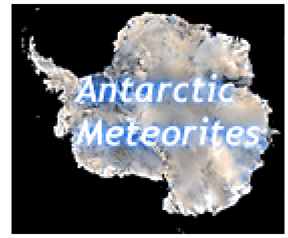
Features

posted November 7, 2001

Meteorites on Ice



--- Antarctic meteorites provide a continuous and readily available supply of extraterrestrial materials, stimulating new research and ideas in cosmochemistry, planetary geology, astronomy, and astrobiology.

Written by Linda M.V. Martel
Hawai'i Institute of Geophysics and Planetology

Annual collections of meteorites from Antarctica are a steady source of new non-microscopic extraterrestrial material including lunar and Martian samples and rare and unusual flotsam from asteroids. This article summarizes research on new kinds of Antarctic meteorites that is not simply changing how meteorites are classified but causing a revolution in our knowledge of the materials and processes in the solar nebula, our solar system, and the formation of asteroids, planets, and ultimately our world. When the 2001-2002 Antarctic Search for Meteorites (ANSMET) field party begins scouting for meteorites on the ice this season, we will be continuing a 25-year tradition of exploration along the Transantarctic Mountains. As a new ANSMET meteorite hunter, I will report to PSRD on this season's search and recovery of specimens and how studies of Antarctic meteorites are unraveling the secrets of solar system formation.

Reference:

U. S. Antarctic Search for Meteorites program.

Finding Rocks That Fall From Outer Space


Ben Bussey, ANSMET '00-'01

The U. S. Antarctic Search for Meteorites (ANSMET) program is a collaborative effort of the National Science Foundation (NSF), NASA, and the Smithsonian Institution. Field collection is supported currently by a grant from the NSF Office of Polar Programs to Principal Investigator Dr. Ralph Harvey at Case Western Reserve University in Cleveland, Ohio. NASA and the Smithsonian Institution provide for the classification, curation, and distribution of Antarctic meteorites. All three agencies sponsor research on the specimens which remain the property of the National Science Foundation. The Meteorite Working Group (MWG) reviews requests for samples by scientists of all countries. The MWG is a peer-review committee that meets twice a year to guide the collection, curation, allocation, and distribution of the U. S. collection of Antarctic meteorites.

The National Institute for Polar Research (NIPR) in Tokyo manages their own expeditions to Antarctica and oversees the curation, allocation, and distribution of Japanese collections of Antarctic meteorites. The Committee on Antarctic Meteorites, which also meets approximately twice a year, reviews all requests for meteorite samples. The samples are the property of the NIPR, and allocations are generally only made for a period of 1 to 2 years.

European expeditions and collection programs in Antarctica include the Italian (PNRA) and German GANOVEX programs. European specimens currently curated at the Open University, UK are available for study and can be requested through the Department of Mineralogy of the Natural History Museum in London.

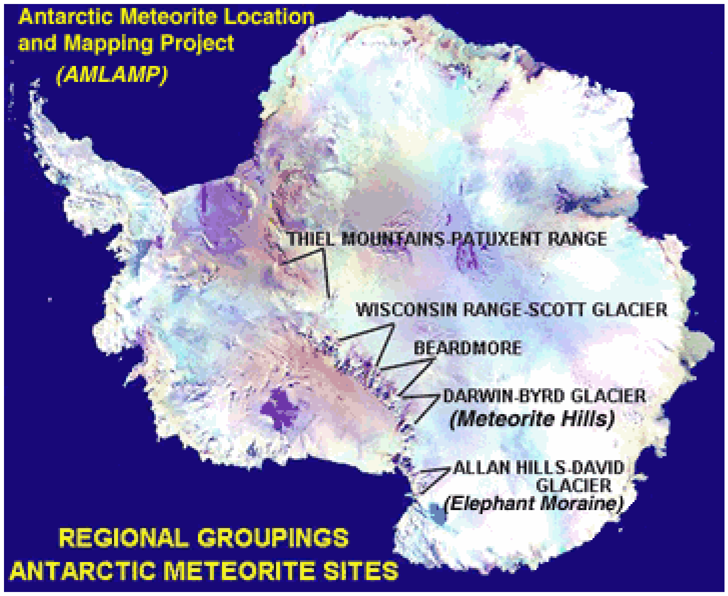
These international collection programs require nothing less than strategic trips to the ice by sturdy, trained individuals working together in a well-coordinated way to survive and succeed in this extraordinary environment. What motivates us to venture to a place that was only a hypothesized landmass until it was actually sighted in 1820-21? The thrill of living in an extreme, remote environment (likened by some to a space outpost) with a rich history of heroic exploration, for the golden chance of finding pieces of rock from space that tell stories of creation. From the beginning, the Antarctic collection programs have aimed to recover large enough numbers of meteorites each season so that something unusual might be served up, possibly one day a sedimentary rock from Mars showing evidence of the planet's watery history.

Tents at Meteorite Hills during the 2000-2001 ANSMET field season. This photo was taken from the helicopter while two of the planetary geologists, Ben Bussey and Ralph Harvey, began a six-day reconnaissance trip to ice fields near Bates Nunatak.

Meteorites Found on the Blue Ice

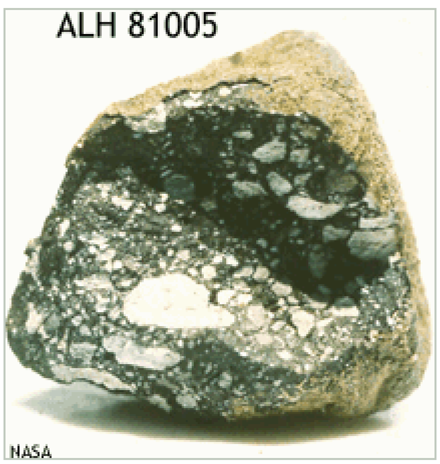
Since 1976, ANSMET has recovered more than 10,000 specimens from meteorite stranding surfaces along the Transantarctic mountains. The total number of Antarctic meteorites is closer to 25,000 when you include Japanese collections (beginning in 1969) and European collections. This large number is uncorrected for pairing--when laboratory examinations show that two or more specimens are actually broken pieces of the same rock. Antarctica (the highest, driest, coldest, windiest, and emptiest place on Earth) has proven to be an exceptionally good hunting ground because meteorites that have been falling on the surface through the millennia become buried in the ice moving slowly seaward. Where mountains or subsurface obstructions block the forward movement of the ice, the old deep ice, laden with meteorites, is pushed up to the surface against the barrier. Strong katabatic winds (winds blowing down the slopes) clear the surface of loose ice and snow and aid sublimation and mechanical erosion which expose the meteorites on the blue ice. These concentrations of meteorites, called stranding surfaces, are not permanent but appear and disappear as the ice cap changes.

The Antarctic Meteorite Location and Mapping Project (AMLAMP) maintains databases of meteorite locations for each ice field searched by ANSMET; see the map below. The **Allan Hills-David Glacier Region** includes samples from Allan Hills, Beckett Nunatak, David Glacier Icefields, Elephant Moraine, MacKay Glacier Icefields, Outpost Nunataks, and Reckling Moraine. The **Darwin-Byrd Glacier Region** includes Bates Nunatak, Derrick Peak, Lonewolf Nunataks, and Meteorite Hills. The **Beardmore Region** includes Bowden Neve, Dominion Range, Geologists Range, Grosvenor Mountains, Lewis Cliff, MacAlpine Hills, Miller Range, and Queen Alexandra Range. The **Wisconsin Range-Scott Glacier Region** includes Gardner Ridge, Graves Nunataks, Klein Glacier, Mt. Howe, Mt. Prestrud, Scott Glacier Icefield, Wisconsin Range, and Mt Wisting. The **Thiel Mountains-Patuxent Region** includes Lapaz Icefield, Patuxent Range, Pecora Escarpment, Stewart Hills, and Thiel Mountains.



A complete set of maps, meteorite listings, and explanations are available from AMLAMP.

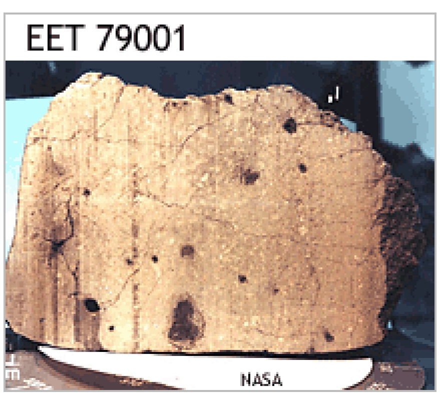
Samples are identified by location (using a three-letter abbreviation), year of collection, and unique sample number. For example, the Allan Hills location is abbreviated as ALH, Elephant Moraine is EET, Queen Alexandra Range is QUE, and Meteorite Hills is MET. Meteorite ALH 81005 was recovered in Allan Hills during the 1981-1982 ANSMET field season and was the fifth rock analyzed in the lab. It was a significant find because it turned out to be a piece of the Moon. The next paragraphs summarize some of the extraordinary discoveries enabled by ANSMET.



A Suite from the Moon

Scientists have identified 21 meteorites from the Moon. About half are from Antarctica and half from hot desert regions. They recognized the first one, ALH 81005, in 1982 on the basis of chemical, mineralogical, and isotopic compositions. These rocks provide lunar scientists with samples from places far from the U. S. Apollo and Russian Luna landing sites, allowing a much better understanding of the composition of the lunar crust. More importantly, the mere fact that impacts could blast rocks off the Moon without melting them, gave some credence to the idea that we might also have meteorites from Mars. See Randy Korotev's web site at Washington University in St. Louis for more information about meteorites from the Moon.

First Martians

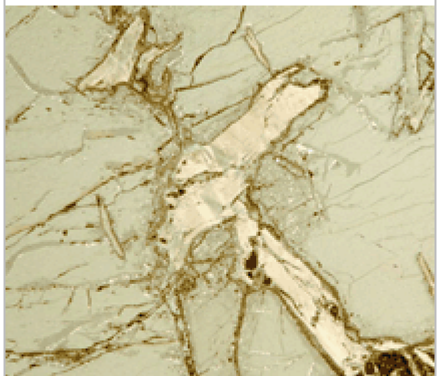


The idea that bits of Mars have fallen to Earth was hotly debated from the late 1970s to the mid-1980s. The evidence centered around the relatively young ages of a group of rocks called the SNC meteorites. They were a mere 1.3 billion years old, some even younger. Since the Moon's volcanic engine stopped more than 2 billion years ago, the argument went, these meteorites must come from a much larger body. The logical choice was Mars. The evidence was circumstantial.

All that changed when scientists measured the gases trapped in melted pockets inside EET 79001, a SNC meteorite found at Elephant Moraine. The abundances of the gases and the isotopic compositions of them were dead ringers for the atmosphere of Mars, as measured by the Viking landers in 1976. The results stopped all arguments about where the SNC meteorites came from--they are our first Martians. There are now 19 Martian meteorites, six of which come from Antarctica and seven from hot deserts.

Diamond-studded Rocks

ALH 83014



(Courtesy of Cyrena Goodrich, Univ. of Hawaii)

The graphite crystals in this rock (pale yellow with gray stripes) are up to ~1mm in length. The graphite is intergrown with the silicate minerals. This indicates that the graphite crystallized with the other minerals and was not injected later.

Ureilites may be the most mysterious of all the meteorites. They were named for Novo Urei, a small rock that fell in Russia in 1886. Until people started collecting meteorites in hot and cold deserts, only six ureilites were known. All contained small grains of diamond (a high-pressure form of carbon), along with graphite (low-pressure carbon). This was a startling discovery because diamonds form at high pressure. Many scientists proposed that the diamonds formed deep inside a large body. But as we understood the effects of large impacts, it became clear that the diamonds were the products of high-pressure shock waves caused by a large impact event on the ureilite body. The key question became the source of the diamond. Was it originally present in the rocks as graphite that crystallized along with the silicate minerals, and was then converted to diamond by shock? Or was the diamond forcibly injected into the rocks by an impact event?

During the past 15 years or so, the number of ureilites has increased dramatically from only six to 110. Some of the new ones are not severely damaged by shock and preserve the original state of the rock and its carbon minerals. Examination showed that they contain long lath-shaped crystals of graphite intergrown with the silicate minerals. The intergrowth clearly indicates that the carbon was not mixed in by a shock event. The original six ureilites fell into distinct groups on the basis of the amount of FeO (iron oxide) in their olivine and pyroxene. This suggested that the rocks within a group were related to each other, but unrelated to the other groups. Analyses of the new samples indicate something different, that there is a complete gradation in the amount of FeO, not separate groups. The relationships among the ureilites are not so simple and researchers are continuing to try to understand the geologic processes on the ureilite parent body.

HH 237

Leftovers From the Birth of the Solar System

Chondrites are meteorites that contain rounded objects (called chondrules) that cooled very rapidly from a molten state. For a long time most scientists thought chondrules formed directly in the solar nebula--the cloud of gas and dust surrounding the primitive Sun. However, chemical and mineralogical properties of chondrules and experiments designed to reproduce the mineral intergrowths in chondrules showed that they could not possibly have condensed from a gas. The condensation idea gave way in the 1980s to the hypothesis that chondrules formed from small aggregations of dust (like those fluffy dust balls that accumulate under your bed) that were melted by some mysterious process in the solar nebula. Thus, meteoriticists concluded that chondrules were secondary products.

Three chondrites found in Antarctica (ALH 85085 and QUE 94411) and the Sahara (Hammadah al Hamra 237) are changing that view. Investigators in the U. S. and Europe may have found direct condensates from the solar nebula in those meteorites. Chondrules and grains of metallic iron-nickel chondrules tell the story of heat and wind in the solar nebula. The chemical compositions of the chondrules indicate formation from a cloud that had become enriched in dust before being completely evaporated. When the gas cloud cooled, the tiny droplets condensed, but were blown into much cooler regions far from the Sun before they had a chance to acquire moderately volatile elements such as sodium, potassium, and sulfur. They appear to have accreted into asteroids before other processes affected them, thus preserving the record of heating and jetting in the nebula that surrounded the infant Sun. The results support new astrophysical theories of chondrule and star formation. (For details on these interesting meteorites, see the PSRD articles: Relicts from the Birth of the Solar System and The Oldest Metal in the Solar System.)

Meteorite Bonanzas in Cold and Hot Deserts

We know that extraterrestrial materials fall randomly on Earth; it is simply easier to find them in deserts where they are well preserved (due to lack of weathering) and concentrated on a plain background so that they are easily recognized. Successful meteorite searches in cold and hot deserts have dramatically increased the number of meteorite finds. While Antarctica is the premier cold desert hunting ground, researchers Ralph Harvey (Case Western Reserve University), Anders Meibom (Stanford University), and Henning Haack (University of Copenhagen) have been using remote sensing images to look at Earth's other ice sheet, Greenland, for evidence of meteorite stranding surfaces. Their work suggests that Greenland would be an excellent place for future meteorite hunts. Several hot desert regions are yielding huge numbers of meteorites, namely the Sahara Desert (Algeria and Libya), the Nullarbor Plains (Western and South Australia), Mojave Desert (Southern California), and high plains of Texas and New Mexico. The three most productive areas in the Sahara are the Reg el Acfer in Algeria (at least 320 meteorites), Dar al Gani (at least 256 meteorites) and Hammahah al Hamra (at least 520 meteorites) in Libya. Over 200 specimens have been collected from an unknown Saharan location (undisclosed by the private collectors). An additional 280 meteorites have been collected in Australia's Nullarbor Region.

To Boldly Look for Meteorites

Antarctic meteorites are collected, preserved, and documented very carefully. They've proven their extraordinary value to science and to our understanding of the history of the Solar System from its origin in the solar nebula to the formation of our Sun and planets. Collecting meteorites in Antarctica is like going on a field trip to the Moon, Mars, and asteroids. Last year, the eight ANSMET team members recovered 740 meteorite specimens during their two-month field trip. This season's team of ten will return to Meteorite Hills to continue searching this portion of the vast East Antarctic Ice Sheet. These annual systematic collection programs offer the best chance of finding Martian meteorites and brand new types of meteorites inspiring new research, ideas, and discoveries.

Ben Bussey

Success! ANSMET 2000-2001 field team.

Additional Resources

ANSMET--Antarctic Search for Meteorites program history, descriptions, and details.

ANSMET 2001-2002 Expedition Website photos and journal entries from the field (dated Nov. 26, 2001 to Feb. 14, 2002.)

Catalogue of Meteorites; additional ordering information from Cambridge University Press.

Exploring Meteorite Mysteries, a teacher's guide with activities for Earth and Space Sciences for grades 5-12. NASA publication EG-1997-08-104-HQ. Companion Slide Set.

Harvey, R. P., Meibom A., and Haack H. (2001) Meteorite stranding surfaces and the Greenland icesheet, *Meteoritics and Planetary Science,* v. 36, p. 807-816.

Italian Antarctic Research Program.

Lindstrom, M. M. and Score, R. (1995) Populations, Pairing, and Rare Meteorites in the U. S. Antarctic Meteorite Collection.

Listing of Antarctic web sites from the Committee for Environmental Protection, Norwegian Polar Institute.

Lunar meteorites.

Martian meteorites.

Meteorites from Antarctica, from the Astromaterials Curation office at NASA Johnson Space Center.

National Institute of Polar Research, Japan.

Office of Polar Programs, National Science Foundation.

Polar Research, National Science Foundation.

Scientific Committee on Antarctic Research, an inter-disciplinary committee of the International Council for Science.

Taylor, G. Jeffrey "Relicts from the Birth of the Solar System." PSR Discoveries. March 2001. http://www.psrd.hawaii.edu/Mar01/relicts.html

Taylor, G. Jeffrey "The Oldest Metal in the Solar System." PSR Discoveries. September 2000. http://www.psrd.hawaii.edu/Sept00/primitiveFeNi.html

---

---

psrd@higp.hawaii.edu
main URL is http://www.psrd.hawaii.edu/