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THE ASUKA-87 AND ASUKA-88 COLLECTIONS OF ANTARCTIC METEORITES: SEARCH, DISCOVERIES, INITIAL PROCESSING, AND PRELIMINARY IDENTIFICATION AND CLASSIFICATION

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Abstract: Over 2400 pieces were collected by the Asuka wintering party of the 29th Japanese Antarctic Research Expedition (JARE-29, 1987–89) on the bare icefields around the Sør Rondane Mountains in Queen Maud Land, East Antarctica. The Asuka party searched almost all of the bare icefields around the mountains in the 1987–88 and 1988–89 field seasons.

About 110 pieces (Asuka-87) of meteorites were collected on the bare ice around Mt. Balchen in the eastern part of the mountains in January and February 1988. In the first reconnaissance, about 240 pieces of meteorites (also Asuka-87) were recovered from the Nansenisen Icefield in February and March 1988. The Asuka-88 meteorites, over 2100 pieces, were found during the systematic search of this icefield during November 1988 and January 1989.

The specimens were named officially the Asuka(A)-87001 to A-87352, and A-880001 to A-882124, in order of discovery. The Asuka-87 and Asuka-88 meteorite collections were filed as the National Institute of Polar Research (NIPR) meteorites with details of date of find, weight, dimensions and comments.

According to the initial processing, the Asuka-87 meteorites comprise one iron, one stony-iron, 9 achondrites, 3 carbonaceous chondrites and over 300 ordinary chondrites, the total weight being 120 kg. The largest specimen in the Asuka-87 collections is an LL-group chondrite of about 46 kg. The Asuka-88 meteorites comprise 7 irons, 5 stony-irons, over 50 achondrites, 31 carbonaceous chondrites and over 2000 ordinary chondirtes. The total weight is about 400 kg. Two specimens in the Asuka-88 collection were tentatively identified as a very coarse-grained and unbrecciated gabbroic meteorite and an olivine-fassaite-plagioclase achondrite with crystalline texture.

1. Introduction

The search for meteorites on the bare icefield around the Sør Rondane Mountains was conceived and planned at the NIPR as an extension to the exploration of the Yamato Mountains area, begun in 1978 (Fig. 1). The first exploration in the Sør Rondane Mountains area was carried out by the JARE-29 Asuka meteorites party in the 1987–88 and 1988–89 field seasons (YANAI and THE JARE-29 ASUKA PARTY, 1989). This is a report of the exploration and discoveries of the Asuka meteorites. It also contains some results of the initial processing and brief identifications of the newly

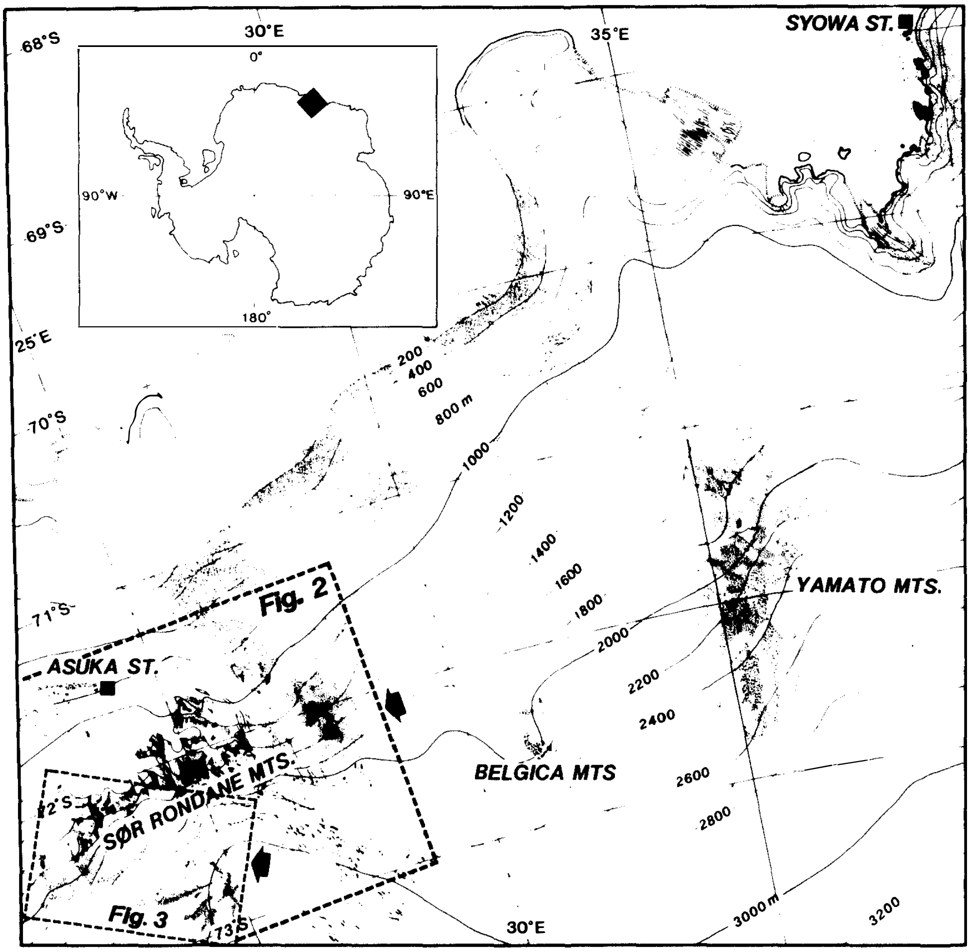

Fig. 1. Location map including the Yamato Mountains, Belgica Mountains and Sør Rondane Mountains in Queen Maud Land, East Antarctica. The locations of the Japanese Base "Syowa Station" and "Asuka Station" are noted.

collected meteorites.

The Asuka collections include Asuka-86, Asuka-87, Asuka-88 and Asuka-90 meteorites. The Asuka-86 and Asuka-87 meteorites were reported in the photographic catalog (Yanai and Kojima, 1987) and at the 16th Symposium of NIPR (Yanai, 1991a), respectively. Here we present the preliminary report on the search, discoveries and initial processing of the Asuka-87 and Asuka-88 meteorites with their brief classification. The Asuka-90 meteorites will be reported in the near future after they have been processed completely. Yanai and the JARE-29 Asuka Party (1989), Yanai (1989), Naraoka *et al.* (1990) and Yanai and Kojima (1992) published preliminary reports on the meteorite search activities on the bare icefields around the Sør Rondane Mountains, East Antarctica in the 1987–88 and 1988–89 field seasons.

The Asuka-86 meteorites are 3 ordinary chondrites, were discovered in November 1986 and January 1987 by the glaciological party of the JARE-27 (1985–87) on the bare ice near Mt. Balchen, at the eastern end of the Sør Rondane Mountains. This was the first meteorite discovery around the Sør Rondane Mountains. The JARE-27 team also found the Yamato-86 meteorites, which consist of over 800 pieces, including the

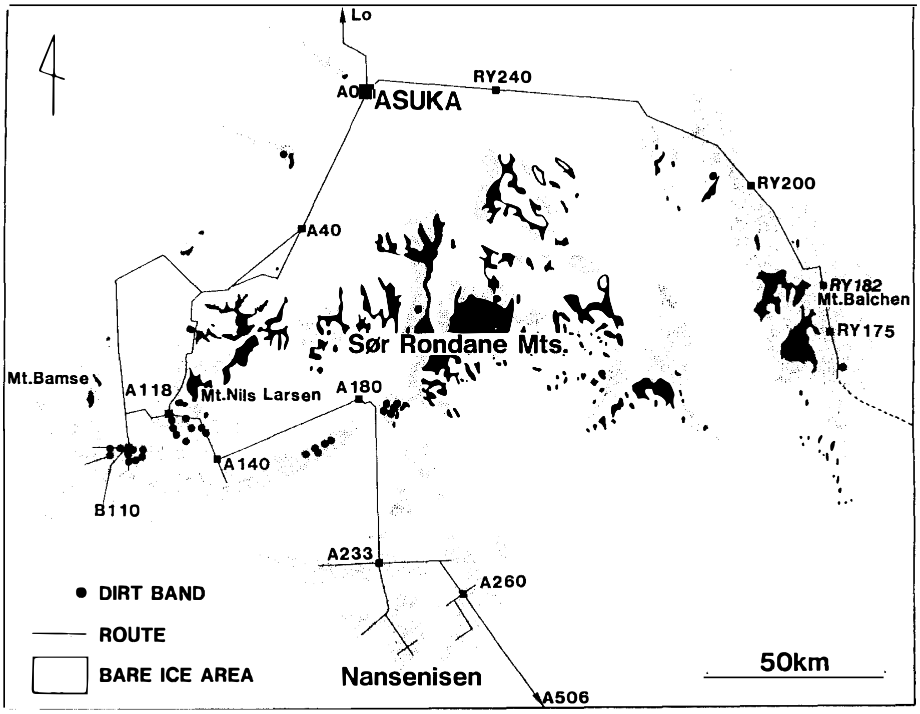

Fig. 2. Expedition routes A and B, approaching the blue icefields around the Sør Rondane Mountains of the JARE-29 Asuka meteorites party. RY is the traverse route to Asuka Station from the Yamato Mountains. See Fig. 1 for location.

second largest lunar meteorite (a highland regolith breccia). These preceded the findings of the Asuka-86 meteorites (NISHIO *et al.*, 1987).

The Asuka-87 meteorites were collected by the Asuka party of the JARE-29 (1987–89). Together with the geology and geomorphology party, this party searched for meteorites on the bare icefield around Mt. Balchen in January 1988. They collected 113 pieces of meteorite there. In February 1988 the Asuka party approached the Nansenisen Icefield for the first time for a reconnaissance search. In a short period over 200 meteorites were collected there. This reconnaissance suggested that the Nansenisen Icefield had very high potential for meteorite concentration.

After over-wintering at Asuka Station, a systematic search of the Nansenisen Icefield was carried out by the Asuka party between October 1988 and January 1989. Over 1500 specimens were recovered from the Icefield, and about 600, mostly fragments, were collected on the bare icefields near the moraines south of Mt. Bamse and Mt. Nils Larsen (Fig. 2). The Asuka-88 meteorites including both those collections, are typified by their large numbers and great variety of types.

2. General View of the Sør Rondane Mountains and the Bare Icefields

The Sør Rondane Mountains are 400 km east of the Yamato Mountains and about 200 km inland from the coast of Bried Bay (24°–25°E) (Fig. 1). The mountains extend for about 200 km E-W between 22° and 28° East longitude and form a substantial barrier to ice flowing off the Plateau. The mountains are breached by many valley-outlet glaciers.

In particular, Mt. Balchen is isolated from the main mountain mass by the Byrd Glacier. Several isolated large blue icefields and ice patches are fully 3000 km^2 in total area. They constitute one of the largest blue ice exposures on the Polar Plateau of Antarctica.

The bare icefields occur in three major regions: (1) around Mt. Balchen (at the eastern end of the mountains), (2) south of Mt. Bamse and Mt. Nils Larsen (at the west end of the mountains) and (3) the Nansenisen Icefield some 50 km south of the mountains (Fig. 2). There are also many small blue ice areas and ice patches with ponds, and much meltwater during the summer, located between Asuka Station and the mountains. Most of these are below 1500 m altitude and developed at the northwest foot of the mountains and nunataks, to leeward of the katabatic wind from the southeast. One of them, the blue ice patch to the south west of the Asuka Station, is 30 km long in a SE-NW direction. It is conspicuous that the blue ice area is larger than the nunatak itself. Although there are many small blue icefields here, they are not stable enough to preserve meteorites on their surfaces. Insolation warms the rocks and meteorites that may be on the surface, so they sink easily into the ice. It is common to see rocks at the bottom of frozen meltwater holes (cryoconite holes), but it is very difficult to find meteorites in them.

In this area, the Nansenisen Icefield is one of the large bare icefields (Fig. 3) at about 3000 m elevation. It is located 150 km south of Asuka Station. Small moraine fields with scattered rock fragments are recognized on the Icefield, but most of the bare ice is rock-free. The Nansenisen Icefield is just within a crevasse zone, and the main bare icefield in particular is bounded by giant crevasses of a few meters to almost ten meters wide. Giant crevasses are also recognized in the bare icefield itself and give it an icefall-like appearance. In the bare icefield, crevasse-free areas are very limited. The other two large bare icefields, around Mt. Balchen and Mt. Bamse–Mt. Nils Larsen,

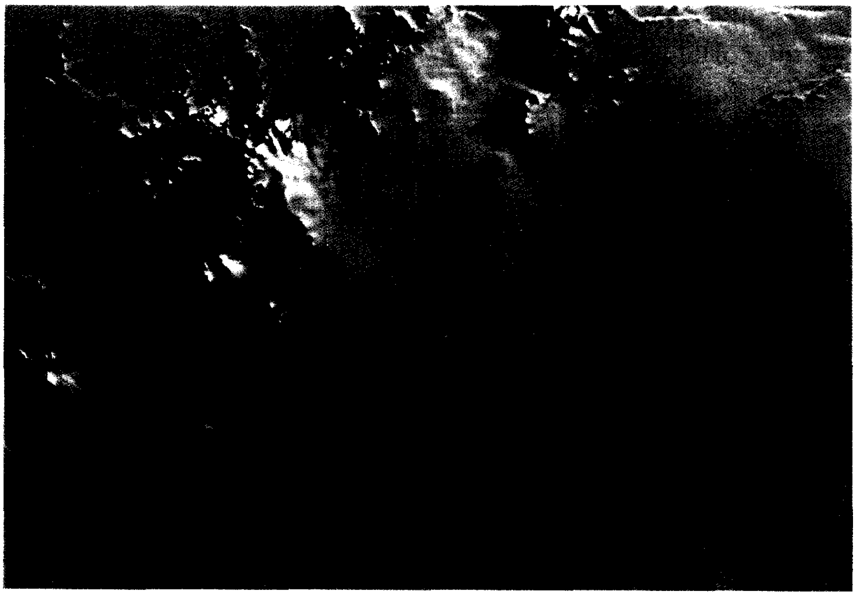

Fig. 3. Satellite photo of southern part of the Sør Rondane Mountains (from USGS). Darkest areas are bedrock, blue areas are bare icefield. See Fig. 1 for location.

are similar to the Nansenisen Icefield, except that they lie at lower levels and are accompanied by large moraines. They are also in a crevasse zone. It seems that those bare ice areas are in fast moving ice streams.

3. The Profile through the Sør Rondane Mountains

NISHIO and URATSUKA (1991) reported a cross section from the Antarctic coast to the Polar Plateau through the Asuka Station, the central Sør Rondane Mountains and the Nansenisen Icefield (Fig. 4). The report gave the results of radio-echo-sounding measuring techniques. The surface elevation gradually increases toward the Sør Rondane Mountains from Bried Bay through Asuka Station. The ice sheet surface is at only 900 m elevation at the new Japanese remote base, Asuka Station, and near 1500 m at the northern foot of the mountains. On the southern side the ice sheet elevation is variable but everywhere more than 2500 m, which is caused by the damming effect of the raised bedrock. The bedrock elevation on the polar plateau is above 1000 m, and the surface elevation on the Plateau side rises continuously and gradually upward to 3000 m at the Nansenisen major icefield. Figure 4 shows clearly the existence of underlying mountains on the plateau side, and the rise in profile corresponds to the appearance of the bare icefield.

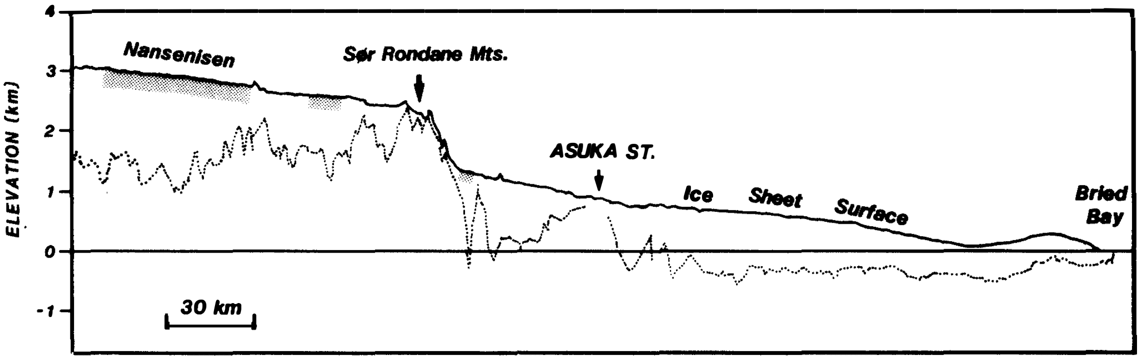

Fig. 4. Ice sheet surface with blue icefield and bedrock elevation from Bried Bay on the coast to the Nansenisen Icefield through the Asuka Station and the central part of the Sør Rondane Mountains in Queen Maud Land, East Antarctica (After NISHIO and URATSUKA, 1991).

4. Search and Recovery of the Asuka Meteorites

The Asuka party consisted of 10 members of the JARE-29. They had planned a systematic search for Antarctic meteorites around the Sør Rondane Mountains during field seasons 1987–88 and 1988–89. During these field seasons the Asuka party carried out five meteorite searchs, as follows:

The first exploration: In January and February 1988, a party of three members, together with a geology and geomorphology party, started searching for meteorites on the bare icefield around Mt. Balchen, at the eastern end of the Sør Rondane Mountains. This party collected over 100 pieces of meteorites. The specimens are mostly fragments with or without fusion crust, but may include the largest stone, 19 kg, an almost

Fig. 5. Field view of an L-group chondrite (A-87034) in the Mt. Balchen area. This view is typical of the Antarctic meteorites. This specimen, field number Y88012005, being at 19 kg, is the largest encountered in this area.

completely fusion-crusted L-group chondrite (Fig. 5). Most of the meteorites were distributed around the locations RY175-RY182 (flag numbers) on the traverse route (Fig. 2), at elevations higher than 1500 m, but a few tiny fragments were found on the bare ice below 1500 m altitude.

Most of the meteorites collected in the Mt. Balchen area are highly weathered, covered by brown limonitic stains, and fragmented into tiny pieces. They might have been exposed on the bare ice surface for a long time, compared with other meteorites in the Asuka region.

The second exploration: In the middle of February 1988, five members of the Asuka party attempted an approach to the Nansenisen Icefield, which was expected to have a potential for meteorite concentration. The party had to overcome extremely adverse natural conditions; especially many large crevasses which often stopped their advance on the route to this icefield. They succeeded only with great difficulty in arriving at the northern edge of the Nansenisen Icefield by the end of the month. As outlined above, not only the route to this icefield but also the bare ice surface itself is very dangerous because of the numerous very large crevasses that must be crossed or detoured around. This first reconnaissance, however, which lasted for one week, was very successful and confirmed our expectation that many meteorites would be found there. The party collected about 230 meteorites and meteorite fragments, including a larger LL-chondrite (Fig. 6) and a eucrite (Fig. 7). Additionally the collection includes an iron, a ureilite, eucrites (crystalline and brecciated types), diogenites, carbonaceous chondrites and ordinary chondrites. Among the ordinary chondrites are a number of less equilibrated specimens.

Meteorites collected from the Nansenisen Icefield, are less weathered larger and more complete than those from the Mt. Balchen area.

The third exploration: The Asuka party of five members tried again to search for meteorites on the bare icefield around Mt. Balchen at the end of March 1988. Unfortunately, there was no well exposed blue ice area during that part of the summer season. No meteorite was collected at that time.

Fig. 6. Field view of LL-group chondrite (A-87251) collected in the Nansenisen Icefield. It is the largest specimen in the Asuka collections, almost 46 kg in weight.

Fig. 7. Field view of an eucrite (A-87272) on the Nansenisen Icefield. It is a 5 kg, almost completely crusted, angular stone.

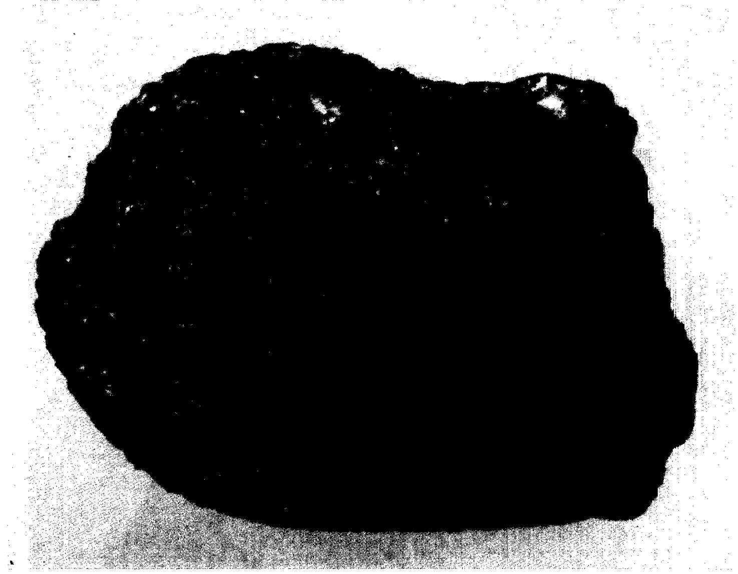

Fig. 8. Field view of a very coarse-grained gabbroic meteorite, one of the most extremely rare specimens in the Asuka collections, originated from a lunar mare region.

The meteorites collected by the above three explorations during January–February, February–March and March–April 1988 were named Asuka-87.

The fourth exploration: After over-wintering, the search for meteorites was resumed. In mid-October the Asuka party of six members searched the bare icefield south of Mt. Bamse and Mt. Nils Larsen, but there was no meteorite concentration. Along the traverse route near A118 (Fig. 2), heavily weathered fragments were collected individually and as groups, sometimes consisting of more than ten. Over five hundred deeply-weathered fragments with several large stones were collected in the moraines near A118. These are quite different from the local terrestrial rocks and similar to weathered limonitic brown-colored chondrites. In the preliminary processing, some of them proved to be meteorites, but others may be terrestrial rocks.

A large area of bare ice lies to the south of A140–A180. It is 50 km long E-W and 5 km wide (Fig. 2). This bare ice looked like a promising meteorite field, but no meteorites or terrestrial rocks were found there, except for faint dust bands that originated from volcanics.

The fifth exploration: At the end of the field season, the most systematic and final attempt to search for meteorites was made by an Asuka party of ten members. The search was begun on the Nansenisen Icefield in mid-November 1988 and continued until the party had a major accident, falling into a large hidden crevasse in mid-January 1989.

In spite of this misfortune, which caused the group to divert its attention to the evacuation of some injured personnel, the total number collected by the party during one and a half month exceeded 1500 pieces. The meteorite collection contains irons, stony-irons, achondrites, carbonaceous chondrites and ordinary chondrites, and includes possible unique types such as a very coarse-grained gabbro (Fig. 8), and an iron with typical Widmannstätten pattern on its weathered surface (Fig. 9). A number of large and complete by fusion-crusted meteorites were collected on the upstream side of the Nansenisen Icefield at the extreme altitude of 3000 m. In contrast, mostly small fragments and moderately weathered pieces were found at lower elevation, downstream

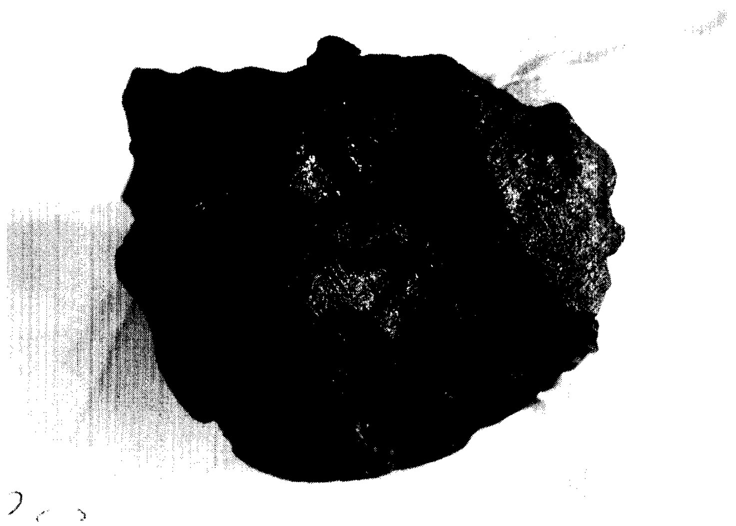

Fig. 9. Field view of iron meteorite (A-881164, 6.2 kg) with typical Widmannstätten pattern as relief on the abrated surface.

and further north of the bare icefield.

5. Asuka Meteorites and Their Special Occurrences

Most of the 2500 pieces of Asuka meteorites were discovered on the bare ice of the Nansenisen Icefield near 3000 m altitude, but about 110 pieces are from the bare ice around Mt. Balchen, above 2000 m altitude. Only a few fragments were recovered from the bare ice near the Mt. Bamse–Mt. Nils Larsen area, almost 1500 m up. But no meteorite was found on any bare ice area under about 1500 m elevation at the north foot of the Sør Rondane Mountains. This suggests that there is little possibility of finding meteorites on any bare icefields under about 1500 m, unless they were blow there by strong winds.

The Asuka meteorites are of major importance because they include various types of irons, stony-irons, achondrites, chondrites and carbonaceous chondrites and they include unique and/or unusual types such as gabbro, fassaite basalt and others. The discoveries of gabbro, and other unique and/or unusual types of meteorite suggest that there is a great possibility of the existence of more, as yet unknown, types of meteorite. Antarctica is particularly important as a source of new types of meteorite.

A conspicuous feature of the occurrence of meteorites at the Nansenisen Icefield is that specimens from the plateau side (upstream) are mostly complete, fusion-crusted, large, fresh individals with few fragments. On the other hand, the meteorites from downstream (near the mountain side) are dominantly fragmental, ablated and moderately weathered pieces, and they are smaller than those from upstream.

Both sets of meteorites collected in the Mt. Balchen and Mt. Bamse–Mt. Nils Larson areas had mostly been broken into small fragments by a strong weathering effect. It seems that these meteorites had been exposed on the bare ice surface for a long time compared with those on the Nansenisen Icefield.

6. Asuka Meteorites: Initial Processing and Brief Identification

All meteorites are put in clean teflon and/or polyethylene bags in the field. The Asuka-87 and Asuka-88 collections were kept frozen (below $-20°C$) and shipped from Antarctica to Japan. Then the collections were put in the refrigerator (under $-20°C$) at the NIPR. The initial processing was started after 1989, using the meteorite processing facilities of the NIPR. The meteorites were first returned to room temperature in a dry nitrogen-filled cabinet. The authors placed each meteorite on a clean flow bench and labelled it as A-87001 to A-87XXX and A-880001 to A-88XXXX, in order of the time when found. The meteorite was weighed, its three dimensions measured and described with brief classification. This initial processing occupied by the authors took two years and a half.

All the Asuka meteorites were processed following the procedure for all Antarctic meteorites in the NIPR. However the photographing of the six-directions is not yet complete, two more years being required. All the Asuka meteorites have been listed in the meteorite catalogs and stored at the NIPR as source materials for further research, detailed identification and classification after the initial processing.

Table 1. The Asuka meteorite collections.

Name (year)	Asuka-86 (1986/87)	Asuka-87 (1988)	Asuka-88 (1988/89)
Total	3	352	2124
The largest (kg)	1.5 (L)	46 (LL)	43 (H)
Irons	—	1	7
Stony-Irons	—	1	5
Achondrites	—	9	53
Carbonaceous chondrites	—	3	31
Ordinary chondrites	3	338 (Ordinary chondrites and Doubtful combined)	2028 (Ordinary chondrites and Doubtful combined)
Doubtful	—		
Total weight	2.2 kg	120.1 kg	394.0 kg

Together with the Asuka-86 collection, the Asuka-87 and Asuka-88 meteorites processed initially and classified briefly are shown in Table 1 with numbers, total weights and brief meteorite types. The Asuka-87 collection consists of one iron, one stony-iron (mesosiderite), 9 achondrites including a ureilite, diogenites, howardite-eucrites and eucrites of breccia/crystalline types (YANAI, 1991c), 3 carbonaceous chondrites and over 300 ordinary chondritic specimens, including a number of low petrologic types. This collection also includes doubtful pieces which appear black and dark brown in color, like deeply weathered H chondrites. However, there is no distinct fusion crust on their surfaces. The total number of the Asuka-87 collection is 352 meteorites and/or meteorite fragments, weighing 120 kg in total. The largest, an LL-group chondrite (Fig. 6) weighs 46 kg and there is a 5.7 kg crystalline eucrite that is covered completely with shiny-black fusion crust (Fig. 7).

The Asuka-88 collection consists of 7 irons, 5 stony irons (both pallasites and mesosiderites), over 50 achondrites including extremely rare and unusual types such as a coarse-grained and unbrecciated gabbroic meteorite (Fig. 8) (YANAI, 1990, 1991d), olivine-fassaite basalt (YANAI, 1991b) and with various types of eucrites (YANAI, 1991c), about 30 carbonaceous meteorites including CM, CO, CV and CI(?) and over 2000 chondritic specimens. The Asuka-88 collection numbers 2124 meteorites and/or meteorite fragments including deeply weathered or doubtful specimens. Total weight of this collection is almost 400 kg. The average mass is 200 g; this is twice as great as the average Yamato meteorite (YANAI and KOJIMA, 1987).

Acknowledgments

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