CLASSIFICATION AND PETROGRAPHY OF SOME YAMATO CHONDRITIC METEORITES

Makoto KIMURA, Kenzo YAGI and Kosuke ONUMA

Department of Geology and Mineralogy, Faculty of Science,
Hokkaido University, Sapporo 060

Abstract: Sixteen Yamato meteorites including the Yamato-69, -74, and -75, all ordinary chondrites, are newly classified. The method for classification adopted here is based on customary microscopic observations, paying attention to the criteria for petrologic types proposed by VAN SCHMUS and WOOD (Geochim. Cosmochim. Acta, **31**, 741, 1967). Compared with this, the convenient method for classification of chondrites proposed by YANAI *et al.* (Mem. Natl Inst. Polar Res., Spec. Issue, **8**, 110, 1978) is examined, and its availability is ascertained. However, the difference between petrologic types of the Yamato-74492 obtained by these two methods is clearly noticed. It may suggest that this meteorite is a monomict breccia.

Since the meteorites studied here are equilibrated ordinary chondrites, several characteristic features of the thermal metamorphism in parent bodies, such as devitrification of glass, mineralogical features of pyroxenes, and type of chondrule, are discussed in relation to petrologic types. For this purpose the samples studied here also include the meteorites described by KIMURA *et al.* (Mem. Natl Inst. Polar Res., Spec. Issue, **8**, 156, 1978).

With the Yamato-74445 extension of veining due to shock effect is described.

1. Introduction

The studies on a great number of the Yamato meteorites are expected to throw light on the origin of the primitive solar nebula, as well as of the meteorites. However, before all these investigations are executed in various fields, the catalog of the meteorites should be completed to be used as a guidebook of distribution of meteorites for investigation (YANAI *et al.*, 1978). Thus OKADA (1975), KIMURA *et al.* (1978), YABUKI *et al.* (1978), and YANAI *et al.* (1978), MATSUMOTO *et al.* (1979) and NISHIDA *et al.* (1979) have classified the Yamato chondritic meteorites. In this paper, some Yamato chondritic meteorites are classified from the above viewpoint.

First we discuss the classification (especially petrologic types) of four Yamato-74 meteorites, which have already been classified by YANAI *et al.* (1978), in order to examine the method of classification proposed by them. Three Yamato-69, eleven Yamato-74, and two Yamato-75 meteorites, all ordinary chondrites, collected by YOSHIDA *et al.* (1971), YANAI (1974), and MATSUMOTO (1978), respectively, are newly classified.

Petrography of these meteorites shows that the degree of thermal metamorphism varies in a wide range. On the other hand, some Yamato-74 meteorites described by KIMURA *et al.* (1978) belong to petrologic types 4 to 6. Therefore, we expect that intensive studies on both samples will clarify the nature of the thermal metamorphism on ordinary chondrites. In this paper some petrographic features of the thermal metamorphism and the shock effect are discussed.

2. Classification

YANAI *et al.* (1978) determined chemical group and petrologic type of VAN SCHMUS and WOOD (1967) on the Yamato-74 chondritic meteorites according to the histograms of iron contents of olivines and orthopyroxenes in the samples. This is a convenient method for classification of a great number of the Yamato meteorites, because classification can be made on small amounts of samples in a short time. However, no trial has been made to correlate the petrologic types obtained by this method with microscopic observations. Therefore, we have observed thin sections of four Yamato-74 meteorites classified by YANAI *et al.* (1978), paying attention to the criteria for petrologic types of ordinary chondrites proposed by VAN SCHMUS and WOOD (1967), *i.e.*, kind of Ca-poor pyroxene, degree of development of secondary feldspar, degree of devitrification of glass, texture of matrix, and outlines of chondrules. Then we determined their petrologic types on the basis of such features. The chemical groups of these meteorites were determined on the basis of the molar compositions of olivines referring to the histogram of VAN SCHMUS (1969). The molar compositions were estimated from d_{130} spacing of X-ray powder pattern of olivines using the calculation method of SHINNO and HAYASHI (1976). Since for three Yamato-69 meteorites only thin sections were available to us, the molar compositions of olivines were estimated from 2V using the determinative curve of DEER *et al.* (1962).

Table 1 shows the results obtained by the above-mentioned method of classification in comparison with those by YANAI *et al.* (1978). Fo molecular percent of

Table 1. Classification of the Yamato-74 meteorites.

Sample No.	Present study		YANAI *et al.* (1978)	
	Classification	Fo	Classification	Mean Fo
Yamato-74001	H5	84	H4-5	77.3
-74082	H5	81	H4	80.6
-74445	L6	76	L6-5	75.1
-74492	H6	85	H3-4	77.8

olivine in each sample is also present. Although the petrologic types of the Yamato-74001, -74082, and -74445 by YANAI *et al.* are slightly lower than those obtained by us, the discrepancies between the types determined by two methods are not serious. The availability of the method of YANAI *et al.* is ascertained, although the method adopted in this paper gives more accurate petrologic types necessarily.

However, the Yamato-74492 was identified by us as type 6, whereas type 3 or 4 by YANAI *et al.* Its chemical group is identified as H by us as well as by them. Microscopic observation of the Yamato-74492 (Fig. 1) shows that its matrix was highly recrystallized, the outlines of chondrules are ambiguous against matrix, and fine-grained plagioclases are noticed, all of which are characteristic features of type 6 chondrite. On the contrary, YANAI *et al.* found the wide range of compositions of olivines and orthopyroxenes, which is inconsistent with our observation as type 6. Because olivines and orthopyroxenes are homogeneous in composition in types 5 and 6 chondrites (VAN SCHMUS and WOOD, 1967). Therefore, it is probable that the Yamato-74492 is a monomict breccia of WAHL (1952).

Table 2. Classification of the Yamato-69 and -74 meteorites.

Sample No.	Classification	Fo
Yamato-696 (f)	H5	84
-698 (h)	H5	82
-699 (i)	L6	76
-74609	H5	83
-74650	L6	78
-74663	L6	74

Table 3. Classification of the Yamato-74 and -75 meteorites.

Sample No.	Chemical group	Fo
Yamato-74384	H	82
-74389	H	83
-74392	H	85
-74409	H	82
-74613	H	82
-74620	H	86
-74624	H	83
-74633	H	83
-75045	L	75
-75051	L	77

Table 2 shows the classification of six Yamato meteorites by our method mentioned above. The Yamato-696, -698, and -699, which have been called the Yamato (f), (h), and (i), respectively, are also classified here.

Table 3 shows the chemical groups of ten Yamato meteorites. The small amounts of the samples available to us (0.05–0.16 g) made it impossible to determine their petrologic types by thin sections. We identified them as ordinary chondrites on the basis of their appearance and the presence of olivines, orthopyroxenes, and metallic irons with the X-ray powder patterns.

3. Thermal Metamorphism

WOOD (1962), DODD *et al.* (1967), VAN SCHMUS and WOOD (1967), and DODD (1969) summarized many petrologic features reflecting various degrees of the thermal metamorphism of ordinary chondrites. We expect that the data of the Yamato meteorites from petrologic types 4 to 6 would contribute to the clarification of the thermal metamorphism. The samples used for this purpose are the Yamato-74155 (H4), -74079 (H5), -74371 (H5), -74647 (H5), -74418 (H6), and -74190 (L6) described by KIMURA *et al.* (1978), and the Yamato-74001, -74082, -74445, and -74492 newly described in this paper.

3.1. Devitrification and crystallization of glass in chondrules

VAN SCHMUS and WOOD (1967) and VAN SCHMUS (1969) summarized the relationship between devitrification and crystallization of glass in chondrules and the degree of the thermal metamorphism (petrologic type). This relationship is well observed also in the Yamato meteorites.

Clear glass observed in chondrules in type 3 chondrites (*e.g.*, Fig. 1 of KIMURA *et al.*, 1979) is absent in type 4 chondrite such as the Yamato-74155. Rare glass which is turbid and weakly birefringent (Fig. 2), and cryptocrystalline material formed by devitrification of glass (Fig. 3) fill the interstices among phenocrysts in chondrules. The EPMA analyses (Table 4) show that the glass and cryptocrystalline material have normative diopside and feldspar. REID and FREDRIKSSON (1967) ascertained that they are very fine-grained crystalline aggregates of pyroxene and plagioclase by X-ray microdifraction.

Fig. 4 shows that fibrous diopside crystals and very fine-grained plagioclase are present in chondrule in type 5 chondrite (Yamato-74371). The cryptocrystalline materials like those in type 4 chondrite are also present in some chondrules. Although MASON (1965) found rare plagioclase as large grains (0.05–0.1 mm) in type 5 chondrite, the plagioclases observed in type 5 Yamato meteorites are very small always, less than 0.02 mm.

In type 6 chondrite such as the Yamato-74445 (Fig. 5), fine-grained diopside and plagioclase, ranging up to 0.15 mm in size, fill the interstices among olivines

Fig. 1. Coarse-grained matrix showing advanced recrystallization. Yamato-74492. Long dimension of photograph =2.2 mm.

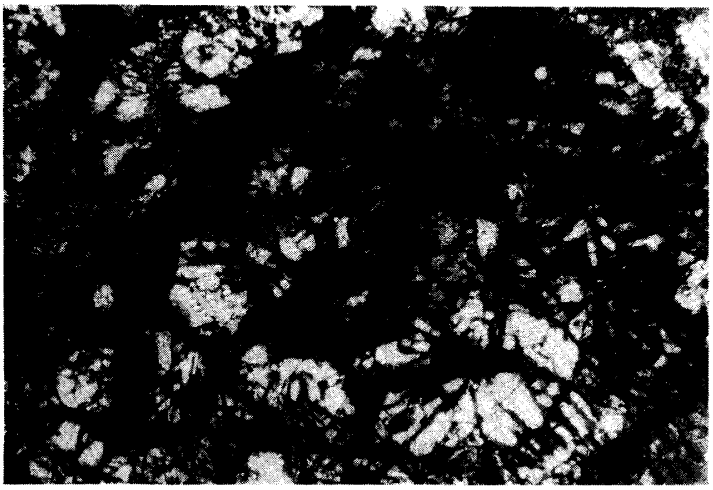

Fig. 2. Turbid and weakly birefringent glass (dark) fills the interstices among olivine phenocrysts (light) in a porphyritic chondrule. Yamato-74155. Long dimension of photograph=0.9 mm.

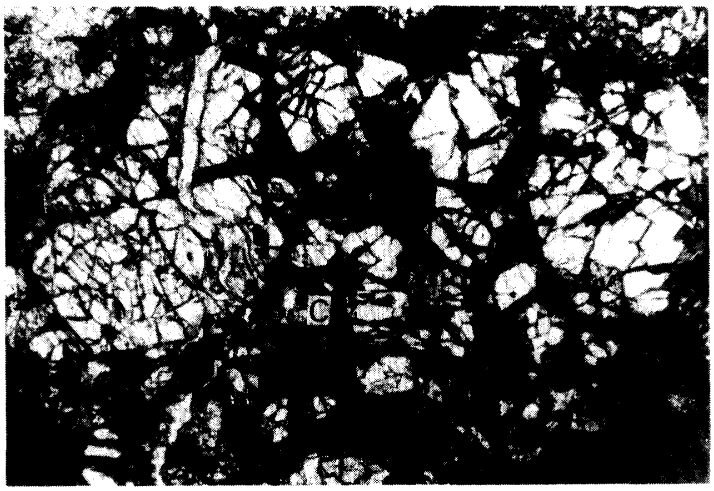

Fig. 3. Olivine (light) and surrounding cryptocrystalline material (C) in a porphyritic chondrule. Yamato-74155. Long dimension of photograph=0.9 mm.

Fig. 4. Fibrous diopside crystals and very fine grained plagioclase are present among pyroxene phenocrysts (light) in a porphyritic chondrule. Yamato-74371. Long dimension of photograph=0.9 mm.

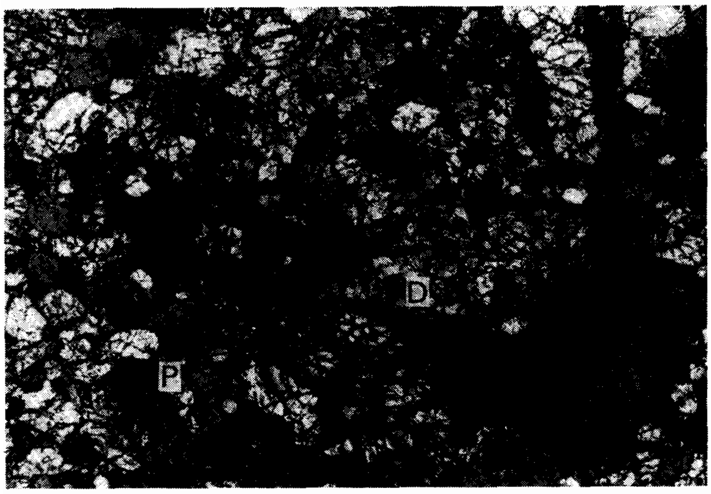

Fig. 5. Diopside (D) and plagioclase (P) grains filling the interstices among olivine and orthopyroxene grains. Yamato-74445. Nicols crossed. Long dimension of photograph=0.9 mm.

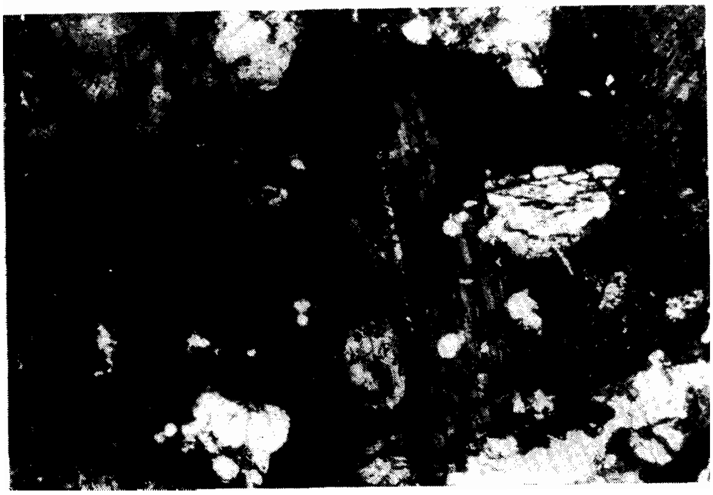

Fig. 6. A relic Ca-poor clinopyroxene twinned polysynthetically in petrologic type 5 chondrite. Nicols crossed. Long dimension of photograph=0.4 mm.

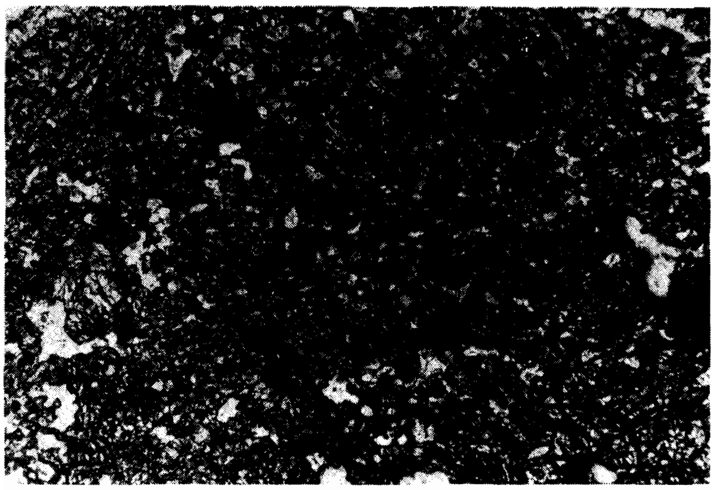

Fig. 7. Highly recrystallized matrix, though fine-grained because of secondary brecciation. No chondrule is noticed. Yamato-74445. Long dimension of photograph=2.2 mm.

Fig. 8. Veining consisting of dark-colored material and fragments of silicate and opaque minerals. The right and left parts show orthodox chondritic texture. Yamato-74445. Long dimension of photograph=2.2 mm.

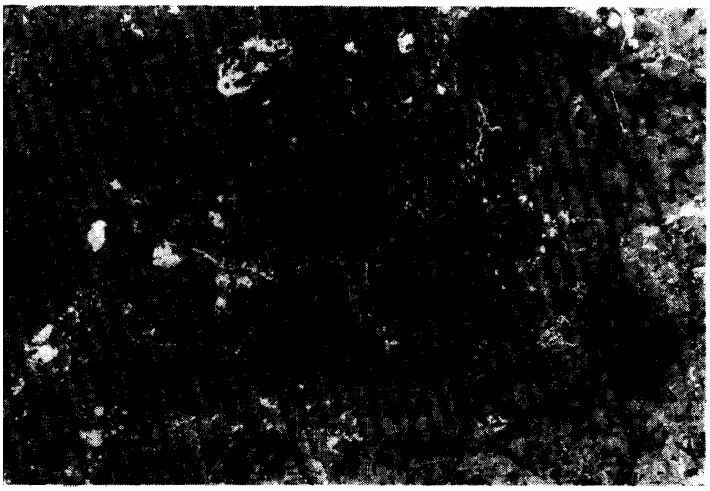

Fig. 9. Very fine spherules and very thin veins composed of fused troilite crystals (light) in veining (gray). Yamato-74445. Reflected light. Long dimension of photograph=2.2 mm.

Table 4. Chemical composition and CIPW norm of glass and cryptocrystalline materials in chondrule (wt. %).

Sample No.		Glass	Cryptocrystalline materials	
		Y-74155	Y-74155	Y-74371
SiO_2		52.84	56.87	61.12
TiO_2		1.43	0.23	0.24
Al_2O_3		24.51	11.12	7.12
Cr_2O_3		5.13	0.66	0.47
FeO		2.93	2.25	2.30
MnO		0	0.12	0.13
MgO		0.67	9.17	9.67
CaO		9.16	14.01	13.98
Na_2O		2.21	4.44	2.85
K_2O		0.09	0.34	0.33
Total		98.97	99.21	98.22
CIPW Norm				
Q		19.28	—	10.87
C		4.18	—	—
Or		—	2.01	2.23
Ab		18.87	34.51	24.12
An		45.34	9.41	5.56
Ne		—	1.66	—
Di	Wo	—	25.09	26.60
	En	—	19.48	20.58
	Fs	—	2.90	3.17
Hy	En	1.71	—	3.51
	Fs	—	—	0.53
Ol	Fo	—	2.36	—
	Fa	—	0.39	—
Cr		5.15	0.97	0.67
Il		2.73	0.44	0.46

and orthopyroxenes in chondrules with ambiguous outlines.

3.2. Wo molecule content in Ca-poor pyroxenes

With increasing petrologic type, average Wo molecule contents in Ca-poor pyroxenes increase (Table 5), agreeing with DODD (1969). It reflects the thermal metamorphism at successively higher temperatures, as expected from pyroxene chemistry of the enstatite-diopside system, where solubility of Wo molecule in enstatite increases with increasing temperature.

Table 5. Average Wo mole % in Ca-poor pyroxene.

Sample No.	Petrologic type	Wo
Yamato-74155	4	0.8
-74079	5	1.1
-74371	5	1.0
-74647	5	1.3
-74418	6	1.5
-74190	6	1.5

3.3. Ca-poor clinopyroxenes in type 5 chondrites

Although the amount of Ca-poor clinopyroxenes decreases with increasing petrologic type (Van Schmus and Wood, 1967; Dodd, 1969; Kimura *et al.*, 1978), it is rarely noticed in type 5 chondrite such as the Yamato-74647 (Fig. 6). According to its appearance and overall texture of the meteorite which shows weak shock effect, the Ca-poor clinopyroxene is clearly different from clinoenstatite of Reid and Cohen (1967), which resulted from deformation of enstatite. Therefore, it is considered a relic of original Ca-poor clinopyroxene. Mason (1967) insisted that Ca-poor clinopyroxene crystallized originally as a protoform, which was quenched rapidly into a clino-form, and orthopyroxene is a product of the thermal metamorphism. However, Dodd (1969) and Onuma *et al.* (1972) estimated the recrystallization temperatures of type 5 chondrites to have been 700–800°C and 950±100°C, respectively. These are far beyond the clinoenstatite-orthoenstatite inversion temperature, probably 600°C at 1 atm (Boyd and England, 1965), even if the pressure-dependence (Boyd and England) and ferrosilite molecule content dependence (Kuno, 1966) of the inversion temperature are taken into account. Therefore, it seems likely that Ca-poor clinopyroxene is easy to survive metastably even at high temperatures for short interval, as shown by the experiments of Smyth (1974). From these estimations, one would postulate that the inversion depends not only on maximum temperatures of the thermal metamorphism, but also on the duration of heating process in parent bodies. In type 6 chondrites, Ca-poor clinopyroxene is absent.

3.4. Type of chondrule

Table 6 shows the proportion of types of chondrule and the amount of chondrule in the thin section of each Yamato meteorite. The definition of types of chondrule is given by Kimura *et al.* (1979). In order to compare the data of types 4 to 6 chondrites, Table 6 also includes the data of the Yamato-74191 (L3) by Kimura (1978), which probably reflects the original abundance of the types of chondrule at accretion to parent body. Type 3 chondrite probably re-

Table 6. Abundance of the type of chondrule (%).

Sample No.	Petrologic type	Type of chondrule							Number of chondrule in a thin section
		P	B	R	C	D	Cr	Total	
Yamato-74191*	3	75.5	6.3	4.2	3.5	10.5	—	100.0	143**
-74155	4	65.7	15.6	6.3	6.3	6.1	—	100.0	32
-74079	5	72.0	4.0	16.0	8.0	—	—	100.0	25
-74371	5	40.0	23.3	23.3	6.7	6.7	—	100.0	30
-74647	5	32.7	10.2	40.9	10.2	4.0	2.0	100.0	49
-74001	5	74.0	7.4	11.1	3.7	3.8	—	100.0	27
-74082	5	58.3	—	25.0	16.7	—	—	100.0	12
-74418	6	27.3	18.2	45.5	9.0	—	—	100.0	11
-74492	6	—	66.7	33.3	—	—	—	100.0	3
-74190	6	—	20.0	80.0	—	—	—	100.0	10
-74445	6	—	—	—	—	—	—	—	0

* After KIMURA (1978).

** The data from two sections.

Type of chondrule — P: Porphyritic, B: Barred, R: Radiating, C: Cryptocrystalline, D: Dark-zoned, Cr: Chromite.

sembles the unmetamorphosed parent materials of the equilibrated chondrites (DODD *et al.*, 1967).

The amount of chondrule decreases with increasing petrologic type. Especially the porphyritic chondrules, consisting of phenocryst and intersticial glass, are the predominant chondrules in type 3 chondrite, whereas they are rarely present or entirely absent in type 6 chondrites. It is noticed in higher petrologic type chondrites that the crystallization of matrix and glass in chondrule made the distinction of chondrules against granular matrix very ambiguous.

It is noteworthy in Table 6 that the Yamato-74445 does not contain any chondrules, although it is certainly a chondrite because of its chondritic mineralogy and the traces of chondrule structures. Fig. 7 shows the advanced stage of recrystallization of this meteorite. These features are similar to those of the Shaw meteorite studied by FREDRIKSSON and MASON (1967) and DODD *et al.* (1975). It differs in texture and mineralogy from type 6 chondrites and was intensively recrystallized. Therefore DODD *et al.* proposed special petrologic type, 7, for this meteorite. However, as the degree of recrystallization of the Yamato-74445 must be further investigated mineralogically and geochemically, we can not yet decide whether this meteorite suffered the thermal metamorphism of higher degree than other type 6 chondrites.

4. Shock Effect

The evidences of the shock effect in various degrees, due to cosmic collision or destruction of parent bodies, are noticed in the meteorites studied here. VAN SCHMUS (1969) summarized such features and showed that veining occurs to some degree in most chondrite. This is also observed in most of the Yamato chondritic meteorites. The chondrites are cut by narrow, dark veins of glassy material probably representing fused chondritic material. In brecciated chondrites, an extension of veining is observed (VAN SCHMUS, 1969), as in the Yamato-74445 and -698. In such chondrites, broken silicate minerals are surrounded by black glassy material (Fig. 8), probably derived *in situ* by localized fusion. The microscopic observation with reflected light (Fig. 9) shows that very fine spherules and very thin veins composed of fused troilite crystals are present in such glassy material, while fused metallic iron crystals are rather rare, because of its higher melting temperature than that of troilite.

In the Yamato-74445 and -698, the evidences of intensive shock effect of CARTER *et al.* (1968), such as kink band and fractured feature of olivines, are also observed very often as in the Yamato-74418 studied by KIMURA *et al.* (1978). All these features show that these meteorites were probably shocked in more intensive degree than the others.

5. Conclusion

The examination of the method of classification proposed by YANAI *et al.* (1978) in comparison with our customary method ascertained its availability, although slight differences between petrologic types obtained by two methods are noticed. Our method which needs comparatively large amounts of samples for thin section, gives more accurate classification of chondrites.

The presence of the meteorite such as the Yamato-74492 which is estimated to be a monomict breccia, makes the classification of the Yamato meteorites troublesome. Namely, it may be possible that a classification based on the small fraction of a sample does not represent overall features of this sample, and classification using several chips from a sample is more desirable. In conclusion, for compiling a catalog of the Yamato meteorites which should be completed as soon as possible, the method of YANAI *et al.* (1978) is preferable, because of quick identification and small quantity of the samples used. For the classification of more significant samples (*e.g.,* type 3 chondrite), our method may be employed in order to confirm the classification using chips from the other parts of the samples.

The presence of many equilibrated chondrites among Yamato meteorites, noticed by this paper, KIMURA *et al.* (1978), and so on, is relevant to the investigations on the structure and evolution of protoplanets. The discussions about the thermal metamorphism may provide fundamental data in such investigations.

Acknowledgments

The meteorites studied here were provided through the courtesy of Prof. T. NAGATA and Dr. K. YANAI of the National Institute of Polar Research. In the EPMA analyses, we are very much indebted to Dr. M. KOMATSU of Niigata University. We are indebted also to Messrs. K. MORIBAYASHI and T. KUWAZIMA of Hokkaido University for their assistance in preparing thin sections. We thank the members of the field party of the Japanese Antarctic Research Expedition in 1969, 1974, and 1975 for collecting the meteorites.

References

BOYD, F. R. and ENGLAND, J. L. (1965): The rhombic enstatite-clinoenstatite inversion. Carnegie Inst. Washington, Yearb., **64**, 117–120.

CARTER, N. L., RALEIGH, C. B. and DECARLI, P. S. (1968): Deformation of olivine in stony meteorites. J. Geophys. Res., **73**, 5439–5461.

DEER, W. A., HOWIE, R. A. and ZUSSMAN, J. (1962): Rock forming minerals, Vol. **1**. London, Longmans, 333p.

DODD, R. T. (1969): Metamorphism of the ordinary chondrites: a review. Geochim. Cosmochim. Acta, **33**, 161–203.

DODD, R. T., GROVER, J. E. and BROWN, G. E. (1975): Pyroxenes in Shaw (L-7) chondrite. Geochim. Cosmochim. Acta, **39**, 1585–1594.

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

FREDRIKSSON, K. and MASON, B. (1967): The Shaw meteorite. Geochim. Cosmochim. Acta, **31**, 1705–1709.

KIMURA, M. (1978): Petrological and mineralogical studies on Yamato-74 meteorites. M. Sc. Thesis, Hokkaido Univ., 104p.

KIMURA, M., YAGI, K. and OBA, Y. (1978): Petrologic studies of Yamato-74 meteorites (2). Mem. Natl Inst. Polar Res., Spec. Issue, **8**, 156–169.

KIMURA, M., YAGI, K. and ONUMA, K. (1979): Petrological studies on chondrules in Yamato -74 meteorites. Mem. Natl Inst. Polar Res., Spec. Issue, **12**, 114–133.

KUNO, H. (1966): Review of pyroxene relations in terrestrial rocks in the light of recent experimental works. Mineral. J., **5**, 21–43.

MASON, B. (1965): Feldspar in chondrites. Science, **148**, 943.

MASON, B. (1967): Extraterrestrial mineralogy. Am. Mineral., **52**, 307–325.

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., 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**, 60–72.

NISHIDA, N., ONUMA, N. and OHTSUKA, Y. (1979): A classification of several Yamato-74 chondrites. Mem. Natl Inst. Polar Res., Spec. Issue, **12**, 135–144.

OKADA, A. (1975): Yamato meteorites collected in Antarctica in 1969. Petrological studies of the Yamato meteorites. Part 1. Mineralogy of the Yamato meteorites. Mem. Natl Inst. Polar Res., Spec. Issue, **5**, 14–66.

ONUMA, N., CLAYTON, R. N. and MAYEDA, T. K. (1972): Oxygen isotope temperatures of equilibrated ordinary chondrites. Geochim. Cosmochim. Acta, **36**, 157–168.

REID, A. M. and COHEN, A. J. (1967): Some characteristics of enstatite from enstatite achondrites. Geochim. Cosmochim. Acta, **31**, 661–672.

REID, A. M. and FREDRIKSSON, K. (1967): Chondrules and chondrites. Research in Geochemistry-II, ed. by P. H. ABELSON. New York, Wiley, 170–203.

SHINNO, I. and HAYASHI, M. (1976): Kanranseki no kagaku sosei to kôshi-men kankaku d_{130} (Chemical composition and d_{130} spacing of olivine). Kôbutsugaku Zasshi (J. Mineral. Soc. Jap.), **12**, Spec. Issue, 194–205.

SMYTH, J. R. (1974): Experimental study on the polymorphism of enstatite. Am. Mineral., **59**, 345–352.

VAN SCHMUS, W. R. (1969): The mineralogy and petrology of chondritic meteorites. Earth Sci. Rev., **5**, 145–184.

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

WAHL, W. (1952): The brecciated stony meteorites and meteorites containing foreign fragments. Geochim. Cosmochim. Acta, **2**, 1269–1278.

WOOD, J. A. (1962): Metamorphism in chondrites. Geochim. Cosmochim. Acta, **26**, 739–749.

YABUKI, H., YAGI, K. and ONUMA, K. (1978): Petrological studies of Yamato-74 meteorites (1). Mem. Natl Inst. Polar Res., Spec. Issue, **8**, 142–155.

YANAI, K. (1976): 1974-nen no Nankyoku-san Yamato inseki no tansa to saishû (Search and collection of Yamato meteorites, Antarctica, in November and December, 1974). Nankyoku Shiryô (Antarct. Rec.), **56**, 70–81.

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

YOSHIDA, M., ANDO, H., OMOTO, K., NARUSE, R. and AGETA, Y. (1971): Discovery of meteorites near Yamato mountains, East Antarctica. Nankyoku Shiryô (Antarct. Rec.), **39**, 62–65.

(*Received April 16, 1979*)