Curation of Antarctic meteorites at the National Institute of Polar Research.

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Introduction

Since the discovery of meteorite concentration on the bare ice fields near the Yamato Mountains by the Japanese Antarctic Meteorite Expedition (JARE-10) [1], the number of Antarctic meteorites collected has increased dramatically. Now, about 70% approved meteorites of the world are from Antarctica. The National Institute of Polar Research (NIPR) has one of the largest meteorite collections in the world (number is about 17,000, including unapproved meteorites). Since meteorites are derived from over hundreds of asteroids (and comets?), and Earth' moon and Mars, they provide the ground truth of remote-sensing missions. Along with the sample recovered by planetary and asteroid missions, research of NIPR meteorite collection will help to understand the origin and early history of solar system and terrestrial planets. Here, we present the initial processing, classification, curation and allocation at NIPR in the last few years.

Curatorial facility

The curatorial facility consists for four parts; meteorite processing and storage rooms (Fig. 1), an EPMA and thin section preparation laboratories. The meteorite storage room is a class 10,000 clean room, and is kept temperatures at 24 °C and humidity of <50 %. The meteorite processing room is kept at a positive pressure and has one clean bench and three diamond wire saws to cut meteorites. The EPMA is JEOL JXA 8800 equipped with five spectrometers.

At present, there are four full-time staffs, one visiting professor, one post-doctoral researcher and two curators. Initial classification is made by H. Kojima (the head of Antarctic meteorite research center), the two curators, N. Imae and A. Yamaguchi, M. Kimura (a visiting professor), and S. Ozawa (a pos-doc). There are four technical assistants who help preparation of polished thin sections (PTSs) (H. Sasaki), EPMA analysis (M. Naito), sample separation (S. Ikadai and T. Tomimura), and data processing (T. Takami).

Initial processing of Antarctic meteorites

Meteorites recovered from Antarctica are carefully processed to avoid potential contaminations, and allocated for scientific research. Meteorites found on ice sheet are packed in plastic bags with field numbers (usually consisting of initial of finders, date, and sequential number). Images and geographical positions from GPS are recorded at the same time. The recovered meteorites are shipped frozen, and stored at a refrigerator (<-20 °C) at NIPR. The frozen meteorites are thawed at room temperatures (~22-24 °C) under dry conditions to avoid precipitation of water. Before 2008, meteorites were thawed in a chamber filled with dry nitrogen. From the meteorites collected in the 2009-2010 season (Asuka 10 meteorites), we started using a new procedure. Meteorites are put into low-pressure box, evacuated using a dry vacuum pump for ~10 hours, and subsequently purged with dry nitrogen, and kept for one days. This procedure removes ice on meteorites without melting, minimizing the damages of the samples. After being thawed, meteorites are stored in Teflon bags, father packed in plastic bags, and stored in the meteorite storage room. The meteorites are renamed from the field numbers to formal names (e.g., Asuka XXX).

Figure 1. Meteorite storage room for Antarctic meteorites. This room is a class 10,000 clean room.

Before sample separation, high-resolution photographs are taken from at least five sides of all meteorites. The measurement of sizes and weights, and macroscopic observations are made. The macroscopic descriptions include the degrees of fragmentation, shapes, the presence or absence of fusion crust, evaporates etc. Samples that seem to be of terrestrial origin are removed and used for geological studies of the area the meteorites are sampled.

Chips of meteorites (typically <1-2 grams) are separated using diamond wire saws and chisels made of stainless steel using without fluids. Separated chips are mounted in epoxy resin for thin sections. Thin sections are mounted on slide glasses (2.5 cm in diameter) made of fused silica. In most cases, fluid during PTS preparation is water, but for some carbonaceous and enstatite chondrites which contain phases susceptible to water, cutting oil is used during entire procedures except secondary cutting of potted butts mounted on slide glasses. The surface of PTS is finished with diamond paste ~1/4 µm. A thin section is prepared for every meteorite. ~600-700 new sections are prepared each year.

All PTSs are examined with an EPMA and optical microscope. About 30-50 points (which depends on the sizes of PTSs and types of meteorites) selected randomly are analyzed. Compositions of olivine and orthopyroxene (plagioclase and FeNi metals in some cases) are determined.

Classification of meteorites

Meteorites are classified using a petrographic microscope equipped with both transmitted and reflected lights. Basic classification is made using both EPMA data (i.e., Fa in olivine) and petrographic observation. Some important meteorites may send for additional analyses (e.g., INAA, oxygen isotopic analysis). Classification of meteorites is made on the basic criteria [e.g., 2]. Chemical types of ordinary and E, R chondrites are determined by Fa in olivine and Fs in pyroxene. Chemical types of type 3 OC are determined by the ratios between FeNi metals and FeS [3]. Petrologic types for OC, R, and E chondrites are determined petrographically. Classification between EL and EH are difficult optically. In some case, we measure Si contents in FeNi metals [e.g., 4].

Degrees of weathering are classified into three stages (A, B, and C) on the basis of the textures of FeNi metals more than a few mm away from the surface of meteorites in PTSs. The index, "A" indicates that limonite haloes on metal particles and limonite veins are minor, "B", 7.5 to 35% of metal particles are weathered to limonite, and "C", most metal particles are weathered to limonite.. Note that veins of weathering products along fractures are not considered for the classification.

For our initial classification, only prominent secondary features are documented. Such textures include shock melt veins, shock darkening, occurrences of maskelynite and ringwoodite etc. Impact melted ordinary chondrites (and some HED meteorites) are classified into two types; melt rocks (impact melt rocks without fragments and clasts) and melt breccias (impact melt rocks with fragments and clasts).

The paring issue is in many cases problematic. In general, we call certain groups of meteorites pair if these rocks share clear petrographic characteristics (e.g., "type A" and “type B” diogenites). Broken meteorites (not covered by fusion crust entirely) sampled from the proximate areas may be called "field paring". However, all of the meteorites with "filed pairing" are not always classified into the same groups. Further studies such as detailed petrologic studies and determination of terrestrial ages are needed.

All meteorite data are stored in the database (*Filemaker 11* basis) developed by *SYSTEM IN FRONTIER Inc.* (Y. Katagiri).

Sample allocation

Classifications of meteorites are presented as *Meteorite Newsletter* routinely issued from NIPR [e.g., 5]. Also, the data are submitted to Nomenclature committee of the Meteoritical society, and are appeared in *Meteorite Bulletins* issued from the Meteorite Society.

All samples are available for scientific research via submission of research proposals including purposes, techniques, and the amounts and types of the samples required. Also, some meteorites (in the form of chips, PTSs, photographs etc.) are available for education and public outreach. Most meteorites can be allocated by the decisions of the curators. However, research proposals for rare meteorites and meteorites with small main masses (typically <10-20 grams) as well as applications of new techniques may be reviewed externally. Consortium studies may be organized for rare and interesting meteorites by the curators or researchers outside NIPR.

Ongoing and future works

Currently, JARE-54 is planning to conduct a meteorite joint expedition with BELARE 2012-2013 (SAMBA; Search for Antarctic Meteorites, Belgian Approach) in the Nansen Ice fields (south of the Sør Rondane Mountains) [6] followed by the two joint expeditions (in 2008-2009 and 2009-2010). The meteorite collected by the joint expeditions will be processed jointly, and allocated for scientific researches. In the future, we are planning to visit other areas including Yamato Mountains.

There are several ongoing projects for further systematic classifications. For subclassification of type 3 chondrites, properties of cathodoluminesence and petrographic observations are being used [7]. Bulk chemical analysis (major elements) using prompt gamma ray analysis (PGA) will replace conventional wet chemical analyses [e.g., 8]. Instrumental neutron activation analysis will be used for classification of iron meteorites. These bulk chemical analysis is performed in collaboration with M. Ebihara and N. Shirai (Tokyo Metropolitan University

References:

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