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U.S. Geological Survey Scientific Activities in the Exploration of Antarctica: 2002–03 Field Season

By Tony K. Meunier
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Introduction^{1, 2, 3, 4}

The U.S. Geological Survey (USGS) mapping program in Antarctica is one of the longest continuously funded projects in the United States Antarctic Program (USAP). This is the 53rd consecutive U.S. expedition to Antarctica in which USGS scientists have participated. The financial support from the National Science Foundation, which extends back to the time of the International Geophysical Year (IGY) in 1956–57, can be attributed to the need for accurate maps of specific field areas or regions where NSF-funded science projects were planned. The epoch of Antarctic exploration during the IGY was being driven by science, and, in a spirit of peaceful cooperation, the international scientific community wanted to limit military activities on the continent to logistical support. The USGS, a Federal civilian science agency in the Department of the Interior, had, since its founding in 1879, carried out numerous field-based national (and some international) programs in biology, geology, hydrology, and mapping. Therefore, the USGS was the obvious choice for these tasks, because it already had a professional staff of experienced mapmakers and program managers with the foresight, dedication, and understanding of the need for accurate maps to support the science programs in Antarctica when asked to do so by the U.S. National Academy of Sciences. Public Laws 85-743 and 87-626, signed in August 1958 and in September 1962, respectively, authorized the Secretary, U.S. Department of the Interior, through the USGS, to support mapping and scientific work in Antarctica. The USGS mapping and science programs still play a significant role in the advancement of science in Antarctica today. Antarctica is the planet's 5th largest continent [13.2 million km² (5.1 million mi²)], it contains the world's largest (of two) remaining ice sheets, and it is considered to be one of the most important scientific laboratories on Earth. This report provides documentation of USGS scientific activities in the exploration of Antarctica during the 2002–03 field season (Mullins, 2002).

Figure 1 shows the primary geographic locations for the scientific work by the USGS during the 2002–03 field season. Figure 2 is a facsimile of the cachet for the field season. It was a modification of the 2000–01 cachet designed and drafted by USGS graphic artist Charlotte Wells.

¹ See Open-File Report 2006–1117, U.S. Geological Survey Scientific Activities in the Exploration of Antarctica: Introduction to Antarctica (including USGS Field Personnel: 1946–1959) at <http://pubs.usgs.gov/of/2006/1117/>.

² See Open-File Report 2006-1116, U.S. Geological Survey Scientific Activities in the Exploration of Antarctica: 1946–2006 Record of Personnel in Antarctica and their Postal Cachets; U.S. Navy (1946–48, 1954–60), International Geophysical Year (1957–58), and USGS (1960–2006) at <http://pubs.usgs.gov/of/2006/1116/>.

³ See Open-File Report 2006–1114, U.S. Geological Survey Scientific Activities in the Exploration of Antarctica: 1995–96 Field Season at <http://pubs.usgs.gov/of/2006/1114/>.

⁴ See Meunier (1979).



Figure 1. Index map to the principal geographic features of Antarctica. Locations for USGS 2002–03 field season operations are also shown (black dots).

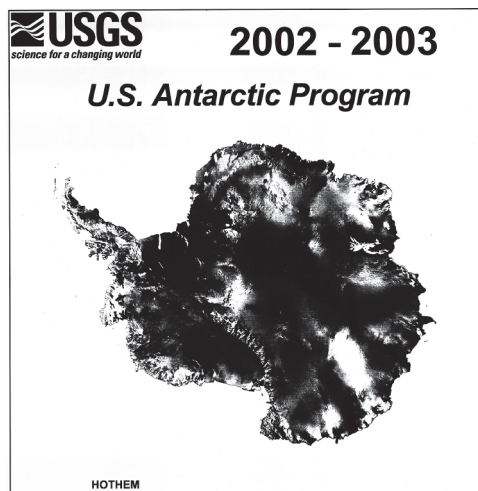


Figure 2. Generic cachet for USGS projects during 2002–03 is a modification by Tony K. Meunier of the original cachet for the 2000–01 field season designed by USGS graphic artist Charlotte Wells.

Scientific Objectives for the 2002–03 Field Season

USGS Geodesy Projects

Larry D. Hothem (USGS) and Herbert M. Thompson (Land Information New Zealand (LINZ)) retrieved 12 months of data and performed maintenance on existing Antarctic Remote Global Positioning System (GPS) Observatories (ARGO) (Hothem, 2003). GPS data from the International GPS Service (IGS) station in McMurdo and the ARGO sites at Cape Roberts, Mount Fleming, and Fishtail Point, all within helicopter range from McMurdo Station, will be used in conjunction with data collected during other continent-wide projects as part of a multinational effort to acquire millimeter-scale accuracy (with the vertical value accurate to within 1 spherical centimeter of the theoretical center of the Earth) for the Transantarctic Mountains Deformation (TAMDEF) studies. This included the Northern Victoria Land (NVL) Deformation Monitoring Network (NVLDEF) operated by the Italian Antarctic Geodetic

Science Program using four USGS GPS receivers. These sites are to the north of the USGS TAMDEF stations. The Jet Propulsion Laboratory (JPL) of the National Aeronautics and Space Administration (NASA) established stations to the south of the USGS TAMDEF sites, as did The Ohio State University (OSU). However, the OSU Station extended beyond the JPL stations during the West Antarctic GPS Network (WAGN) campaign. Data from all projects are being processed and evaluated by the TAMDEF group at Byrd Polar Research Center (BPRC), OSU, Columbus, Ohio.

Gravity

The original gravity hut enclosing one of Antarctica's important gravity stations is to be removed during construction of a new building at McMurdo Station. This gravity station, whose monument has been used by surveys since the IGY to reference field surveys, was transferred from its original site in the hut to a concrete pillar located in another building (Building 146). The new gravity station monument marker was accurately referenced to the old monument by a very precise, geodetic ground survey of the McMurdo Station's network of geodetic control points.

Tide-Gauge Stations

Tide-gauge stations established and maintained by LINZ at Cape Roberts and Scott Base (NZ) were visited to retrieve data, conduct annual maintenance, and perform a high accuracy (millimeter-scale) calibration of the instrumentation.

Ground-Control Points (GCP)

GCPs, which by definition are photo- or image-identifiable locations that are not monumented, were established by the Italian Antarctic Program at Cape Hallett (using USGS 1983 aerial photography) and by the USGS geodetic team at Cape Crozier (using high-resolution IKONOS commercial satellite imagery (1-m pixels)). The GCPs are needed by the USGS to produce planned orthorectified aerial photographic mosaic maps of the sites, with elevation contours. The orthophoto maps were requested by the NSF to support biological research at Emperor and Adélie penguin rookeries in the area.

McMurdo Station IGS

A second IGS station in McMurdo tracks and logs data from both the GPS and the Russian Global Navigation Satellite System (GLONASS) satellite constellations on a continuous basis, in support of the IGS International GLONASS Service (IGLOS) and a geodetic project of the Scientific Committee on Antarctic Research (SCAR) Working Group on Geodesy and Geographic Information. The IGLOS station in McMurdo contributes data used to produce high-accuracy orbital coordinates for the GLONASS satellites that are referenced to the International Terrestrial Reference Frame (ITRF).

South Pole Station Geodetic Reference Network (SP-GEONET)

In cooperation with Raytheon civil engineers, funded by the NSF, four existing and six new stations were occupied and surveyed by the USGS at the Amundsen-Scott South Pole Station using differential GPS positioning to establish high-accuracy coordinates for the monumented sites. The SP-GEONET provide a high-accuracy geodetic reference for three-dimensional (3-D) monitoring of the facilities at Amundsen-Scott South Pole Station. The network is systematically used by the civil engineers to make optical-instrument readings that monitor the stability of the structures on the snow-and-ice surface at South Pole and detect changes in structural deformation of buildings at the sub-centimeter level of accuracy (L. Hothem, USGS, written commun., 2003).

Microbiological Investigations

USGS microbiologist Russell Rodriguez, Co-Principal Investigator with Laurie Connell, University of Maine, and USGS Volunteer for Science geneticist, Regina Redman, began a multidisciplinary, collaborative research effort that will characterize the role that soil yeasts play in the McMurdo Dry Valleys ecosystem. Yeasts are the only endemic fungal species in the soil community of what is essentially a polar desert. By using deoxyribonucleic acid (DNA) sequencing, the study is correlating the abundance, distribution, and evolution of yeasts in Antarctic soils. The scientific objectives of the project are to identify all of the fungal species in the soil, measure their levels of activity, and determine the evolutionary relationship between the various species (Connell and Rodriguez, 2002).

Scientific Accomplishments

USGS Geodetic Projects

The continuously operating International GPS Service (IGS) observatories at McMurdo, Palmer, and South Pole Stations transmit data daily to the NASA Crustal Dynamics Database Information Service (CDDIS) in Greenbelt, MD. The data are used to compute high-accuracy orbital parameters for GPS satellites; to evaluate the accuracy for the predicted orbits of satellites in the Southern Hemisphere for the National Geospatial-Intelligence Agency (NGA); to evaluate atmospheric refraction effects on the GPS observations; to monitor (by the USGS and OSU) the horizontal and vertical motion of the snow-and-ice surface at the South Pole; to measure vertical rebound of the Transantarctic Mountains by crustal unloading caused by loss of glacier ice following the most recent deglaciation; and to serve as a reference base station for other geopositioning projects (Hothem, 2003). Preliminary results that compare postglacial rebound models and GPS measurements (Willis and Hothem, 2003) detected horizontal motion rates in the vicinity of 4 mm a^{-1} . Relative to the horizontal motion, vertical-motion rates were expected to be in the 20 mm a^{-1} range but, surprisingly, both horizontal- and vertical-motion rates were of the same order of magnitude. Consequently, the motion in the Transantarctic Mountains is now attributed to tectonic activity rather than isostatic rebound (Willis and others, 2003). Efforts are underway by OSU to try to detect and remove any factors that would produce bias in the horizontal- and vertical-motion rate.

Geodetic ground-control points (GCPs) were obtained from Italian surveyors at Cape Hallett, and an orthorectified digital photomap is now available for scientific studies in the Northern Victoria Land (NVL) region. Fourteen GCPs were established by the USGS at seven Cape Crozier sites for future use in mapping Emperor and Adélie penguin rookeries. Also, a series of gradient-gravity ties were conducted between a new gravity station at the McMurdo Station relative to the original historic gravity hut monument. The precisely repositioned gravity station will provide the scientific community continuity with past, present, and future gravity readings.

A recent structural-engineering survey of the new South Pole Station using the USGS SP-Geonet discovered that the “jack-up” pylons used to elevate the new station above the snow surface were settling unevenly, thereby causing deformation of the structure. Since the discovery of this problem, NSF contract engineers have taken corrective action to the Station’s leveling mechanisms.

Repositioning of the Geographic South Pole monument was conducted on 1 January 2003 using static GPS techniques. A USGS benchmark with the latitude 90°S . was embedded in the ice. The location of the South Pole continues to move 9.98 m a^{-1} in a northwesterly direction each year from its previously surveyed location.

Microbiology

The role of yeast in the McMurdo Dry Valleys soil ecosystem is a multiyear project. During this first field season, the distribution and abundance patterns of soil yeast were determined in Taylor Valley. Chemical analysis did not reveal significant relationships between the occurrence of the microbes and carbon or nitrogen in soil samples. (Russell Rodriguez, USGS, written commun., 2003).

USGS and Collaborating Scientific Personnel in Antarctica in 2002–03 Participating in USGS Science and Mapping Projects

NSF Project S–052M/S

- Larry D. Hothem, Co-Principal Investigator (PI) of NSF Award #02–33246 and Geodetic and Geospatial Program Team Leader, McMurdo Station and the Transantarctic Mountains.
- Herbert M. Thompson, Geodesist, Land Information New Zealand (LINZ), Geodesy and Geospatial Program; and tide-gauge surveys of McMurdo Sound, McMurdo Station and the Transantarctic Mountains.

NSF Project B–019–0

- Russell Rodriguez, Microbiologist; and Regina Redman, Geneticist, Co-PI’s, Yeasts in the McMurdo Dry Valleys: Biological role, distribution, and evolution of microorganisms in Taylor Valley.

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- Hothem, Larry D., 2003, Antarctic Geodesy Projects and Achievements, FY2003: Reston, VA, U.S. Antarctic Resource Center (USARC) Special Collection, 7 p. unpub. report.
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Relevant Websites

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<http://www.geoscience.scar.org>

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