ON HOMOGENEITY OF THE YAMATO-75110 CHONDRITE

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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: Mem. Natl Inst. Polar Res., Spec. Issue, **8**, 38, 1978; MATSUMOTO *et al.*: *Ibid.*, **12**, 72, 1979; MATSUMOTO and HAYASHI: *Ibid.*, **17**, 21, 1980). Electron microprobe analyses have been made on olivine and orthopyroxene, and microscopic studies on four different portions (such as Nos. 90, 91, 93 and 95) of the Yamato-75110 chondrite. Textural characters of chondrules, matrix, igneous glass and secondary feldspar, and the mean composition, mean deviation, and percent mean deviation of the iron contents of olivines and orthopyroxenes are given. The value of % M.D. for the olivine in the Yamato-75110 chondrite ranges from 2.02 to 2.98; but that in the matrix is from 1.79 to 2.12, and that in chondrule is from 0.88 to 2.05. The value of % M.D. for the orthopyroxene in this chondrite ranges from 2.38 to 5.27; but that in the matrix is from 2.15 to 7.17, and that in the chondrule is from 2.12 to 4.43. Such a chemical variety of the Yamato-75110 chondrite is observed cleary in this study. However, this chondrite is classified as L group and petrologic type 4–5.

1. Introduction

The 150 meteorites (*i.e.* 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). In appearance all of the accumulated meteorite-fragments looked the same kind of chondrite.

Previously, a preliminary classification of eleven chondrites (*i.e.* Yamato-75108,

-75109, -75110, -75111, -75112, -75113, -75114, -75115, -75129, -75131 and -75139) out of the above 150 meteorites was performed, based on the textural characteristics and electron microprobe analyses of olivine and orthopyroxene. On the basis of the histogram of iron contents of olivine and orthopyroxene, and microscopic characters, these chondrites are classified as L group and petrologic type 4–5. On the basis of the above results, it was considered that these 150 meteorites were possibly one meteorite originally (MATSUMOTO *et al.*, 1979; MATSUMOTO and HAYASHI, 1980).

However, the value of % M.D. for the olivine in eleven chondrites ranges from 1.11 to 3.61, and for the orthopyroxene in these chondrites it varies from 0.84 to 5.27.

The classification of chondritic meteorite based on the chemical composition of olivine and pyroxene (DODD *et al.*, 1967; VAN SCHMUS and WOOD, 1967), is one of the most approved methods. It seems to be an effectual method for a chemical classification, but a petrologic classification based upon the percent mean deviation (% M.D.) requires further examination for the homogeneity of one chondrite.

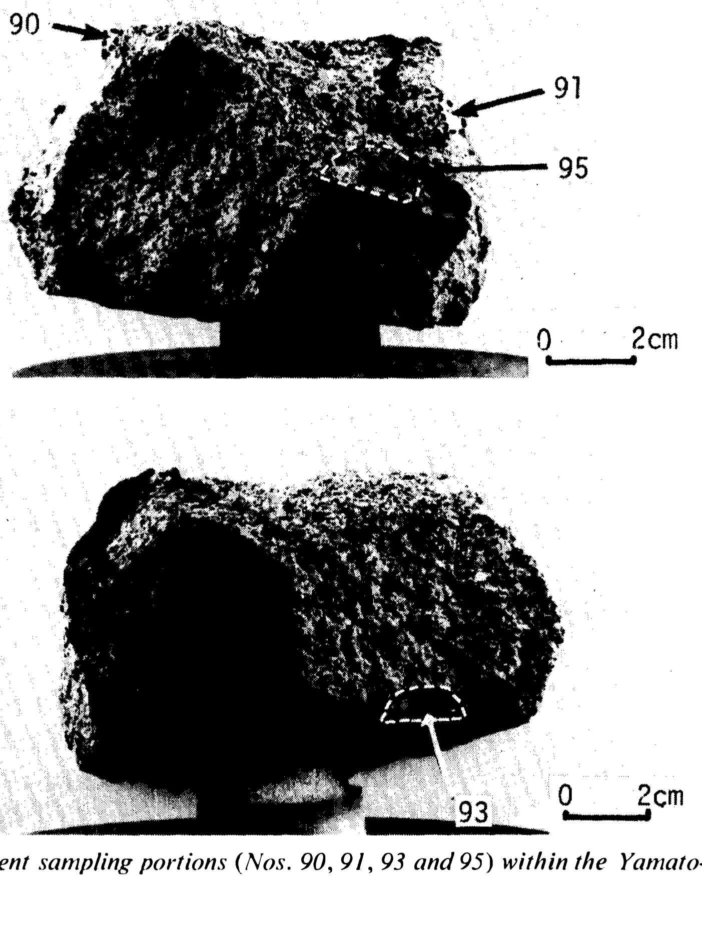

Fig. 1. Four different sampling portions (Nos. 90, 91, 93 and 95) within the Yamato-75110 chondrite.

The primary purpose of this study is to investigate the homogeneity, so that petrographic observation and chemical analyses with a microprobe have been carried out on the specimens from the four different portions (such as Nos. 90, 91, 93 and 95; Fig. 1) in the Yamato-75110 chondrite, one of the 150 meteorites.

The samples for microprobe analyses have been prepared with an efficient manner as described later. The SiO_2, CaO, MgO and FeO contents of olivine and orthopyroxene in the four specimens have been determined, and the histograms of iron contents of the two minerals such as given by DODD *et al.* (1967) have been obtained. Then, the chondrites have been classified based upon the method by VAN SCHMUS and WOOD (1967).

2. Experimental Method

The thin sections, 40 to 70 mm^2, of four specimens were made and mounted on glass, polished and prepared for the electron microprobe analyses by coating them with carbon.

Chemical analyses of olivine and pyroxene were 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 orthopyroxene in different chondrules and matrix. The chemical homogeneity of the 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 to form either olivine or pyroxene formula were also discarded. Thus, the total number of measurements was generally less than 20 for each sample. Atomic % of calcium, magnesium, and iron in olivine and pyroxene were calculated. Then the "percent mean deviation" proposed by DODD *et al.* (1967) was 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 olivine and pyroxene (DODD *et al.*, 1967), it is found that the frequency distribution of atomic % iron is more useful.

3. Textural Characteristics

The above four thin sections show similar textural characteristics. They belong to L-type chondrite and the texture shows considerably weak recrystallization. Some chondrules are easily defined while others are not. Internal textures of chondrules,

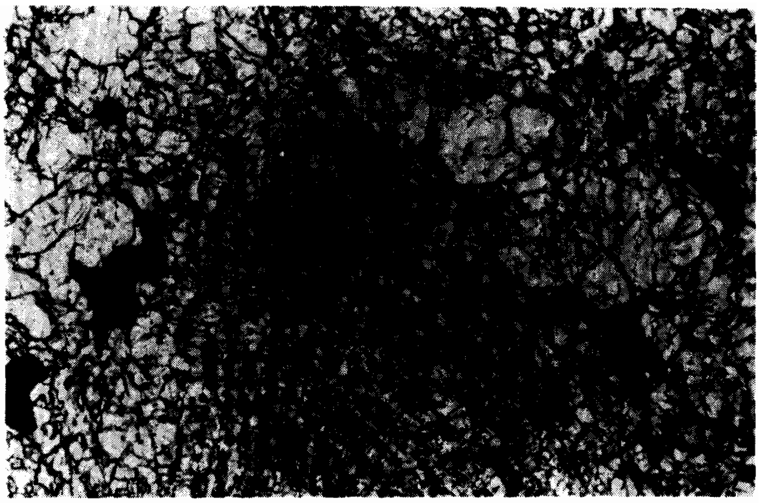

Fig. 2. Radial chondrule consisting of aggregate of fine prismatic orthopyroxene crystals and microcrystalline materials in Yamato-75110, 90 chondrite. One nicol. Long dimension of photograph = 1.3 mm.

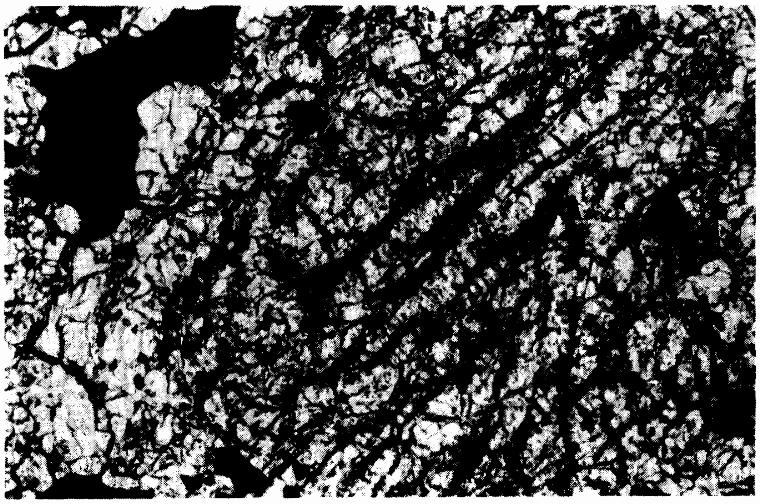

Fig. 3. A relic structure of barred orthopyroxene chondrule composed of parallel sets of orthopyroxene crystals, microcrystalline and cryptocrystalline materials in Yamato-75110, 90 chondrite. One nicol. Long dimension of photograph = 1.3 mm.

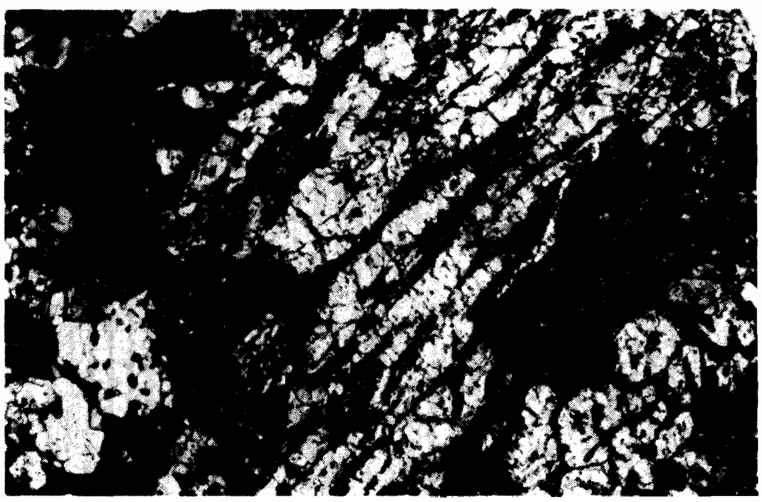

Fig. 4. The same as in Fig. 2. Crossed nicols.

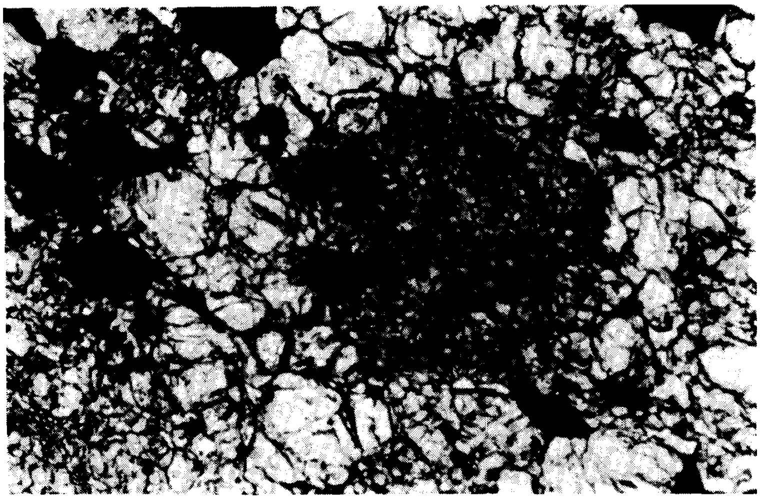

Fig. 5. Microcrystalline chondrule consisting of fine-grained olivine and orthopyroxene crystals, and weakly recrystallized glass in Yamato-75110,91 chondrite. One nicol. Long dimension of photograph = 1.3 mm.

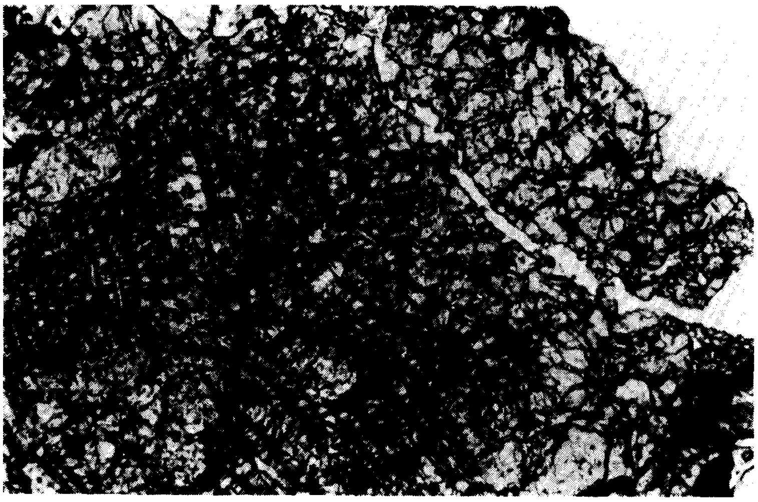

Fig. 6. Barred chondrule forming the herringbone pattern, consisting of prismatic olivine crystals, prismatic orthopyroxene, microcrystalline materials in Yamato-75110,91 chondrite. One nicol. Long dimension of photograph = 1.3 mm.

Fig. 7. The same as in Fig. 6. Crossed nicols.

Fig. 8. A relic structure of barred-olivine chondrule composed of alternate layers of olivine crystals in Yamato-75110,93 chondrite. The interstices between olivine bars are filled with cryptocrystalline materials and devitrified glass. Crossed nicols. Long dimension of photograph = 1.3 mm.

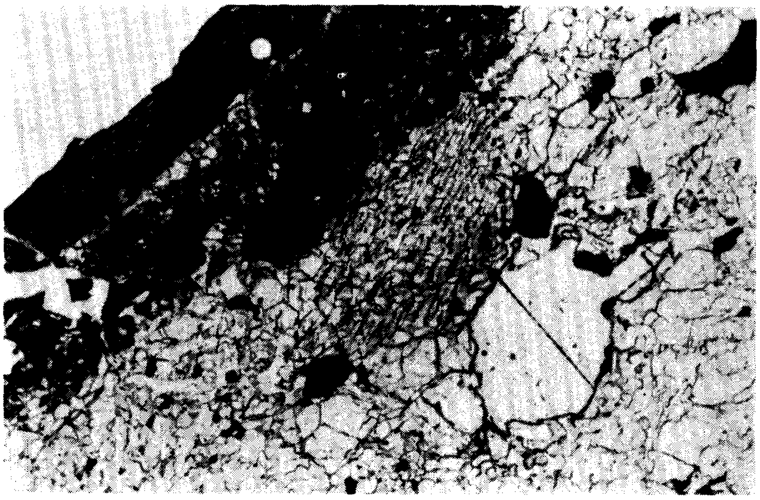

Fig. 9. A part of fusion crust and a relic structure of barred olivine chondrule composed of alternate layers of olivine crystals in Yamato-75110,93 chondrite. The interstices between olivine bars are filled with cryptocrystalline materials. One nicol. Long dimension of photograph = 1.3 mm.

Fig. 10. The same as in Fig. 9. Crossed nicols.

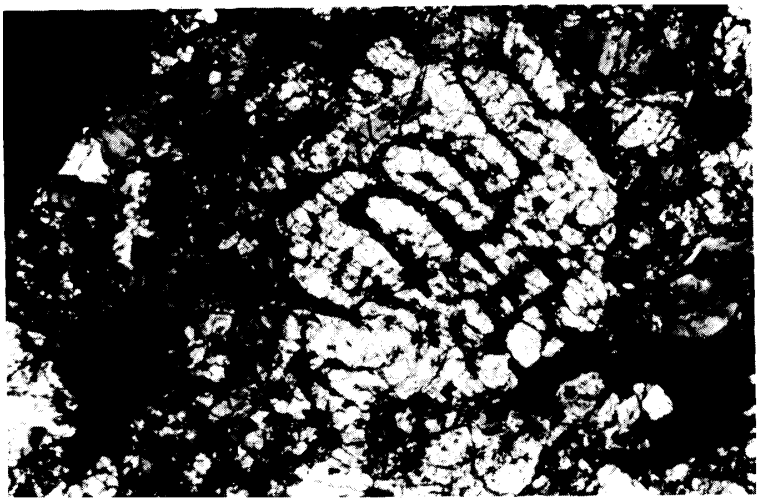

Fig. 11. Graphic and barred-chondrule consisting of prismatic olivine crystals in Yamato-75110,93 chondrite. The interstices between olivine crystals are filled with microcrystalline and cryptocrystalline materials, and devitrified glass. Crossed nicol. Long dimension of photograph = 1.3mm.

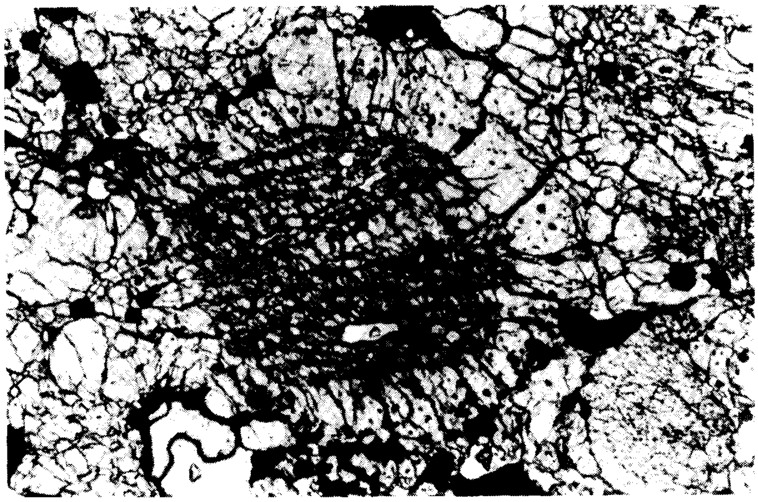

Fig. 12. Concentric and barred-chondrule consisting of prismatic olivine crystals (in the core), fine olivine crystals (in the margin), and weakly recrystallized glass in Yamato-75110,95 chondrite. One nicol. Long dimension of photograph = 1.3mm.

Fig. 13. A relic structure of porphyritic olivine chondrule consisting of prismatic olivine crystals, orthopyroxene crystals and microcrystalline materials in Yamato-75110,95 chondrite. Crossed nicols. Long dimension of photograph = 1.3 mm.

such as radial-orthopyroxene (Fig. 2), barred-orthopyroxene (Figs. 3 and 4), porphyritic-orthopyroxene, barred-olivine (Figs. 6, 7, 8, 9, 10, 11 and 12), porphyritic olivine (Fig. 13), radial-olivine, granular-olivine, cryptocrystalline and microcrystalline textures (Fig. 5), are well preserved. Some chondrules show a graphic texture (Fig. 11) or a concentric texture (Fig. 12). Rarely, a barred-olivine chondrule shows the herringbone pattern (Figs. 6 and 7). Rarely, the chondrule consisting of glass or wholly devitrified glass is 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 are mainly composed of parallel sets of olivine crystals and glass or weakly devitrified glass. Some barred-olivine chondrules show the graphic texture, that consists mostly of prismatic olivine crystals, and the interstices between olivine crystals are filled with microcrystalline and cryptocrystalline materials and devitrified glass (Fig. 11). Rarely, a barred-olivine chondrule shows the herringbone pattern, which is mainly composed of parallel sets of prismatic olivine crystals, prismatic orthopyroxene and microcrystalline materials (Fig. 6). Porphyritic-orthopyroxene chondrules consist mainly of fine-grained orthopyroxene and olivine crystals, and glassy or cryptocrystalline materials. Barred-orthopyroxene chondrules are composed largely 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.

Table 1. Petrologic type determined by textural characteristics of the Yamato-75110 chondrite.

Sample No.	Texture of chondrule	Texture of matrix	Igneous glass	Development of feldspar	Petrologic type
Yamato -75110, 90	Readily delineated	Microcrystalline and weakly recrystallized	Turbid glass	Microcrystalline aggregates	4–5
Yamato -75110, 91	Well defined and readily delineated	ditto	ditto	Microcrystalline aggregates and interstitial grains	4–5
Yamato -75110, 93	Readily delineated	Microcrystalline	ditto	Microcrystalline aggregates	4–5
Yamato -75110, 95	Well defined and readily delineated	Weakly recrystallized	ditto	Microcrystalline aggregates and interstitial grains	4–5

Rarely, secondary feldspar occurs in chondrules and matrix as microcrystalline aggregates. Clear plagioclase is not present in the chondrite either within the chondrules or in the matrix. Metal occurs not only in the matrix, but also within the chondrules.

Table 1 shows the petrologic type of the specimens determined by the textural characteristic of chondrules, matrix, igneous glass and secondary feldspar (VAN SCHMUS and WOOD, 1967). Namely, the four specimens from different portions of the Yamato-75110 chondrite correspond to petrologic type 4–5.

4. Problem of Homogeneity

Histograms of iron contents (by atomic %) of olivine and orthopyroxene in the analyzed samples are given in Figs. 14 to 16. Histograms in Fig. 15 are from olivine and orthopyroxene in "matrix"; in Fig. 16, from the minerals in "chondrule"; in Fig. 14, from the minerals both in the matrix and the chondrule. In these figures, the range of iron contents (by atomic %) for the average H6, L6 and LL6 chondrites is shown at the top.

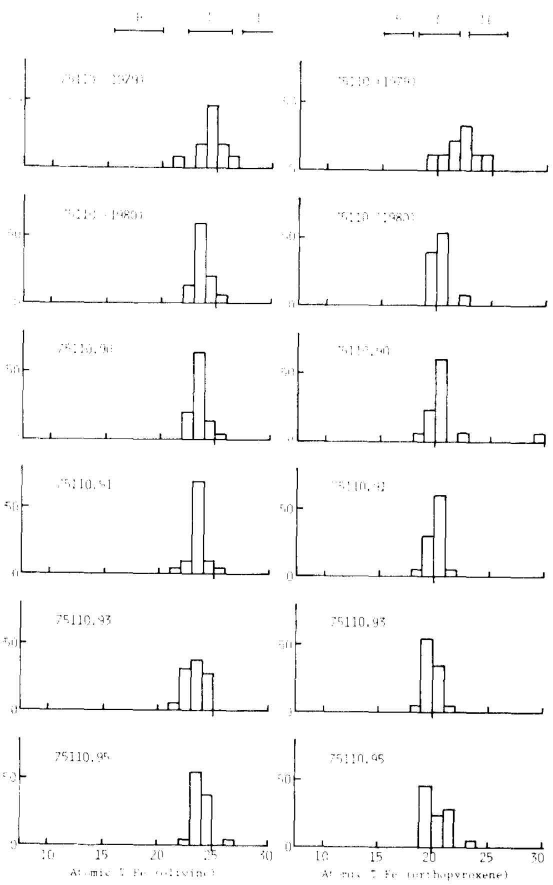

Fig. 14. Iron contents of olivine and orthopyroxene in the Yamato-75110 chondrite.

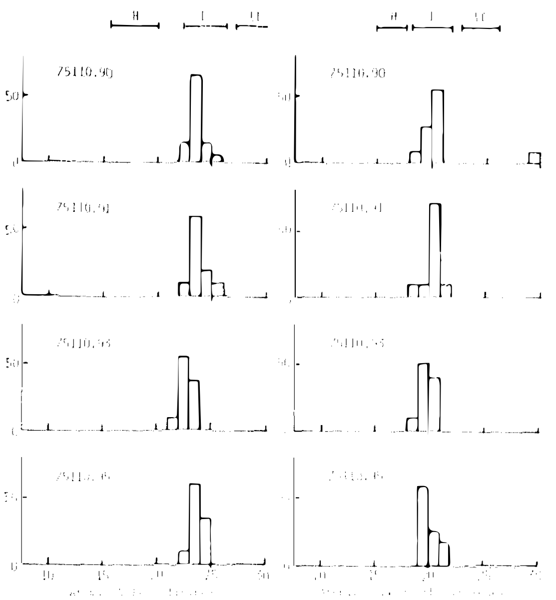

Fig. 15. Iron contents of matrix-olivine and matrix-orthopyroxene in the Yamato-75110 chondrite.

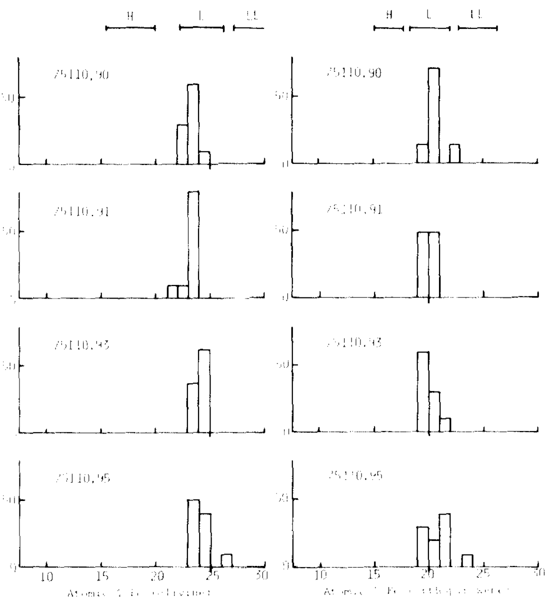

Fig. 16. Iron contents of chondrule-olivine and chondrule-orthopyroxene in the Yamato-75110 chondrite.

The mean compositions (Ca, Mg and Fe), the number of measurements, the mean deviations of iron contents and the percent mean deviations of iron contents in the olivines are given in Tables 2 to 4; and those of the orthopyroxene are shown in Tables 5 to 7. Analytical data in Tables 3 and 6 are from the olivine and orthopyroxene in the "matrix"; those in Tables 4 and 7 are from the minerals in the "chondrule". Tables 2 and 5 show analytical data of these minerals both in the matrix and the chondrule, of which results should correspond to those of the whole area in the "chondrule". In

Table 2. Mean compositions of olivine and percent mean deviations of the iron concentrations in the analyzed Yamato-75110 chondrite.

Sample No.	Mean composition			No. of measurements	Mean deviation	% Mean deviation
	Ca	Mg	Fe			
Yamato-75110*	0.00	75.69	24.31	11	0.878	3.61
-75110**	0.00	76.42	23.58	15	0.546	2.32
-75110,90	0.01	76.39	23.60	30	0.477	2.02
-75110,91	0.01	76.48	23.51	20	0.498	2.12
-75110,93	0.03	76.69	23.28	19	0.693	2.98
-75110,95	0.00	76.09	23.91	22	0.493	2.06

* Matsumoto *et al.* (1979)
** Matsumoto and Hayashi (1980)

Table 3. Mean compositions of matrix olivine and percent mean deviations of the iron concentrations in the analyzed Yamato-75110 chondrite.

Sample No.	Mean composition			No. of measurements	Mean deviation	% Mean deviation
	Ca	Mg	Fe			
Yamato-75110,90	0.00	76.28	23.72	20	0.427	1.80
-75110,91	0.01	76.13	23.86	10	0.505	2.12
-75110,93	0.00	77.30	22.70	11	0.407	1.79
-75110,95	0.00	76.40	23.60	12	0.483	2.05

Table 4. Mean compositions of chondrule olivine and percent mean deviations of the iron concentrations in the analyzed Yamato-75110 chondrite.

Sample No.	Mean composition			No. of measurements	Mean deviation	% Mean deviation
	Ca	Mg	Fe			
Yamato-75110,90	0.03	76.60	23.37	10	0.456	1.95
-75110,91	0.01	76.83	23.16	10	0.331	1.43
-75110,93	0.06	75.86	24.08	8	0.212	0.88
-75110,95	0.00	75.72	24.28	10	0.497	2.05

Table 5. Mean compositions of orthopyroxene and percent mean deviations of the iron concentrations in the analyzed Yamato-75110 chondrite.

Sample No.	Mean composition			No. of measurements	Mean deviation	% Mean deviation
	Ca	Mg	Fe			
Yamato-75110*	0.00	77.96	22.04	9	1.161	5.27
-75110**	1.20	78.47	20.33	15	0.453	2.23
-75110,90	1.44	77.82	20.74	18	1.092	5.27
-75110,91	1.03	78.82	20.15	20	0.501	2.49
-75110,93	1.33	78.81	19.86	20	0.472	2.38
-75110,95	1.23	78.33	20.44	22	0.739	3.61

* MATSUMOTO *et al.* (1979)
** MATSUMOTO and HAYASHI (1980)

Fig. 14 and Tables 2 and 5, the first and second rows are quoted from MATSUMOTO *et al.* (1979) and MATSUMOTO and HAYASHI (1980).

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

The value of % M.D. for the olivine in four thin sections within the Yamato-75110 chondrite ranges from 2.02 to 2.98; but that in the matrix is from 1.79 to 2.12;

Table 6. Mean compositions of matrix orthopyroxene and percent mean deviations of the iron concentrations in the analyzed Yamato-75110 chondrite.

Sample No.	Mean composition			No. of measure-ments	Mean deviation	% Mean deviation
	Ca	Mg	Fe			
Yamato-75110,90	1.52	77.58	20.90	11	1.499	7.17
-75110,91	1.26	78.41	20.33	10	0.563	2.77
-75110,93	1.43	78 81	19.76	10	0.513	2.60
-75110,95	1.47	78.46	20.07	12	0.431	2.15

Table 7. Mean compositions of chondrule orthopyroxene and percent mean deviations of the iron concentrations in the analyzed Yamato-75110 chondrite.

Sample No.	Mean composition			No. of measure-ments	Mean deviation	% Mean deviation
	Ca	Ma	Fe			
Yamato-75110,90	1.32	78.21	20.47	7	0.551	2.69
-75110,91	0.81	79.24	19.95	10	0.423	2.12
-75110,93	1.23	78.80	19.97	10	0.433	2.17
-75110,95	0.94	78.16	20.90	10	0 925	4.43

and that in chondrule, from 0.88 to 2.05. In addition, the % M.D. for the olivine in this chondrite (MATSUMOTO *et al.*, 1979) is 3.61, and that for the orthopyroxene is 5.27. One of the reasons for a large value of % M.D. is conceivably due to the paucity of the observation points (11 and 9 points) on account of infinitesimally small chip.

The value of % M.D. for the orthopyroxene in four thin sections in this chondrite ranges from 2.38 to 5.27; but that in the matrix is from 2.15 to 7.17 and that in the chondrule is from 2.12 to 4.43.

Therefore, the above values of % M.D. of the olivine and orthopyroxene depend both on matrix and chondrule, and also on sampled portion. Such a chemical variety of the Yamato-75110 chondrite is observed clearly in this study.

5. Conclusion

For the main purpose of investigating the homogeneity within one chondrite, the four specimens (Nos. 90, 91, 93 and 95) from different portions of the Yamato-75110 chondrite from East Antarctica were examined, based on the textural characteristic and electron microprobe analyses of olivine and orthopyroxene. This Yamato-75110 chondrite is one out of the 150 meteorites which were found in the limited area (MATSUMOTO, 1978).

On the basis of the histogram of iron contents of olivine and orthopyroxene, and the microscopical characters, these sections arė classified as L group and petrologic type 4–5. However, the values of % M.D. of olivine and orthopyroxene depend both on matrix and chondrule, and also on sampled portion.

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