Proc. NIPR Symp. Antarct. Meteorites, 4, 118–130, 1991

YAMATO-74063: CHONDRITIC METEORITE CLASSIFIED BETWEEN E AND H CHONDRITE GROUPS

Keizo YANAI and Hideyasu KOJIMA

National Institute of Polar Research, 9–10, Kaga 1-chome, Itabashi-ku, Tokyo 173

Abstract: Yamato-74063 (Y-74063) was found in Antarctica by the Japanese Antarctic Research Expedition in November 1974. Y-74063 is an almost complete, smoothly rounded stone weighing 35.4 g covered with brownish-black fusion crust. The thin section shows that this meteorite has generally poorly traced chondritic texture and "chondrules" merge into the recrystallized matrix. Compositions of olivine and low-Ca pyroxene are homogeneous and average $Fa_{10.9}$ and $Fs_{10.7}$ respectively. These compositions strongly suggest that Y-74063 is not similar to all the previously known chondrites. Bulk analysis shows that the total iron content of Y-74063 is the lowest of the ordinary chondrite groups, and the abundance of troilite is much higher than those of all ordinary chondrites. Texture, bulk and mineral compositions of Y-74063 indicate that this meteorite is identified as chondrite and classified into a new type of chondrite group which is between E and H chondrite groups.

Y-74063 is similar to Acapulco, ALH-77081 and ALH-78230 in mineral composition which occupies the intermediate site between the E and H chondrites. But the latter 3 chondrites have no evidence of chondrules in spite of "chondritic" texture, mineral assemblage and compositions. Bulk composition indicates that Y-74063 differs from Acapulco-type meteorites and all previously known chondrite groups.

The presence of Y-74063 suggests that there is a great possibility of the existence of more unknown meteorite types in Antarctica, and non-Antarctic regions.

1. Introduction

It is well known that chondrites are primitive meteorites and classified into several types such as enstatite chondrite, ordinary chondrites (including H, L, LL types) and carbonaceous chondrite by their chemical and mineral compositions. Each chondrite group formed "families" which may have come from the same parent bodies. Recently various anomalous chondritic meteorites have been classified as much more oxidized chondrites which have more iron(Fa)-rich olivines than those of carbonaceous chondrites (YANAI *et al.*, 1985; RUBIN and KALLEMEYN, 1989). On the other hand, it was thought that no chondrite group occupied the hiatus between enstatite chondrite and H chondrite groups, except for a few meteorites such as Acapulco (PALME *et al.*, 1981). However, recent work on the classification of chondritic meteorites from Antarctica shows that some specimen(s) are included in this hiatus judging from their mineral compositions. Their bulk compositions are quite different from those of known chondrite groups. Table 1 is the list of such anomalous chon-

Table 1. List of the anomalous chondritic meteorites in NIPR collections.

Name	Original weight (g)	Fa in olivine	Fs in pyroxene	
Y-74063	35.41	10.9	10.9	With chondrules Pl ($Ab_{82.7}An_{13.6}Or_{3.7}$) $En_{51.0}Fs_{4.4}Wo_{44.5}$
Y-74357	13.8	7.9	13.8	
Y-74359	1.53	19.2	16.7	
Y-74360	3.29	20.5	15.4	
Y-75097	(clast)	24 (21.9–25.4)	—	L7 clast Pl ($An_{11.7-25.9}$)
Y-75261	0.59	0.3	0.3	
Y-75274	5.1	3.9	3.9	
Y-75300	1.5	1.6	2.1	
Y-75302	3.62	33.6 (10.6–41.7)	18.3–28.7	
Y-75305	2.06	1.8	2.1	
ALH-77081	4.24	10.7	10.3	Pl ($An_{12.2-14.4}$) $En_{52.2}Fs_{4.2}Wo_{43.6}$
ALH-78230	3.87	10.3	9.8	Pl ($An_{13.1-14.9}$) $En_{52.0}Fs_{4.5}Wo_{43.6}$
Y-791491	31.60			similar to Y-791493
Y-791493	5.13	11.6	12.2	
Y-793241	(clast)	24		Pl ($An_{29.0-30.7}$), $En_{47.8}Fs_{7.1}Wo_{45.2}$ chondrule in clast (Fa_{24-25}, Pl: $An_{30.7-32.2}$)
Y-794046	(clast)	19.4	14.7	$En_{58.3}Fs_{10.9}Wo_{30.8}$
Y-8002	2.27	3.5–3.9	3.5–4.0	

drites in the National Institute of Polar Research (NIPR) collections.

Yamato(Y)-74063 meteorite is the first chondrite with chondrules belonging to the space between E-chondrite and H-chondrite groups. Y-74063 was found on the bare ice field at the south end of the Yamato Mountains, Antarctica by the meteorites search party (led by K. YANAI) of the 15th Japanese Antarctic Research Expedition (JARE-15) on November 28, 1974. Y-74063 was originally identified and classified as a unique specimen (KOJIMA and YANAI, 1984; YANAI and KOJIMA, 1987), but new petrographic and chemical evidences indicate that it is one of very rare type of chondrite classified between E and H chondrites (YANAI and KOJIMA, 1990).

KIMURA (1987) reported that Y-74063 shows granoblastic texture with chondrule relict, and contains trace amounts of apatite, whitlockite and pentlandite. All features of Y-74063 show that it belongs to the group of Acapulco meteorite. Recently FUKUOKA and KIMURA (1990), and YAMAMOTO *et al.* (1990) reported the chemical abundances by INAA and abundances of lithophile trace elements of Y-74063, respectively. NAGAHARA *et al.* (1990) discussed that some unique meteorites from Antarctica including Y-74063 are of igneous origin; olivine and pyroxenes are cumulus phases, and plagioclase and/or merrillite are intercumulus.

Besides Y-74063, Allan Hills (ALH)-77081 has been classified as intermediate between the H- and E-group chondrites and has some resemblance to Acapulco (MASON, 1978). PRINZ *et al.* (1980), TAKEDA *et al.* (1980) and SCHULTZ *et al.* (1980)

also described this meteorite and discussed its relationship to the other meteorites. ALH-77081 and ALH-78230 show holocrystalline texture without chondrules, but their mineral assemblage and texture are very similar to some petrologic type 6–7 chondrites with chondrules (YANAI and KOJIMA, 1987). These two meteorites occupy the blank region according to by their mineral compositions. The Acapulco meteorite from Mexico is similar to ALH-77081 and ALH-78230 in lithology and mineral compositions (PALME *et al.*, 1981), and was rated as one of the unique meteorites. Unfortunately, these three meteorites do not have any chondrules, so that they have been classified as unique meteorites. Nevertheless, their mineral assemblages are chondritic, and their textures are remarkably chondritic in comparison with those of all achondrites.

Bulk and mineral compositions of Y-74063 indicate that it is classified between E- and H-chondrite groups as a new type chondrite with chondrules. Y-74063 is distinct from Acapulco type meteorites with chondritic texture because of the differences in their chemical compositions.

2. General Description

The Y-74063 stone measures $3.2 \times 2.6 \times 2.2$ cm and weighs 35.41 g. It was found in association with ten or more specimens in the field in Antarctica. This stone is almost complete and smoothly rounded with brownish-black fusion crust approximately 0.5 mm thick, showing general features of most of ordinary chondrites (Fig. 1a). The fusion crust of Y-74063 is quite distinct from that of an achondrite which is shiny black.

3. General Petrography of Y-74063

The cut surface of Y-74063 exhibits a compact and homogeneous feature, and shows gray color with much FeS (golden color) and less metal (silver color) grains up to 1 mm in size. No chondrules were recognized on the cut surface nor on the weathered broken surfaces, in spite of the appearance of fragmental chondrules on the weathered surface of Antarctic chondrites.

In the thin section, chondrules are generally poorly traced and merge into the recrystallized matrix (Fig. 1b), but some chondrules are clearly recognized under the polarized microscope. They are suggestive of originally barred-olivine chondrules (Fig. 2). The matrix is highly recrystallized, and is more coarse-grained than type 6 chondrite matrices. Y-74063 seems to have suffered thermal effects, because its granular texture resembles remarkably that those of terrestrial thermally metamorphosed rocks. Most of relatively large crystals of olivine and pyroxene include dust-like opaque minerals in their cores (Fig. 3). The chemical homogeneity of olivine and low-Ca pyroxene and the existence a lot of plagioclase and completely recrystallized matrix, indicate that Y-74063 is an equilibrated chondrite and belongs to petrologic type 6 of VAN SCHUMS and WOOD (1967) or type 7.

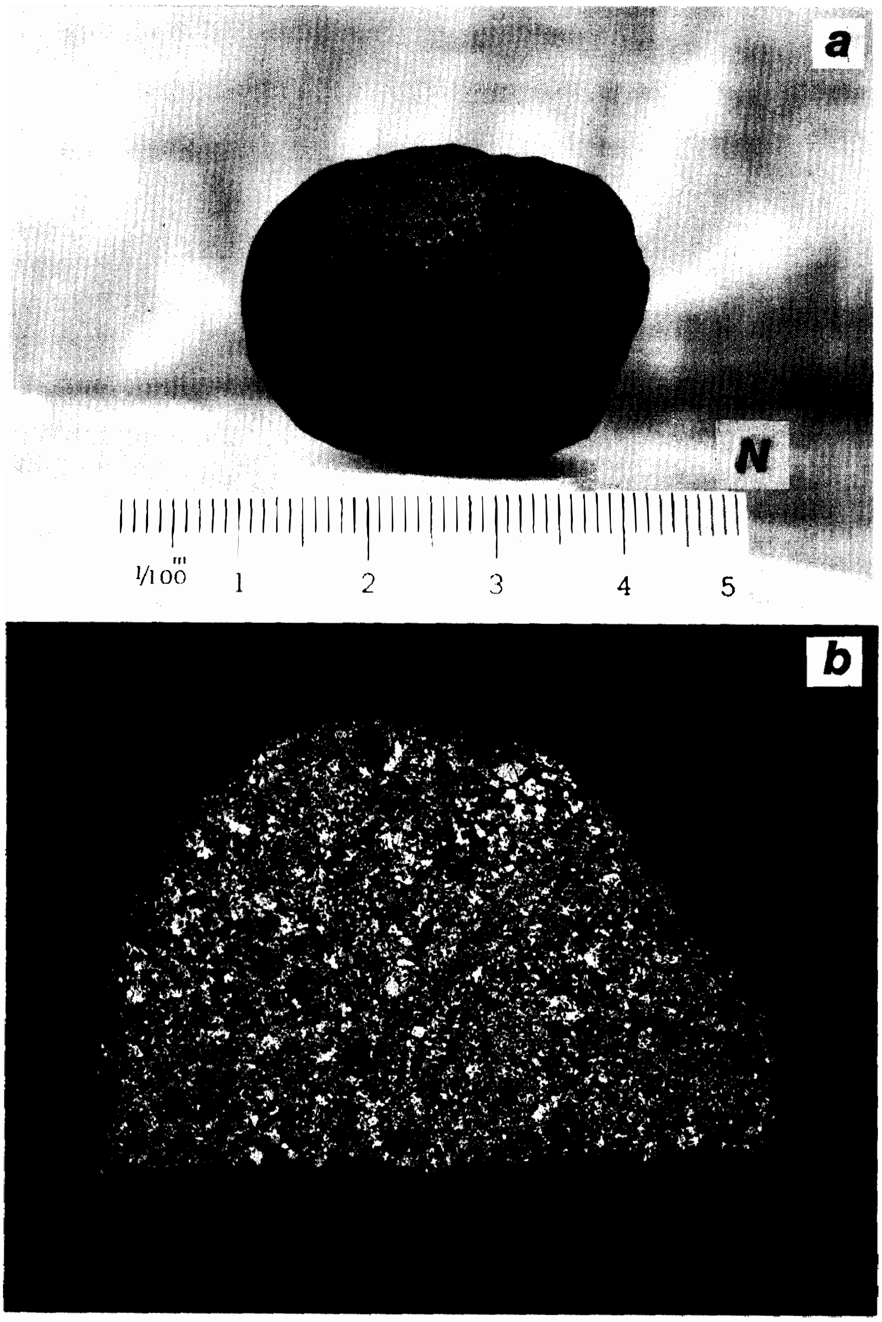

Fig. 1a. *Y-74063 chondritic unique meteorite found in Antarctica. It is 3.2 × 2.6 × 2.2 cm, 35.41 g rounded stone with brownish-black fusion crust. N-surface is fairly smooth. Scale in mm.*

Fig. 1b. *Thin section of Y-74063 chondrite photomicrographed in transmitted light. Y-74063 is more coarsely grained, showing only vague outlines of chondrules which merged into the recrystallized matrix. Only two "chondrules" were traced through the section, but not clear in this photo. Long dimension 13 mm.*

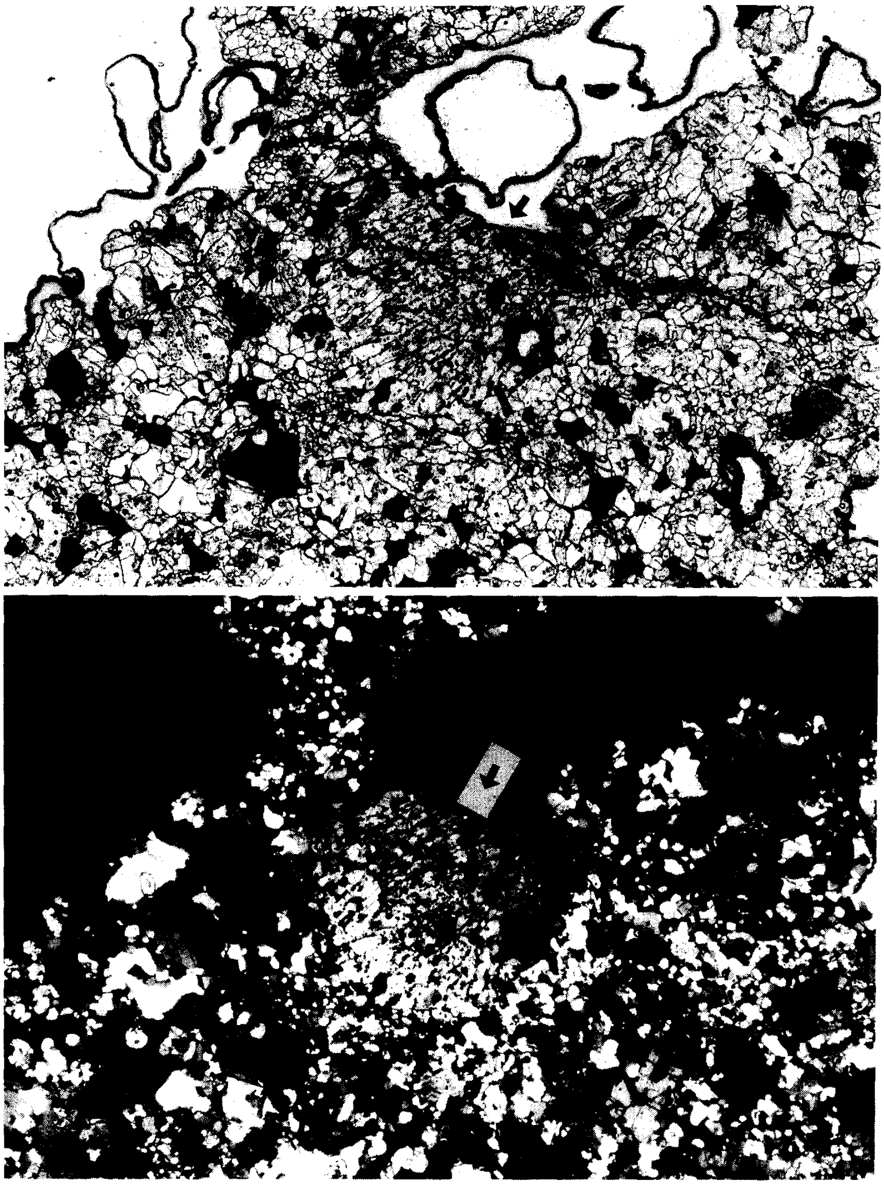

Fig. 2. Chondrule (center) merged into the crystalline matrix. Diameter of the chondrule is about 0.6 mm. Long dimension 2 mm.

4. Minerals and their Compositions

The constituent minerals were analyzed using an electron-probe microanalyzer. The data of the average composition of silicate minerals are shown in Table 2. Olivine and pyroxene have a homogenized composition regardless of their grain sizes. Both olivines from chondrules and matrix, have homogeneous composition, with an average Fa content of 10.9%. Low-Ca pyroxene is also homogeneous in composition, having an average Fs content of 10.7%. This is clearly lower than that of ordinary chondrites, but higher compared with that of E chondrite group. Clinopyroxene has average composition of $En_{51.0}$ $Fs_{4.4}$ $Wo_{44.5}$. Plagioclase is well recrystallized showing interstitial grains. Chemically plagioclases fall in the range of slightly Ca-rich (An_{15})

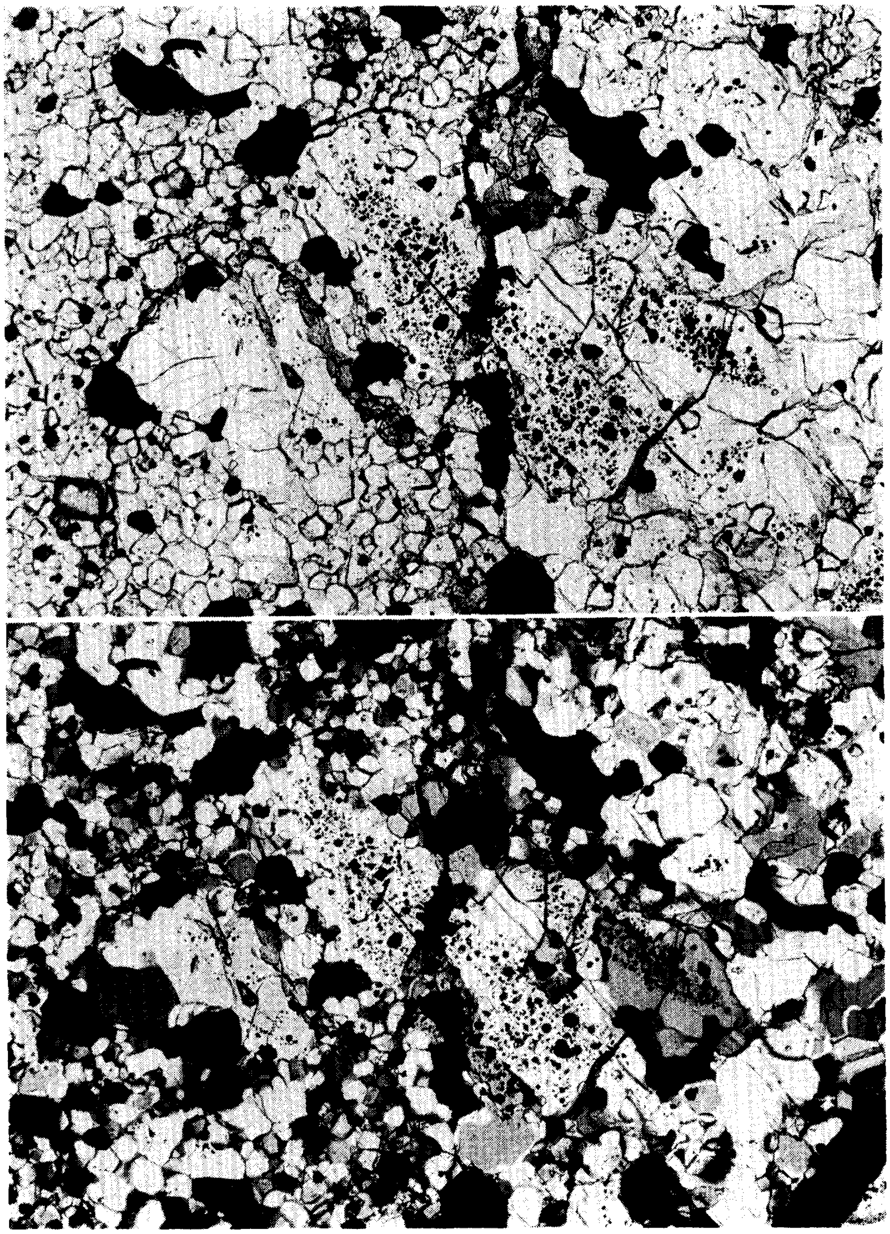

Fig. 3. Photograph showing highly recrystallized matrix. Relatively large grains of olivine and pyroxene include dust-like opaque inclusions in their cores, but recrystallized (relatively fine-grained) olivine and pyroxene are very clear. Width is 1.1 mm.

in comparison with ordinary chondrites (DODD, 1981). The chemical compositions of olivine, orthopyroxene, clinopyroxene, plagioclase and chromite are very similar to those of Acapulco meteorite, excepting high MgO and low Na_2O in clinopyroxene of Acapulco meteorite (PALME *et al.*, 1981).

The Fa/Fs diagram (Fig. 4) shows that olivine and pyroxene in Y-74063 are distributed in the intermediate region between E- and H-chondrite group together with Lodran, Acapulco, ALH-77081 and ALH-78230 meteorites. Especially, Y-74063 and 4 meteorites except Lodran should be assigned to the same group.

Fe-Ni metal and troilite occur as main constituent minerals, mostly as irregular

Table 2. Electron microprobe analyses (average wt%) of silicates and oxides from Y-74063 chondritic meteorite. The number of analyses is given in parentheses.

	Olivine (58)	Opx (118)	Cpx (9)	Plagioclase (22)	Chromite (5)
SiO_2	39.72	56.35	53.81	64.18	0.02
TiO_2	0.01	0.21	0.61	0.05	1.33
Al_2O	0.01	0.27	0.71	21.49	6.58
Cr_2O_3	0.01	0.25	1.10	0.01	59.06
FeO	10.56	7.29	2.73	0.23	21.86
MnO	0.48	0.53	0.28	0.01	1.23
MgO	48.20	33.40	17.69	0.03	6.94
CaO	0.02	0.82	21.48	3.36	0.04
Na_2O	0.01	0.02	0.72	10.07	0.02
K_2O	0.01	0.01	0.01	0.69	0.01
Total	99.02	99.15	99.14	100.11	97.08
	$Fo_{89.1}$ $Fa_{10.9}$	$En_{87.7}$ $Fs_{10.7}$ $Wo_{1.6}$	$En_{51.0}$ $Fs_{4.4}$ $Wo_{44.5}$	$Ab_{81.3}$ $An_{15.0}$ $Or_{3.7}$	

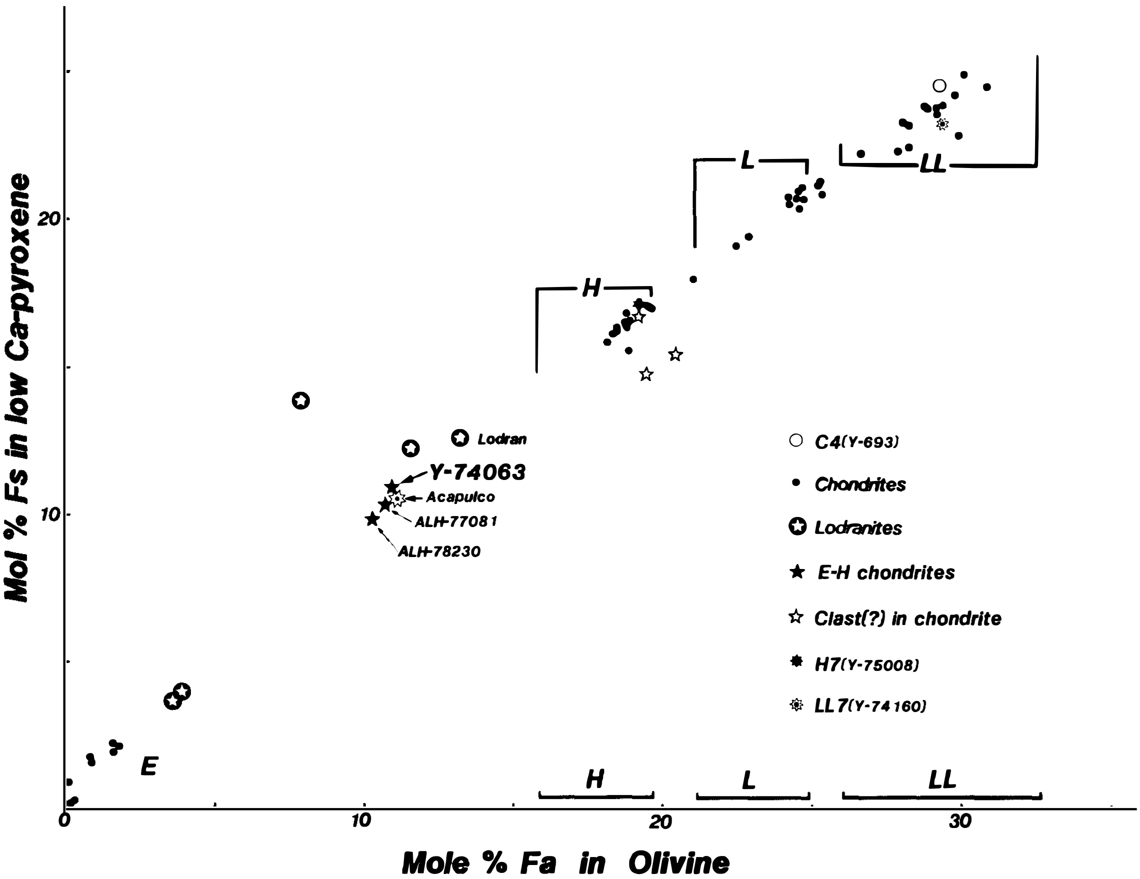

Fig. 4. Iron contents, expressed as mol% Fe_2SiO_4 (fayalite, Fa) and $FeSiO_3$ (ferrosilite, Fs), of olivine and low-calcium pyroxene in equilibrated chondrite with some chondritic unique meteorites and lodranites. Meteorites shown by symbols come from our unpublished data.

Table 3. Representative chemical compositions of Fe-Ni metal and troilite in Y-74063 in wt%.

	Fe–Ni Metal		Metal inclusion in silicates		Troilite
	Ni-poor	Ni-rich	Ni-poor	Ni-rich	
Fe	94.94	51.72	94.79	89.15	63.80
Ni	4.33	48.04	4.48	10.03	0.45
Co	0.67	0.13	0.58	0.63	0.12
S	0.22	0.02	0.04	0.02	36.38
Si	0	0.01	0.03	0.04	0.01
Mg	0.05	0.06	0	0	0.01
Cr	0.05	0	0.08	0.05	0.10
Total	100.26	99.98	100.00	99.92	100.87

grains showing some oxidation. Troilite is much more abundant than metal and sometimes associated with metal. There are two types of occurrence. One is that grains are scattered throughout the section as main constituents. These grains are similar in size or a little smaller than most olivines and pyroxenes. The most of those grains have compositional variation of Ni content from 4.3 to 48 wt%. The other occurrence is that metal and troilite are included in olivine and pyroxene as very fine-grained opaques like dusts. In this case, most metal and troilite are round in shape, and metal is much more abundant than troilite. The dust-like metal grains have small compositional range of the Ni 4.5–10.0 wt%. Table 3 shows representative chemical compositions of metal and troilite in Y-74063. Kamacite (average Ni content 6–7 wt%) is dominant compared with some taenite/plessite of fairly high Ni content. This is typical of equilibrated chondrite.

Chromite occurs as accessory mineral, and its composition is shown in Table 2. Chromite of Y-74063 is similar to that of the Acapulco, is quite different from those of all ordinary chondrites, especially with high Cr_2O_3, MnO and MgO, low TiO_2 and FeO in Y-74063 (BUNCH *et al.*, 1967; PALME *et al.*, 1981).

5. Comparison of the MnO/FeO Ratio in Y-74063, Ordinary Chondrites, Acapulco, ALH-77081 and -78230 Meteorites

Chemical difference between Y-74063 and equilibrated ordinary chondrites is evidently pointed out by the Fa/Fs diagram (Fig. 4). The MnO/FeO ratio of pyroxene (Fig. 5) also shows that they are different. Pyroxene in Y-74063 has remarkably low FeO content and slightly high MnO content in comparison with those of ordinary chondrites.

Similarity of Y-74063 to Acapulco, ALH-77081 and ALH-78230 has been already pointed out in Fa/Fs diagram. Although the MnO content of these pyroxenes varies (0.45–0.9 wt%), pyroxene of Y-74063 has relatively low MnO content compare with Acapulco and two ALH (Fig. 5).

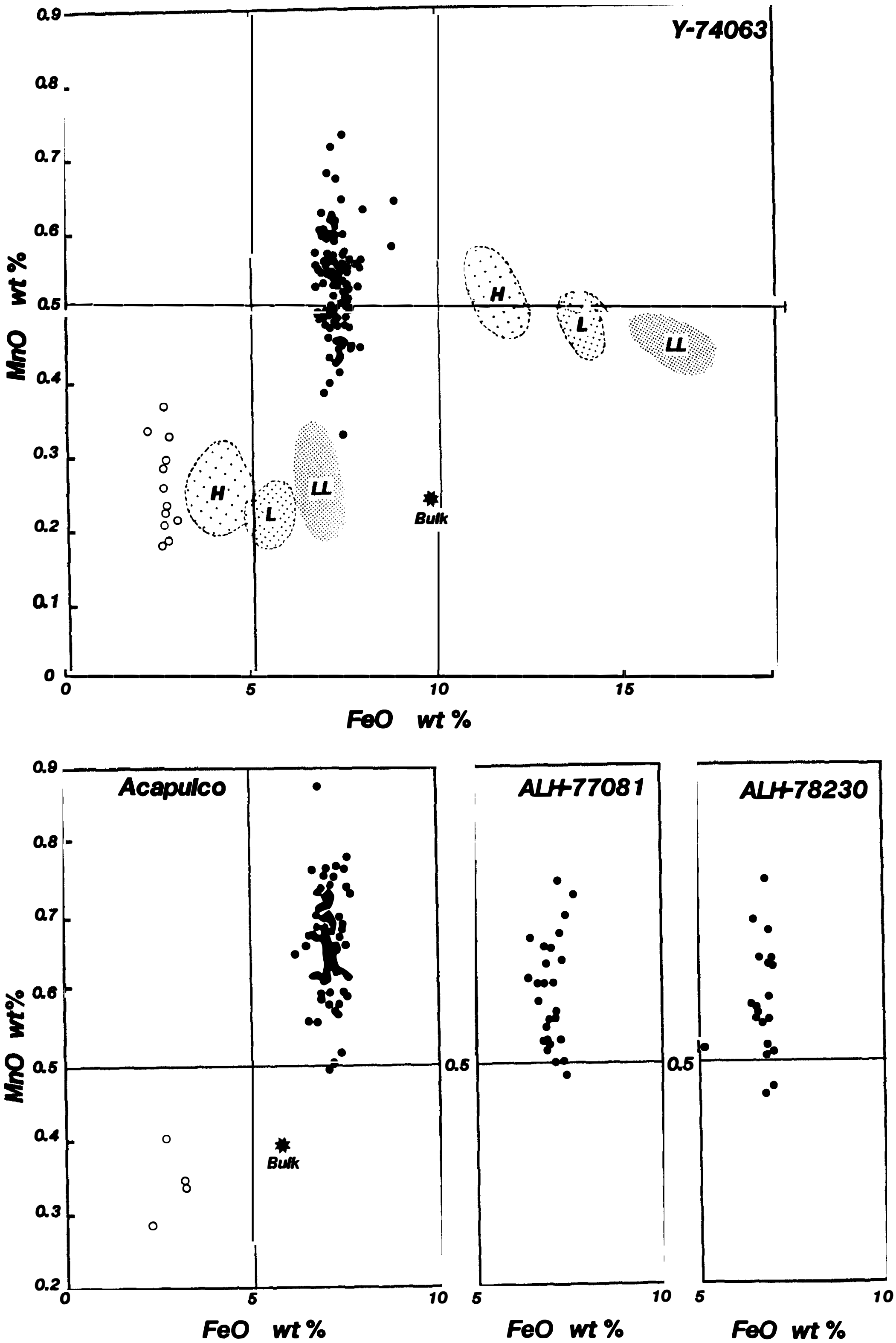

Fig. 5. MnO/FeO variation diagram for pyroxenes in equilibrated chondrite (H, L, LL) and Y-74063, compared with Acapulco, ALH-77081 and ALH-78230 (author's data). Solid: orthopyroxene. Open circle: clinopyroxene. Average H, L, LL: Data from the chondrites after BUNCH *and* OLSEN *(1973).*

6. Bulk Composition of Y-74063, and Comparison with Chondrites and Acapulco Meteorites

A bulk analysis using the standard wet chemical analysis method was carried out by H. HARAMURA. About 1.083 g of sample was removed from a relatively fresh part of the original mass for this analysis. The sample was pulverized, then the magnetic (metal) and non magnetic (most silicates) fractions were separated. Details of the separation and analysis techniques are described by HARAMURA *et al.* (1983). The results are presented in Table 4 for comparison with those of other analyzed ordinary chondrites from Antarctica and Acapulco meteorite. About 1.28 g of Acapulco was removed for the recent analysis by H. HARAMURA.

The bulk data show that Y-74063 has suffered little oxidization, as its Fe_2O_3 content is low. It is noteworthy that the total iron and MnO of Y-74063 (18.97 and 0.19 wt%, respectively) are the lowest of all chondrites and Acapulco, which is different from INAA analytical results (MnO 0.34 wt%) by FUKUOKA and KIMURA (1988). While it has fairly high content of MgO and CaO, FeO is within the range of ordinary chondrites. Nickel-iron metal content is similar to L chondrite, but the abundance of troilite (FeS) is much higher than those of all ordinary chondrites and Acapulco. Other components are almost similar to chondrites and Acapulco.

Y-74063 on the U-C diagram shows that it differs distinctly from all known

Table 4. Major element chemical analysis of Y-74063 in comparison with those of E chondrites and ordinary chondrites from Antarctica and Acapulco meteorite, in wt%. Numbers in parentherse are those of analyses averaged.

	Y-74063	Acapulco		Y-691	H	L	LL
	(a)	(a)	(b)	(E)	(12)	(26)	(17)
SiO_2	38.98	37.75	37.88	36.31	35.64	39.32	39.58
TiO_2	0.08	0.07	—	0.08	0.10	0.10	0.14
Al_2O_3	2.96	2.06	2.25	2.93	2.00	2.39	2.52
Fe_2O_3	0.91	1.82	—	0	—	—	—
FeO	9.69	5.69	33.69	0.96	11.71	15.13	19.86
MnO	0.19	0.39	0.38	0.24	0.28	0.33	0.34
MgO	27.01	26.83	26.36	19.59	23.73	25.52	25.70
CaO	2.68	1.94	—	1.29	1.76	1.85	1.78
Na_2O	0.83	0.86	0.78	0.83	0.73	0.90	0.87
K_2O	0.07	0.06	0.05	0.07	0.08	0.09	0.11
H_2O (−)	0.04	0.00	—	0.50	0.07	0.10	0.10
H_2O (+)	0.3	0.1	—	0.5	0.22	0.17	0.39
P_2O_5	0.46	0.37	—	0.46	0.23	0.24	0.25
Cr_2O_3	0.34	0.45	0.95	0.45	0.46	0.52	0.58
FeS	9.31	5.79	—	16.31	5.45	6.04	5.27
Fe	4.89	14.48	—	17.8	15.80	6.10	1.33
Ni	0.98	1.31	2.09	1.717	1.70	1.10	0.95
Co	0.031	0.107	0.13	0.07	0.058	0.036	0.025
Total	99.75	100.07	104.56	100.10	100.01	99.93	99.79
Total Fe	18.97	23.85	26.18	28.9	28.36	21.70	20.11

(a) Standard wet analysis by H. HARAMURA. (b) NAA by PALME *et al.* (1981). H, L, LL: Average composition (HARAMURA *et al.*, 1983)

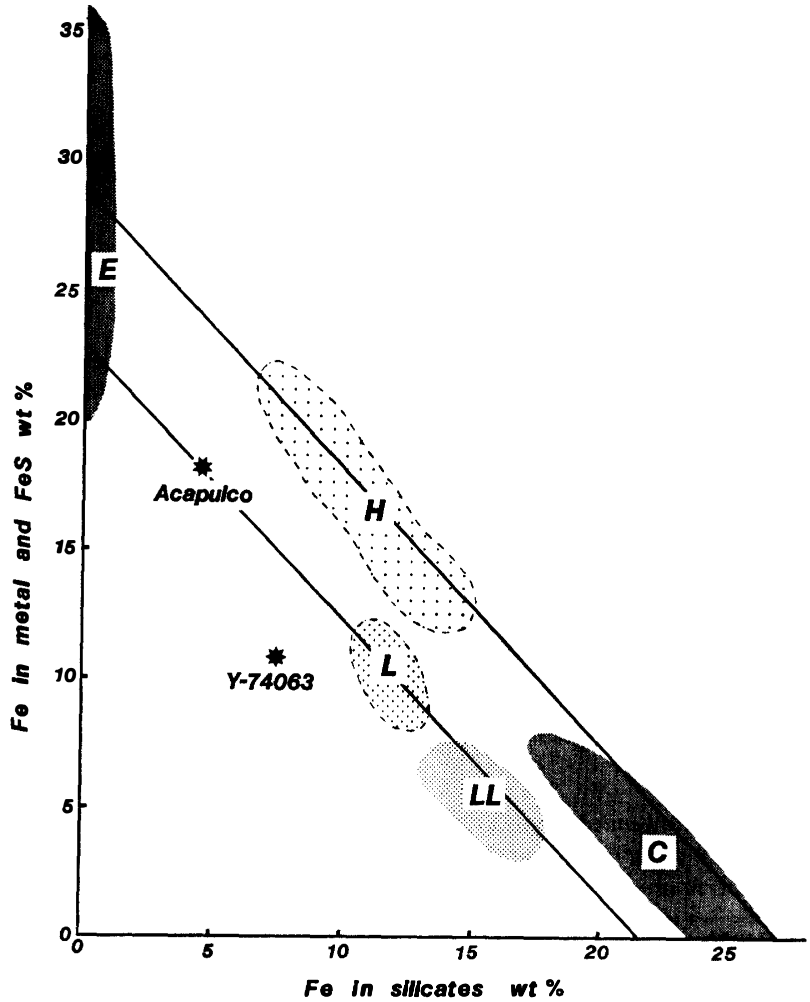

Fig. 6. Y-74063 in U-C diagram which indicates Fe in metal-troilite phases and Fe in silicate phase. Y-74063 is different from all previously known chondrites in the diagram.

chondrite groups and Acapulco (Fig. 6) in the well-known classification of chondrites. Y-74063 does not belong to any ordinary chondrite groups and it is not similar to Acapulco meteorite. Therefore, Y-74063 meteorite should be classified as a new type of chondrite because of the peculiarity of its bulk chemical composition.

7. Classification of Y-74063 and Conclusion

Y-74063 is a relatively coarse-grained chondrite, retaining traces of chondrules and "chondritic" texture. Olivine and pyroxene compositions are distinct from those of the ordinary chondrite groups, but are between E- and H-chondrite groups specifications. The bulk chemical data are distinct from all known chondrites and are plotted on new point (Figs. 4 and 6). So-called "matrix" turned to fine- to coarse-grained groundmass due to a possible thermal effect. Y-74063 meteorite has to be classified as a new type of petrologic type 6–7 chondritic unique meteorite.

Similarity of Y-74063 to Acapulco, ALH-77081 and ALH-78230 has been pointed out by their mineral compositions which occupied the intermediate site between the

E and H chondrites. But the latter 3 meteorites have no evidence of chondrules in spite of their "chondritic" texture, mineral assemblage and compositions. Bulk composition indicates that Y-74063 differs from Acapulco-type meteorites and all previously known chondrite groups. The FeO and MnO contents of orthopyroxene in Y-74063 are distinct from those of all ordinary chondrites (Fig. 5). Y-74063 and Acapulco-type meteorites have been formed originally as chondrite, but the difference between of these meteorites might be caused by secondary effects; metamorphism or igneous process.

Yamato-74063 strongly suggests a great possibility of the existence of more unsampled meteorite types in Antarctica, and that there are new types of meteorites in Antarctica and non-Antarctic regions.

Acknwledgments

We are grateful in particular to Mr. H. HARAMURA and Ms. M. NAITO for bulk analysis and the electron microprobe work. We thank to Mses. N. OKI and K. YAMANE for typing and drawing.

References

BUNCH, T.E. and OLSEN, E. (1973): Ortho-clinopyroxene compositions in ordinary chondrites and related Blander model calculation procedures. NASA Tech. Memo. NASA TMX-62, **259**, 16 p.

BUNCH, T. E., KEIL, K. and SNETSINGER, K. G. (1967): Chromite composition in relation to chemistry and texture of ordinary chondrites. Geochim. Cosmochim. Acta, **31**, 1569–1582.

DODD, R. T. (1981): Meteorites: A Petrologic-Chemical Synthesis. Cambridge, Cambridge Univ. Press, 368 p.

FUKUOKA, T. and KIMURA, M. (1988): Chemistry of Y-74025 chondrite (abstract). Papers Presented to the 13th Symposium on Antarctic Meteorites, June 7–9, 1988. Tokyo, Natl Inst. Polar Res., 44–45.

FUKUOKA, T. and KIMURA, M. (1990): Chemistry of Y-74063, -75357 and ALH-78230 unique meteorites (abstract). Papers Presented to the 15th Symposium on Antarctic Meteorites, May 30–June 1, 1990. Tokyo, Natl Inst. Polar Res., 99–100.

HARAMURA, H., KUSHIRO, I. and YANAI, K. (1983): Chemical compositions of Antarctic meteorites I. Mem. Natl Inst. Polar Res., Spec. Issue, **30**, 109–121.

KIMURA, M. (1987): Petrology of unique Antarctic chondrites, Y-74025 and Y-74063 (abstract). Papers Presented to the 12th Symposium on Antarctic Meteorites, June 8–10, 1987. Tokyo, Natl Inst. Polar Res., 47.

KOJIMA, H. and YANAI, K. (1984): Classification of the pebble size meteorites in the Yamato-74 collection (abstract). Papers Presented to the 9th Symposium on Antarctic Meteorites, March 22–24, 1984. Tokyo, Natl Inst. Polar Res., 11–13.

MASON, B. (1978): Antarctic Meteorite Newsletter, **1** (1–3).

NAGAHARA, H., FUKUOKA, T., KANEOKA, I., KIMURA, M., KOJIMA, H., KUSHIRO, I., TAKEDA, H., TSUCHIYAMA, A. and YANAI, K. (1990): Petrology of unique meteorites Y-74063, Y-74357, Y-75261, Y-75274, Y-75300, Y-75305, A-77081, A-78230 and Y-8002 (abstract). Papers Presented to the 15th Symposium on Antarctic Meteorites, May 30–June 1, 1990. Tokyo, Natl Inst. Polar Res., 92–94.

PALME, H., SCULTZ, L., SPETTEL, B., WEBER, H. W. and WÄNKE, H. (1981): The Acapulco meteorite: Chemistry, mineralogy and irradiator effects. Geochim. Cosmochim. Acta, **45**, 727–752.

PRINZ, M., WAGGONER, D.G. and HAMILTON, P. J. (1980): Winonaites: A primitive achondritic group related to silicate inclusions in IAB irons (abstract). Lunar and Planetary Science XI. Houston, Lunar Planet. Inst., 902–904.

RUBIN, A. E. and KALLEMEYN, G. W. (1989): Carlisle Lakes and Allan Hills 85151: Members of a new chondrite grouplet. Geochim. Cosmochim. Acta, **53**, 3035–3044.

SCHULTZ, L., PALME, H., SPETTEL, B., WÄNKE, H. and WEBER, H. W. (1980): Chemistry and noble gases of the unusual stony meteorite Allan Hills A77081 (abstract). Lunar and Planetary Science XI. Houston, Lunar Planet. Inst., 1003–1005.

TAKEDA, H., MORI, H., YANAI, K. and SHIRAISHI, K. (1980): Mineralogical examination of the Allan Hills achondrites and their bearing on the parent bodies. Mem. Natl Inst. Polar Res., Spec. Issue, **17**, 119–144.

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

YAMAMOTO, K., NAKAMURA, N., MISAWA, K., YANAI, K. and MATSUMOTO, Y. (1990): Lithophile trace element abundances in Antarctic unique meteorites and in unique clast from L6 chondrites (abstract). Paper Presented to the 15th Symposium on Antarctic Meteorites, May 30–June 1, 1990. Tokyo, Natl Inst. Polar Res., 97–98.

YANAI, K. and KOJIMA, H., comp. (1987): Photographic Catalog of Antarctic Meteorites. Tokyo, Natl Inst. Polar Res., 298 p.

YANAI, K. and KOJIMA, H. (1990): Y-74063: Unique meteorite classified between E and H chondrite (abstract). Papers Presented to the 15th Symposium on Antarctic Meteorites, May 30–June 1, 1990. Tokyo, Natl Inst. Polar Res., 95–96.

YANAI, K., KOJIMA, H. and MATSUMOTO, Y. (1985): A new type chondrite? Yamoto-75302 consists mostly of very high iron olivine (abstract). Meteoritics, **20**, 791.

(Received August 10, 1990; Revised manuscript received November 5, 1990)