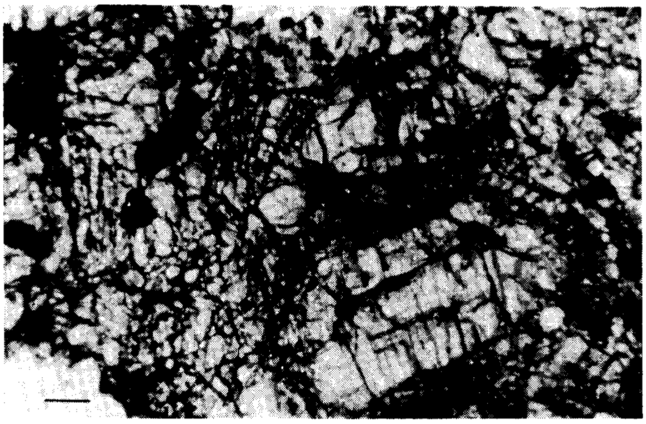

Fig. 18. *A few sets of barred-olivine chondrules in Yamato-75133,93. The chondrule in the center of the figure is barred olivine one with porphyritic olivine in rim, and with barred microcrystalline olivine in core. Barred chondrules with diffuse rims are also exists in the left side of this figure. Crossed nicols. Scale bar 100 μm.*

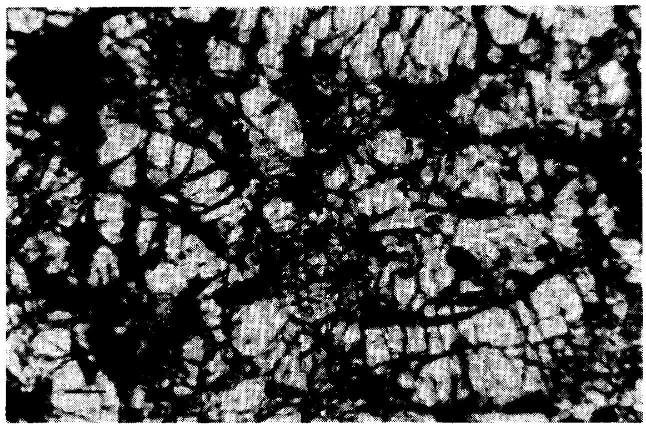

Fig. 19. *Porphyritic-olivine chondrule with cryptocrystalline materials and devitrified glass in Yamato-75133,93. One nicol. Scale bar 100 μm.*

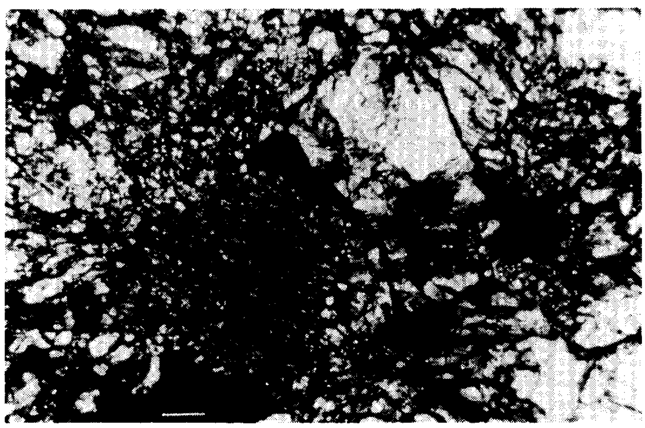

Fig. 20. *Recrystallized barred-olivine chondrule with glassy matrix in Yamato-75102,74. One nicol. Scale bar 100 μm.*

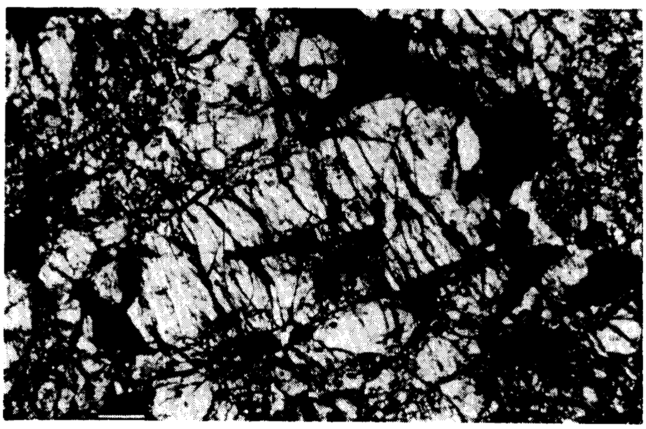

Fig. 21. *Porphyritic and barred chondrule with recrystallized rim in Yamato-75102,74. One nicol. Scale bar 100 μm.*

extremely fine-grained materials with a small amount of plagioclase (*cf.* Figs. 6, 8, 9 and 14). Some chondrules have glassy or poorly recrystallized rims (*cf.* Figs. 3, 6, 13, 15 and 20).

Textural characteristics in the Yamato-75 chondrites are difficult to determine only by the polarized microscope without careful check by microprobe. The barred-olivine chondrules with olivine rim of about 500×600 μm in Yamato-75125,91 consist mainly of medium-grained olivine crystals and plagioclase ($Ab_{67.7}An_{24.6}Or_{7.7}$) in the matrix (Fig. 6). The barred ortho- and clinopyroxenes chondrules in Yamato-75125,91 are mainly composed of patchy sets of orthopyroxene crystals with clinopyroxene and plagioclase ($Ab_{72.7}An_{23.6}Or_{3.7}$) in the matrix (Figs. 8 and 9). Pseudo-barred-olivine chondrule forming a herringbone pattern coexists with medium-grained olivine crystals and glasses of clinopyroxene and plagioclase in the matrix (Fig. 14). Electron microprobe study of Yamato-75128,92 shows that there exists clear compositional zoning from olivine (in rim) to orthopyroxene to plagioclase (in core) in the matrix. Barred-olivine chondrules are mainly composed of sets of olivine crystals and glasses of olivine and plagioclase in the matrix. Complicated barred-orthopyroxene chondrule observed in Yamato-75128,92 consists of orthopyroxene crystals with partly relict olivine, chromite and glass of olivine in the matrix, rimmed by olivine grains and metal phase. Barred-olivine chondrule in Yamato-75133,93 consists of olivine crystals and glasses of plagioclase and chromite, generally rimmed by orthopyroxene crystals and metal phases. Barred-olivine chondrule in Yamato-75126,91 is composed of olivine crystals and relict orthopyroxene with clinopyroxene in the matrix. Barred-olivine chondrule in Yamato-75102,74 is composed of medium-grained olivine of about 150×150 μm and aggregates of plagioclases. The micro-radiated orthopyroxene chondrule with orthopyroxene rim is composed of wormy grains of orthopyroxene of 200×250 μm and olivine grains of 60×80 μm in core and rims (Fig. 20). Barred-olivine and orthopyroxene chondrules contain clinopyroxene grains of 30×50 μm and 200×100 μm, respectively, in the core. Yamato-75102,74 contains many vacant holes and glassy veins probably formed by strong impact metamorphism. Clinopyroxene could not be found in Yamato-75119,91 and -75124,91 in this study.

Plagioclase feldspar occurs in both chondrules and matrix as microcrystalline aggregates. Plagioclases with compositions of $Ab_{82.4-86.8}An_{10.5-12.6}Or_{2.4-7.0}$ are observed in the matrix of Yamato-75102,74. Yamato-75119,91 shows $Ab_{83.3}An_{11.5}Or_{5.2}$ (50×50 μm) next to a whitlockite group mineral in the matrix; $Ab_{82.6}An_{10.0}Or_{7.4}$ and $Ab_{81.2}An_{11.0}Or_{7.8}$ (30×50 μm) in the matrix. Yamato-75124,91 shows $Ab_{86.4}An_{11.9}Or_{1.7}$ (50×50 μm), $Ab_{82.8}An_{12.5}Or_{4.7}$ (50×100 μm) in the matrix, and $Ab_{89.5}An_{10.1}Or_{0.4}$ (20×50 μm) in the glassy matrix of fusion crust. Yamato-75125,91 shows $Ab_{72.7}An_{23.6}Or_{3.7}$ (Figs. 8 and 9) in the matrix of a patchy ortho- and clinopyroxenes chondrule, and $Ab_{67.7}An_{24.6}Or_{7.7}$ in the matrix of a barred-olivine chondrule. Yamato-75126,91 shows $Ab_{88.0}An_{11.5}Or_{0.5}$ in glassy matrix, and $Ab_{81.5-87.9}An_{10.8-15.3}Or_{1.2-3.0}$ in the glassy area of fusion crust. Yamato-75128,92 shows $Ab_{78.8}An_{15.3}Or_{5.9}$ and $Ab_{68.4}An_{29.1}Or_{2.5}$ in the matrix of a chondrule. Yamato-75133,93 shows $Ab_{76.8}An_{14.7}Or_{8.5}$ in the matrix of a barred-olivine chondrule, and $Ab_{27.9}An_{52.8}Or_{19.3}$ (100×150 μm) next to chlorapatite.

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	Low-Ca pyroxene	Petrologic type
Yamato -75119,91	Readily delineated	Micro-crystalline and recrystallized	Turbid glass	Microcrystalline aggregates (30×50; 50×50 μm)	opx	4∼5
Yamato -75124,91	Readily delineated	Micro-crystalline and recrystallized	Turbid (in fusion crust)	Microcrystalline aggregates (50×50, 50×20, 50×100 μm)	opx	5∼4
Yamato -75125,91	Well-defined and readily delineated	Micro-crystalline and recrystallized	Absent	Microcrystalline aggregates	opx + cpx (∼10%)	4∼5
Yamato -75126,91	Well-defined and readily delineated	Micro-crystalline and recrystallized	Turbid glass	Microcrystalline aggregates	opx + cpx (∼10%)	4∼5
Yamato -75128,92	Well-defined and readily delineated	Micro-crystalline	Turbid glass	Microcrystalline aggregates	opx + cpx (∼10%)	4∼5
Yamato -75133,93	Well-defined and readily delineated	Micro-crystalline	Turbid glass	Microcrystalline aggregates, well-developed (100×150 μm)	opx + cpx (∼10%)	4∼5
Yamato -75102,74	Readily delineated	Micro-crystalline and recrystallized	Turbid glass	Microcrystalline aggregates (40×60, 50×50 μm)	opx + cpx (∼10%)	4∼5

Table 2. Frequency distribution of petrologic types in several Yamato-75 chondritic meteorites.

Sample No.	Percent of observations and measurements				Type of maximum value of petrologic type	Average type (%)
	Type 4		Type 5			
	4	4–5	5–4	5		
Yamato-75119,91	33.3	**33.4**	—	33.3	4–5	4 (67%)
Yamato-75124,91	16.6	16.6	16.8	**50.0**	5	5 (67%)
Yamato-75125,91	16.6	**50.0**	16.8	16.6	4–5	4 (67%)
Yamato-75126,91	33.3	**50.0**	16.7	—	4–5	4 (83%)
Yamato-75128,92	**50.0**	33.3	16.7	—	4	4 (83%)
Yamato-75133,93	**50.0**	16.7	33.3	—	4	4 (67%)
Yamato-75102,74	33.3	**33.3**	16.7	16.7	4–5	4 (67%)

Another constituent minerals are also observed in this study. A whitlockite-group mineral (esp. merrillite) could be observed in the matrices of Yamato-75102,74, -75119,91, -75124,91, -75126,91 and -75128,92. Chlorapatite crystals are observed in Yamato-75102,74, -74124,91, -75128,92 and -75133,93. Chromite and metal phases are observed in all samples.

Table 1 shows petrologic types of the specimens determined by the textural characteristics of chondrule, matrix, plagioclase and igneous glass proposed by VAN SCHMUS and WOOD (1967). The results of statistical analyses of the six essential items to determine the petrologic type are shown in Table 2.

4. Classification of Yamato-75 chondrites

Tables 1 and 2 show that petrologic type in Yamato-75128,92 and -75133,93 is 4~5 with much trend to 4 (*i.e.* 4 (83%), (67%), respectively); that in Yamato-75119,91, -75125,91, -75126,91 and -75102,74, 4~5 (*i.e.* 4 (67%), (67%), (83%), (67%), respectively); that in Yamato-75124,91, 5~4 with trend to 5 (*i.e.* 5 (67%)). This intermediate expression of the petrologic types is characteristic of the Yamato-75 chondrites. Although the items of "igneous glass' and "low Ca-pyroxene" are assigned to 4 or 5, another items for determination of petrologic type are assigned to 4~5 or 5~4, even in the item of "development of feldspar". It is found in Table 2 that there are two

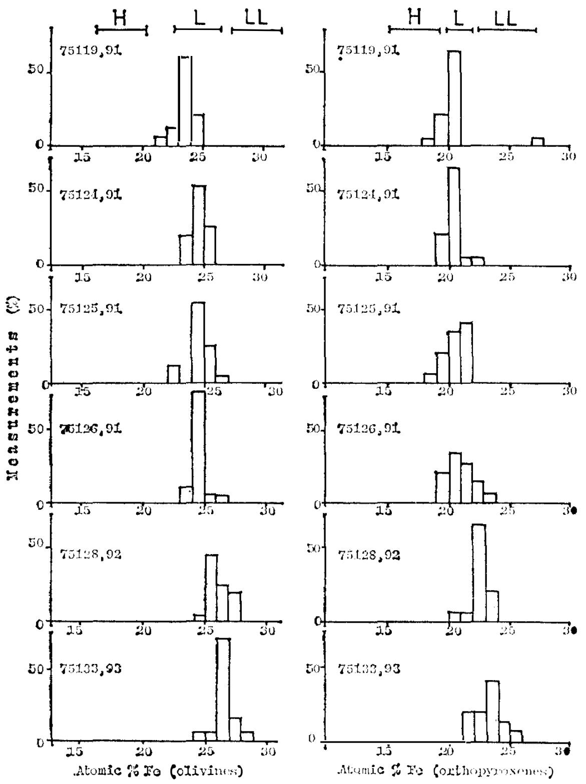

Fig. 22. Histograms of iron contents of olivines and orthopyroxenes in the analyzed Yamato-75 chondrites.

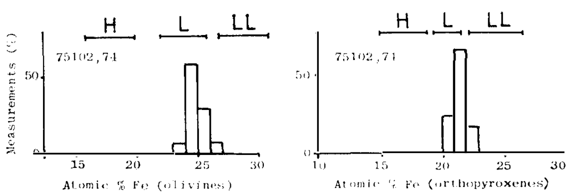

Fig. 23. Histograms of iron contents of olivines and orthopyroxenes in the Yamato-75102,74 chondrite.

Table 3. Frequency distribution of iron contents of olivines

	Olivine							
Atomic % Fe	21	22	23	24	25	26	27	28
Sample No.	Percent of measurements							
Yamato-75119,91	6.7	13.3	**60.0**	20.0	—	—	—	—
-75124,91	—	—	20.0	**53.3**	26.7	—	—	—
-75125,91	—	12.5	—	**56.3**	25.0	6.2	—	—
-75126,91	—	—	12.5	**75.0**	6.3	6.2	—	—
-75128,92	—	—	—	6.7	**46.6**	26.7	20.0	—
-75133,93	—	—	—	6.7	6.7	**66.6**	13.3	6.7
-75102,74	—	—	5.9	**58.8**	29.4	5.9	—	—

Table 4. Statistical analyses of frequency distribution of iron contents of olivines and orthopyroxenes in Yamato-75 chondritic meteorites.

	Olivine							
Atomic % Fe	21	22	23	24	25	26	27	28
Sample No.	Percent of measurements							
Yamato-75	—	3.8	25.6	44.4	21.6	3.8	0.8	—
[18]*		(48)**	(233)	(206)	(224)	(68)	(25)	—
In this study	1.0	3.7	14.1	39.5	20.1	15.9	4.7	1.0
[7]	(23)	(58)	(200)	(257)	(157)	(223)	(77)	(23)

	Orthopyroxene									
Atomic % Fe	18	19	20	21	22	23	24	25	26	27
Sample No.	Percent of measurements									
Yamato-75	—	13.1	41.9	33.9	7.7	2.8	0.6	—	—	—
[18]		(169)	(302)	(277)	(104)	(53)	(25)			
In this study	1.9	11.4	32.9	22.7	17.8	9.5	1.9	1.0	—	0.9
[7]	(33)	(99)	(234)	(195)	(213)	(142)	(47)	(23)		(23)

* Numbers of samples analyzed are shown in square brackets.
** Numbers in parentheses are standard deviation referring to the last decimal place.

different ways of descriptions of petrologic type. One is a type number having maximum value of percent of observations and measurements (*i.e.* 5 in Yamato-75124,91). The other is an average type number; for example, 4 (including 4 and 4–5) or 5 (including 5–4 and 5). A description of petrologic type shown in Table 1 is still used in this study as a general classification (*i. e.* 4~5 or 5~4).

Histograms of iron contents (atomic percent; =100 Fe/(Mg+Fe)) of olivines and orthopyroxenes for the analyzed samples are shown in Table 3 and Figs. 22 and 23. The ranges of iron content (atomic %) for the average H6, L6 and LL6 chondrites are shown at the top of Figs. 22 and 23 (*cf.* VAN SCHMUS and WOOD, 1967; VAN SCHMUS, 1969). The numerals in Figs. 22 and 23 are sample numbers of the analyzed Yamato meteorites. Table 4 shows the statistical analyses of frequency distribution of iron contents of olivines and orthopyroxenes, compared with eighteen Yamato-75 chondrites reported previously and seven chondrites in this study. Distribution of atomic % Fe in the seven chondrites in this study shows wider trends than that of the *and orthopyroxenes in six Yamato-75 chondritic meteorites.*

	Orthopyroxene								
Atomic % Fe	18	19	20	21	22	23	24	25	27
Sample No.	Percent of measurements								
Yamato-75119,91	6.7	20.0	**66.6**	—	—	—	—	—	6.7
-75124,91	—	20.0	**66.6**	6.7	6.7	—	—	—	—
-75125,91	6.7	20.0	33.3	40.0	—	—	—	—	—
-75126,91	—	20.0	**33.3**	26.7	13.3	6.7	—	—	—
-75128,92	—	—	6.7	6.7	**66.6**	20.0	—	—	—
-75133,93	—	—	—	20.0	20.0	**40.0**	13.3	6.7	—
-75102,74	—	—	23.5	**58.8**	17.7	—	—	—	—

eighteen Yamato-75 chondrites reported previously. However, the highest values of "percent of measurements" in the olivines and orthopyroxenes are the same in this study; that is, the atomic % Fe, 24 and 20, respectively.

The mean compositions of the olivines and orthopyroxenes in the six chondrites (*i.e.* Yamato-75119,91, -75124,91, -75125,91, -75126,91, -75128,92 and -75102,74 chondrites) fall within the compositional range of the relevant mineral determined for the type L chondrite. But the Yamato-75133,93 chondrite shows a different complicated pattern. That is, the mean composition of orthopyroxene in the Yamato-75133,93 chondrite falls clearly within the compositional range of type LL chondrite,

Table 5. Mean compositions of olivines and percent mean deviations of their iron contents in the analyzed Yamato-75 chondrites.

Sample No.	Mean composition (%) Ca	Mg	Fe	No. of measure-ments	M.D.	% M.D.	Remarks
Yamato-75119,91	0.01	76.61	23.38	15	0.509	2.18	L4~5
-75124,91	0.01	75.55	24.44	15	0.622	2.55	L5~4
-75125,91	0.01	75.40	24.59	16	0.714	2.91	L4~5
-75126,91	0.03	75.50	24.47	16	0.437	1.79	L4~5
-75128,92	0.02	73.91	26.07	15	0.710	2.72	L4~5
-75133,93	0.01	73.37	26.62	15	0.654	2.46	LL4~5
-75102,74	0.01	75.00	24.99	17	0.500	2.00	L4~5

Table 6. Mean compositions of orthopyroxenes and percent mean deviations of their iron contents in the analyzed Yamato-75 chondrites.

Sample No.	Mean composition (%) Ca	Mg	Fe	No. of measure-ments	M.D.	% M.D.	Remarks
Yamato-75119,91	1.11	78.31	20.58	15	0.681	3.31	L4~5
-75124,91	1.10	78.20	20.70	15	0.615	2.97	L5~4
-75125,91	1.13	78.29	20.58	15	0.703	3.42	L4~5
-75126,91	1.15	77.94	20.91	15	0.888	4.25	L4~5
-75128,92	1.52	76.09	22.39	15	0.541	2.42	L4~5
-75133,93	1.40	75.36	23.24	15	0.811	3.49	LL4~5
-75102,74	1.32	77.18	21.50	17	0.382	1.78	L4~5

Table 7. Statistical analyses of mean compositions of olivines and orthopyroxenes and percent mean deviations of their iron contents in the analyzed Yamato-75 chondrites.

Sample No.	Mean composition (%) Ca	Mg	Fe	M.D.	% M.D.
Olivines					
Yamato-75 chondrites [18]*	0.00	75.63	24.37	0.425 (155)	1.75 (64)
(*cf.* MIÚRA and MATSUMOTO, 1981)	(2)**	(56)	(55)		
In this study [7]	0.01	75.05	24.94	0.592 (102)	2.37 (37)
	(1)	(101)	(101)		
Orthopyroxenes					
Yamato-75 chondrites [18]*	0.97	78.15	20.88	0.450 (227)	2.13 (101)
(*cf.* MIÚRA and MATSUMOTO, 1981)	(36)	(65)	(68)		
In this study [7]	1.25	77.34	21.41	0.660 (156)	3.09 (74)
	(15)	(110)	(96)		

* Numbers of samples analyzed are shown in square brackets.

** Numbers in parentheses are standard deviation referring to the last decimal place.

Table 8. Chemical compositions of plagioclases in the analyzed Yamato-75 chondrites.

Sample No.	Or	Ab	An (mol %)	Or	Ab	An (mol %)
Yamato-75119,91	7.8	81.2	11.0			
-75124,91	0.4	89.5	10.1			
-75125,91	3.7	72.7	23.6;	7.7	67.7	24.6
-75126,91	0.5	87.9	11.6			
-75128,92	5.1	79.2	15.7;	7.5	63.4	29.1
-75133,93	8.5	76.8	14.7			
-75102,74	3.2	84.2	12.6			

though that of olivine falls between types L and LL chondrites.

Tables 5 and 6 show the mean compositions (for Ca, Mg and Fe) of olivines and orthopyroxenes, the number of measurements, the mean deviations (M.D.) of iron contents and the percent mean deviations (%M.D.) of iron contents in their olivines and orthopyroxenes, respectively. The %M.D. for olivines of Yamato-75126,91 chondrite shows a smaller value of 1.79, and that for orthopyroxenes is 4.25 (*cf.* MATSUMOTO *et al.*, 1981).

Table 7 shows the statistical analyses of the above data in the olivines and orthopyroxenes, compared with the eighteen Yamato-75 chondrites reported previously and the seven chondrites in this study. Table 7 shows that the values of M.D. and %M.D. in this study are greater than those of the eighteen Yamato-75 chondrites. In spite of the higher values of the M.D. and %M.D. in the olivine and orthopyroxene, the homogeneity of the olivine and pyroxene compositions is less than 5% M.D. (*i.e.* 1.8 to 4.3%), which corresponds to that of type 4.

The compositional cluster of plagioclase feldspars in recrystallized (type 6) chondritic meteorites from L, LL, H and E groups has a narrow range in anorthite content up to An_{16} (mol %), reported by VAN SCHMUS and RIBBE (1968). The chemical compositions of the plagioclase of the six Yamato-75 chondrites reported by MIÚRA and MATSUMOTO (1981) vary from oligoclase to andesine. Also in this study, the seven Yamato-75 chondrites have plagioclase feldspars with compositions from $Ab_{89}An_{10}$ to $Ab_{63}An_{29}$, and from $Or_{0.4}$ to $Or_{8.5}$, as shown in Table 8, where the data of the total weight percents (SiO_2+FeO+CaO+Na_2O+K_2O+Al_2O_3) are lying within 98–102 wt%. However, there exist many plagioclases except those listed in Table 8, which show the total weight percents varying from 105 to 115 wt%. The plagioclases with excess of total weight percents observed in the Yamato-75102,74, -75119,91, -75124,91 and -75126,91 chondrites, showing microcrystalline aggregates or coexistence with adjacent calcium phosphates and/or silicate minerals, do not change the An and Or contents largely, if the ratio of K, Na and Ca are induced only from the analyzed plagioclase clusters.

Anyhow, it is no wonder that the compositional modulation in a small domain is commonly observed in the lunar and terrestrial plagioclases which were formed under solid-state reaction of subsolidus conditions.

5. Conclusions

Classification of seven Yamato-75 chondrites (*i.e.* Yamato-75119,91, -75124,91, -75125,91, -75126,91, -75128,92, -75133,93 and -75102,74) from East Antarctica was performed, based on the statistical analyses of the textural characteristics and electron microprobe analyses of olivine and orthopyroxene.

One the basis of the histogram of iron contents of olivine and orthopyroxene, the six Yamato-75 chondrites (*i.e.* Yamato-75119,91, -75124,91, -75125,91, -75128,92 and -75102,74) and the Yamato-75133,93 chondrite are classified as L and LL groups, respectively. The statistical analyses of textural characteristics and electron microprobe data show that Yamato-75119,91, -75125,91, -75126,91 and -75102,74 chondrites are classified as L4$\sim$5 type (*i.e.* L4 (67%), (67%), (83%), (67%), respectively); Yamato-75128,92, L4$\sim$5 type with much trend to 4 (*i.e.* L4 (83%)); Yamato-75124,91, L5$\sim$4 type with much trend to 5 (*i.e.* L5 (67%)) (Table 9).

Table 9. Classification of several Yamato-75 chondrites.

Yamato number	Type of max. value of petrologic type	Average type (%)	% Fa* in olivine	% Fs** in orthopyroxene	Class***
75119,91	4–5	4 (67%)	21–24	18–27	L
75124,91	5	5 (67%)	23–25	19–22	L
75125,91	4–5	4 (67%)	22–26	18–21	L
75126,91	4–5	4 (83%)	23–26	19–23	L
75128,92	4	4 (83%)	24–27	20–23	L
75133,93	4	4 (67%)	24–28	21–25	LL
75102,74	4–5	4 (67%)	23–26	20–22	L

* Olivine composition in mole percent Fe_2SiO_4 (Fa).
** Orthopyroxene composition in mole percent $FeSiO_3$ (Fs).
*** L=Low-iron chondrite; LL=Low-iron low-metal chondrite.

Although the values of the M.D. and %M.D. in the olivine and orthopyroxene are higher than those of the previous eighteen Yamato-75 chondrites, it might be considered that five chondrites were the product of the single meteorite in a meteorite shower, but Yamato-75133,93 is probably assumed to be a different fragment from the above meteorite fragments.

Compositional variation of plagioclase feldspars in the seven Yamato-75 chondrites is also observed in this study. Their compositions change up to oligoclase as shown in Table 8.

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References

ALBEE, A. L. and RAY, L. (1970): Correction factors for electron probe microanalysis of silicates, oxides, carbonates, and sulfates. Anal. Chem., **42**, 1408–1414.

BENCE, A. E. and ALBEE, A. L. (1968): Empirical correction factors for the electron microanalysis of silicates and oxides. J. Geol., **76**, 382–403.

DODD, T. R., Jr., VAN SCHMUS, W. R. and KOFFMANN, D. M. (1967): A survey of the unequilibrated ordinary chondrites. Geochim. Cosmochim. Acta, **31**, 921–951.

MARVIN, U. and MASON, B. (1980): Catalog of Antarctic meteorites, 1977–1978. Smithson. Contrib. Earth Sci., **23**, 1–50.

MATSUMOTO, Y. (1978): Collection of Yamato meteorites, East Antarctica in November and December 1975, and January 1976. Mem. Natl Inst. Polar Res., Spec. Issue, **8**, 38–50.

MATSUMOTO, Y. and HAYASHI, M. (1980): A classification of several Yamato-75 chondrites. Mem. Natl Inst. Polar Res., Spec. Issue, **17**, 21–31.

MATSUMOTO, Y., HAYASHI, M., MIYAMOTO, M., TAKEDA, H. and YANAI, K. (1979): A classification of the Yamato-75 chondrites based on chemical compositions of olivines and pyroxenes. Mem. Natl Inst. Polar Res., Spec. Issue, **12**, 72–81.

MATSUMOTO, Y., HAYASHI, M., DAISHI, M. and MIÚRA, Y. (1981): On homogeneity of the Yamato-75110 chondrite. Mem. Natl Inst. Polar Res., Spec. Issue, **20**, 106–118.

MIÚRA, Y. (1978): Color zoning in labradorescence. Mineral. J., **9**(2), 91–105.

MIÚRA, Y. and MATSUMOTO, Y. (1981): Classification of several Yamato-75 chondrites (III). Mem. Natl Inst. Polar Res., Spec. Issue, **20**, 53–68.

MIÚRA, Y. and TOMISAKA, T. (1978): Ion microprobe mass analysis of exsolution lamellae in labradorite feldspar. Am. Mineral., **63**, 584–590.

VAN SCHMUS, W. R. (1968): The mineralogy and petrology of chondritic meteorites. Earth Sci. Rev., **5**, 145–184.

VAN SCHMUS, W. R. and RIBBE, P. H. (1968): The composition and structural state of feldspar from chondritic meteorites. Geochim. Cosmochim. Acta, **32**, 1327–1342.

VAN SCHMUS, W. R and WOOD, J. R. (1967): A 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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