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Searching for Meteorites in Antarctica

by Leslie F. Bleamaster, III

Each year a team of eager planetary scientists treks to Antarctica to live "on the ice" for seven weeks, battling subzero temperatures to search for the holy grail of planetary science — meteorites. They are called meteorite hunters and this year I was lucky enough to be on the exclusive nine-member team. My journey not only provided an indebted service to the planetary community, it fulfilled a lifelong desire to visit the icy continent.

We had a very good hunting season, collecting a handful of potential lunar and Martian meteorites, plus other enigmatic finds. Some were isolated in the open blue-ice fields, others were camouflaged by terrestrial rocks that accumulate in glacial moraines. Search days resulted in as few as one meteorite found to our best day when we collected seventy.

In total, 710 meteorites were collected. Each was given a unique number and logged into a Global Positioning System database. The meteorites are treated with the utmost respect, gathered with clean tongs and sterile collection bags. Later they are shipped to Houston for analysis and curation, where the Apollo moon rocks were analyzed.

This year's camp was located in the Miller Range at 83.4° South longitude, 156° East latitude, along the Trans-Antarctic Mountains, halfway between McMurdo Station and the geographic South Pole. Beautifully set at the margin between the Ross Ice Shelf and the polar plateau, leaders of the Antarctic Search for Meteorites (ANSMET) program have determined that this area is ideal for hunting, not to mention its spectacular views. ANSMET, funded by the Office of Polar Programs of the National Science Foundation, has sent teams to the ice since 1976 and has collected nearly 20,000 meteorites which are available to the world-wide scientific community for research.

Getting to the Miller Range from San Antonio was half the battle, requiring six flights on a

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Les Bleamaster, ice axe in hand, stands high atop Milan Ridge above the Ascent Glacier in Antarctica. He was at the South Pole on a meteorite-collecting expedition from December 2007 to late January 2008. This year's study also included collecting rock samples for exposure age-dating to help understand glaciation in the Trans-Antarctic Ranges.

Beautiful, blue Antarctic ice, wide open spaces, big sky: the perfect landscape for finding meteorites. ***(Photo by Les Bleamaster.)***

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Searching in Antarctica

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variety of aircraft. The most impressive flight was aboard the magnificent Air Force C-17, a far cry from the old C-130s I rode in the Navy. Finally, we flew the Antarctic workhorses provided by Kenn Borek Air Ltd.: the mighty Twin Otters and the Basler, a converted DC-3, which happened to crash two weeks after putting us into our field location (check out http://www.ipy.org/index.php?/ipy/detail/polenet_hazard/ for details).

We had a layover in Christchurch, New Zealand, to receive our cold weather gear including the famous "big red" parka, insulating socks, boots, gloves, hats, and, of course, long underwear. All USAP (U. S. Antarctic Program) participants are provided with a customized wardrobe, depending on their specific Antarctic task.

In McMurdo we spent days preparing our gear and learning how to survive the elements. This included instruction in mountaineering and crevasse rescue, snowmobile maintenance, tent pitching, and cold weather first aid. We also selected our food — my tent mate and I packed about 400 lbs. of meats and treats.

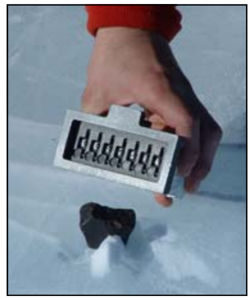
Once on the plateau, we set up camp with six tents: four living quarters, a restroom facility, and a community tent for social gatherings. Living in a tent for 48 days is difficult under the best of conditions, but move that tent to the brutal Antarctic Plateau and life gets even more interesting. The Scott tent is an 8' x 8' (inside) x 12' (tall) muted yellow cave. The 30" circular door opens to the combination living, kitchen, bedroom area. Don't get me wrong, these are wonderful pieces of equipment, capable of withstanding winds in excess of 100 knots, but lower backs and knees were not meant to live in such tight quarters for so long. And though we had stoves for heating, they cannot be used while sleeping. One morning the temperature at the floor was 8°F and ice crystals had formed on my sleeping bag. On the other hand, the apex of the tent could reach 90°F (the heat rises to the top and vents to the outside through a chimney); consequently, your feet could be on ice while your head was in a sauna.

We ate very well, however, with a fine selection of frozen food. Beef, pork, chicken, and shrimp — all only a quick dash to the environmentally-friendly outdoor refrigerator. We took almost everything with us on the first flights from McMurdo to the field, and the Twin Otters flew in twice to re-supply us with propane, snowmobile fuel, mail, and freshies (fruit, veggies, bread and cheese). They also took away our trash, human waste, and outgoing mail. The planes were always a very welcome sight.

We used Bombardier snowmobiles daily for our meteorite hunts. The problem is "snow" mobiles are not really meant to drive on ice — very hard on their suspensions — and we had four mechanical breakdowns. Somehow, I was involved with all four repairs. I definitely earned my Antarctica field-mechanic's badge.

All in all, this was an incredible experience. I did miss my wife and kids *tremendously*, I did not get to keep a meteorite (that's a big no-no!), and I didn't even see a penguin, but it was not as cold as I'd feared, I met some great people, and I will always remember the feeling of the ice underfoot, the quietest quiet I have ever heard, and the perpetual glow of that giant sun ball casting light across the pristine landscape. I want to thank Dr. Ralph Harvey of Case Western Reserve University in Cleveland, Ohio, (Principal Investigator of the ANSMET program) for inviting me to join the 2007-2008 search team.

For more information about ANSMET, visit http://geology.cwru.edu/~ansmet/



Numbering and measuring a meteorite. They ranged from half a centimeter to 20 centimeters in size.

Meteorites are tagged, collected as cleanly as possible, and their locations marked by GPS.

Here I am cozy in my Scott tent. On stormy days we stayed in reading, playing cards, or writing letters. Sometimes a day inside was a nice break, but once we spent four straight days in the tents due to very high winds. Overall, I spent 14 of 48 possible workdays IN THE TENT.

Temperatures ranged from -10°F to a balmy 25°F with winds up to 50 knots. This was a particularly cold day.

My Scott tent — home for 48 days!

That's me, working on one of the broken snowmobiles. Did you know that wrenches are very cold when it's 10°F?

MYSTERIES OF PHOBOS *by William K. Hartmann*

The two small moons of Mars, Phobos and Deimos, are coming onto NASA radar screens as one of the next logical targets of exploration. This was the theme of a conference in November 2007 at NASA Ames Research Center, called the First International Conference on Phobos and Deimos — the name itself confirming that Phobos-mania is surprisingly new.

A NASA mission to Phobos/Deimos would let us test Mars flight designs and give us two "free samples" of asteroid-like bodies. Phobos, (at right) the larger of the two (~27 x 19 km) and closest to Mars, has features that make it an especially attractive target.

View of Mars' satellite, Phobos, showing the largest crater, named Stickney. Upper half of the image is dominated by parallel fractures possibly produced by tidal forces, and possibly aggravated by the impact that produced Stickney. Rows of pits along the fractures suggest release of gas from Phobos' interior. ***(Mosaic of Viking Orbiter frames, NASA.)***

PSI has a long, if sporadic, interest in Phobos. In 1971, Cornell graduate student Steve Soter wrote a now-classic paper showing that when meteorites strike Phobos and Deimos, the dust blasted from these low gravity objects would not fly off into deep space, but go into orbit around Mars, creating dust belts. Phobos and Deimos would then re-accrete their own dust, meaning that the surface material has been recycled many times. Soter didn't get around to publishing the paper, but Don Davis, Clark Chapman, Rick Greenberg, and I invited him to PSI where we all wrote a paper on the origin and history of Phobos, published in 1975.

Amazingly, most of the vexing mysteries we discussed then are just as murky today. Start with the surface material: Observations from Earth and spacecraft prove that Phobos and Deimos have very dark surfaces, matching the carbonaceous asteroids and comets from the outer asteroid belt to the outermost solar system. But the actual spectral color properties are still notoriously uncertain. Observations from Earth contend with red light scattered by Mars. No one is sure if the moons are neutral black, like C-type asteroids in the outer belt, or reddish-black, like more remote asteroids and comet nuclei. Furthermore, all the surface dust has probably been impact-shocked and recycled through the "Soter dust belts," so we can't be sure if it represents the true interior of Phobos. Boulders ejected from craters (see close-up image at right) may give better samples of the interior.

An even bigger mystery is how Phobos and Deimos were created in the first place. The most popular assumption is that they started as asteroids. But that means they had to get captured into orbit around Mars. And capture (a process studied by PSI's Steve Kortenkamp, among others) is difficult. Drag forces from an extended atmosphere might allow capture, but then you have to get rid of most of the atmosphere just after the capture event to keep them from spiraling in and crashing on Mars. It sounds jury-rigged.

The more you study the problem, the worse it gets. As noted Phobos researcher Fred Singer emphasized, the two moons are now just over the equator of Mars. Capture would tend to leave them in whatever randomly inclined orbits they had initially. How do you bring a moon into the equatorial plane? Possibly a larger asteroid was captured, brought into the equatorial plane by tidal forces, then broken into fragments. Again, it's a jury-rigged chain of improbable events.

In 1987 and 1990 papers, I suggested a possible helpful factor in the origin dilemma. Since the clearing of interplanetary bodies in the outer solar system scattered millions of asteroids into the inner solar system, the improbability might be ameliorated by having millions of opportunities.

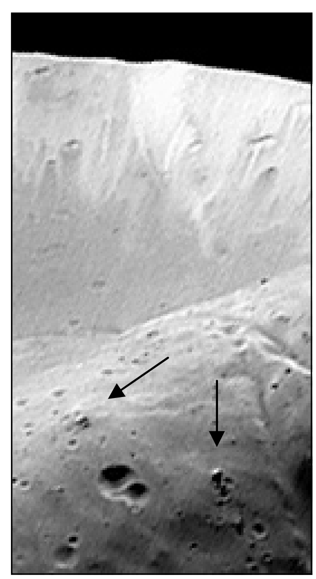
A final problem is the question of possible water content and use of Phobos as a resource base for future astronauts. Water on Phobos is usually dismissed by observers, who remark that the spectra show no bound water molecules in the surface minerals. However, as we've seen, the surface dust is probably all shocked ejecta that has cycled through the Soter dust belts and reaccreted on Phobos – several times over. Initially water-rich surface dust probably lost all its water during impact-shock processes.

Oddly enough, there are tantalizing hints of internal water. Some classes of carbonaceous meteorites contain as much as 10% to 20% bound water (which could easily be driven off by mild heating and collected by astronauts who might be lucky enough to find that material). Also, the low density of Phobos (and Deimos), about 1.9 g/cm^3, requires either a rubble pile structure with empty pore space, or lots of ice, or both.

Another hint of internal ice comes from rows of nearly parallel fractures, lined with craters that have raised rims. At the conference, Cornell researcher Peter Thomas argued that this pattern matches fractures suggested from tidal stresses induced in Phobos by Mars. One possible origin for raised-rim craters would be that gas blew *out* through the fractures and overlying dust piled up on the rims of the blown-out craters. The gas could have come from ices subliming inside Phobos. The crater chains may be a smoking gun that reveals the presence of ices inside Phobos.

Various missions are on the drawing boards to explore Phobos. Most notable is the Russian "GRUNT" lander, already being built for launch around 2009 as part of a European/Russian project. The odd name comes from the Russian word for soil; the Russian engineers hope to return soil sample to Earth.

From Earth, Phobos is an easy-to-reach moon. It has unknown surface material, unknown origin, unknown history, unknown (perhaps non-existent) amounts of interior ice, and a growing community of people wanting to get there. It is likely to be a subject for winning research proposals in the next few years! □



(Right) Close-up of the rim of Stickney crater on Phobos shows two house-sized (50 m) boulders (see arrows), which have been suggested as good targets for sampling the interior composition of Phobos. ***(1998 photo from Mars Global Surveyor, Malin Space Science Systems, JPL, NASA)***

PSI Welcomes Scott Mest

Scott Mest joined PSI in July 2007 while he was a NASA Postdoctoral Research Scientist under the NASA Postdoctoral Program, operated by Oak Ridge Associated Universities (ORAU), at the NASA Goddard Space Flight Center (GSFC), Greenbelt, MD. He is currently an Associate Research Scientist with PSI, in residence at the Planetary Geodynamics Laboratory at GSFC.

Scott spent his first 30 years in East Greenville, Pennsylvania, where his family still resides. Growing up, he spent most of his time outdoors enjoying nature, fishing and hunting with his grandfather, playing with his sisters, gardening with his parents, or stargazing on the deck. His fondness for the outdoors kindled a desire to learn all he could about the world around him.

Scott's undergraduate degree is from West Chester University of Pennsylvania; there his love of space and geology was galvanized into a BS in Geology. He conducted his graduate work at the University of Pittsburgh, earning Masters and PhD degrees in Planetary Geology under the tutelage of Dr. David Crown (now also at PSI). In between his MS and PhD, he took a year "off" from heavy thinking to work for his brother-in-law in the HVAC trade. During this time, Scott met and married his lovely wife, Debra.

Scott left Pittsburgh and spent the last year of his doctorate working at NASA Goddard Space Flight Center, through which he had a NASA GSRP Fellowship to use MOLA (Mars Orbiter Laser Altimeter) data to model the hydrology of Martian highland terrains. He was awarded an NRC Postdoctoral Research Fellowship (later turned over to ORAU), which allowed him to stay at Goddard to analyze impact crater floor deposits in the southern highlands of Mars, and map the geology and geomorphology of the north and south polar regions of the Moon.

Much of Scott's research involves geologic and geomorphic mapping and analysis of data acquired from orbiting instruments. Currently he is working with PSI Scientists David Crown and Les Bleamaster on several of their funded research projects to map the Reull Vallis source region, map an area northwest of Hellas basin, and characterize impact craters and sedimentary basins in several areas surrounding the Hellas basin on Mars. He is able to incorporate much of the Mars-related impact crater work that he did for his post-doctoral research.

Scott with his children Tori (right) and Zack, and a pretty nifty Father's Day gift.

Scott and his family reside in Pasadena, MD. When not working, Scott enjoys spending time with Debra and their two highly energetic children, Tori (5) and Zack (2½). The local park along the Chesapeake is a big draw for the Mest family with its long trails for walking — and for Tori to learn bike-riding — summertime concerts, and for just enjoying the Bay. Although Scott tells everyone that working at GSFC is his main reason for living in Maryland, his love of steamed blue crabs secretly remains near the top of the list.

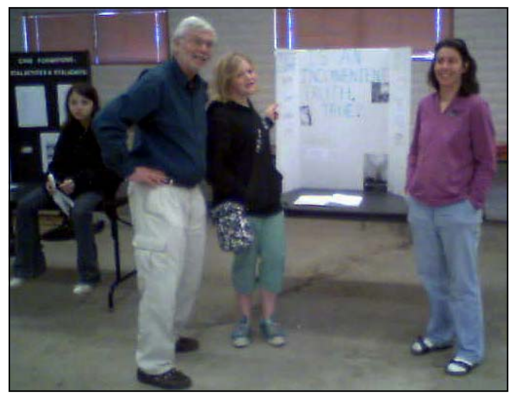
Your secret is safe with us, Scott! Welcome aboard!

Our Scientists Judge a Science Fair

by Donald R. Davis

Presidio Charter School, across the street from PSI, held their first science fair this year and PSI was asked to judge the event. PSI Senior Scientist Beatrice Mueller and I were joined by Dr. Diana Wheeler from the University of Arizona for this event. Exhibits were entered in three classes: elementary, middle school, and high school, and covered a wide range of projects including volcanoes, clean energy, an electro-mechanical system, and measuring the speed of light in Jello. The kids (and parents) had a great time putting projects together and the enthusiasm and dedication of the participants was impressive.

In the end hard choices had to be made, and though there were not blue ribbons for all, everyone was very supportive and positive during the award ceremony. From the judge's perspective, this was a fun event since there was time to interact with the students to really probe their knowledge. Hopefully, this will be an annual event at Presidio with even more projects on display next year. Next stop: the regional science fair.



Presidio Middle Schooler Ginger, between PSI Senior Scientists Don Davis and Beatrice Mueller, points out key features of her science fair entry on global warming, specifically critiquing the movie "An Inconvenient Truth."

Late-breaking News from Australia

PSI Associate Research Scientist Mark Bishop and his wife Rachel Humeniuk are the proud parents of a baby girl, Astrid, born March 18 in Goodwood, Adelaide, South Australia. Vital statistics: 7 lbs 3 oz, 19 ½" long, stunningly attractive. Older brother Rommy (2) is totally delighted with his new little sister.

Welcome, Astrid, and congratulations Mark and Rachel!

L-r, Nalin Samarasinha leans on his cricket bat. Matt Chamberlain (orange jersey) and Matt Balme explain the rules of cricket during the laugh-filled talk on one of Matt Chamberlain's last days at PSI. Matt Balme demonstrates defensive cricket technique.

Hello Cricket, Goodbye Chamberlain

In January, three PSI scientists and avid cricket enthusiasts gave a rousing primer on the "second most popular game in the world" at our Wednesday tea. All three grew up playing the British-origin sport: Senior Scientist Nalin Samarasinha in Sri Lanka, Research Scientist Matt Balme in England, and Postdoctoral Research Scientist Matt Chamberlain in Australia.

So, by popular request, they presented a fun introduction to cricket, outlining its history, rules, and formats using video clips and real cricket gear. They explained such fascinating terms as sticky wicket, silly point, leg before wicket, middle stump, deep square leg, and many more. It was science at its highest and best use!

Sadly, this was Matt Chamberlain's last week at PSI since he accepted a position in Australia and moved with Yen and their three small children back "down under" in early February.

We will miss them, greatly!

Aurora Fellowship for Balme

Congratulations to PSI Research Scientist Matt Balme who was awarded the United Kingdom's prestigious Aurora Fellowship by the UK Science and Technology Facilities Council. The STFC was formed by Royal Charter and is one of Europe's largest multidisciplinary research organizations. Only three awards are made each year. Matt was recognized for his proposal to explore water, ice, and climate on Mars. His work will lay the groundwork for future human exploration and the search for life on Mars by seeking to understand where and when water and ice have been stable on the surface of Mars in the very recent past. Balme will be working on this Fellowship for the next three years at Open University at Milton Keynes, England, and will continue to spend a couple of months a year pursuing his research at PSI's corporate headquarters in Tucson.

Good going, Matt!

Successful first year for PSI Scientific Publication series

Since its online launch in February 2007, 1,427 copies of the first publication in our scientific series have been downloaded. ***A Photographic Atlas of Rock Breakdown Features in Geomorphic Environments*** (2007) Edited by Dr. Mary Bourke and Dr. Heather Viles is still available for free download at http://www.psi.edu/staff/bourkepubs/atlas/

Director's Note

I have just returned from Chicago where Brother Guy Consolmagno (Vatican Observatory) and I engaged in the "Great Planet Debate" at the Adler Planetarium. Guy defended the IAU's decision to define planets as objects orbiting the Sun that have "cleared their orbits," leaving eight after lopping off Pluto. I promoted an alternative geophysical perspective, defining planets as "round objects (in hydrostatic equilibrium) that orbit a star." My solar system has 12 planets, retaining Pluto and adding Charon to it as a double-planet, and including Ceres and Eris — leaving the door open for many more planets in the future. In fact, Japanese scientists are predicting the existence of a planet around 100 AU from the Sun, in an inclined orbit of 40 degrees, with a mass two-thirds that of Earth! Even though it would be more than six times the mass of Mars, this new object (if discovered) would not be a planet according to the IAU because to clear its orbit an IAU planet has to be more and more massive the further it is from the Sun. At 100 AU, even Neptune's IAU planetary status starts getting dicey…

When we define a class of objects in science, we are identifying those characteristics by which we group things together. Studying those characteristics across different objects can provide important clues about the physical processes underlying them. Classification is an important tool in science. Ultimately, definitions are judged by how useful they are. The IAU definition may have value to dynamicists, but for those engaged in the robotic exploration of the solar system a geophysical approach has greater value. For the public, however, the most valuable lesson is in the planet definition debate itself: It is accessible to the public and reveals the process of science which is ever ongoing. Science is not about majority rules or votes behind closed doors. We are constantly testing our theories and refining our models and perspectives, finding out what works better or explains things better.

Viva Planets!

Mark V. Sykes
March, 2008

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