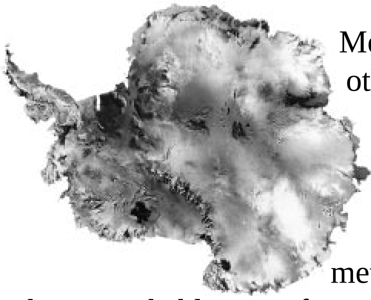
Exploring the Solar System with

Meteorites from Antarctica



Meteorites are rocks from space that have fallen on Earth. They are fragments of other bodies in the solar system: asteroids, comets, the Moon, and planets. These ancient rocks give us clues to the origin and history of the solar system. Meteorites are sometimes called the "poor man's space probe" because they arrived on Earth free of charge.

Antarctica is a very special place to collect meteorites. As many meteorites have been recovered in Antarctica as in the rest of the world combined. This remarkable rate of meteorite discovery is due to special conditions in Antarctica. Meteorites which have fallen on Antarctic ice are preserved for long periods of time. The meteorites are moved along by glacial ice which concentrates the meteorites where the ice comes up against a rock barrier and gradually erodes away. Dark meteorites, even small ones, are also easy to find on the ice.

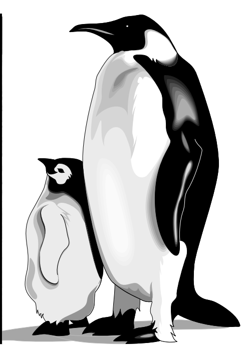
The first Antarctic meteorites were found in the coastal mountains of Queen Maud Land by Japanese scientists in 1969. Europeans have participated in U.S. expeditions and collected several hundreds of meteorites on European expeditions to Victoria Land. The U.S. meteorite collection program began in 1976 at Allan Hills near McMurdo base. Since then about 8000 meteorite fragments have been collected during yearly expeditions along the Transantarctic mountains.

A member of the U.S. meteorite collection team is standing outside an ice cave in Antarctica.

Collecting Meteorites

The U.S. Antarctic meteorite program is a joint project of the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the Smithsonian Institution. NSF runs the collection program in Antarctica, while NASA and the Smithsonian curate the recovered meteorites by classifying, distributing and storing them.

Collecting meteorites in Antarctica is a hazardous and physically difficult job that requires teamwork. Survival is the major part of the job, just as it is for astronauts in space. The environment is extremely dangerous to the human body, with high winds and temperatures well below freezing. Many layers of clothing offer some protection while working outside. Storms can cause complete whiteouts that are



Left: *Polar tents offer the only protection from this Antarctic storm.* ***Above:*** *One of the largest meteorites collected in Antarctica, 250 lb. LEW85320.*

disorientating and make it impossible to go anywhere outside. Furthermore, the glaciers have numerous crevasses which can cause a person to fall to his/her death.

Teams of four to eight scientists work together collecting meteorites in remote field locations for about six weeks during the southern summer (Nov-Jan). The team leader and ice expert plan the expedition and are responsible for safety. Transportation to field sites is by helicopter or cargo airplane. On the ground the team travels by snowmobiles and lives in special polar tents. Teams use the buddy system for safety and are never alone. Cooking and heating are done with gas stoves; food is frozen, canned or freeze-dried; water is made by melting ice. Imagine not having to (or being able to) take a shower for over a month!

Scientists documenting a meteorite as they collect it.

A numbering device is used to document the sample.

Collecting meteorites is the fun part of the job. In some areas they are the only rocks around and are easy to see on the ice. In other areas, especially glacial moraines, there are many Earth rocks and scientists must know how to recognize various types of meteorites. Sometimes meteorites are found while driving around on snowmobiles; other times they are identified while walking or crawling on a rock-covered icefield. Each time a meteorite is collected, the scientists document it by assigning it a number, photographing it, and recording its geographic location and package it in clean bags.

Meteorite Curation

After collection, the meteorites are shipped frozen to the Antarctic Meteorite Processing Laboratory at NASA Johnson Space Center. It is a special clean lab similar to that which houses the Apollo Moon rocks. The meteorites are thawed in stainless steel glove cabinets containing nitrogen gas. This drives off all the water and ice that could otherwise rust the metal in the meteorites. The cabinets also keep the samples clean from many types of possible contaminants, therefore most samples are stored in these cabinets.

The clean lab at NASA Johnson Space Center is where meteorites are curated.

Curation of meteorites involves storing, describing, classifying, and announcing new meteorites for study, and later splitting them for distribution to investigators around the world. Most meteorites are described and split into smaller chips on flow benches using clean tools.

There are many different varieties of meteorites, but the major classifications are stony, iron, and stony-iron meteorites. Stony meteorites are made mostly of the same silicate minerals as are found in Earth rocks. Iron meteorites are made mostly of iron-nickel metal. Stony-irons are part of each. Stony meteorites are the most common meteorites and are divided into chondrites, which contain round silicate blobs called chondrules, and achondrites which do not. There are numerous subdivisions of each type of meteorite.

Meteorites are described and split on a flow bench in the clean lab.

Meteorite Research

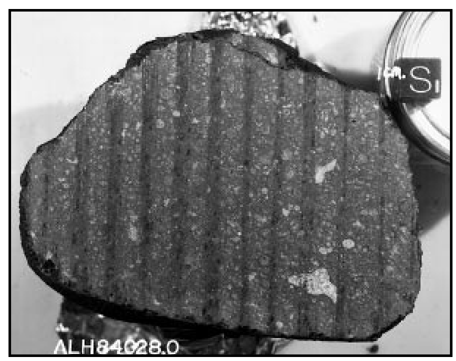
Stories the Meteorites Tell . . .

Research scientists study meteorites to learn the history of the solar system. They use various scientific techniques to study each of the different types of meteorites. They have learned that meteorites are very ancient rocks that come from many different bodies in the solar system.

Scientist is examining a sample under the microscope in meteorite lab.

Chondrites, stony meteorites which contain round chondrules, are by far the most common types of meteorites. They have primitive compositions that are similar to that of the Sun without the gaseous elements. Most of them are ordinary chondrites, but a few are carbonaceous chondrites which contain carbon and water in addition to the rocky minerals, and these are the most primitive.

Scientists use optical microscopes and electron microscopes and microprobes to study meteorites. They look at the types and compositions of minerals and their textural relationships. They have found that some minerals in carbonaceous chondrites were the first minerals to crystallize during the formation of the solar system and that chondrules are the building blocks of the planets.



Carbonaceous chondrite Allan Hills 84028.

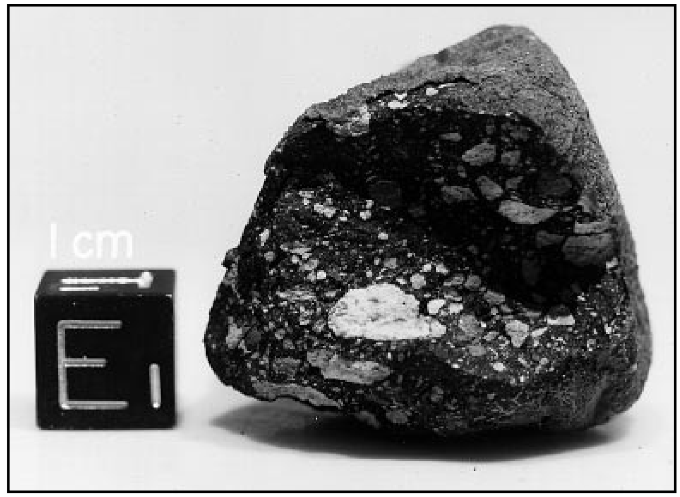
Scientists have concluded that chondrites and most other stony, stony-iron, and iron meteorites come from asteroids. There are two major reasons for this conclusion, astronomical and geological. Astronomers measured the orbits of several falling meteorites and found that they reach out to the asteroid belt between Mars and Jupiter. Geologists and geochemists measured the ages of many meteorites and found them to be as old as the solar system (4.5 billion years), and unlikely to be from younger, more geologically active planets and moons.

Scientist using a scanning electron microscope to study the mineralogy of a meteorite.

Meteorites from the Moon

Some achondrites are very distinct from other meteorites in their mineralogy and composition. They are made up mostly of the white mineral feldspar, in broken, melted and mixed form. These meteorites look very similar to rocks collected in the lunar highlands by the Apollo astronauts.

Scientists studied the mineralogy and bulk rock composition of these unusual achondrites and found them to be almost identical to those of some Apollo moon rocks. They are also distinctly younger than other meteorites (less than 4 billion years) and similar in age to lunar highland rocks. There are also basaltic meteorites from the dark-colored lunar mare.

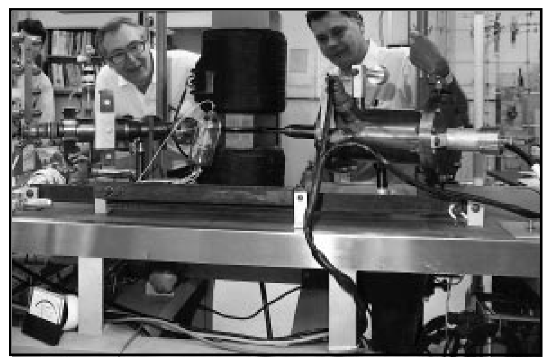


The first lunar meteorite, Allan Hills 81005.

These similarities with Apollo moon rocks and differences from other achondrites make this group of lunar meteorites the only group of meteorites for which scientists are certain of their parent body. They were presumably blasted off the Moon by several meteorite impacts and eventually landed on Earth. There are 11 distinct meteorites (15 separate collected fragments) which are from sites in the highlands and mare regions of the Moon. Studies of these random lunar samples supplement the information obtained from the nine regions of the Moon sampled by the American Apollo and Russian Luna missions.

Meteorites from Mars

Some achondrites are basalts and related igneous rocks similar in mineralogy and bulk composition to other achondrites, but much younger (less than 1.3 billion years) than other meteorites.



Scientists using mass spectrometry to measure the isotopic composition of a meteorite.

Scientists use mass spectrometry to measure the age and isotopic composition of meteorites and other rocks. When scientists measured young ages for several of these meteorites they argued that it made more sense if the meteorites came from a large body like a planet rather than a small one like an asteroid. The clincher was measurement of the noble gas isotopic composition of gases in dark glass in EETA79001. They were the same composition as those measured in the Mars atmosphere by the Viking lander spacecraft, and distinct from gases on Earth and in other meteorites.

An origin on Mars is thus very likely, and indeed widely believed, for this group of 12 igneous achondrite meteorites. However, this martian origin is not as certain as the Moon origin for lunar meteorites because we don't have documented martian rocks for comparison. These probable martian meteorites give us valuable information about the surface of Mars to supplement remote sensing photos and data, and are useful in planning science experiments for space probes to Mars.

Meteorites, from chondrites, through achondrites, irons, and stony irons, to lunar and martian meteorites, are indeed valuable assests in exploring the origin and history of the solar system.

EETA79001, martian meteorite having trapped martian atmosphere.

For more information write to: Antarctic Meteorites, Mail code SN2, NASA Johnson Space Center, Houston, TX 77058
http://www-curator.jsc.nasa.gov/curator/antmet/antmet.htm