A PRELIMINARY PROCESSING OF YAMATO-79 METEORITES

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Abstract: About 3300 meteorites were collected in the area surrounding the Yamato Mountains, East Antarctica in the 1979–1980 season. About 1000 meteorites were numbered, weighed, measured and photographed, among which 500 specimens were classified by the Preliminary Examination Team into 9 eucrites, 3 diogenites, 6 carbonaceous chondrites, and many ordinary chondrites possibly including 19 unique specimens. Achondrites and carbonaceous chondrites are similar to the specimens that have been recovered from the same area in the past. This paper describes mainly physical features of the selected meteorites processed till March 1981, and describes their types based on preliminary classification by the Preliminary Examination Team of the Japanese Committee on Antarctic Meteorites and by foreign scientists.

1. Introduction

The traverse party of the 20th Japanese Antarctic Research Expedition visited the Yamato Mountains in the 1979–1980 field season to search for Antarctic meteorites. Over 3300 new meteorite specimens were collected between October 1979 and January 1980 on the bare ice adjacent to the Yamato Mountains, and these collections were named officially the Yamato-79 meteorites (YANAI, 1981a). These specimens stored in the wooden boxes at temperatures below freezing were taken back from the Yamato Mountains to the icebreaker FUJI. Then the specimens were brought to Tokyo in the refrigerator of the ship, and kept in the cold storage at $-20°C$ at the National Institute of Polar Research.

2. Processing

The meteorite specimens were unpacked and transferred from the cold storage room to a cabinet in order of discovery. The specimens were thawed and dried in the cabinet filled with dry nitrogen. After thawing, every meteorite specimen was numbered, weighed, the size was measured in three dimensions, and six orthogonal faces were photographed with both color and black & white films in the processing

laboratory at the National Institute of Polar Research. The lettered cube shown in the photographs (S, E, N, W, B, T) indicates relative orientation of the specimens as assigned during the processing. Up to date, about 1000 meteorite specimens were processed, and 500 of them were classified preliminarily under a stereomicroscope by the Preliminary Examination Team of the Japanese Committee on Antarctic Meteorites.

3. Statistics of the Processed Samples

A preliminary classification of 500 specimens resulted 9 eucrites, 3 diogenites, 6 carbonaceous chondrites, and many ordinary chondrites possibly including 19 unique specimens. Frequency of mass of the Yamato-79 meteorites is shown in Table 1. The largest specimen is Yamato-790448 weighing 3480 g. This frequency is similar to that of the Yamato-74 meteorites (YANAI, 1978).

Table 1. Frequency of mass of the Yamato-79 meteorites.

Weight in grams	Numbers	%
< 1	36	7.2
1– 5	171	34.4
5– 10	81	16.3
10– 50	137	27.5
50– 100	31	6.2
100– 500	35	7.0
500–1000	3	0.6
1000–5000	4	0.8
Total	498	100

The possibly unique specimens are classified into two types by the visual features. Thirteen specimens among them are characterized by the presence of many vesicles like those in volcanic rocks. The others are of fine-grained crystalline compact type. These are similar to some lithic fragments known in the LL-group chondrites (YANAI *et al.*, 1981).

There are three diogenites among 500 specimens. These diogenites are very similar in features, especially in texture and color, to Yamato-74097 which is the largest of all the Yamato-74 diogenites. The diogenite specimens of Yamato-79 are very small in size. The classification of the specimens is summarized as follows.

Chondrites

Carbonaceous chondrites: Yamato-790003, 790032, 790033, 790034, 790112, 790123.

Possibly unique chondrites:

Vesicular type; Yamato-790143, 790169, 790170, 790250, 790311, 790327, 790397,

790398, 790415, 790485, 790486, 790488, 790489.

Compact fine-grained type; Yamato-790144, 790332, 790345, 790392, 790414, 790450.

Ordinary chondrites over 300 g: Yamato-790247, 790256, 790269, 790401, 790445, 790446, 790448, 790460, 790461, 790462, 790499.

Achondrites

Diogenites: Yamato-790022, 790111, 790118.

Eucrites (polymict): Yamato-790006, 790007, 790020, 790113, 790114, 790122, 790260, 790266, 790447.

Most of the eucrites (polymict) in the processed specimens of the Yamato-79 meteorites were examined and classified by TAKEDA and YANAI (1981). Yamato-790446 and 790499 were described in the Photographic Catalog of the Selected Antarctic Meteorites (YANAI, 1981b), so the details are not given in this paper.

4. Physical Description of the Selected Specimens

4.1. Carbonaceous chondrites

Yamato-790003 4.292 g

This is a very fragile specimen. The sample was well rounded, but during the processing it was broken into several pieces. The specimen included white material which may be one of the evaporites that was formed on the surface before discovery. In the interior, black matrix and some pale yellow chondrules are observed.

Yamato-790032 $2.5 \times 1.5 \times 1.3$ cm 6.081 g

A patch of the fusion crust remains on the S surface only and it is charcoal-brown in color. The crust-free surfaces are fracture surfaces. The interior is a fine-grained black matrix with light colored inclusions throughout the groundmass (Fig. 1).

Yamato-790033 $1.2 \times 1.2 \times 0.8$ cm 1.360 g

Yamato-790034 $0.9 \times 0.6 \times 0.4$ cm 0.295 g

These are very small specimens.

Yamato-790112 $3.1 \times 2.6 \times 2.5$ cm 23.97 g

Yamato-790123 $2.3 \times 2.2 \times 1.6$ cm 6.796 g

These were described briefly in the Photographic Catalog of the Selected Antarctic Meteorites (YANAI, 1981b).

4.2. Chondrites

4.2.1. Vesicular type

Yamato-790143 $4.1 \times 3.9 \times 2.2$ cm 52.262 g

The specimen was classified as an LL chondrite (YANAI, 1981b). The specimen is rounded and approximately complete. The fusion crust suffered abrasion for the most part. Small patches of the fusion crust remain on the S and B surfaces which are dull, black in color and 1 mm in thickness. Other portions of the exterior are light greenish gray, partially stained orange brown. This specimen is remarkably

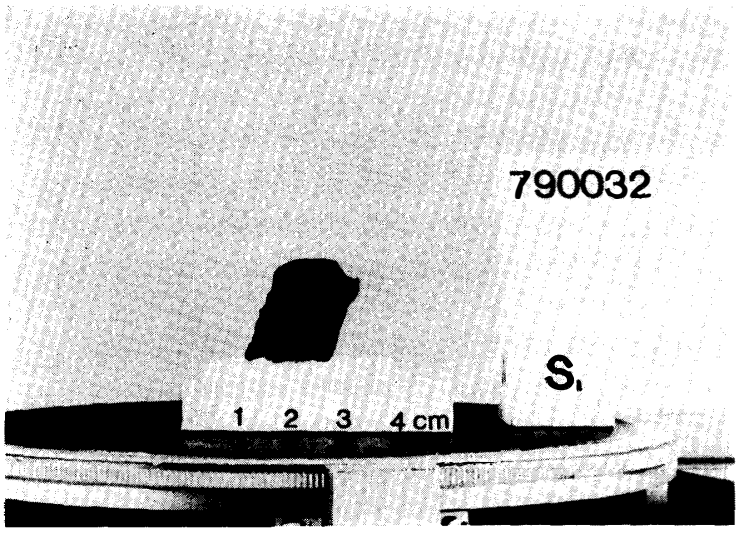

Fig. 1. Showing the S surface of Yamato-790032, carbonaceous chondrite.

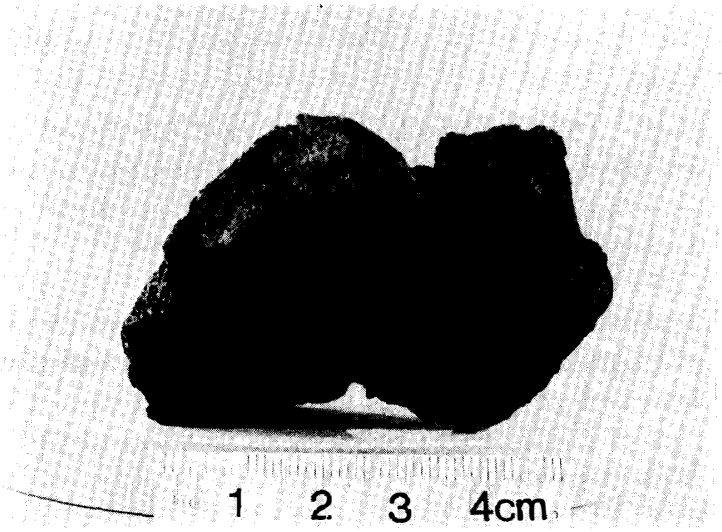

Fig. 2. Showing Yamato-790169 and Yamato-790170 fit together.

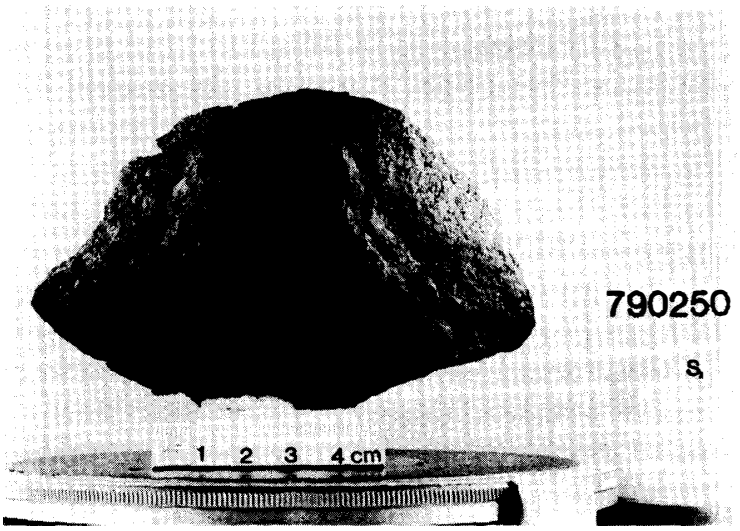

Fig. 3. Showing the S surface of Yamato-790250, porous chondrite.

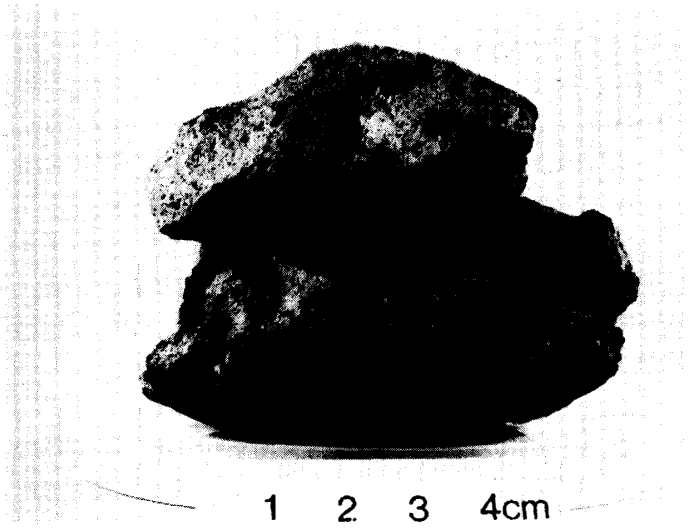

Fig. 4. Large fractures on the N surface of Yamato-790269.

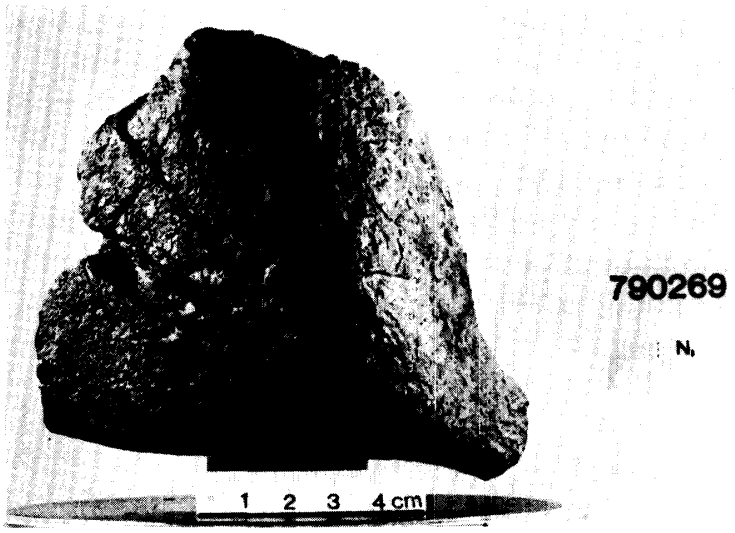

Fig. 5. Showing Yamato-790397, -790398 and -790415 fit together.

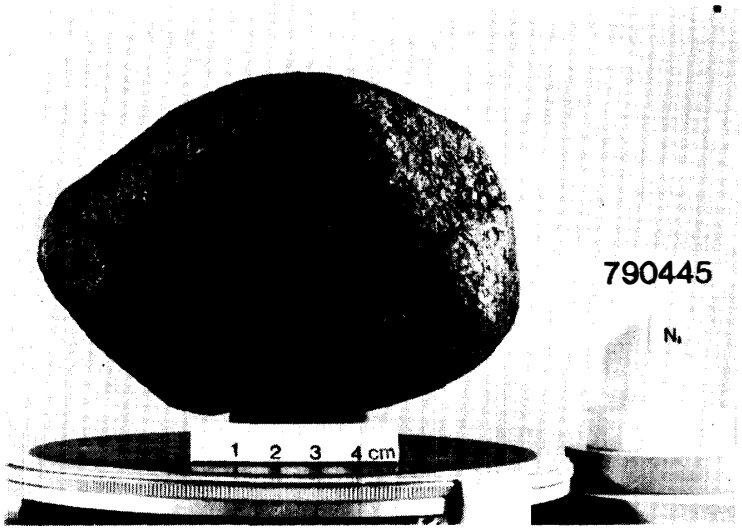

Fig. 6. Yamato-790445 approximately complete specimen with large fractures.

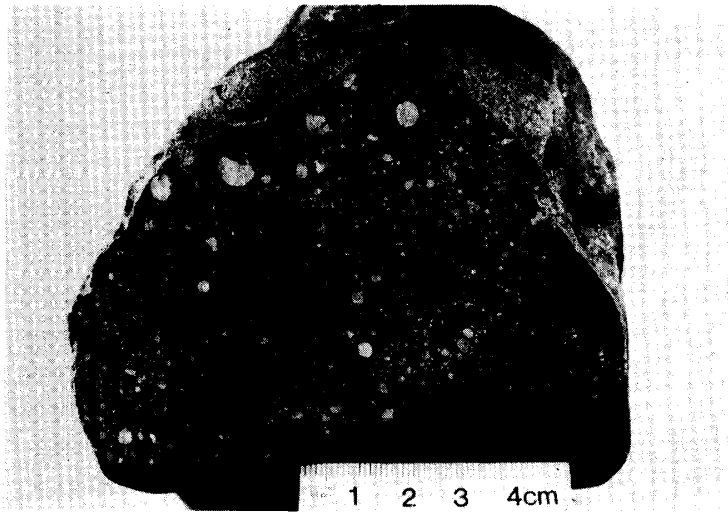

Fig. 7. Cut surface of Yamato-790448 showing numerous chondrules.

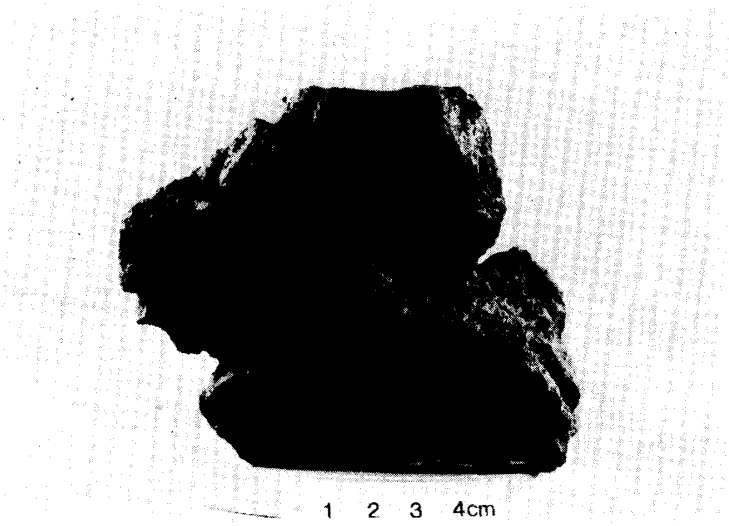

Fig. 8. Showing Yamato-790460 and -790461 fit together.

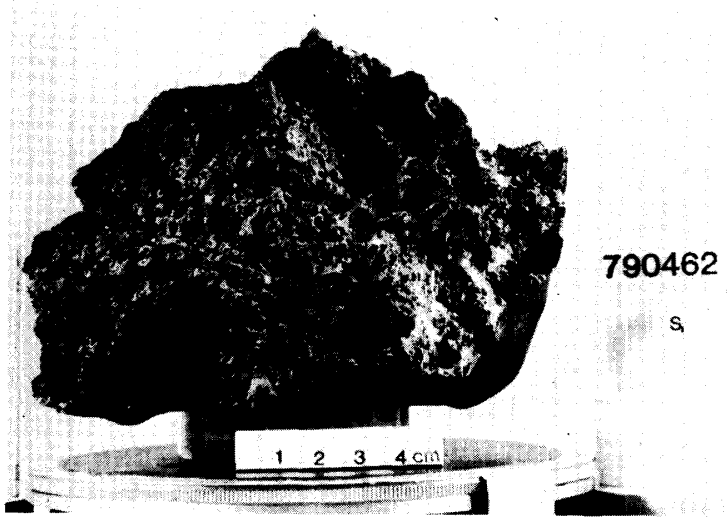

Fig. 9. Showing the fracture surface of Yamato-790462.

porous but indurated. Irregular voids are distributed on the exterior and in the interior. No obvious chondrules were recognized in the specimen.

Yamato-790169	4.2×3.2×1.0 cm	41.005 g
Yamato-790170	4.6×4.6×3.1 cm	65.954 g

These two samples fit together along the B surface of Y-790169 and the N surface of Y-790170 (Fig. 2), and make an almost complete shape. No fusion crust is apparent on these specimens. The overall color is greenish gray.

Yamato-790250	11.8×7.8×3.3 cm	354.2 g

Approximately half of the specimen is rounded, but the N surface is flat and shows a fracture surface. The fusion crust was all lost from the specimen (Fig. 3). Most of the exterior is greenish gray in color and the remaining small surface is light greenish gray. There are many elongated voids along the boundary of the dark-colored portion and the light-colored portion. The light-colored portion is more porous than the dark-colored portion.

Yamato-790311	0.9×0.7×0.7 cm	0.64 g
Yamato-790327	1.0×0.8×0.6 cm	0.55 g

These are very small specimens with numerous irregular voids.

Yamato-790397	8.0×5.5×2.8 cm	161.995 g
Yamato-790398	2.4×1.6×1.4 cm	6.71 g
Yamato-790415	5.8×3.2×3.1 cm	63.445 g

These three specimens fit together along the S surfaces of Y-790397 and Y-790415 and the N surface of Y-790398 (Fig. 4). The E surfaces of Y-790397 and Y-790415 have small patchy remnants of thin, dull, black fusion crusts. Almost patchy crusts seem to remain in the concave portions of the samples. The remainder of the exterior is greenish gray and porous.

Yamato-790485	1.6×1.2×0.7 cm	1.66 g
Yamato-790486	1.4×0.9×0.4 cm	0.67 g

These specimens are fragments separated from the S surface of Y-790489. Y-790486 has dull black fusion crust in small areas.

Yamato-790488	2.7×2.0×1.4 cm	10.23 g

The N surface is a weathered surface and other surfaces are fracture surfaces. The fusion crust is missing. The overall color is light greenish gray. The specimen is similar to Y-790489, but the two do not fit together.

Yamato-790489	6.5×5.8×4.8 cm	222.8 g

This is a very porous and nearly complete specimen, but the S surface is a fracture surface. Some patches of dull, black fusion crust remain. The overall color is light greenish gray with a brown stain on the S surface.

4.2.2. Compact fine-grained type

Yamato-790144	6.0×3.3×2.9 cm	92.32 g

The specimen was classified as an LL chondrite (YANAI, 1981b). The specimen is

well rounded, indurated and almost complete. The fusion crust is entirely weathered. The overall color of the specimen is greenish black to dark gray. Under the stereomicroscope, no obvious chondrule and lithic clast are observed. This specimen seems to have a fine-grained crystalline texture.

Yamato-790332 $3.8 \times 2.8 \times 1.8$ cm 28.66 g

The specimen is about one fourth of a complete stone without the fusion crust. The W and B surfaces are fracture surfaces. The exterior is glassy black in color.

Yamato-790345 $6.9 \times 5.2 \times 3.4$ cm 233.6 g

The specimen was classified as an LL6 chondrite (YANAI, 1981b). The specimen is well rounded on all faces. Very small areas of the fusion crust remain in patches only on the N surface. The overall color is black and partially stained brown. The sample is highly coherent and difficult to chip. No obvious chondrule and lithic clast are observed in hand specimen and under the stereomicroscope.

Yamato-790392 $3.4 \times 2.2 \times 1.8$ cm 21.99 g

The specimen is a small fragment. The N and B surfaces are fracture surfaces. This sample is similar to Y-790144 in exterior view.

Yamato-790414 $4.5 \times 3.5 \times 2.7$ cm 67.02 g

The sample is rounded and approximately complete. No fusion crust is apparent on this specimen. The exterior is smooth and glassy, black in color. There is a heterogeneous light greenish gray portion on the S surface. Some orange-color chondrules are noticed in the black matrix of the dark colored portion, but no obvious chondrule is observed in the light colored portion.

Yamato-790450 $1.7 \times 1.5 \times 0.7$ cm 3.12 g

The small specimen has a characteristic discus shape without the fusion crust. The overall color is greenish gray with partly shiny dark brown stain.

4.2.3. Ordinary chondrites over 300 g

Yamato-790247 $9.5 \times 6.1 \times 5.5$ cm 475.9 g

This appears to be a complete specimen. The sample is compact and hard. Approximately 60% of the sample is covered with shiny black fusion crust with brown stain in part. 80% of the S surface and 40% of the N surface are weathered surface. These surfaces are covered with a shiny dark brown weathering rind. But under the rind, numerous chondrules are observed. The largest chondrule about 3 mm in diameter is revealed on the S surface. The interior is a dark gray to black matrix with many chondrules which are light brown to yellow in color. No fracture is observed on the all surfaces.

Yamato-790256 $7.5 \times 6.4 \times 5.0$ cm 381.2 g

The specimen is approximately complete. 90% of the exterior surface is covered with dull, dark brown to black fusion crust of 0.5 mm in thickness. On the B surface, the fusion crust is stained shiny brown. The fusion crust has polygonal fractures over most of the exterior surfaces. The remaining brown exterior seems to have been

weathered not only mechanically but also chemically. The interior is light gray in color and contains no chondrule.

Yamato-790269 $11.1 \times 10.9 \times 7.2$ cm 1269.2 g

The specimen is about half of one complete stone. The S surface is a fracture surface. 60% of other surfaces are covered with patchy, thin, dull, black fusion crust. The remainder of the exterior is a dark brown stained rind, so that the interior is not observed. Some large fractures are developed on the S, E and B surfaces (Fig. 5).

Yamato-790401 $6.7 \times 6.6 \times 4.8$ cm 389.5 g

The specimen is approximately complete. The W surface is a rough fracture surface. Most of the remaining surfaces are covered with the thin, dull, black fusion crust which is partially stained brown. The fusion crust has less pronounced polygonal fractures. On the W surface, some dark gray chondrules released from the matrix are observed. The diameter of chondrules is under 1.5 mm.

Yamato-790445 $13.0 \times 8.9 \times 8.0$ cm 1574 g

This is a rounded and complete specimen. 80% to 90% of the sample is covered with thin, dull, black fusion crust. Some large fractures 5 mm wide are recognized on the N and T surfaces (Fig. 6). The remaining exterior is a brown-stained rind with some chondrules. On the N surface, there is a white material which may be some kind of evaporites.

Yamato-790448 $14.8 \times 13.2 \times 10.4$ cm 3480 g

This is the largest one in 500 specimens. The specimen is rounded and complete in shape. Thin, dull, black fusion crust covers the specimen nearly all over the exterior except for small broken surfaces. Several small fractures are recognized on the B and T surfaces. On the cut surface, the interior consists of fine matrix (black color) and many chondrules (dark gray to light gray in color) (Fig. 7). The largest chondrule is 5×7 mm in size.

Yamato-790460 $9.7 \times 7.1 \times 4.9$ cm 586.0 g
Yamato-790461 $8.8 \times 8.2 \times 5.1$ cm 778.9 g

These two specimens fit together along their S surfaces (Fig. 8), but these samples do not make a complete specimen. Thick, dull, black fusion crust remains on about 50% of the N surface of Y-790460. Straight flow lines in the N-S direction are recognized on the fusion crust of B surfaces of the both. Crust-free surface is a stained dark brown to brown.

Yamato-790462 $11.8 \times 11.4 \times 6.1$ cm 1371 g

The specimen is nearly half of one complete stone. The S surface is a fracture surface (Fig. 9). Two different stages of the fusion crust are recognized. The crust on the E, N, W, B and T surfaces is thick, dull and brownish black in color and shows polygonal fractures, but the crust on the S surface is very thin and has a net-like appearence. The interior is light gray in color and limonitic stains are present around the metal.

4.3. Achondrite

4.3.1. Polymict eucrites

TAKEDA and YANAI (1981) described several eucrites among the processed specimens of the Yamato-79 meteorites. The description of these eucrites in this paper is quoted from the paper by YANAI (1981b).

Yamato-790006 $3.8 \times 3.0 \times 2.2$ cm 29.426 g

Almost completely covered with black fusion crust. Similar to other Yamato polymict eucrites.

Yamato-790007 $5.6 \times 5.0 \times 2.6$ cm 80.386 g

A black shiny fusion crust cuvers this specimen. The exposed surface is dark gray and shows a very fine-grained breccia matrix containing scattered fragments of fine-grained basalt.

Yamato-790020 $7.1 \times 4.6 \times 3.4$ cm 86.275 g

Angular stone with one side preserving black shiny fusion crust. Two lithic clasts up to 1 cm in diameter with ophitic textures are seen on the broken surface.

Yamato-790113 $3.3 \times 2.6 \times 1.6$ cm 19.006 g

Angular stone with nearly complete black shiny fusion crust. A stained lithic clast 1×0.8 mm in size is found.

Yamato-790114 $2.0 \times 1.6 \times 1.4$ cm 23.920 g

Blacky small stone with remaining fusion crust scattered. Very fine-grained crushed matrix, with rock fragments up to 2 mm.

Yamato-790122 $5.7 \times 5.0 \times 3.1$ cm 109.548 g

Partly covered with fusion crust. There are large clasts consisting of black clinopyroxene and white feldspar. Many other mostly dark clasts are shown on other broken surfaces of this meteorite.

Yamato-790260 $9.2 \times 6.7 \times 5.0$ cm 433.9 g

Subrounded rectangular-shaped and almost complete stone with considerable fusion crusts covering most of the meteorite. Two sides have less fusion crust, where abundant lithic and mineral clasts can be seen. The textures of clasts range from fine-grained, variolitic to ophitic, to coarse-grained, subophitic. The largest clasts are 1.5 cm in diameter. Mineral clasts include white angular plagioclases and honey brown pyroxenes.

Yamato-790266 $7.4 \times 5.9 \times 5.0$ cm 208.0 g

Angular stone covered with thin fusion crust, partly lost. The interior is difficult to be seen. About half of this meteorite consists of fine-grained crystalline eucrite clasts, one clast shows a coarser-grained texture. Mineral fragments are not abundant. The exterior except fusion crusts shows fine pyroxene-plagioclase intergrowth. The variolitic textures shown by this meteorite are typical of the Yamato achondrites, but the abundance of clasts in this sample (and also Yamato-790260) is exceptional. Variolitic texture is rare in common eucrites from other parts of the Earth.

Yamato-790447 $1.8 \times 1.3 \times 1.0$ cm 3.033 g

This specimen is very small.

4.3.2. Diogenites

Yamato-790022 $1.4 \times 1.0 \times 0.7$ cm 1.660 g

The sample is subrounded with the fusion crust covering about 25% of the specimen.

Yamato-790111 $1.0 \times 0.8 \times 0.7$ cm 0.812 g

This is a subrounded specimen. The specimen is approximately one fourth of a complete specimen.

Yamato-790118 $2.2 \times 2.0 \times 1.7$ cm 12.257 g

The specimen is subrounded and approximately complete. Small patches of dull, black fusion crusts remain. Some shiny, black chromites are recognized.

5. Discussion and Conclusion

The processed 500 specimens in the Yamato-79 collection comprise 9 eucrites, 3 diogenites, 6 carbonaceous chondrites and many ordinary chondrites including 19 possibly unique specimens.

The newly collected carbonaceous chondrites, polymict eucrites and diogenites are similar to those of the previous collections, except for the slight variation in grain size and amount of the clasts in hand specimen. Most of the specimens were recovered in the same area of the bare ice as that in the case of the previous collections. But the possibly unique chondrites including vesicular type and compact fine-grained type are not among the previous collections. In particular, the vesicle-rich type specimen belonging to LL-group chondrite has not been found as a complete specimen except lithic fragments of LL-group chondrites (YANAI *et al.*, 1981). As the origin of the vesicles is not clear, it is difficult to suggest whether the vesicles are the products of volcanic activities or a result of intense impaction on the surface of parent bodies.

Acknowledgments

The authors thank the members of the Yamato-Belgica traverse party of the 20th Japanese Antarctic Research Expedition for their help in collecting the meteorites. The authors also thank the member of the Preliminary Examination Teams of the Japanese Committee on Antarctic Meteorites (Prof. Naoki ONUMA and Dr. Yukio IKEDA of Ibaraki University and Dr. Hiroshi TAKEDA of the University of Tokyo) and Dr. Michael B. DUKE (Chief, Planetary and Earth Sciences Division, NASA, Johnson Space Center) and Prof. Carleton B. MOORE (Director, Center for Meteorite Studies, Arizona State University) for information of the preliminary classification, and Dr. Gen SATO of Chiba University for helping in the preliminary examination.

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(Received June 19, 1981: Revised manuscript received September 1, 1981)