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(Continued)

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Greenwich Mean Time is used throughout the issue

A REVIEW OF THE 1965-1966 SUMMER SEASON

Introduction

On March 2, 1966, the United States completed another highly successful field season in Antarctica. This issue of the *Antarctic Journal* is devoted to a review of these activities. To a large extent the participants have set down their own experiences and accomplishments. These brief summaries constitute neither complete histories nor final scientific reports. Both may be modified in the light of further review and analysis.

Several steps in the long-range objectives of the United States were accomplished. Scientific exploration was carried into new areas of the Continent and the oceans around it, and new research projects were begun. The United States Naval Support Force, Antarctica, with the assistance of Army, Air Force, and Coast Guard units, provided support to the United States Antarctic Research Program (USARP) to enable it to carry out its scientific studies.

No activity of the past season better represents this collaboration between scientific activity and military technology than the geophysical survey of the Pensacola Mountains. In all, six scientific projects were involved, and the investigators and their equipment, including an Army aviation unit equipped with three turbine-powered helicopters, were placed and supported in the field by naval aircraft. The results contributed to the long-range goals of the scientific program to complete the systematic geological reconnaissance of exposed land in West Antarctica.

The erection of a station on the polar plateau, in an area higher and more remote than any the United States had previously chosen, was an example of cooperation, good planning, and sound organization. In the process the concept, design, and techniques for compact mobile stations were considerably advanced, and it was shown that aircraft could operate with payloads of 23,000 pounds at an elevation of over 3,600 meters (11,800 feet). Plateau Station enables research to be carried out in a part of Antarctica that would have been considered almost impossible to attain a few years ago.

Plateau Station furthermore served as the terminus of the second phase of the geophysical traverse from the South Pole into Queen Maud Land, one of the few remaining unexplored areas on Earth. The successful execution of this segment of the journey brought closer to completion the large-scale geophysical exploration of the Continent.

Many other projects were successfully undertaken. A substation was built near Byrd Station to permit year-around studies with the 21-mile-long antenna laid on the surface of the snow for upper atmosphere research. Coast Guard and Navy icebreakers carried scientists on surveys of the coastal regions of the Antarctic Peninsula and of Victoria Land, and cleared the way for cargo ships and tankers bringing in the thousands of items needed to sustain the antarctic program. Construction personnel built new facilities and repaired existing ones to ameliorate conditions for those who live and work in Antarctica.

On the international scene, the United States hosted representatives of foreign countries and was itself represented on three foreign expeditions. One of the United States stations was inspected by foreign governments under terms of the Antarctic Treaty.

The United States Antarctic Policy Group approved a conservation policy, using as a guideline the Agreed Measures for the Conservation of Antarctic Fauna and Flora which had been adopted at a consultative meeting of the Treaty signatories in Brussels in 1964. The National Science Foundation inaugurated a system of permits for all USARP personnel, to control the collection of indigenous mammals and birds.

Unfortunately, for the first time since 1961, several fatalities occurred to United States personnel. On February 2, an LC-47 crashed on the Ross Ice Shelf with a crew of six, all of whom were killed. Eleven days later, a member of the wintering-over party at the South Pole died as the result of a cargo unloading accident.

On the following pages are presented summaries of the scientific and logistic programs carried out during the 1965-1966 summer season. A similar review of year-around programs and stateside activities will be presented in the September-October issue of the *Antarctic Journal*.

UNITED STATES ANTARCTIC RESEARCH PROGRAM FIELD SEASON 1965-1966

KENDALL N. MOULTON [1]

Office of Antarctic Programs
National Science Foundation

The 1965-1966 antarctic field season is the eighth since the National Science Foundation initiated the United States Antarctic Research Program at the conclusion of the International Geophysical Year. In spite of the difficult logistic problems posed, this past season was a most successful one. The main objectives of the scientific program were accomplished, and the support of the many and diverse projects presented the U.S. Naval Support Force, Antarctica, with one of its greatest challenges since the establishment of the first United States stations in 1955-1956. The challenge was met enthusiastically and effectively.

Research Station Network Extended

The highlight of the past season was the further extension of the United States scientific station network in Antarctica. The first addition to this network since the IGY was Eights Station, built in the 1962-1963 season. The second was Palmer Station in the Antarctic Peninsula, built in early 1964. This year an eight-man research facility was built on the high polar plateau of East Antarctica at 79°15′S. 40°30′E. and an elevation of 3,624 meters (11,890 feet). This station is equipped to support new research projects in aurora, geomagnetism, meteorology, and very-low-frequency propagation and was designed to be completely air transportable. The facility was placed on site by Navy LC-130F aircraft during the month of January, assembled, and made fully operational before the last aircraft departed the station on February 11, 1966. This airborne operation was truly an outstanding example of professional airmanship and demonstrated the quality and effectiveness of the U.S. Navy antarctic logistic capability.

Concurrently, the operation of Eights Station was suspended. Much scientific equipment at the station was transferred to Plateau Station. The rest of the facility has been secured for possible reactivation during the next period of maximum solar activity.

[1] U.S. Antarctic Research Program Representative, McMurdo Station, 1965-1966.

A second major project was the establishment of a permanent facility at the site of the long-wire antenna, 21 kilometers (13 miles) from Byrd Station. This facility houses two men during the first winter and affords researchers the opportunity to expand the program of very-low-frequency (VLF) and extra-low-frequency (ELF) ionospheric studies. The three air-transportable units which make up the facility and which are similar to those used at Plateau Station, were flown by Navy LC-130F aircraft directly to the site in January. The units were then installed and covered with a steel arch to protect them from heavy snow accumulation.

The installation of these air-transportable facilities points to a trend over the past few seasons toward the development of small, compact facilities that can be easily transported to a site, set up, and then moved if required.

Remote Areas Explored

A geological, geophysical, topographical, and biological survey of the Pensacola Mountains carried eastward the exploration of the Transantarctic Mountains. Six separate scientific projects with a total of 18 scientists were combined to accomplish the survey. In order to establish such a party approximately 1,700 kilometers (1,050 miles) from McMurdo Station and provide mobility in the field, three Army UH-1B turbine helicopters were airlifted by Navy LC-130F aircraft to a base camp in the Pensacola Mountains. With the close support of the helicopter unit, the research party accomplished in one season what would previously have taken several years to complete with ground transportation alone.

While the Pensacola Mountains were being explored, a seven-man party undertook the preliminary geologic reconnaissance of the recently discovered nunataks and mountain ranges bounding the northwestern edge of the Filchner Ice Shelf at the base of the Antarctic Peninsula. Fielded 2,400 kilometers (1,550 miles) from McMurdo Station by LC-130F and LC-117 aircraft and utilizing motor toboggans for transportation, the party spent from November 8, 1965, to January 17, 1966, mapping and surveying an area of 13,000 square kilometers (5,000 square miles).

The second phase of the South Pole-Queen Maud Land Traverse was successfully accomplished. Recommencing at the Pole of Inaccessibility on December 15, 1965, an 11-man research team traveled 1,340 kilometers (725 n. miles) on a zigzag course to the new Plateau Station. The vehicles had been left at the Pole of Inaccessibility at the completion of last year's traverse and were readied in the field for this year's project.

This program of geophysical exploration included ice depth soundings, magnetic observations, gravity readings, glaciological studies, altimetry, and surface weather observations along the following route: 82°07'S. 55°06'E. (Pole of Inaccessibility) to 82°00'S. 09°06'E., to 79°15'S. 40°30'E. (Plateau Station). At the conclusion of the traverse, vehicles were loaded aboard U.S. Navy LC-130F aircraft and flown to McMurdo Station for servicing. The takeoffs from Plateau Station at 3,624 meters (11,890 feet) were accomplished without JATO at a maximum cargo weight of 23,000 pounds per aircraft and set a record for Navy Air Development Squadron Six LC-130F operations in Antarctica.

Significant ice thickness data were obtained by the traverse personnel on the polar plateau, using radio sounding equipment. The results compared favorably with traditional seismic sounding methods and proved conclusively that this method of measuring the ice thickness and detailing the rock surface beneath the ice is reliable. Successful development of this equipment and its application to Antarctica will contribute greatly to future geophysical investigations, particularly in East Antarctica, where relatively little work has been completed. Further, if the sounding method proves to operate reliably from a long-range aircraft, a technique to map antarctic sub-ice features quickly and efficiently will be available for future exploration.

Individual Research Projects

In addition to the seasonal highlights described above, many individual research projects were carried out. Some of these were continuations of past years' work. Some of them inaugurated new studies. Most of them occurred, however, in geographical areas where the reconnaissance surveys were already completed and where specific, more detailed, and often more basic research is required.

Geology—A study of ancient, glacial tillites (nonsorted, nonstratified sediments deposited by a glacier and cemented into rock form) in the Ohio and Wisconsin Ranges of the Transantarctic Mountains continued a program begun last year in the Falkland Islands. This study is directed toward understanding the geologic relationship of Antarctica to other continents of the Southern Hemisphere. Pursuing a parallel objective, a study of plant fossils was conducted in the same area and in selected areas of Victoria Land. Both of these projects were extended to the Pensacola Mountains as part of the large-scale survey there. A special program to study antarctic cirques (steep-walled recesses in mountains caused by glacial erosion) of the Royal Society Range was inaugurated in an area between the Koettlitz and Mackay Glaciers. A study of the stratigraphy, deposition, and petrography of the Beacon sediments was made in the dry valley area. The paleomagnetic properties of volcanic rocks in the McMurdo Sound area were examined.

The long-term patterned ground studies near McMurdo Station were continued. These programs in the vicinity of McMurdo made use of 585 hours of local Navy helicopter support and were further assisted by the completion of an earth sciences laboratory facility at McMurdo Station.

Glaciology—A six-man field party remeasured strain stakes laid out between Ross Island and Roosevelt Island during the 1962-1963 season. The party, using four motor toboggans and eight Nansen sledges, left McMurdo November 18, 1965, traveled approximately 1,050 kilometers (650 miles), and arrived at its pickup point south of Roosevelt Island on January 7, 1966. They were supplied by LC-117 aircraft operating from McMurdo Station and were picked up at their destination and returned to McMurdo by an LC-130F aircraft on a routine cargo flight from Byrd Station.

A glaciological project was initiated this season at the Meserve Glacier in the lower Wright Valley west of McMurdo Sound. The glacier, like several others in the dry valleys, is independent of the antarctic ice sheet itself. Nourished by the névé fields in the hills between the ice-free valleys, the glacier is in an apparent state of balance between accumulation and ablation. To study the mechanics of this unique glacier, a tunnel was dug at its base and continued some 40 meters (130 feet) into the ice, allowing samples and data to be taken inside the glacier as well as on its surface.

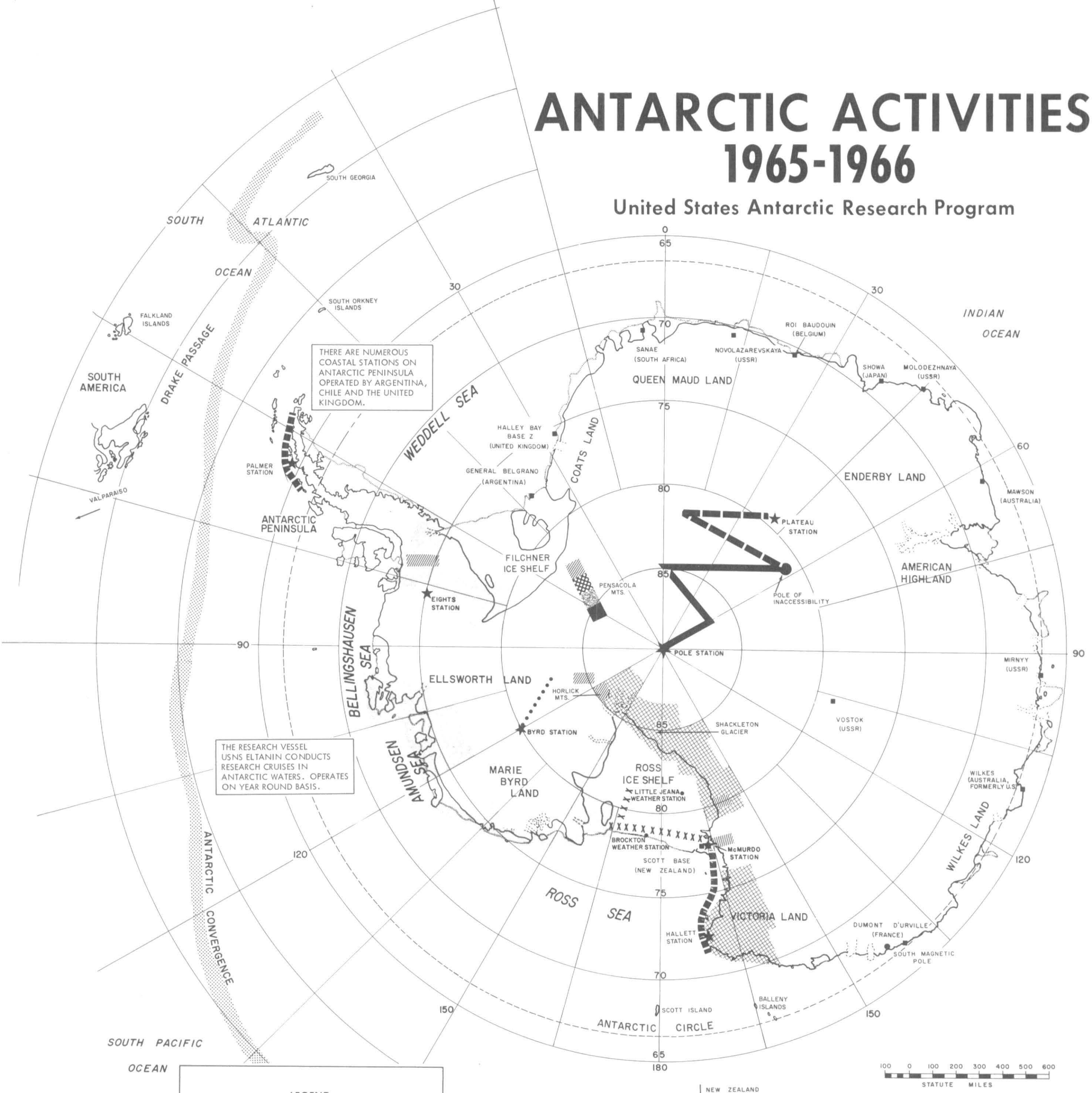
A study to measure the amount of lead pollutants in antarctic snow was carried out. Samples, which will be analyzed in the United States, were obtained near Byrd Station and at a site 200 kilometers (125 miles) from Byrd Station.

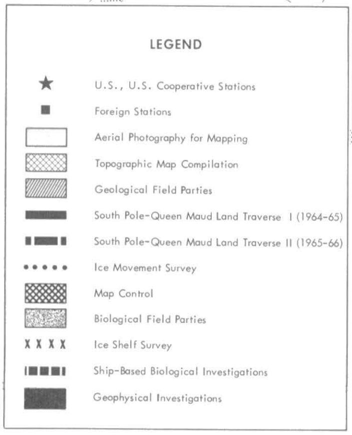
A glaciological party reexamined the chain of surface triangulation markers extending from Byrd Station 320 kilometers (200 miles) to the Whitmore Mountains. It is planned to obtain aerial photography over this network in the 1966-1967 season to determine horizontal ice movement and strain along the survey line. Movement and accumulation stake networks were also remeasured at Byrd, Eights, and Pole Stations as a part of the long-term study of the direction and rate of the movement of ice in these areas.

Biology—The seasonal biological program cen-

ANTARCTIC ACTIVITIES 1965-1966

United States Antarctic Research Program





STATION DESCRIPTION

	BYRD	HALLETT (U.S.-NEW ZEALAND)	McMURDO	PALMER	PLATEAU	POLE	USNS ELTANIN
LOCATION	LAT. 79° 59'S LONG. 120° 01'W	LAT. 72°18'S LONG. 170°18'E	LAT. 77° 51'S LONG. 166° 37'E	LAT. 64° 45'S LONG. 64° 05'W	LAT. 79° 30'S LONG. 40°E	LAT. 90°S	Western Terminus-Wellington Eastern Terminus-Valparaiso
FEET ABOVE SEA LEVEL	4,971	16	102	25	-	9,184	-
ESTABLISHED	1957	1957	1956	1965	1966	1957	1962
TERRAIN	ON INLAND ICE	ON GLACIAL MORAINE	ON VOLCANIC ASH	ON BEDROCK	ON INLAND ICE	ON INLAND ICE	-
METHOD OF SUPPLY	AIR	AIR SEA	AIR SEA	SEA	AIR	AIR	-
NUMBER OF BUILDINGS	15	10	70	2	8	11	-
MEAN ANNUAL TEMPERATURE (°F)	-18.6	+4.2	+0.1	+20 (estimated)	-	-56.7	-
MEAN TEMP. (°F) DEC., JAN., FEB.	+1.6	+28.2	+21.6	+30 (estimated)	-	-25.2	-
APPROXIMATE WINTER PERSONNEL (SCIENTISTS) (NAVY)	9 17	SUMMER STATION ONLY	7 260	5 4	4 4	7 13	scientists 34 (year round MSTS crew 48 operation)
AIR DISTANCE FROM McMURDO (STATUTE MILES)	885	380	-	2,360	1,350	820	-

tered around the biology laboratory at McMurdo Station, where numerous projects continued the pattern of research that has been productively pursued over the past several years. A long-term study of the Adélie penguin was supplemented by a study of the adaptive mechanisms of the emperor penguin, making use of field research facilities at Cape Crozier. In addition, a biologist at Hallett Station continued his analysis of parent-chick individual recognition in the Adélie penguin. A comparative biochemical study of protein in the Adélie penguin egg was carried on for the second consecutive summer, and endoparasites in antarctic penguins and antarctic fish, collected in the vicinity of McMurdo Station, were studied.

A new study of the thermal-metabolic relationships in antarctic stenothermal fishes was begun, utilizing scuba diving techniques at McMurdo to obtain specimens for study. A long-term entomological study of the antarctic area, with particular emphasis on Victoria Land, was continued at Terra Nova Bay, Cape Hallett, and in the Royal Society Range west of McMurdo. The study of the submarine ecology, acoustics, and parasitology of certain antarctic seals was continued utilizing the sub-ice observation chamber at McMurdo Station. In connection with this work, a two-week biological survey was made of the Victoria Land coast from the icebreaker *Burton Island* in January. In addition to the seal studies, collections of algae and insects were obtained using shipboard helicopters.

International Cooperation

Included in the U.S. Antarctic Research Program for the 1965-1966 summer were a number of cooperative activities involving scientists of other countries. A Norwegian glaciologist accompanied the South Pole-Queen Maud Land Traverse II. Four Japanese limnologists continued studies of the lakes in the dry valleys, and a Belgian geologist conducted glacial geology studies in the same area. A New Zealand team conducted a snow and ice craft school at McMurdo Station for members of USARP field projects and for the pararescue team of the Navy's Air Development Squadron Six.

U.S. Antarctic Research Program personnel also joined foreign research expeditions. A representative of the U.S. Antarctic Research Program participated in the recommencement of Japanese field activities and the reopening of Showa Station. United States biologists visited a king penguin study area of the Australians at Macquarie Island. A United States meteorologist joined the South African reconnaissance of Bouvet Island. New Zealand and Chilean research personnel continued to participate in the cruises of *Eltanin*.

U.S. Antarctic Research Program Field Personnel, Summer 1965-1966

Palmer Station—*Eastwind* Expedition

Angle, J. Phillip, Biology, Smithsonian Inst.
Dunser, Wolfgang S., Biology, Univ. of Miami
Fell, Jack W., Biology, Univ. of Miami
Flint, Oliver S., Jr., Biology, Smithsonian Inst.
Gressitt, J. Linsley, Biology, Bishop Museum
*Lippert, George E., Biology, Bishop Museum
Llano, George A., USARP Rep., Natl. Science Found.
Martin, Christopher, Biology, Univ. of Miami
Pastula, Edward J., Jr., Biology, Florida State Univ.
Pawson, David L., Biology, Smithsonian Inst.
Richter, Joseph J., Biology, Florida State Univ.
Squires, Donald F., Biology, Smithsonian Inst.
*Strong, Jack E., Biology, Bishop Museum
Walsh, John J., Biology, Univ. of Miami
Warnke, Detlef A., Biology, Florida State Univ.
Watson, George E., Biology, Smithsonian Inst.
Yeater, Larry W., Biology, Florida State Univ.

Pensacola Mountains

Behrendt, John C., Geophysics, U.S. Geol. Survey
Boyd, Walter W., Geology, U.S. Geol. Survey
Ford, Arthur B., Geology, U.S. Geol. Survey (Calif.)
Heiser, James R., Topo Engineer, U.S. Geol. Survey
Henderson, John R., Geophysics, U.S. Geol. Survey
Huffman, Jerry W., USARP Rep., Natl. Science Found.
Meister, Laurent J., Geophysics, U.S. Geol. Survey
Nelson, Willis H., Geology, U.S. Geol. Survey (Calif.)
Rambo, William L., Geophysics, U.S. Geol. Survey
Rosser, Earl W., Topo Engineer, U.S. Geol. Survey
Ruthven, Richard W., Topo Engineer, U.S. Geol. Survey
Schmidt, Dwight L., Geology, U.S. Geol. Survey
Soza, Ezekiel R., Topo Engineer, U.S. Geol. Survey
Wanous, Richard E., Geophysics, U.S. Geol. Survey
Weber, Max K., Topo Engineer, U.S. Geol. Survey
Wilkes, Owen, Biology, Bishop Museum

South Pole-Queen Maud Land Traverse II

Behling, Robert E., Glaciology, Ohio State Univ.
Beitzel, John E., Geophysics, Univ. of Wisconsin
*Boman, William M., Traverse Engineer, Univ. of Wisconsin
Clough, John W., Geophysics, Univ. of Wisconsin
Elvers, Douglas J., Geomag., U.S. Coast & Geod. Survey
Isherwood, William F., Geophysics, Univ. of Wisconsin
Kane, H. Scott, Glaciology, Ohio State Univ.
Orheim, Olav, Glaciology, Norsk Polarinstitutt (Norway)
Parrish, Edward N., Traverse Engineer, Univ. of Wisconsin
Picciotto, Edgard E., Glaciology, Free Univ. of Brussels (Belgium)
Robinson, Richard R., Traverse Engineer, Univ. of Wisconsin

Ohio Range-Wisconsin Range

Frakes, Lawrence A., Geology, Univ. of California, L.A.
Matthews, Jerry L., Geology, Univ. of California, L.A.
Neder, Irving R., Geology, Univ. of California, L.A.
Skinner, Courtney J., Geology, Univ. of California, L.A.

Ross Ice Shelf Survey

Dorrer, Egon, Glaciology, Grand Valley State College
Nottarp, Klemens J., Glaciology, Grand Valley State Col.
O'Hara, Norbert W., Glaciology, Grand Valley State Col.
Reinwarth, Oskar, Glaciology, Grand Valley State College
Seufert, Wilfried, Glaciology, Grand Valley State College
Stelling, David W., Glaciology, Grand Valley State College

Ellsworth Land

Halpern, Martin, Geology, Grad. Res. Ctr. of the Southwest
Lackey, Larry L., Geology, Univ. of Wisconsin
Laudon, Thomas S., Geology, Univ. of Wisconsin
Otway, Peter M., Surveying, Univ. of Wisconsin
Quilty, Patrick G., Geology, Univ. of Wisconsin
Wasilewski, Peter J., Geology, Univ. of Wisconsin

Byrd Station

Brecher, Henry H., Glaciology, Ohio State Univ.
*Burtis, William J., Ionospheric Physics, Stanford Univ.
Carlson, Paul R., Meteorology, U.S. Weather Bureau
Dewe, Michael B., Glaciology, Calif. Inst. of Technol.
Galkin, William L., Meteorology, U.S. Weather Bureau
Gow, Anthony J., Glaciology, Cold Regions R&E Lab.
Gunn, Robert C., Glaciology, Ohio State Univ.
Helms, Ward J., Electrical Engineer, Univ. of Washington
Jensen, Curtis M., Glaciology, Calif. Inst. of Technol.
Katsufrakis, John P., Radioscience, Stanford Univ.
Kieffer, Hugh H., Glaciology, Calif. Inst. of Technol.
Lang, James F., Asst. USARP Rep., Arctic Inst. of N. Am.
Leek, Gouke M., Glaciology, Calif. Inst. of Technol.
Minsch, John H., Seismology, U.S. Coast & Geod. Survey
Novocin, Norbert W., Meteorology, U.S. Weather Bureau
Patterson, Clair C., Glaciology, Calif. Inst. of Technol.
Potter, Christopher J., Glaciology, Calif. Inst. of Technol.
Rees, Manfred H., Aurora, Univ. of Colorado
Savin, Samuel M., Glaciology, Calif. Inst. of Technol.
Schoofs, Gerald J., Radioscience, Stanford Univ.
*Smith, Rossman W., Ionospheric Physics, Stanford Univ.
Squires, Peter L., Glaciology, Calif. Inst. of Technol.
Staack, Karl J., Meteorology, U.S. Weather Bureau
Toth, Stephen R., Glaciology, Cold Regions R&E Lab.
Wright, Sir Charles S., Radioscience, Pacific Naval Lab. (Canada)

Hallett Station

Collins, Eric J., Biology, Roanoke College
Gless, Elmer E., Biology, Bishop Museum
Plymale, John R., Biology, Roanoke College
Roberts, Charles L., Jr., Meteorology, U.S. Weather Bureau
Thompson, David H., Biology, Univ. of Wisconsin

McMurdo Station

Allison, Richard G., Biology, Univ. of California (Davis)
Anderton, Peter W., Glaciology, Ohio State Univ.
Black, Robert F., Geology, Univ. of Wisconsin
Bowser, Carl J., Geology, Univ. of Wisconsin
Boyd, John C., Biology, Johns Hopkins Univ.
Calfee, David W., Field Assistant, Arctic Inst. of N. Am.
Cameron, Richard L., Glaciology, Ohio State Univ.
Carnein, Carl R., Glaciology, Ohio State Univ.
Clingman, Otis, Jr., Biology, Univ. of Oregon
*Cook, David L., Logistics Assistant, Arctic Inst. of N. Am.
Cox, Allan V., Geology, U.S. Geol. Survey
Crawford, Douglas I., Biology, Johns Hopkins Univ.
Dort, Wakefield, Jr., Geology, Univ. of Kansas
Emison, William B., Biology, Johns Hopkins Univ.
Feeney, Robert E., Biology, Univ. of California (Davis)
Fenton, Michael D., Geology, Ohio State Univ.
Fitzsimmons, John M., Biology, Bishop Museum
Folk, John E., Biolab Technician, North Star R&D Inst.
Gadsden, Michael, Radioscience, Natl. Bur. of Standards
Gray, Alvin M., Radioscience, Natl. Bur. of Standards
Harrow, Geoffrey N., Biology, Johns Hopkins Univ.
Hayes, Miles O., Geology, Univ. of Massachusetts
Heer, Ray R., Jr., OAP Progr. Dir., Natl. Science Found.
Holdsworth, Gerald, Geology, Ohio State Univ.
Kassack, Nathan, Public Info. Off., Natl. Science Found.
Keinath, Gerald E., Biolab Administrator, North Star R&D
Kinet, Urbain J., Biology, Bishop Museum
Koga, Akito, Geochemistry, D.S.I.R., New Zealand
Koob, Derry D., Biology, Ohio State Univ.
Leister, Geoffrey L., Biology, Ohio State Univ.
Long, Jack B., Transport Engineer, Univ. of Wisconsin
Lowry, George, Biology, Johns Hopkins Univ.
McGee, Lawrence E., Geology, Univ. of Massachusetts
Mankinen, Edward A., Geology, U.S. Geol. Survey (Calif.)
Matz, David B., Geology, Univ. of Massachusetts
Miller, Herman T., Biology, Univ. of California (Davis)
Mills, J. Peter, Geology, Univ. of Kansas
Morris, Robert W., Biology, Univ. of Oregon
Moulton, Kendall N., USARP Rep., Natl. Science Found.
Nash, Harold A., Biolab Management, North Star R&D
Pedersen, John M., Biology, Johns Hopkins Univ.
Perkins, R. Marlin, Biology, St. Louis Zoo
Peterson, Roger T., Biology, Johns Hopkins Univ.
Pinckard, William, Biology, N.Y. Zool. Society
Potter, Neal, Economist, Resources for the Future, Inc.
Ray, Carleton, Biology, N.Y. Zool. Society
Renirie, Jack, Public Info. Off., Natl. Science Found.
Rigby, John F., Geology, U.S. Geol. Survey
Robinson, John W., Public Info. Off., Natl. Science Found.
Saunders, Jeffrey J., Biolab Technician, North Star R&D
Schopf, James M., Geology, U.S. Geol. Survey
Shima, Makoto, Geology, Inst. Phys. & Chem. Res. (Japan)
Sladen, William J. L., Biology, Johns Hopkins Univ.
Smith, Philip M., OAP Progr. Dir., Natl. Science Found.
Sorensen, Douglas J., Field Assistant, Arctic Inst. of N. Am.
Souchez, Roland A., Geology, Univ. of Brussels
Sugiyama, Junta, Biology, Chiba Inst. of Technol. (Japan)
Thern, Michael G., Station Engineer, Univ. of Wisconsin
Torii, Tetsuya, Biology, Chiba Inst. of Technol. (Japan)
Vartzikos, Nicholas, OAP Adm. Off., Natl. Science Found.
Whitcomb, Jean P., Radioscience, Natl. Bur. of Standards
Willows, A. O. Dennis, Biology, Univ. of Oregon
Wood, Robert C., Biology, Johns Hopkins Univ.
Yamagata, Noboru, Biology, Chiba Inst. of Technol. (Japan)

Plateau Station

Austin, William T., USARP Rep., Natl. Science Found.
Stroschein, Leander A., Meteorology, U.S. Army Natick Lab.
Yarbrough, Leonard S., Industr. Engineer, NASA

South Pole Station

Mabe, Charlie D., Meteorology, U.S. Weather Bureau
Preston, Harold A., Meteorology, U.S. Weather Bureau

Vostok Station

Hessler, Victor P., Ionospheric Physics, Univ. of Alaska
Jacobs, John D., Ionospheric Physics, Dartmouth College

Christchurch

Brown, Harvey E., Field Assistant, Arctic Inst. of N. Am.
Derrick, Robert O., Asst. USARP Rep., U.S. Weather Bur.
Goodale, Edward E., USARP Rep., Natl. Science Found.
MacDonald, William R., Photogrammetry, U.S.G.S.
McCallum, Donald J. B., Field Assistant, Arctic Inst. of N. Am.
Melrose, Robert L., Field Assistant, Arctic Inst. of N. Am.

Japanese Antarctic Research Expedition

Francis, Henry S., Jr., OAP Progr. Dir., Natl. Science Found.

South African Expedition to Bouvet Island

Starke, Parke, Meteorology, U.S. Weather Bureau

Campbell Island

Hughes, Wayne B., Cosmic Radiation, Univ. of California (Davis)

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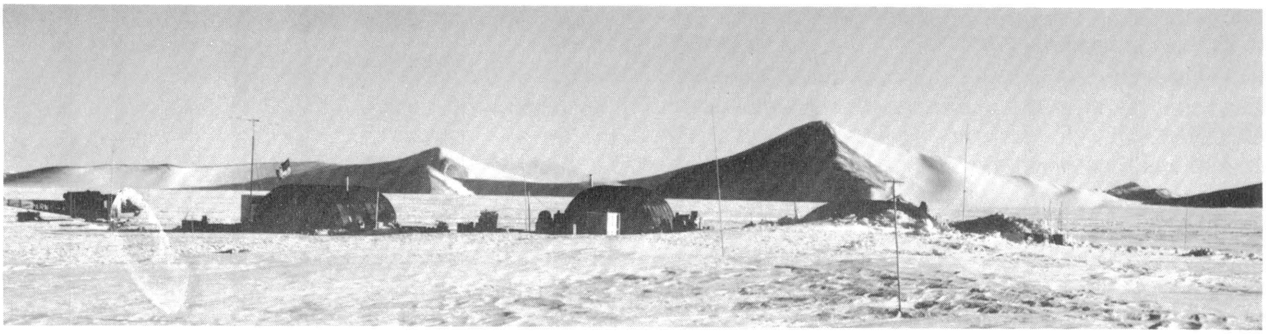
* *Wintered over in 1965.*



Camp Neptune, Pensacola Mountains *(U.S. Navy Photo)*

Pensacola Mountains Project

JERRY W. HUFFMAN [1]

Office of Antarctic Programs
National Science Foundation

and

DWIGHT L. SCHMIDT

Eastern States Branch
U. S. Geological Survey

The most ambitious field project of the 1965-1966 season was a comprehensive study of the Pensacola Mountains. The principal area explored lies between 82°15'S. 45°W., 82°15'S. 56°W., 85°S. 60°W., and 85°S. 70°W., and included the Dufek Massif, Forrestal Range, Neptune Range, and Patuxent Range (fig. 1). Adjacent areas, including the nunataks to the far south and Mts. Spann and Ferrara to the northeast, were also visited. The scientific party conducted six integrated projects including geologic mapping, geophysics (aeromagnetic, seismic, and gravimetric), geodetic control, paleobotany, paleosedimentation, and entomology. The paleobotany, paleosedimentation, and entomology projects in the Pensacola Mountains were conducted as part of broader antarctic studies which also cover other areas. Reports on these three activities are included elsewhere in this issue of the *Antarctic Journal.*

The scientific party was placed and maintained in the field for 83 days by support of U. S. Navy aircraft of Air Development Squadron Six. Close, effective helicopter field support was provided by the U. S. Army Aviation Detachment under the command of Major William C. Hampton, U.S.A.

[1] U.S. Antarctic Research Program Representative, Pensacola Mountains, 1965-1966.

The base of operations for the project was Camp Neptune, located at approximately 83°30'S. 57°00' W. Camp Neptune consisted of a 28-foot Jamesway for the galley, a 36-foot Jamesway for the Army Detachment sleeping quarters, and two 24-foot Jamesways for the USARP and Navy personnel sleeping quarters. The 34-man field party was composed of 18 scientists and engineers, a USARP representative, a Navy aerographer, and 14 officers

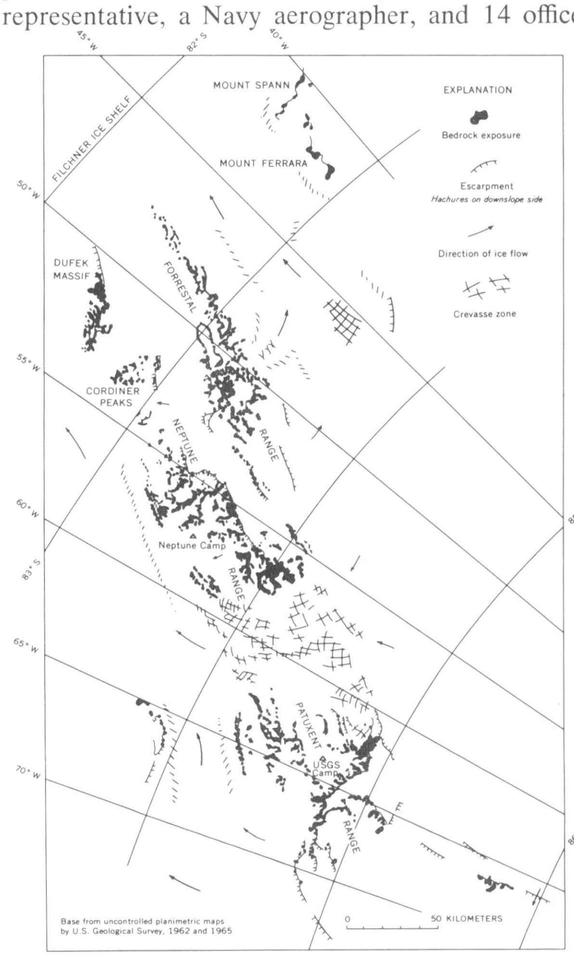


Fig. 1. Index Map of Pensacola Mountains

and men of the Army Aviation Detachment. Six additional Navy personnel were at the camp during the eight-day aeromagnetic survey in mid-December. The initial landing at Neptune was made on October 26, 1965, and the majority of the scientific party arrived on November 2. The major portion of the program was completed by January 9, 1966, and the final airlift from the Pensacolas took place on January 17.

Three UH-1B turbine helicopters transported the scientists and engineers to their areas of study, and an LC-117 aircraft flew 7,500 kilometers (4,700 miles) of aeromagnetic survey. LC-130F aircraft from McMurdo Station provided the heavy transport for 250 tons of fuel and supplies, including the helicopters. Four Polaris snow toboggans served as supplementary surface transportation for scientific parties as well as transport for fuel and supplies in the camp vicinity.

The advent of large-scale air support for a complex program of investigations in the Pensacola Mountains accelerated their exploration on a broad front. These mountains were discovered only 10 years ago, on January 13, 1956, during an aerial photographic mission by the U. S. Navy. In December 1957, members of the Ellsworth Station traverse party briefly examined the northwestern part of the Dufek Massif (Aughenbaugh, 1961). In the austral summer of 1962-1963, a U. S. Geological Survey party began systematic mapping of the Patuxent Range using three motor toboggans, and continued in the Neptune Range during the 1963-1964 field season. The U. S. Navy completed the aerial photography of the region during the 1964-1965 season.

The geological study of the Pensacola Mountains was divided between the complex, layered gabbro of the Dufek Massif, and the sedimentary units throughout the several mountain ranges. Paleobotanists collected fossil material as an integral part of the geological study of the area. The geological studies were combined with topographic and geophysical projects. The topographic survey provided control for the compilation of topographic maps utilizing aerial photography. The geophysical program, including seismic reflections, gravity and aeromagnetic observations, measured ice thicknesses and defined major sub-ice features. Data were also obtained on the structure of the Earth's crust across the contact of East and West Antarctica.

The entomologist sampled the various mountain ranges for insects and environmental data related to their development and habitat. In addition, a microclimate observation station, which recorded soil temperatures continuously, was operated near Camp Neptune. Mite species were widespread and were found at elevations as high as 1,830 meters (6,000 feet). Distribution appeared to be controlled by soil moisture content. During much of the season, one helicopter was used for the Dufek Massif study, and a geophysicist with a gravimeter accompanied two geologists. The remaining helicopters were used for the combined topographical survey and geological study. While two topographic engineers in each of two helicopters were conducting survey operations, the third man, a geologist, obtained gravity data during his reconnaissance of nearby areas. The topographic survey required approximately two hours for each traverse station, which allowed the geologist time to map the local features. Other gravity readings were obtained by brief landings of the helicopters during transfer of a topographic crew from peak to peak. The second topographic crew, using theodolites, obtained precise elevation control of the gravity stations. Numerous additional gravity readings on outcrops and ice stations were controlled by altimetry. Over 350 gravity stations were established during the operation. The entomologist and paleobotanists accompanied the geologic and topographic parties as opportunity permitted.

The early-November operations were somewhat less efficient than midsummer operations because of extremely cold weather, −33°C. (−27°F.), and high winds on the eastern peaks where the topographic traverse was then being conducted. Seismic operations were curtailed by low snow-surface temperatures early in the summer season. The low temperatures produced a noise effect which masked the sound energy return from the sub-ice interface. For this reason, the seismic traverse was deferred until test soundings at Camp Neptune indicated favorable conditions for a concentrated effort. During the seismic sounding operation, one helicopter was devoted entirely to transporting the seismic crew and equipment, while a second was utilized by the topographic engineers in determining the locations of the seismic stations by sun, moon, and star observations. The topographic crew also took gravity readings as it progressed along the seismic traverse following the geophysicists. The Army helicopter pilots predetermined standard headings for the seismic traverse lines prior to leaving known mountain areas. These headings provided references for flying over the featureless snow terrain, and the pilots were able to locate the flagged seismic stations the following day to resume operations. The aeromagnetic survey required 38 flight hours between December 9 and December 16, 1965.

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Geology of the Northern Pensacola Mountains and Adjacent Areas

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U. S. Geological Survey

The northern Pensacola Mountains are composed of folded sedimentary rocks and stratiform gabbroic rock. About half of the northern Pensacolas consists of folded, interbedded graywacke and slate (Patuxent Formation) of Precambrian age that is unconformably overlain by folded limestone (Nelson Limestone), volcanic rocks, and shale of Cambrian age. This, in turn, is unconformably overlain by folded sandstone of middle Paleozoic age (Schmidt *et al.*, 1965). A gentle regional plunge to the north results in prominent outcrops of pebbly mudstone (Gale Mudstone) of Permian (?) age and overlaying coal- and *Glossopteris*-bearing siltstone and shale of Permian age. The Permian rocks in the northern Pensacolas were broadly folded at the same time that the middle Paleozoic rocks were folded, but before the intrusion of stratiform gabbroic rock. The Gale Mudstone, a diamictite containing clasts of all the older sedimentary and igneous rocks of the area, is a tillite occurring within an area 50 by 100 kilometers (30 by 60 miles) (Frakes *et al.*, in press).

Stratiform gabbroic rock in the Dufek Massif and Forrestal Range of the northern Pensacola Mountains has been mapped and sampled in detail. If the mafic rock of these two ranges is part of a single intrusion, as seems likely, it forms one of the largest stratiform bodies in the world; its exposed part underlies a minimum area of 8,000 square kilometers (3,000 square miles) and is a minimum of 2,000 meters (6,600 feet) thick. Widespread feldspathic pyroxenite, in layers 1 to 3 meters (3 to 10 feet) thick, and less widespread magnetite layers and lenses lie with sharp contact on thick layers of anorthosite or leucogabbro. They grade upward into thick layers of gray gabbro. Centimeter-scale, rhythmic layering is characteristic. Numerous channel-like structures, tens of meters wide, are filled with layered pyroxenites, iron oxides, anorthosite, and leucogabbro, with sharp basal contacts. The rock which fills the channels grades across an upper contact into normally interlayered gabbroic rock. These channels may have been formed by currents of probably convective origin. Neither the base nor the top of the stratiform pile is exposed, but fine-grained, chilled phases border locally contact-metamorphosed Paleozoic quartz sandstone. The layers dip about 10°SE. The body has been uplifted along high-angle faults bordering the southeastern margin of the Filchner Ice Shelf. The age of the body is uncertain, but a post-Permian age is indicated by the metamorphic effects on nearby carbonaceous, *Glossopteris*-bearing, sedimentary rocks.

Three areas outside of the Pensacola Mountains, not previously visited by man, were mapped. A group of nunataks, 120 kilometers (75 miles) southwest of the Neptune Range, consists of intensely folded, rhythmically interbedded graywacke and slate (Patuxent Formation) of Precambrian age and folded quartz sandstone that unconformably overlies the graywacke. The Mount Ferrara area, 95 kilometers (60 miles) east of the Forrestal Range, consists of folded Nelson Limestone containing abundant archaeocyathids. The Mount Spann area, 120 kilometers (75 miles) northeast of the Forrestal Range, consists of interbedded, metasedimentary quartzite and siltstone that probably underlies the Cambrian Nelson Limestone and is probably much thicker than the estimated 1,000 meters (3,300 feet) of exposed section. This quartzitic formation is not exposed in the Pensacola Mountains, and its relation to the Patuxent Formation is not known.

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Geophysical Reconnaissance in the Pensacola Mountains

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A seismic reflection, gravity, and aeromagnetic reconnaissance was made in the Pensacola Mountains, Antarctica, during the 1965-1966 austral summer. Prominent ice streams between the Neptune and Patuxent Ranges and east of the Forrestal Range overlie channels, probably of glacial origin, in the rock surface 2,000 meters (6,600 feet) below sea level. Seismic reflections show the Filchner Ice Shelf to be 1,250 meters (4,100 feet) thick near its southern margin.

Bouguer anomalies decrease from +60 to —80 mgal. across the boundary from West to East Antarctica. An abrupt change in crustal structure across this boundary is required to explain the 2 mgal./km. gradient. Aeromagnetic profiles delineate anomalies up to 1,800 gammas associated with the basic stratiform intrusion comprising the Dufek Massif and Forrestal Range. A probable minimum areal extent of 9,500 square kilometers (3,700 square miles) is calculated for the intrusive on the basis of the magnetic anomalies, making it one of the largest bodies of its type in the world. The extent of this magnetic anomaly across a fault forming the north border of the Pensacola Mountains probably precludes transcurrent movement.

Topographic Field Operations

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Topographic mapping in Antarctica was continued in 1965-1966. Five topographic engineers were assigned to obtain geodetic control for the topographic mapping program and to execute surveys in support of projects in geology, seismology, geophysics, and glaciology.

Eight hundred twenty-five kilometers (512 miles) of electronic traverse were completed in the Pensacola Mountains, expanding the work begun in 1962 and completing ground survey control for topographic mapping of the Pensacola Mountains area. This traverse was begun in the Neptune Range and extended north through the Forrestal Range to Mt. Spann and Mt. Ferrara, thence to the nunataks to the far south. At the beginning, midpoint, and end of the main traverse, control lines were run 160 kilometers (100 miles) to either side to determine the positions of seismic stations. As part of this project, an evaluation of the Airborne Control (ABC) system was made in which a hovering helicopter is used as a survey platform. The future value of this system in Antarctica is doubtful with existing equipment.

A 1:25,000-scale topographic map of the Dufek Massif was prepared at the request of the geological team. After laying out a base line using electronic distance-measuring instruments and altimeters, the Massif area was mapped using standard plane-table procedures and terrestrial photographs.

USCGC *Eastwind* Oceanographic Cruise

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National Science Foundation

The cruise of USCGC *Eastwind* supported marine biological and oceanographic studies which constituted the major 1965-1966 summer scientific effort of the U. S. Antarctic Research Program in the Antarctic Peninsula. The cruise began at Valparaíso, Chile, December 25, 1965, and terminated on February 26, 1966, at Punta Arenas, Chile. Of the 57 days aboard ship, 35 were applied to scientific work, 7 to port calls, and 15 to the resupply of Palmer Station. The area of study included Marguerite Bay, Anvers Island, Gerlache and Bransfield Straits, the Weddell Sea, the South Orkney Islands, and the Drake Passage. During the major effort from January 1 to February 26, *Eastwind* steamed 6,877 nautical miles (fig. 1). Fifty-nine ocean stations were made. Twenty-one land sorties were completed, primarily by helicopters which flew 65 hours in support of the terrestrial and related scientific work. The ship's complement consisted of 21 officers, including 4 aviators, 182 enlisted men, and 15 scientists.

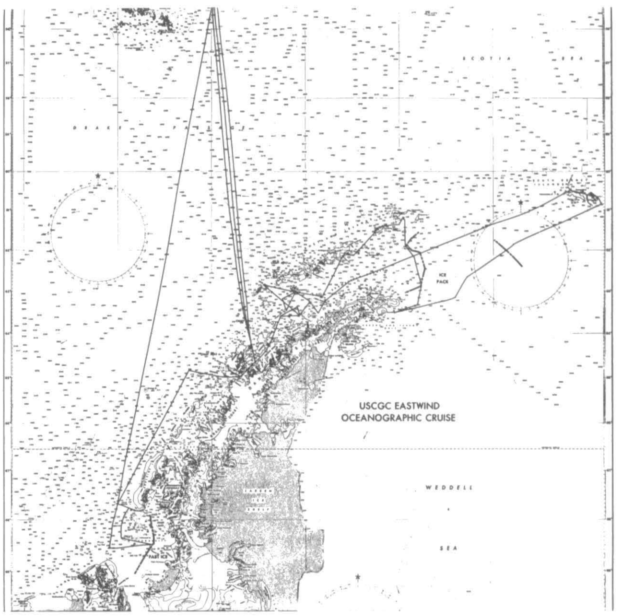

Fig. 1.

[1] U.S. Antarctic Research Program Representative, Antarctic Peninsula, 1965-1966.

The oceanographic cruise was planned in three stages in order to accommodate the scientific work to the resupply of Palmer Station. *Eastwind* departed Valparaíso on Christmas Day to begin the first phase. The six-day run to Punta Arenas provided the opportunity to check scientific stores, to set up instruments, and to prepare the laboratories. Nets for the collection of wind-borne insects were streamed from the halyards, and this activity was continued throughout the cruise. An empty CONEX cargo box was fitted with a worktable and equipped with lights for use as a deck laboratory.

Eastwind departed Punta Arenas on New Year's Day for Palmer Station on Anvers Island to deliver personnel, fuel oil, and general cargo; on January 14, the ship returned to Punta Arenas disembarking the winter party and taking on cargo, fuel, and the remaining five scientists for the shipboard program. Coordination of the cruise plans and the scientific program requirements were finalized by the scientific party and coordinated with the captain.

The second phase extended from January 18 to January 29 and saw the commencement of the full-scale research program coordinated with the mission of *Eastwind* to escort the cargo ship USNS *Wyandot* to Anvers Island. During this time, 9 sorties were made to 12 islands in the vicinity of Anvers Island for ornithological and entomological studies. *Eastwind* then proceeded south to Marguerite Bay, where four oceanographic stations were completed, and biologists were landed on nearby Avian Islet. One further oceanographic station was completed northwest of Anvers Island while *Eastwind* waited for *Wyandot*.

At the conclusion of the resupply of Palmer Station, the third phase was initiated with oceanographic stations in Gerlache and Bransfield Straits, and ended with a series in Port Foster, Deception Island. Land sorties were completed throughout this period in Bransfield and Gerlache Straits.

On February 6, in response to a call for medical assistance, *Eastwind* broke off scientific work and proceeded directly to the United Kingdom base on Signy Island. Oceanographic work was then resumed northwest of Coronation Island in the South Orkney Islands, and was continued across the Weddell Sea to Dundee Island in Erebus and Terror Gulf. Here, heavy pack ice, a large number of icebergs, and severe storms made landings impossible although oceanographic stations were completed. The ship broke out of the Weddell Sea pack ice halfway across Bransfield Strait en route to Elephant Island, then proceeded to Gibbs, King George, and Tower Islands, arriving back at Anvers Island on February 20. Visits to provide a briefing on the U. S. Antarctic Research Program, Palmer Station, and the *Eastwind* oceanographic cruise were also made in Arthur Harbor, January 26, to the Argentine vessels *Irigoyen* and *Lapataia*.

Collection equipment on *Eastwind* consisted of a hydraulic winch and platform, Phleger corers, Van Dorn and Niskin biological samplers, a one-meter plankton net, and several Blake bottom trawls. The hydrographic laboratory was provided with a Wood-Kimball continuous centrifuge, Millipore filtration equipment, incubator and refrigerator, and several microscopes, including one for fluorescent studies. Berlese funnels were mounted in the forward hold for the entomological work. An area forward of the stack served as a dissecting and skin preparation laboratory for the ornithologists.

In addition to the individual research projects reported hereafter, the USARP Representative trawled for krill, *Euphausia* sp., obtaining 20 kilograms required for chemical and nutritional studies at the University of California, Davis. All plant materials collected for screening arthropods in the Berlese funnels were preserved for systematic studies. Mosses and hepatics were forwarded to the New York Botanical Garden; lichens are being accessioned by the United States National Museum.

Distribution of Marine Fungi

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Institute of Marine Science
University of Miami

Two studies were conducted, one on the occurrence and distribution of marine fungi and the other on the vertical distribution of phytoplankton. Parallel work was also carried out at Palmer Station for information on the marine fungi in the inshore waters. Collecting for the two shipboard projects was integrated into one operation. An Institute hydrographer provided the required physical data for all oceanographic programs. Thirty stations were taken, sampling at standard depths from surface to bottom with Niskin samplers. A one-meter plankton net was used at 27 vertical phytoplankton stations. In addition, 35 water samples were taken at hourly intervals for data on diurnal phytoplankton fluctuations, and 21 Phleger cores were pulled for bottom samples. Sea ice, bird feces, and terrestrial soil samples were examined for algal and fungal materials. The combined work on the ship and at Palmer Station resulted in a collection of about 400 pure cultures of marine yeasts and other fungi; the phytoplankton materials amounted to 600 water and sediment samples. Cultures and samples were shipped to the University of Miami for analysis.

Geomicrobiological Parameters Along the Antarctic Peninsula Shelf

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Florida State University

The objective of this program was to obtain information on the interrelationships of bacterial and other microbiological populations to the physiochemical properties of the water masses and the sediments. Shipboard observations were made in cooperation with the University of Miami because of common objectives and working procedures. Phleger cores and bottom grabs provided bacteriological and bottom specimens for data on patterns of sedimentation. Stations were occupied in water depths ranging from 25 to 1,800 fathoms. Successful inoculations were obtained from all stations which were sampled bacteriologically, but not at all sampled levels. Over 300 pounds of geological materials and cores were returned to the University.

Entomological Collections

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and
OLIVER S. FLINT, JR.

Department of Entomology
Smithsonian Institution

Entomological research was conducted by personnel from the Bernice P. Bishop Museum and the Smithsonian Institution. Smithsonian personnel picked over all the bird specimens for external parasites. Mallophaga (biting lice) were taken on 13 species (47 birds) and feather mites on 4 species. It was observed that birds taken on nesting sites were only rarely infected with lice, whereas those shot at sea were frequently heavily parasitized. Fine pumice grains were found in the feathers of two skuas shot at sea during passage through Lemaire Channel. In addition, plant materials and soil placed in Berlese funnels provided 56 species of Collembola and about seven species of Acarina. An estimated 15- to 20,000 arthropods were collected for the national collections. The Bishop Museum made an additional 125 collections from 17 land sorties, consisting of about 20 species with new observations on geographical ranges and ecological data.

Benthic Invertebrate Collections

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Smithsonian Institution

and

LARRY W. YEATER

Department of Biological Science
Florida State University

Benthic trawling was carried out by personnel of the Department of Invertebrate Zoology of the Smithsonian Institution in cooperation with a graduate student from the Department of Biology of Florida State University. The Smithsonian obtained scleractinian corals and holothurians. The Florida State zoologist sought octopus to obtain mesozoan parasites. Live corals were obtained at several stations. The corals were easily kept alive aboard ship for more than three weeks, permitting important observations on the reproductive behavior of three species of the genus *Flabellum* and one species of *Gardineria*. Breeding information was also obtained on the psolid holothurians, as well as valuable information on habitat, faunal associations, and commensalism. Approximately 500 gallons of samples of invertebrate specimens and fishes were collected in the course of the cruise, from which 145 gallons of specimens were selected. Live corals were successfully returned to the Smithsonian Institution. Twenty-three cephalopods were collected in the trawls; five of them proved to be infected.

Identification Guide to Antarctic Birds

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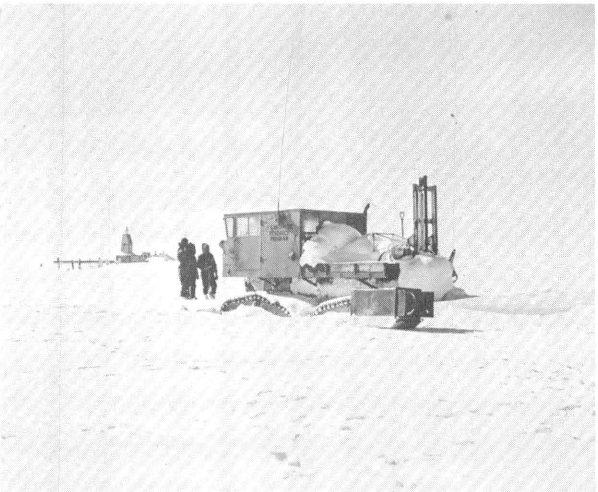
Smithsonian Institution

For the ornithological work of the Department of Vertebrate Zoology of the Smithsonian Institution, specimens and field observations were obtained for preparation of a manual on antarctic birds. Specimens were collected at 20 land localities, and a few additional specimens were secured at sea. In addition to 349 bird specimens, large samples of avian blood and stomach contents were preserved. Observational data included taped records of bird calls and visual, still, and cinephotographic records. About 100 birds were banded. For a number of species collected, the specimens represent very valuable examples for the national collections of the Smithsonian Institution.

The South Pole-Queen Maud Land Traverse II, 1965-1966



(Photo: E. E. Picciotto)

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On November 22, 1965, a U.S. Navy LC-130F aircraft took off from the South Pole Station with the 11-man party of the South Pole-Queen Maud Land Traverse II (SP-QMLT II) and 22,000 lbs. of equipment and fuel. Its mission was to unload the men and cargo at the Soviet station at the Pole of Inaccessibility, 82°07′S. 55°06′E., a small, unoccupied station, 800 kilometers (500 miles) from the South Pole.

At the end of the 1964-1965 season, a party of nine scientists and technicians in three Sno-Cats had arrived at this station after completing a 1,340 kilometer (725 n. mile) traverse from the South Pole. This event marked the end of the South Pole-Queen Maud Land Traverse I. The three vehicles were left at the Pole of Inaccessibility for use on the 1965-1966 traverse.

The South Pole-Queen Maud Land Traverse is a major project of the U.S. Antarctic Research Program. Its objective is the scientific exploration of the area between the Greenwich meridian and the 40° East longitude. This zone of Queen Maud Land is the last, large, unknown area in Antarctica, and probably on the Earth's surface. It was first crossed during the summer of 1963-1964 by the Soviet traverse, Vostok-Pole of Inaccessibility-Molodezhnaya, led by A. P. Kapitsa.

The plan is to investigate this area in four summer traverses along a zigzag route extending from the South Pole to the Princess Ragnhild Coast. The scientific objectives include the determination of the surface and subglacial rock topography, observations of the geomagnetic field, and studies of the physical properties of the ice sheet. Weather observations and collection of snow samples for various geochemical studies are also included in the program.

The group of the SP-QMLT II included eight scientists and three traverse engineers representing the Free University of Brussels, Ohio State University, University of Wisconsin, and U.S. Coast and Geodetic Survey, and an exchange scientist from the Norwegian Polar Institute. Four of the party were also on last year's traverse (SP-QMLT I). During the three weeks spent at the Pole of Inaccessibility, an additional traverse engineer assisted in the preparation of the vehicles, a Tucker Sno-Cat, model 743, which was equipped with a drill for boring 40-meter (130-foot) holes, and two Tucker Sno-Cats, model 843, which were used as living quarters by most of the members (three men slept in tents).

An expansion of the scientific program raised serious problems in installing equipment in the limited space still available in the vehicles. The two 843 Sno-Cats were turned into moving physics laboratories. In addition to the usual equipment—seismograph, altimeters, magnetometers, Tellurometers, radio transmitters and receivers, etc.—three new instruments were used for the first time on a major antarctic traverse: a radio sounding device, an electronic quartz thermometer, and a neutron density probe designed to record continuous density and profiles in 40-meter (130-foot) boreholes.

After a 10-day period of acclimatization at the South Pole Station, the traverse team proceeded by air to the Pole of Inaccessibility. The landing was brilliantly carried out in good weather, with no wind, and temperature around −40°C. (−40°F.). The 22,000 pounds of cargo were unloaded in less than 40 minutes, but owing to the soft snow conditions, the takeoff required several hours of effort. No appreciable changes had taken place at the site since the previous summer. The cached equipment was quickly excavated from a slight drift, and the vehicles were easily started. The initial plan was to spend 10 to 15 days fixing the vehicles and to start the traverse on December 1. In fact, 23 days, from November 22 to December 15, were required to put the vehicles in working order and to install the scientific instruments. In spite of strenuous efforts, the efficiency of the work was not too high,

[1] Leader, South Pole-Queen Maud Land Traverse II; designated by the National Science Foundation.

owing to the high elevation, intense cold, and relatively strong wind.

An interesting attempt to improve working conditions was carried out. The whole vehicle park was covered with a 25- by 30-meter (80- by 100-foot) translucent plastic sheet. This "greenhouse" provided an excellent shelter against the wind, with an inside temperature 15° to 20°C. higher than on the outside. Unfortunately, this comfortable shelter lasted only three days before it was destroyed by high winds.

From the previous year's experience, unfavorably soft snow was to be expected at least during the first 185 kilometers (100 n. miles) from the Pole of Inaccessibility; ergo, it was essential to keep the weight of the vehicles at a minimum. With this in mind, one of the Rolli-trailers was disassembled, the heavy steel bed was discarded, and the four tires, used as fuel containers, were put together in a light assembly. The weight of food, fuel, and explosives was also kept at a minimum. About one ton of food and 300 gallons of fuel were left near the station.

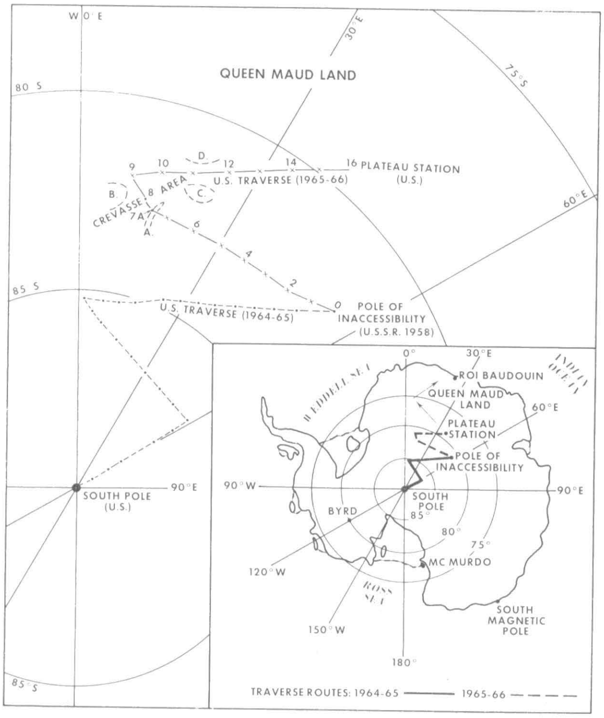

Fig. 1.

During the three-week stay at the station, the SP-QMLT II achieved the following scientific objectives: an astronomical determination of the position and a detailed map of the station; tellurometric measurement of the strain-rate network established by the Soviet expedition in 1964; studies of the magnetic field; measurements of the accumulation stake network established in February 1965 by the SP-QMLT I; the establishment of a new five-kilometer (three-mile) accumulation stake line; studies by seismic and by radio soundings of the thickness and the physical properties of the ice sheet; surface weather observations; and glaciological pit studies.

On December 15, everything was finally ready, and the leading Sno-Cat started west. The three Sno-Cats were hauling, in all, three one-ton sleds, three two-ton Maudheim sleds, one Rolli-trailer, and the four-wheel assembly. The total load was approximately 40,000 pounds including about 12,000 pounds of fuel, 2,000 pounds of food, and 2,000 pounds of explosives. This equipment had been airlifted from McMurdo Station by LC-130F on the initial flight of November 22 and a second flight on December 3, 1965.

The proposed plan was to reach the Greenwich meridian and then turn on an approximately northeast course to the site of Plateau Station, which was to be established in January 1966. There the Sno-Cats were to be taken apart and flown back to McMurdo Station. The traverse was expected to arrive at Plateau Station not later than February 1, after which date weather conditions were expected to be too severe for air operations and traverse activities.

Owing to its late departure, the traverse had to turn northeast at 82°00′S. 09°35′E. on January 8, and reached Plateau Station at 79°15′S. 40°30′E., on January 29, 1966 (fig. 1). A total distance of 1,340 kilometers (725 n. miles) was covered in 45 days at an average speed of 30 kilometers (16.1 nautical miles) per day. Several days were spent at Plateau Station making additional observations and preparing the vehicles for backloading. Six LC-130F flights were needed for this operation. The last flight left Plateau Station on February 10, 1966.

Several delays were encountered en route. Mechanical failures were exceptionally few. The only important one, which delayed the traverse for two and one-half days, was a broken front axle. On December 30, at the end of a drilling operation, 28 five-foot drill sections fell back into the borehole. The retrieval of the sections, an absolute necessity for the continuation of the seismic program, was successfully accomplished at the cost of excavating a 15-meter (50-foot) trench, which took five days of unceasing digging. In compensation, this trench allowed the measurement of the snow density profile down to 15 meters (50 feet), affording an opportunity to calibrate the neutron density probe.

On January 4, the traverse unexpectedly encountered a heavily crevassed zone at 82°45′S. 15°02′E., and a day was spent retrieving one of the Sno-Cats, the front pontoons of which broke through a snowbridge. The main crevasses, several tens of meters in width and 5 to 7 kilometers (3 to 4.5 n. miles) in length, were oriented in an approximate east-west direction. The crevassed zone is above a major anomaly in the bedrock topography, an abrupt rise of over 1,200 meters (3,900 feet) over a horizontal distance of less than 9 kilometers (5 n. miles). Two similar crevassed zones were identified by aerial reconnaissance at approximately 82°30′S. 08°E. and 82°S. 22°E.

Two scheduled airdrops, on December 26, 1965, and on January 17, 1966, resupplied the traverse with fuel. An additional airdrop on January 6 supplied spare parts. The rapidity and efficiency of these aerial resupply missions contributed in a major way to the success of the traverse.

Geomagnetism and Navigation on the South Pole-Queen Maud Land Traverse II

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DOUGLAS J. ELVERS

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Environmental Science Services Administration

Responsibilities of the U.S. Coast and Geodetic Survey on the South Pole-Queen Maud Land Traverse II were to perform a magnetic survey over the entire traverse route for determining the distribution of intensity and direction of the Earth's magnetic field, and navigation duties in guiding the party over its previously determined course. Magnetic measurements of total intensity were taken with a portable Varian M-49 proton magnetometer every nine kilometers (five n. miles). At major stations every 40 n. miles, in addition to the total intensity measurements with the proton magnetometer, magnetic measurements of declination and inclination were taken with a saturable-core, inductor (fluxgate) magnetometer mounted on a Gurley transit. Fig. 1 shows the total intensity (F) measurements along the track. Several magnetic anomalies are evident. The largest one, MA3, is over 500 gammas below the smoothed F line. The curves of MA3 and MA7 are shapes typical of plotted total intensity values taken on a crossing at right angles to the strike of a magnetic body. Fig. 2 shows declination values determined at the major stations. The data showed good self-consistency along the straight-line portions of the track, with expected departures where the track line jogged.

Magnetic data, ranging from recordings of rapid and secular change to accurately observed values of the vector field at many points throughout this previously unexplored region, are vital for adequate knowledge of the geomagnetic processes in Antarctica, as well as throughout the world. A preliminary comparison of SP-QMLT II data with the latest version of the World Magnetic Charts shows differences in excess of those usually encoun-

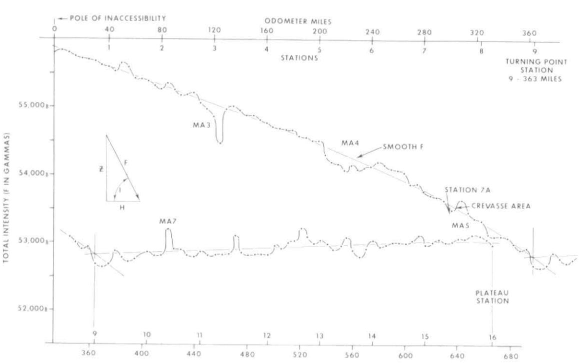

Fig. 1.

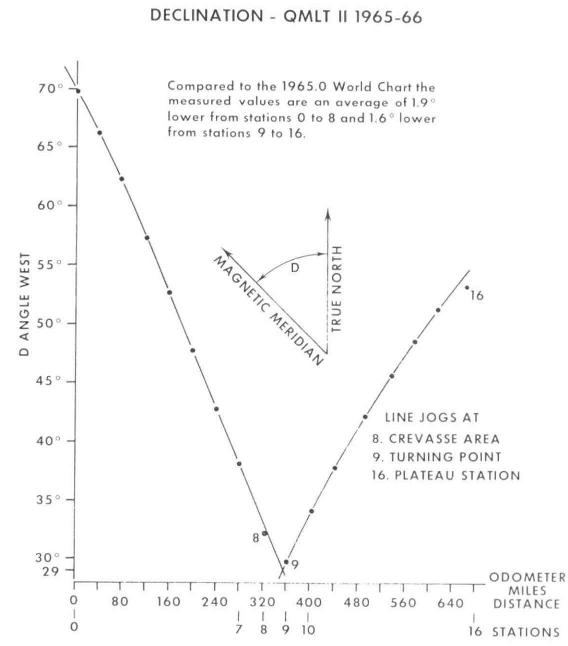

Fig. 2.

tered in other parts of the world. These new data from SP-QMLT II will be used in the compilation of the next version of the charts and will greatly strengthen the chart values for Antarctica.

Geodetic positions were determined every 40 nautical miles at the 17 major stations using a Kern DKM-2 theodolite. Severe weather conditions and extreme refraction of the sun sometimes hampered position determinations. Between these principal points, navigation was performed by use of a simple sun compass and a tank magnetic compass mounted near the driver of the lead Sno-Cat. Trail azimuth and slope shots were taken with a transit at more frequent, nine-kilometer intervals to check the track further. These slope shots also recorded as surface highs the three suspected crevassed areas, and a fourth area was also sighted as a possible crevassed zone.

Glaciological Studies on the South Pole-Queen Maud Land Traverse II

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During the 1965-1966 antarctic field season, an intensive glaciological program was conducted on the South Pole-Queen Maud Land Traverse II from the Pole of Inaccessibility to Plateau Station. Twenty-seven glaciological stations were established along the route of the traverse. At each station a 2- to 3-meter (7- to 10-foot) pit was excavated, and stratigraphy and density were measured. Samples were also taken for laboratory analysis of Sr^{90} and Pb^{210}, to determine the rate of snow accumulation. Measurement of stable oxygen and hydrogen isotopes and analysis of chemical elements and particulates will also be made on these samples. Additionally, 8- to 10-meter (25- to 30-foot) core sections were taken for subsequent analysis of the microparticle profile.

Temperature measurements were taken in twenty 40-meter (130-foot) deep boreholes, the emphasis being placed on the temperature gradient between 20 and 40 meters (65 and 130 feet). The temperatures were measured to $\pm 0.002°C$. with the new Dymec Quartz Crystal Thermometer in order to determine, to a meaningful accuracy, the small geothermal/climatic temperature gradient at the surface of the ice sheet. This new electronic device records temperatures by measuring the variation of frequency with temperature of a quartz crystal sensor.

Forty-meter (130-foot) boreholes were logged at 16 sites with an automatic neutron density probe. This piece of equipment, designed at the Institute of Polar Studies, proved to be a useful tool for rapid measurement of depth-density profiles.

In addition to these studies, continuous meteorological, surface hardness, and surface relief records were kept by Mr. Olav Orheim, the Norwegian exchange scientist. Surface snow samples were collected at 27 stations to begin studies on the distribution of particulate deposition across this portion of Antarctica. Additional studies will be initiated to determine the mechanism of particulate deposition as well as the migration of such particles during metamorphism of the firn.

Geophysical Studies on the South Pole-Queen Maud Land Traverse II

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Ice surface elevations along the traverse route were determined with 12 aneroid altimeters, which were read at intervals of approximately nine kilometers (five n. miles). In addition, two altimeters were monitored almost continuously. The elevations ranged from 3,718 meters (12,198 feet) above sea level at Pole of Inaccessibility, to 2,512 meters (8,241 feet) at the turning point. The ice surface sloped upward from the traverse turning point (82°00'S. 09°35'E.) eastward with regional gradients of 2 to 5 meters (7 to 16 feet) per nautical mile (see fig. 1). Smaller topographic features of the order of tens of meters in height and of kilometers in horizontal extent were ubiquitous.

The ice thickness, which averaged nearly 2,800 meters (9,200 feet), was measured seismically at 18 vertical reflection stations, generally spaced about 75 kilometers (40 n. miles) apart. Gravity field measurements at nine-kilometer (five-mile) intervals provided additional ice thickness information. The tentative results of these measurements are shown in the ice and rock surface profile, (fig. 1). Three short seismic refraction profiles and three wide-angle reflection profiles were established to help determine more accurately the velocity of seismic waves in the ice cap. Four long refraction profiles were attempted, but yielded poor results.

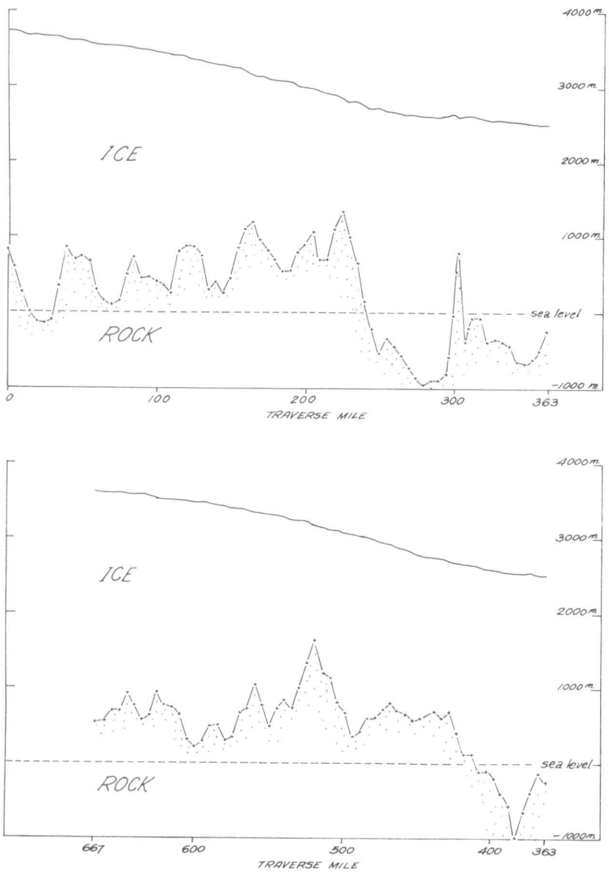

Fig. 1.

Radio-frequency depth measurements were made on a major antarctic traverse for the first time. The equipment, which was developed for the U.S. Army Electronics Command, consists of a 30 mc./s. pulsed radar transmitter and receiver. The pulse travel-time is measured on an oscilloscope. The travel time was recorded every 0.37 kilometers (0.2 n. miles) and photographs were obtained at one-mile intervals. Echoes were received from depths as great as 3,500 meters (11,500 feet) and were received over 90 percent of the radio sounding profile. This profile extended over 1,000 kilometers (530 n. miles) of the traverse.

Velocity determinations by the wide-angle reflection technique were attempted. The horizontal ranges, limited by usable echo strength, were less than adequate for a reliable velocity result. Therefore, the radio sounding travel-time was instead tied to the seismic depth at 15 stations, and the velocity thus obtained was used to provide a detailed profile of ice thickness. The character of this profile agrees very well with that provided by gravity measurements on the rock surface profile (fig. 2).

The strain network which was established by U.S.S.R. personnel at the Pole of Inaccessibility in February 1964 was remeasured in December 1965 with Tellurometers. Another strain network, in the form of a quadrilateral 19 kilometers (10 n. miles) in circumference, was established at Plateau Station at the conclusion of the traverse.

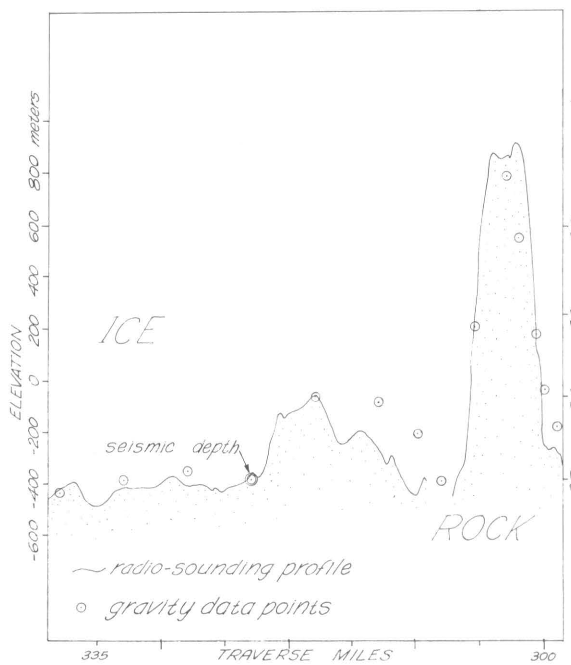

Fig. 2.

Geology

(Photo: P. M. Otway)

Late Paleozoic Glacial Rocks, Pensacola and Horlick Mountains

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Permian (?) glacigene rocks in the Ohio and Wisconsin Ranges of the Horlick Mountains consist of up to 300 meters (1,000 feet) of flat-lying diamictite with stones as large as 6 meters (20 feet) in diameter. These are composed mostly of gray metasiltstone of unknown source and also of locally exposed rock types. The strata, assigned to the Buckeye Tillite, are subdivided into six sedimentary facies: for example, at four different levels within the tillite, concentrations of large clasts with faceted and striated tops are bedded. Striae also occur at the base and at the top of some sandstone layers. Intercalated beds include water-laid sandstone and conglomerate, along with shale containing dropstones. The Discovery Ridge Formation (Permian(?)), consisting of shale and siltstone, unconformably overlies the Buckeye Tillite with slight discordance.

In the Pensacola Mountains, the Gale Mudstone (Devonian to Permian) consists of massive diamictite resting conformably on Dover Sandstone (Devonian (?)). Although the top of the formation is not exposed, at least 315 meters (1,035 feet) are present. Sandstone and conglomerate layers are intercalated. At several levels, sandstone beds are striated, and numerous stones display tops that have been striated in place. Contorted sandstone blocks suggest some downslope movement.

Paleoglacial transport directions, based upon position of bevelled and striated surfaces of stones lying on striated surfaces, and upon morphological features—such as orientation of crescentic gouges and friction cracks on striated surfaces—indicate westward movement. Paleocurrent transport directions within intercalated strata, based on cross-stratification, sole marks, and ripple marks, suggest that currents flowed southwestward, but with considerable dispersion so that more than one source area may have contributed. Paleoglaciers with associated aqueous deposits, therefore, probably flowed away from the late Paleozoic high area toward western Queen Maud Land. Such paleogeographic data provide information helpful in appraising continental drift and in understanding paleoclimates.

Sedimentary Petrology of Beacon Sediments

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Stratigraphic sections were measured in detail, and rock specimens were collected at four localities in southern Victoria Land in order to interpret the stratigraphy, environments of deposition, and sedimentary petrography of the Beacon sediments of this region. In addition, over 800 paleocurrent readings were taken on orientations of cross-bedding, ripple marks, parting lineations, petrified logs, pebbles, and slump folds at the four measured sections and at other scattered localities for the purpose of delineating sediment dispersal patterns.

Of considerable stratigraphic significance was the discovery of a strikingly disconformable contact between two major lithologic units within the Beacon sediments at Mt. Fleming, Aztec Mountain, and West Beacon. Rocks immediately below the disconformity consist of pure orthoquartzites and interbedded quartz sandstone and red and green siltstone. Excellently preserved, *in situ* fish remains were collected from a siltstone bed situated 15 to 30 meters (50 to 100 feet) below the disconformity at Mt. Fleming and from the same horizon at Aztec Mountain and West Beacon. These fish are thought to be Devonian, but precise age and taxonomy have not yet been determined. Rocks above the disconformity consist of very coarse-grained arkosic sandstone and conglomerate, indicating a conspicuous change in the sedimentary regime and mineralogy of the source area during the hiatus marked by the unconformity. Coal, black shale, and carbonaceous and micaceous siltstones occur higher in the section above the disconformity. Plant fossils of *Glossopteris,* collected from black shales just above the contact, indicate a probable Permian age for these rocks.

Paleocurrent patterns in the Permian (?) sediments above the disconformity show a general north-northeast trend, whereas the Devonian (?) sediments below the contact show a more eastward trend. Rose diagrams for individual stations of Devonian (?) cross-bedding indicate a general fanning of currents from a northern direction at Mt. Gran to a southeastern direction at West Beacon. Current patterns above the disconformity appear to be more consistent.

A cyclothem sequence, approximately 82 meters (270 feet) thick and containing 17 cycles, occurs within the Permian (?) rocks at Mount Bastion. The base of each cyclothem consists of cross-bedded, coarse, arkosic sandstone or conglomerate that grades upward into medium- to fine-grained carbonaceous, microcross-bedded sandstone. Sandy siltstone overlies the sandstone and grades upward into burrowed claystone, which marks the top of each cyclic unit.

Antarctic Paleobotany and Palynology

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This project was started in December 1964, continuing studies of antarctic fossil plants carried on intermittently since about 1960. Objectives are to trace the history of such plants in sufficient detail to serve more precise purposes of geologic correlation. Plant microfossils (spores and pollen) and megafossils (wood and foliage specimens) are being studied. Laboratory work has consisted of indexing and cataloging the collections available, preparation of transfers, maceration residues, photographs and drawings, and preliminary study of referred sets of antarctic plants which contribute to general objectives of the project (Craddock *et al.,* 1965; Wade *et al.,* 1965). Detailed drawings of *Glossopteris* leaves used for venation analysis are illustrated (fig. 1).

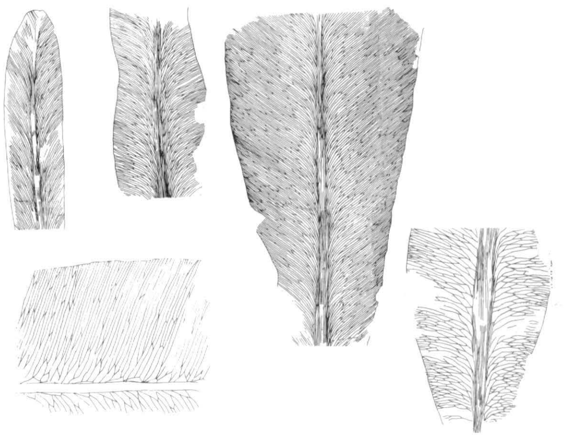

Fig. 1.

Additional collections, maceration samples, and information about stratigraphic occurrences were obtained from the following areas during the 1965-1966 field season: in the Pensacola Mountains at about 85° 45′S. 67°W. (Permian); "Okanagan Nunatak," Patuxent Range (Late Devonian(?)); Forrestal Range (Permian); in the Horlick Mountains at Ohio Range (Early Devonian); and in Victoria Land at Aztec Mountain (Permian), Robison Peak (Late Permian and Early Triassic), Carapace Nunatak (Jurassic (?)), and Allan Nunatak (Permian and Triassic).

The most interesting observation involves a general comparison of the Pensacola Mountains (Forrestal Range) with the Ellsworth Mountains (Sentinel Range) (Craddock *et al.,* 1965), both of which have provided assemblages of Permian plant fossils from beds involved in mountain folding. It seems that the Pensacola Mountains and the Ellsworth Mountains were subject to a post-Paleozoic (?) deformation that does not appear to have affected flat-lying, block-faulted areas of the Transantarctic Mountains.

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Paleomagnetic Research on Volcanic Rocks of McMurdo Sound

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Paleomagnetic research was conducted on young volcanic rocks exposed in the vicinity of McMurdo Sound. The primary research objective was to identify in these rocks, evidence for reversals of the Earth's magnetic field. At most latitudes, such reversals are recorded as north-south switches in the remanent magnetization of lava flows which became magnetized at the same time that the flows cooled from the molten state. By also determining the ages of these rocks, using radiometric dating methods, it has proven possible to subdivide the past four million years into the broad epochs noted below. During these periods, the field was predominantly either normal, i.e., directed toward the north, or reversed, i.e., directed toward the south:

0.0 million years
Brunhes normal polarity epoch
0.7 million years
Matuyama reversed polarity epoch
2.4 million years
Gauss normal polarity epoch
3.35 million years
Gilbert reversed polarity epoch

The boundary between the two most recent polarity epochs is especially useful geologically for establishing the time equivalence of rock strata of diverse types ranging from deep-sea cores to volcanic formations. Rocks younger than 0.7 million years invariably have normal magnetization, whereas reversed magnetization always means that the rocks are older than this.

In the Ross Sea region, the present field is directed steeply upward with a weak and rather erratically directed horizontal component. Accordingly, the direction to be expected for the reverse magnetic field is steeply downward. This magnetic direction was, in fact, observed in lava flows from many localities in Antarctica, including the Walcott Glacier outlet, Mt. Morning, Mt. Discovery, Black Island, Cape Crozier, and the vicinity of McMurdo Station, where the tranchyte at Observation Hill was found to be reversely magnetized. Many normally magnetized flows were also found. The reversed lava flows and cones show remarkably little erosion and weathering, indicating that in Antarctica these processes occur much more slowly than in Alaska, Hawaii, and other places where comparable paleomagnetic measurements have been made.

A total of about 400 oriented samples was collected from the younger lava flows of the McMurdo area for laboratory analysis of their magnetic properties and potassium-argon ages.

Geology of the Ellsworth Land Nunataks

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The University of Wisconsin geological field party mapped and studied exposed bedrock in a 10,000-square-kilometer (4,000-square-mile) area of eastern Ellsworth Land centered about 160 kilometers (100 miles) east of Eights Station. The mountains under investigation were first seen from a distance of 190 to 225 kilometers (120 to 140 miles) by Lincoln Ellsworth on November 23, 1935. The peaks were next seen by members of the Ronne Antarctic Research Expedition on a flight of November 21, 1947, when the area was photographed for the first time. The Ellsworth Land Traverse of 1961-1962 passed through this area and conducted geophysical observations on February 2, 1962, at a spot about 6.5 kilometers (4 miles) west of this year's base camp.

The Wisconsin party was placed in the field on November 8, 1965, by two aircraft. An LC-117, flying from Byrd by way of Eights Station, provided aerial reconnaissance of the mountains for two of the geologists before landing at 75°28′S. 72°20′W. An LC-130F brought the other five party members, the vehicles, and most of the fuel and materiel for the summer from McMurdo Station.

The outcrops studied occur in a number of separate ranges and isolated nunataks. In order to visit these, members of the party traveled approximately 1,520 kilometers (950 miles) by motor toboggan and established seven separate camps in various parts of the region. The geologic reconnaissance indicates that these peaks represent a westward continuation of structural, sedimentary, volcanic, and intrusive trends occurring in the ranges of the Antarctic Peninsula. A thick, fossiliferous, sedimentary sequence and a variety of volcanic and plutonic igneous rocks, with associated contact metamorphics, are present.

Survey control, with estimated relative accuracy of 1:10,000, was established over an area of about 13,000 square kilometers (5,000 square miles) by means of triangulation involving 32 stations, controlled for scale by two base lines. The position of the network was determined from 26 sets of stellar and solar observations and 12 sets of sun-azimuth observations. A result of the survey has been the determination of new positions for several major features mislocated by as much as 160 kilometers (100 miles) on present maps. These include Mt. Hassage, the Lowell Thomas Mountains, and the Sweeney Mountains.

Several hundred miles of magnetometer traverse were carried out and oriented rock samples were collected for paleomagnetic analysis. The results of laboratory work on the magnetic properties of rocks will yield contour maps of bulk susceptibility and intensity of residual magnetism, along with the total-field contour map. All magnetic data will be correlated with the geology of the area. Paleomagnetic studies will also be carried out. A comparison of the data on the total intensity of the geomagnetic field from 1962 and 1966 indicates that the field has decreased 500 gammas over the four-year period.

Geochronologic Investigations in Eastern Ellsworth Land

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Nunataks in eastern Ellsworth Land around 75°S. 72°W. were visited to investigate the theory of a southern continuation of the Antarctic Peninsula Mesozoic fold belt. Igneous material was collected for radiometric age determination, and the bedrock geology was studied.

The geologic setting is one of thick, marine Jurassic (field communication from Patrick G. Quilty) sandstones and shales intruded by a plutonic suite ranging from granite to gabbro. Dacite flows, probably older than the intrusive suite, occur in the area. Strong preintrusive folding of the clastic sedimentary and volcanic rocks has occurred. Fold axes have a general southeast-northwest orientation, indicating structural trends similar to the Mesozoic folding north of the area.

These field investigations indicate a closer chronological linkage of eastern Ellsworth Land to the Antarctic Peninsula and the fjord region of Tierra del Fuego than to the Paleozoic mountains of the Sentinel Range to the south. Absolute age dating of the eastern Ellsworth Land plutonics will soon be under way at the Graduate Research Center of the Southwest. Variation diagrams for K-Na-Ca and Fe-Alk-Mg, based on atomic-absorption spectrophotometric analyses, will be made for comparative study with the Andean intrusive suite of the Antarctic Peninsula.

Patterned Ground Studies in Antarctica

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Patterned ground studies around McMurdo Station, at Cape Evans, and in the Taylor, Wright, and Beacon Valleys, have been under way since 1960. About 500 wedges of ice, sand, and mixtures of ice and sand have been instrumented and annual growth rates measured. These data are believed indicative of the correct order of magnitude for long-term growth rates, if such data were available over a period of many years, e.g., a decade. In addition to growth-rate data, measurements of near-surface ground temperatures are being made at two semiautomatic recording stations.

Field activities during the 1965-1966 season included activation of 15 thermal recording stations in Windy Crater and servicing of 10 recorders in the Taylor Valley. Field investigations were also made at the snout of the Taylor Glacier, at the Hobbs Glacier, and at Castle Rock.

Antarctic Cirques and Glaciated Valleys

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The University of Kansas field research party was in Antarctica from November 5, 1965, till February 15, 1966. Helicopter support made possible a wide-ranging study of geologic and geomorphic features in southern Victoria Land between the Koettlitz and Mackay Glaciers extending west from the sea to the farthest nunataks. Studies were conducted on the ground at 48 different locations, including 5 areas surrounding central camp sites, and highly informative aerial observations were made along approximately 8,000 kilometers (5,000 miles) of flight lines. Prior intensive study of aerial photographs greatly aided planning of operations as well as synthesis of data gathered from many localities.

With direct application to the antarctic studies, comparative field observations were carried on in New Zealand before going to Antarctica, and in both New Zealand and Australia, following the field season in Antarctica. Invaluable field guidance was provided by local geologists in both countries.

The primary purpose of the project was to study the size, shape, and distribution of antarctic cirques, to compare these with temperate region types, and to interpret findings with respect to both geomorphic processes and climatic variations. Much of this was accomplished. In addition, projects arising from observation of features unexpectedly encountered in the field include: an interpretation, with reference to fundamental processes of glacier accumulation and movement, of an unusual glacier composed of thin, alternating layers of ice and windblown sand; analysis of field evidence of recent glacier fluctuations suggesting synchronous, minor climatic variations in both the Northern and Southern Hemispheres; and investigation of physiochemical implications of certain unusual mineral occurrences.

Glaciology

Glaciological Investigation of a Cold Glacier

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A project was begun on the Meserve Glacier in Wright Valley, Victoria Land, to elucidate the physical processes that take place at the base of a cold ice slab, i.e., one that remains essentially below the pressure melting point throughout its depth. An 82-meter (270-foot) system of ice tunnels was excavated at the bedrock-ice interface, where microvelocity and strain are being recorded. In conjunction with this, ice stratigraphy, structure, and crystal fabric analyses are being made. The heat balance of the slab is also being examined in order to include thermal factors in the overall analysis. Local climatic factors that influence mass transfer are being studied to determine their effect on the mass balance of the body of ice, which in turn influences ice-flow characteristics.

Some of the important observations include:

(1) The identification of short sections of "fossil" striae or rock scorings on the crests of sub-ice granite boulders. It has been found that ice velocities at three centimeters above the base of the slab (30 to 50 meters or 100 to 160 feet thick) are of the order of 0.0006 cm./day in clear ice and an order of magnitude greater in dirty ice.

(2) The occurrence of cavities around large boulders which constitute part of the bed material. Most of these cavities have been found to contain well-developed sublimation ice crystals of skeletal cup and spiral form.

(3) The existence of friable, weathered rock material in some cavities. Other soils have been found to occur frozen in the substratum.

Ross Ice Shelf Survey II, 1965-1966

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The main purpose of this program was to redetermine the geographic coordinates of 114 marked points on the Ross Ice Shelf between Ross Island and Mile 100 along the "Dawson Trail," west of Roosevelt Island. Additional points were established on an approximate north-south line along the 168°W. meridian between latitudes 78°46′S. and 81°15′S. The geographic coordinates of the marked points, about 7 to 11 kilometers (4 to 7 miles) apart, were established in 1962-1963 (Hofmann *et al.,* 1964). Tellurometers were employed for high accuracy horizontal measurements. A distance of 695 kilometers (432 miles) was measured along the "Dawson Trail" and 305 kilometers (187 miles) along the north-south profile. The coordinates determined this year will be compared with those established in 1962-1963, thereby providing the basis for measuring absolute movement of the shelf ice.

Other accomplishments included the following: 20 strain rosettes, emplaced in 1958-1959 at the Bay of Whales, were remeasured in order to provide a check on horizontal strains calculated on the basis of measurements made in 1962-1963 (Zumberge, 1964); snow accumulation measurements along the traverse were made for additional data (Heap *and* Rundle, 1964); finally, a horizontal strain network at South Pole Station that was installed in 1962-1963, was remeasured.

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Measurement of Ice Surface Movement by Aerial Triangulation

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During the austral summer of 1962-1963, photographic markers were placed about three kilometers (two miles) apart between Byrd Station and Mt. Chapman (83°34′S. 105°55′W.). These markers were placed to study the surface movement of the ice sheet by means of aerial strip photography and independent geodetic control. The necessary ground control and photography were performed, and the positions of the markers were obtained by aerial triangulation. In addition, accumulation at seven photogrammetric control arrays was determined from stratigraphic studies in shallow pits, and 163 accumulation markers were set out.

(Photo: H. H. Brecher)

Back-sighting from Photogrammetric Marker. Mt. Chapman in Background.

The positions of the photographic markers were to be redetermined this year. In preparation for the aerial photography, a three-man party was in the field during November and December 1965. The party was equipped with a Sno-Cat, a motor toboggan, and two Maudheim sledges. On November 14, they were flown in an LC-130F from McMurdo Station to the vicinity of Mt. Chapman and completed the traverse to Byrd Station in one month.

The party carried out the required ground control for the new aerial triangulation and measured accumulation at the markers which had been set out three years before. Some rearrangements of the photographic markers in the control arrays were made, and all the markers were raised above the new snow surface, so that they will be available for future observations.

Ground control consisted of the determination of the relative azimuths and lengths of base lines, and the determination of elevation differences in seven control arrays. Azimuth was carried from array to array by theodolite, base line lengths were measured by Tellurometer, and elevation differences in the arrays were determined by reciprocal vertical angle measurements. Unfortunately, because of bad weather, the photography for this project could not be taken so that new positions of the markers cannot be determined.

Accumulation, determined from the stake measurements, averaged 16.1 gm. cm.$^{-2}$ yr.$^{-1}$ for the first 300 kilometers (190 miles) from Byrd Station and 21.3 gm. cm.$^{-2}$ yr.$^{-1}$ for the remaining 60 kilometers (40 miles). Ranges of accumulation in six networks of 10 to 15 stakes, each covering a 100- by 300-meter (330- by 1,000-foot) area, were relatively small. Comparison of the above with the accumulation figures from the stratigraphic studies indicated that the latter underestimated the accumulation by 4 to 28 percent.

Measurement of Common Lead in Antarctic Snow

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The field activities in this project took place between November 13, 1965, and February 18, 1966.

They consisted of digging a deep, inclined shaft at Byrd Station and a shallow, inclined shaft at a location 200 kilometers (125 miles) northeast of Byrd Station; collecting snow samples from the shafts; melting and bottling the snow samples; and collecting ice from two glaciers near McMurdo Station.

In November, a Jamesway was assembled as a combined laboratory and machine shop, a warming hut was built, a power transmission line laid, a transformer distribution system installed, and a winch set up at the deep shaft site located two thirds of a mile north-northeast of Byrd Station. A shaft, approximately 90 meters (295 feet) long, was dug at an incline of 30° from the horizontal. The shaft was 2.1 meters (7 feet) wide and 2.4 meters (8 feet) high in cross section. The bottom of this shaft reached snow layers deposited about 1750 A.D. Excavations were completed about January 15, 1966.

During the period from January 10 to January 23, a sled traverse was made 200 kilometers (125 miles) to the northeast of Byrd Station to 78°52'S. 111°19'W. It was believed that snow in this area had not been significantly contaminated during the last 10 years by local vehicular traffic in the vicinity of Byrd. A shaft 30 meters (100 feet) long and inclined 30° from the horizontal, was dug. The bottom of this shaft reached snow layers deposited about 1950 A.D.

Samples of snow were collected from the surface and at various depths in the shaft. On the return trip to Byrd Station, other surface samples were collected.

From January 25 to February 12, 1966, ten snow samples were removed from different levels of the inclined shaft at Byrd Station. Each sample consisted of 450 liters (120 gallons) of snow. At each level a platform was constructed, and a shallow side adit was driven into the wall, using dry, clean chain saws. Care was taken to prevent contamination of the snow in the adit. The working crew donned plastic suits and gloves and, using stainless steel tools that had been cleaned in nitric acid, adzed the working face back another 15 centimeters (0.5 foot), drilled holes, sawed ice blocks out between the holes, and wedged the blocks loose. Four large plastic drums were brought down, unsealed, and filled with ice blocks using large steel tongs. The drums were resealed and taken to the laboratory, where the blocks were melted without breaking the seals. The meltwater was siphoned into large plastic bottles, the seals of which were broken momentarily for this operation. The bottles were resealed and boxed for shipment back to the United States. Seven other samples, collected on the sled traverse and from the shallow shaft, were melted and aliquoted.

Chemical analyses of these samples for lead and other elements may provide information concerning the sequence of the progressive contamination of the atmosphere by industrialized societies.

During the period February 16 to February 21, 1966, the Meserve Glacier and Erebus Glacier Tongue were visited. The ice samples collected were melted and bottled at McMurdo Station. These were the oldest samples collected and should provide material least contaminated by the industrial activities of man.

Glaciological Studies in Antarctica

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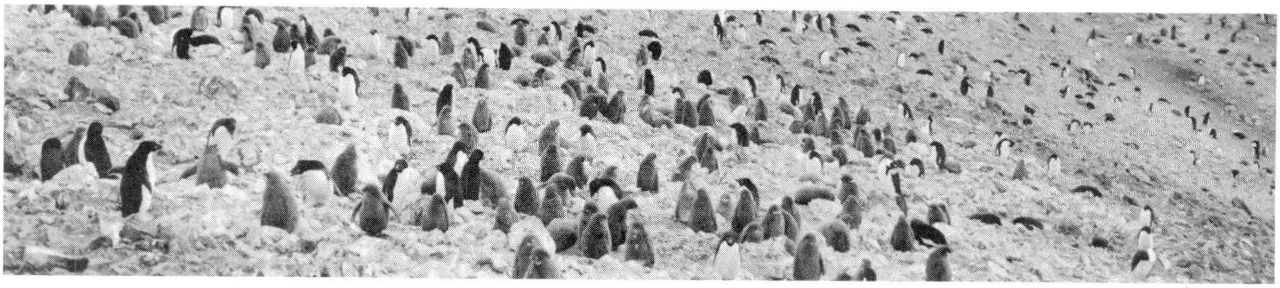
During the austral summer of 1965-1966, a number of glaciological projects were carried out in Antarctica by personnel from the Cold Regions Research and Engineering Laboratory. Further studies of the thermal and compositional structure of the Koettlitz Glacier tongue were made, and two lines of aluminum poles were emplaced for measuring both the movement and surface ablation of the ice tongue in the general vicinity of the Dailey Islands. Thin-section analyses of the granular and crystalline structure of snow and firn to a depth of 30 meters (100 feet) were done at Eights Station. Two accumulation stake lines at Byrd Station were remeasured. Isotope sampling of snow at two control pits, dug beside two four-year-old accumulation markers, were made, and temperature and deformation in the deep drill hole at old Byrd Station were remeasured. Electrical conductivity of firn from various depths at Eights, Byrd, and South Pole Stations, and of samples of freshly precipitated snow at McMurdo Sound, was measured.

The field party spent approximately 15 weeks in Antarctica. A total of 12 weeks was devoted to field work and laboratory studies in McMurdo Sound. Three to four days each were spent at Eights Station and the South Pole, and the remaining two weeks were devoted to studies at Byrd Station.



(Photo: F. O'Leary)

Biology

Antarctic Avian Population Studies, 1965-1966

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The antarctic avian population studies aim at understanding the population dynamics and social behavior of the long-lived antarctic seabirds. The interactions of polar communities are simple when compared with communities in the warmer regions; therefore, insight into basic ecological principles may be collected more easily from these populations. Moreover, a better knowledge of their breeding biology is required to formulate good conservation measures.

At the Cape Crozier, Ross Island, study area some 300,000 Adélie penguins, *Pygoscelis adeliae,* interact in specific social groups in one enormous rookery. Their eggs and young are preyed upon by only one species of bird, the south polar skua, *Catharacta maccormicki,* while at sea the leopard seal, *Hydrurga leptonyx,* takes a toll of adults and young alike. The social organization of the avian component of these populations is being studied from individually marked birds.

During the past five seasons, a total of 21,474 Adélie chicks and 1,174 skua chicks has been banded in selected study areas. Each year a different check mark (web-punch) has been used on the chicks as a precaution against band loss and as further evidence of known age. Over 24,500 chicks have been web-punched and/or banded. The chicks leave the rookery at the end of the breeding season to reside in the pack ice, returning to land in later seasons, first as juveniles, then as inexperienced breeders, and finally as established breeders (Sladen, 1958).

No marked birds have been recovered during their first year, but a preliminary analysis of the data shows that approximately seven percent of each of three age groups (in their second, third, and fourth years) are returning to the rookery of their origin. These figures represent a total of nearly 1,000 recoveries of Adélies of known age, and they are concentrated mainly in the areas where they were originally banded as chicks, giving enough birds to study and compare with the older, established breeders.

Band loss and immigration to other rookeries (a few have been seen at the Beaufort Island, Cape Bird, and Cape Royds rookeries) are estimated as small in comparison with the high mortality to which these young birds must be subjected during their first two years in the pack ice. The only offshore predator is the leopard seal, which takes a heavy toll of chicks when they are leaving the rookery and probably continues to diminish their numbers throughout their first two years.

A few three- and four-year-old Adélie penguins have bred at Crozier, though all but one three-year- and three four-year-olds have lost their eggs or chicks. These successful but inexperienced breeders reared only one chick each instead of the usual two. However, the majority of these juveniles do not breed and have been observed wandering around the rookery individually or in small groups. Their social interactions, which may be detrimental to successful breeding of the older birds, have been the subject of much of the studies.

A food habit study of the Adélie penguin was carried out at Cape Crozier during the austral summers of 1964-1965 and 1965-1966 as part of the overall avian population studies. The objectives of this study were to obtain as complete a record as possible of marine animals taken as food by the Cape Crozier Adélies, to determine what proportion each individual food item made up of the total amount of food being brought in, to determine if the composition of food items found in breeding Adélies changed as the chick-rearing period progressed, and to estimate the amount of food removed from the sea during chick rearing.

During the summer of 1964-1965, three kilograms of food samples were collected, preserved, and shipped to the United States for final analysis. These samples were found to contain 15 identifiable species of Crustacea (all from the orders Euphausiacea and Amphipoda), at least three species of fish, one species of Cephalopoda, and minor amounts of marine algae, parasites, stones and other debris. By weight, the identifiable food items were in the following proportions: Crustacea, 60 percent; fish remains, 39 percent; and miscellaneous, one percent. The high percentage of fish in the stomachs is surprising, as earlier work done in other parts of the Antarctic usually makes reference only to krill, *Euphausia superba,* in stomachs collected. Not only was the proportion of fish quite high but the common food organism *E. superba,* found in stomachs of Adélies in most other areas studied, was replaced in the Crozier birds by the much smaller *E. crystallorophias.*

This study was continued and expanded during the 1965-1966 season. A technique was devised whereby food could be removed from the stomachs without harming the birds, thus making the collection of a large number of samples possible. Twenty kilograms of samples, collected during the 1965-1966 season, are now being analyzed.

Studies of the south polar skua have continued for four seasons in a study area containing about 115 pairs of breeding birds. Of 205 banded breeders present in 1964-1965, 197 (96 percent) returned in 1965-1966. This figure and data from previous years indicate an annual mortality of breeding adults of 4 to 8 percent, 12 to 18 percent annual breakup of mated pairs, and a high degree of nest-site tenacity.

Totals of 9 two-year-old, 117 three-year-old, and 51 four-year-old skuas were recorded, all banded at Crozier as chicks. None of these was known to breed although three- and four-year-olds have bred in other areas, possibly reflecting a lower mortality of established breeders at Crozier and a stable and undisturbed population.

During a visit to Beaufort Island, 80 kilometers (50 miles) from Cape Crozier, further evidence of the wandering behavior of immature skuas was gathered when a three-year-old, banded originally at Crozier, was observed. This bird was also recorded at Crozier 10 days before and 17 days after the Beaufort sighting. Crozier skuas were observed feeding 80 kilometers (50 miles) away at the McMurdo Station garbage dump early in the season. Evidence of longer travels during winter comes from a one-year-old skua found dead on a beach in southeastern Australia. This is the fourth recovery of a banded skua north of Antarctica and, to our knowledge, the sixth observation of a one-year-old bird after fledging.

The presence of DDT and its residues in Adélie penguins and a crabeater seal, *Lobodon carcinophagus,* was reported (Sladen *et al.,* 1966) for the first time in Antarctica from specimens collected in February 1964. This report has been confirmed from analysis made from Adélies, skuas, and one fish, *Rhigophila,* collected in December 1964 and January 1965 (George *and* Frear, in press). Specimens of muscle and heart collected from Adélies in extremes of physiological conditions during the breeding season have demonstrated the stability of the isozymes of lactate dehydrogenase (Markert *and* Sladen, 1966).

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Biotelemetry Studies on Penguin Body Temperatures

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The purpose of this program is an investigation of the adaptive mechanisms permitting the emperor, *Aptenodytes forsteri,* and the Adélie, *Pygoscelis adeliae,* penguins to survive the rigorous antarctic environment. Special emphasis is being placed on the physiological and behavioral mechanisms of thermoregulation in these species (Goldsmith *and* Sladen, 1961; Prévost, 1961). The new techniques of biotelemetry (the means of gaining and transmitting information from an organism to a remote observer) were used for the first time to monitor the body temperature in these species. Previous biotelemetry investigations in Antarctica have involved measuring the incubation temperatures of eggs (Eklund *and* Charlton, 1959) and tracking the movements of Adélie penguins (Penney, 1965).

This work and related studies on the breeding biology of the emperor penguin began on October 14, 1965, from a temporary field station on the sea ice below the Ross Ice Shelf at the Cape Crozier emperor rookery.

The early part of the season was spent testing telethermometer equipment and exploring the techniques for anaesthesia and surgery. Halothane anaesthesia proved ideal. It produced rapid induction and relaxation, had a wide margin of safety, and allowed the penguins to return to their normal activities a few minutes after the operation. Fourteen plastic dummy transmitters were implanted subcutaneously or into the body cavity to test surgical procedures. Of five sites tested, the one in the abdominal cavity proved superior.

Internal body temperatures recorded from a thermistor probe introduced into the stomach by swallowing were monitored from two adult emperors for over two days in a pen on the sea ice at the emperor rookery. Internal temperatures averaged 38.7°C. (range 37.6°C. to 39.7°C.) and 38.6°C. (range 37.8°C. to 39.3°C.), respectively. A captive emperor at the Adélie rookery was monitored in this manner for over three days after implantation of a dummy transmitter and the average temperature was 38.6°C. (range 37.8°C. to 39.0°C.), thus indicating that the effects of transmitter implantation on body temperature are minimal.

Biotelemetering started in late December. The transmitters, designed and constructed by Kenneth Bindle, were placed in plastic capsules measuring 7.0 by 1.6 by 1.6 centimeters. Weighing 18 grams, they had a battery life of up to two months. The transmitted pulses, the rate of which varied according to the body temperature, could be received up to a distance of 20 meters (65 feet) from the bird. Transmitters were surgically implanted into four adult and two chick Adélies. Three of the birds were free-living and were monitored from a tent alongside a colony. The others were confined to a pen but still able to move around freely.

Continuous data on body temperature fluctuations were collected from both probes and transmitters in individual birds for as long as 14 days in an adult Adélie (average 38.7° C., with a range from 37.7°C. to 39.6°C.). As a check on the accuracy of telemetered data, simultaneous recordings of body temperature were made from thermistor probes introduced into the proventriculus. It was found, from simultaneous probe recordings at both body sites, that the abdominal cavity registered a temperature about 0.3°C. lower than that of the proventriculus. With this factor taken into account, our most stable transmitter, in 23 hours of simultaneous recording, gave an estimated average abdominal body temperature 0.1°C. higher than the corrected average probe reading. Of particular interest were the fluctuations in body temperature recorded from birds in loud mutual display, a behavioral pattern occasioned by placing together a pair of adults for the first time: a 1.0° C. rise in 15 minutes was noted. Similar fluctuations were noted when birds were disturbed by helicopters.

Other general observations on the breeding habits of the emperor penguin were made. A new design of flipper band (Penney *and* Sladen, in press), made of Teflon and placed on emperor penguins in October 1964 by Richard L. Penney and Rear Admiral James R. Reedy, was found to be in perfect condition after one year on the birds. One emperor banded with a pre-crèche chick in 1964 was again seen guarding a chick. This appears to be the first evidence that these birds have an annual breeding cycle despite their very long breeding season of almost 10 months.

Studies were made of the movements of the emperor rookery along the Ice Shelf; of the rate of growth of chicks to compare with the work of Prévost (1961); and of the winter and spring mortality of eggs and chicks (from well-preserved frozen remains on the sea ice). Environmental conditions affecting the rookery in the drift zone at the base of the cliffs were noted. A fracture in the sea ice, apparently caused by the same factors described by Dubrovin and Konovalov (1964), developed during a severe storm and caused losses among the emperor chicks and damage to the field station.

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The Ecology of Antarctic Seals

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During this third year of investigation into the ecology, including the underwater aspects, of the lobodontine seals (Weddell, crabeater, Ross, and leopard), the icebreaker USS *Burton Island* supported a cruise from December 29, 1965, through January 13, 1966, in the western Ross Sea from McMurdo Sound to Cape Adare and Robertson Bay in a quest for seals. The ship's helicopters were utilized in a systematic density count. This aerial method proved efficient for both counting and close observation. The maneuverability of the helicopter, its variable speed and hovering ability, enabled a thorough coverage of predesignated sample areas so that few animals were missed owing to their seclusion behind pressure ridges and broken ice. Further, the observer could be let out on the ice with the seals almost at will.

At locations of high seal density, landings on the ice were made to obtain tape recordings of underwater noises of seals. During a total of 17 reconnaissance flights, in which over 500 Weddell seals, 250 crabeater seals, 31 leopard seals, and 22 Ross seals were counted, 18 tape recordings were made. Analysis is still in progress, but it is thought that all four species of seals were recorded, the crabeater and Ross for the first time. Mixed in with seal calls is a great variety of background sounds from ice, which has led to a systematic investigation of these two classes of sounds, as well as the behavioral use of sound by the animals.

A total of 10 seals, representing all species, was killed. A number of uses are being made of the material: analysis of the parasites of the gut, tissue samples for C^{14} dating, examination of the anatomy of the larynx and trachea for sound resonation mechanisms, and skeletal material for use by museum collections. Extensive use was made of photography to record the ecology and appearance of these little-known animals, particularly the Ross seal, which has been infrequently observed. This work has provided a better understanding of some of the ecological relationships of the lobodontines, and it is hoped that when sound analysis is complete, the data will be useful in population and behavioral studies.

Finally, work at McMurdo Station continued in parasitology under coprincipal investigator Paul L. Montreuil. Six additional Weddell seals were killed to examine Acanthocephala in particular. These parasites have been of use as population indicators of some northern species and might prove to be of similar use in antarctic species.

Parent-Chick Individual Recognition in the Adélie Penguin

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Individual recognition between parent and chick has been shown to occur in a variety of colonial seabirds, including penguins, but little attention has been paid to the underlying mechanisms. Previous studies have indicated that Adélie penguin chicks are fed only by their own parents (Sladen, 1958) and that recognition of the call of the parent by the chick plays a major role in bringing them together at feeding time (Penney, 1963).

Experiments undertaken during the 1964-1965 and 1965-1966 summer seasons at the Cape Crozier and Cape Hallett rookeries, respectively, attempted a more detailed description of parent-chick recognition in the context of parental behavior and developing chick abilities, such as mobility, homing, display, and vocalization. The major observational technique was the exchange of marked, known-age chicks between pairs of nests. Adult rejection of most chicks older than 13 days indicated that recognition became well developed by that time, a week before the chicks left the nests and banded together in crèches.

Other experiments, as yet incompletely analyzed, showed that before the thirteenth day of age, chicks that were repeatedly exchanged between nests were fed less than control chicks, and that adult rejection of the exchanged chicks occurred in the absence of a previous, prolonged association with any one chick. Observations were made on the responses of parent and chick during rejection. Additional observations were made of reunions at the territory and of chicks chasing parents for food.

There was no evidence that recognition occurred away from the nest at the end of the season when both parents and chicks gathered on the beaches. Mistakes in recognition were found to be rare in undisturbed birds.

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Ecology of Some Antarctic Algae

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A two-phase study was conducted during the 1965-1966 austral summer. The first phase was a continuation of the Victoria Land algal survey begun in 1964. Collections were made at 12 localities between Coulman Island and Cape Adare. A new record for "green snow" was made on the Possession Islands. Other new stations contained floras similar to those already reported from southern Victoria Land and Ross Island.

The second phase involved a study of carbon assimilation by plankton organisms in Lakes Bonney and Vanda. A close correlation among photosynthetic uptake of C^{14}-labeled bicarbonate, dissolved oxygen concentration, and standing crop of *Chlamydomonas subcaudata* was found in Lake Bonney. A deep, photosynthetic layer at 50 meters (165 feet) in Lake Vanda coincided with a narrow layer of nitrate- and nitrite-rich water. Rapid heterotrophic uptake of C^{14}-labeled acetate in Lake Bonney was found only in the mixolimnion; in Lake Vanda, higher uptake rates occurred at the 15-meter (50-foot) and 50-meter (165-foot) levels than at the 5-meter (16-foot) and 10-meter (32-foot) levels.

Lake Bonney appears to illustrate a simple ecosystem with both autotrophic and heterotrophic carbon assimilation occurring primarily in the mixolimnion; Lake Vanda has a more complex system with deep photosynthetic and organic carbon assimilation contributing to the overall production of the lake.

Comparative Biochemistry of Proteins

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During the past antarctic summer, a three-member team (Richard G. Allison, Herman T. Miller, and R. E. Feeney) from the University of California continued studies for a second season at McMurdo Station and Cape Crozier on the comparative biochemistry of proteins of the Adélie penguin and several species of antarctic fish. The two primary objectives of the project are to study the biochemical evolution of molecules through the study of proteins of antarctic species, and to study the structures and functions of proteins, including enzymes, from marine species adapted to low temperatures. The evolutionary studies are being done with the proteins of the eggs and blood sera of the Adélie penguin and with the blood sera and muscle of the fish *Trematomus borchgrevinki*.

Definitive and detailed biochemical studies are under way on the egg-white proteins of the Adélie penguin as an example of an isolated biological species. Very little genetic variation has been found to date. During the last antarctic summer, approximately 600 very fresh (less than 24 hours old) eggs were obtained, and the whites and yolks were separated and frozen for studies in the United States. These studies should require approximately five years of sophisticated biochemical characterization.

The studies with the low-temperature fish, *Trematomus borchgrevinki,* were initiated this year. Approximately 300 fish were obtained through ice holes in McMurdo Sound. Blood sera and muscles were removed from approximately 225 specimens and frozen without being allowed to warm. The effects of temperature on their proteins are presently being studied. In addition, studies were started on the defense of these cold fish to disease by injecting other specimens with four different antigens and holding them in tanks at 0°C. (32°F.) at the biology laboratory. Antibody production is under study.

Thermal-Metabolic Relationships in Stenothermal Fishes

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Studies were initiated in McMurdo Sound to describe the gross anatomy of the fish, *Trematomus bernacchii,* with particular reference to anatomical modifications which appear to be of singular adaptive significance with regard to the cold environment. Experiments were conducted on a total of 68 specimens to evaluate methods and procedures in respirometry. Approximately 80 measurements involving 26 specimens were made of respiratory quotient. Thiourea treatment was used to investigate thyroid effect in maintaining the unusually high metabolic rate under conditions of supercooling. No significant decrease in metabolic rate was caused either by the antithyroid properties of the treatment or by its effect as a reducing agent *per se.* The thiourea results were unquestionably negative.

Entomological Studies

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The Bernice P. Bishop Museum program for the 1965-1966 season continued entomological investigations in dispersal, environmental, and biological factors. A survey of the arthropod fauna was conducted in the Pensacola Mountains. These studies included spot temperature checks in several areas where live specimens were found. Ecological work in and around McMurdo Station continued including laboratory tests on temperature tolerances and phototropism. With logistical support of USS *Burton Island,* a survey was made of the arthropod fauna along the Ross Sea coast between McMurdo Station and Cape Adare. Helicopter support made possible a number of collections from previously uninspected sites along the mountains of Victoria Land.

Biological investigations concerned with life cycles and embryology of the several species of mites and Collembola were initiated at Hallett Station. It is hoped that continued work at the station will reveal more information concerning basic thresholds and conditions surrounding the various stages of mite and insect development. Live specimens were taken to Iowa State University for experimental studies.

Biological and ecological research was conducted on the more abundant arthropod fauna of Palmer Station. Live specimens were taken to Bishop Museum laboratories for continued studies *in vitro*.

Endoparasites of Antarctic Vertebrates

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The present investigations continued for a second year the collection of helminths from vertebrate hosts at varying geographic locales in Antarctica to increase understanding of the ecology, zoogeography, systematics, and biology of the antarctic helminths. Helminthological studies may also lead to a better understanding of host zoogeography, dispersal routes, and systematic relationships.

Twenty-eight Adélie penguins, *Pygoscelis adeliae*, and 25 skuas, *Catharacta skua maccormicki*, were collected at Hallett Station from rookeries on Seabee Hook and examined for helminths. Of the Adélies, 57 percent harbored intestinal helminths, 39 percent were infected with cestodes, and 42 percent with nematodes. It may be that some of the nematodes were ingested with fish and are not true parasites of penguins. Skuas proved to be the most interesting host collected in the area. Seventy-six percent of the skuas examined were infected with worms, including 64 percent infection with cestodes, 16 percent infection with trematodes, and 50 percent infection with nematodes. The incidence of helminthiasis of Adélie penguins and skuas is somewhat higher for the specimens examined at Hallett Station than ascertained for these hosts collected during 1964-1965 around Ross Island, the Dailey Islands, and Marble Point.

Helicopter support from the icebreakers USS *Atka* and USS *Burton Island* on December 5 and January 3 and 4 made possible several trips to the western shore of Edisto Inlet to collect snow petrels, *Pagodroma nivea nivea,* and Wilson's petrels, *Oceanites oceanicus*. All of the 23 snow petrels collected were infected with cestodes and 4 percent with nematodes. None of the Wilson's petrels examined appeared to be infected.

An attempt is in progress at the biological laboratory at McMurdo Station to demonstrate stages in the life cycle of the spiny-headed worm, *Corynosoma hamanni* (Linstow, 1892). Juveniles found encysted in fishes taken from McMurdo Sound are being fed to guinea pigs. The experimental feeding of 10 cysts recovered from *Rhigophila dearborni* to a guinea pig in 1964-1965 resulted in the premature recovery, 18 days later, of three intestinal, immature *Corynosoma* spp. with "semerme-like" body spination. The host-parasite relationship remains unclear. The development of sexually mature worms will serve to differentiate helminths of seals from members of this genus which may occur in fish-eating birds. As a result of the work of Nybelin (1924), who recognized the juvenile *Corynosoma semerme* (Forsell, 1904) in an amphipod, and the analyses made by the author in the 1964-1965 season of piscine stomach contents, amphipods have been exposed to eggs obtained from the body cavity of intestinal *C. hamanni* recovered from seals. Upon establishment of the infection in amphipods, the juvenile worms will be fed to fishes and guinea pigs. Thus the development will be followed in amphipods, fishes, and mammals.

Five hundred ninety-two amphipods from the stomachs of *Rhigophila dearborni* have been dissected and examined at Roanoke College. All were found negative for juveniles of *Corynosoma hamanni*. However, considering the incidence of naturally infected arthropods in other life-cycle studies, this does not appear to be unusual. The incidence of juvenile *Corynosoma* spp. in fishes of McMurdo Sound appears to indicate a significant percentage (above 2 percent; Margolis, 1958) of infection in four species of Nototheniidae examined and one species of Zoarcidae. Insufficient numbers of four other species of Nototheniidae and one species of Chaenichthyidae were examined to be conclusive. However, one species of Nototheniidae had a significantly higher percentage of infection and a larger mean number of cysts per infected fish. The high incidence of juvenile *Corynosoma* spp. in the four species of Nototheniidae suggests that they were significant during 1964-1965 in transmitting *Corynosoma* infections to pinnipeds or other definitive hosts.

The examination of the antarctic cods, *Trematomus bernacchii* and *T. hansoni,* trapped near Wilkes Station and in McMurdo Sound, produced specimens of *Ascarophis nototheniae* Johnston and Mawson, 1945, which, in conjunction with alternative type materials from the South Australian Museum, has made possible the reexamination and completion of the species description.

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OPERATION DEEP FREEZE 66

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For the eleventh consecutive year, the United States Navy conducted operations in Antarctica in support of science. It allocated to this task nine ships, an air squadron, a construction battalion detachment, and about 3,000 men. Assistance was received from United States Army and Air Force units, the Coast Guard, and from the Royal New Zealand Navy and Air Force. Even with a reduction from former years in the number of SeaBees, an ambitious construction program was carried through to completion.

Air Operations

In this issue of the *Antarctic Journal,* accounts are presented of some of the season's many activities by the men who were engaged in them. Commander Morris reviews the accomplishments of Air Development Squadron Six (VX-6) and notes the contribution of Army, Air Force, and New Zealand air units and of the helicopters based aboard Navy icebreakers. It should be noted also that the Coast Guard icebreaker *Eastwind,* operating about the Antarctic Peninsula, had Coast Guard aviators aboard who were flying HH-52A turbine-powered helicopters.

In addition to its many other activities, VX-6 is also responsible for photographic coverage of antarctic operations, including both motion and still pictures. For this purpose, the Squadron operates a photographic laboratory at McMurdo Station. An important part of this responsibility is obtaining aerial photography for mapping purposes. During the past season 19,075 flight-line miles of trimetrogon coverage was requested, and 7,645 miles were flown. Requests were also received for 4,900 miles of special and 1,500 miles of reconnaissance photography. Some 4,524 miles of the special and 620 miles of the reconnaissance photography were completed by the end of the season. An article in an earlier issue of the *Antarctic Journal* explains the equipment and techniques used in this endeavor.[1] As the areas to be photographed become more distant from McMurdo Station, weather poses an increasingly serious problem. The sky must be relatively cloud-free over the objective and the weather must remain good for a considerable period of time at McMurdo for takeoff and landing. This combination is not easy to obtain, and, as a result, many scheduled photographic flights have to be cancelled or aborted. Further delays occurred during the past season because of necessary repairs to one of the photographic planes and because difficulties were encountered by USNS *Alatna* during December in reaching McMurdo Station with needed aviation fuel. Mapping, however, is important in both planning and executing scientific programs. Photography not flown this season will be rescheduled in the future.

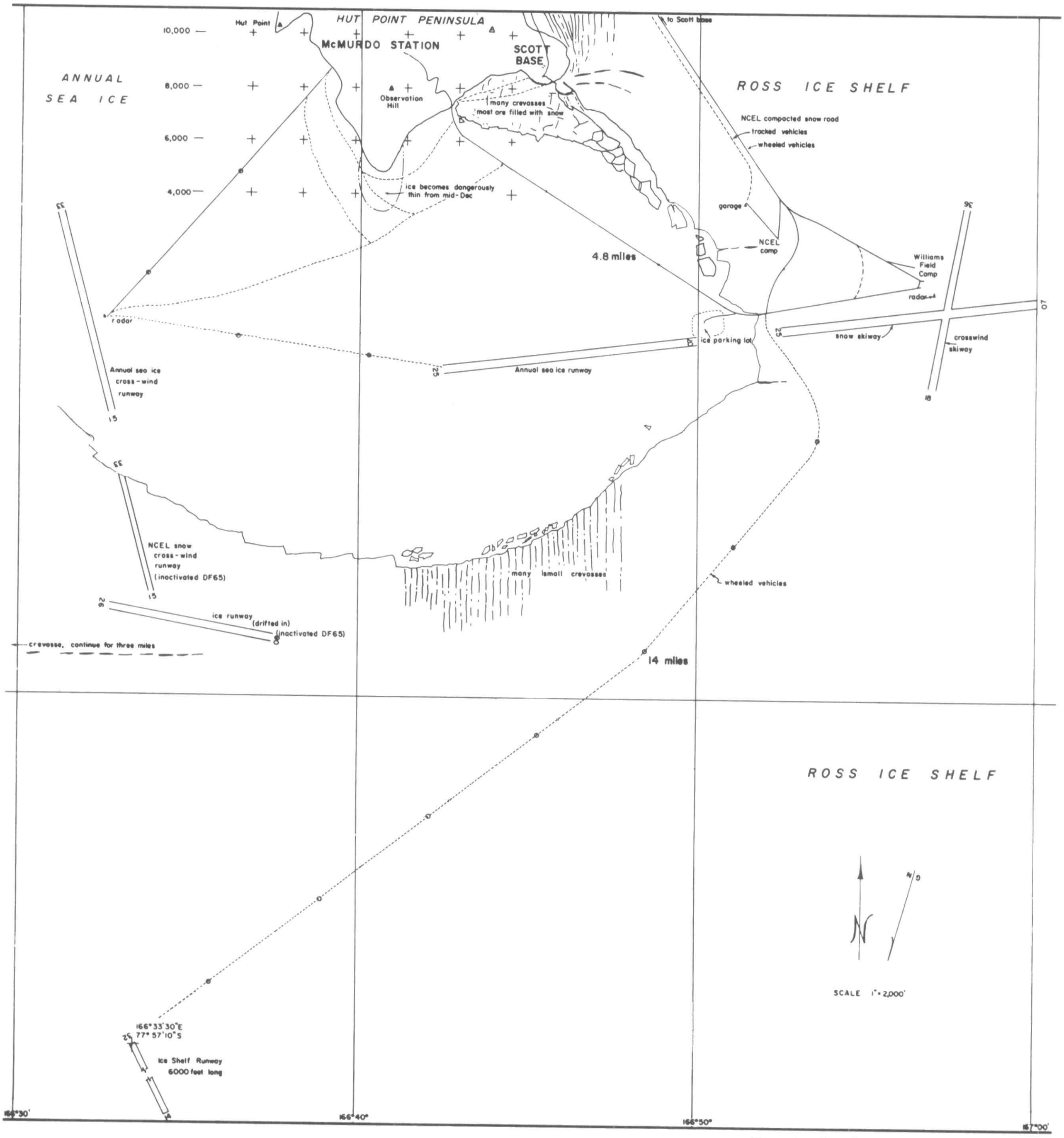
[1] E. W. Van Reeth, "Aerial Photography in Antarctica," *Antarctic Journal,* 1 (2): 66-67.

Construction

Lieutenant Whitmer has covered the highlights of the construction done by Detachment *Whiskey* of Mobile Construction Battalion Six (MCB-6). Other construction is performed by Antarctic Support Activities (ASA) as part of its normal function of operating and maintaining the stations. Perhaps the greatest accomplishment of this latter organization was the building of a runway 6,000 feet long on the Ross Ice Shelf some 14 miles from McMurdo Station. On February 18, an LC-130F made the first wheeled landing on this new shelf-ice runway, and on February 22, the runway was used by a Super-Constellation, an aircraft that is not equipped with skis. The practicability of such a runway would make possible air operations with wheeled aircraft throughout the year, and free air operations from dependence on a sea-ice runway that may either melt or break out.

Antarctic Support Activities is also responsible for laying out and maintaining other runways at McMurdo. These include the annual sea-ice runway, 10,000 feet long and oriented into the prevailing wind, and a crosswind runway of 7,000 feet. Midway in the season, use of these runways was suspended because of deteriorating ice conditions. The last wheeled aircraft took off from the sea ice on January 12, but the runway aligned with the wind retained a restricted availability until the breaking up of the ice on February 3. Because of the extensive breakout of ice that occurred during 1964-1965, it was necessary to relocate and rebuild the Williams Field skiway, used principally by the LC-130Fs. This was done by personnel of the wintering-over detachment. All these runways, together with their access roads, are indicated on fig. 1.

Elsewhere in the Antarctic, ASA maintains skiways at Byrd, South Pole, and Plateau Stations and an annual sea-ice runway at Hallett as long as ice conditions will permit. This year the Hallett runway closed down on December 2. The same organization also provides navigational aids and operates traffic control centers at both Christchurch, New Zealand, and McMurdo Station, Antarctica.



(Drawing by Antarctic Support Activities)

Fig. 1. Runways in the McMurdo Station Area.

Both Commander Morris and Lieutenant Whitmer touch upon the outstanding feat of the year, the establishment of Plateau Station at 79°15′S. 40°30′E. The problems encountered, the effort expended, and the success achieved, all seem to merit extended treatment. As the authoritative account written by Commander S. K. Kauffman, CEC, USN, Assistant Chief of Staff for Engineering, U. S. Naval Support Force, Antarctica, and Mr. Arthur M. Weber, architect with the Naval Facilities Engineering Command demonstrates, almost all the elements of the U.S. Naval Support Force, Antarctica, as well as the National Science Foundation's Office of Antarctic Programs, were involved in the planning and construction of Plateau Station.

At Palmer Station, on the other hand, maintenance and construction were done largely by work parties from the Coast Guard icebreaker *Eastwind*. While the ship was at anchor off Anvers Island, personnel were put ashore daily. When it went on scientific cruises, from January 21 to 26 and again from January 29 to February 21, a group from the ship remained ashore and carried on with many projects to improve the station's efficiency and to render it more habitable. The Coast Guard's men also unloaded the ships, using landing craft and helicopters, and stowed the cargo ashore. In all, they contributed close to 1,000 man-hours to the support of Palmer Station.

International Activities

While operating about the Antarctic Peninsula, the Commanding Officer of *Eastwind,* Captain W. M. Benkert, USCG, and Dr. George A. Llano, U. S. Antarctic Research Program Representative, made informal calls on Argentine, British, and Chilean bases in the area. Among those visited were British stations in the Argentine Islands (January 9) and on Adelaide Island (January 24). Shortly thereafter, they flew to Argentina's Almirante Brown Base in Paradise Harbor (January 30) and, on February 2, visited installations of all three countries at Deception Island.

A visit of another nature very nearly occurred to the United Kingdom base on Signy Island, in the South Orkney Islands. On February 5, information was received that X-ray equipment was needed to determine the location of a one-inch dental wedge accidentally swallowed by one of the men. The Chileans at Deception offered to evacuate the patient by air, but their amphibious aircraft developed mechanical trouble. When this occurred, *Eastwind* suspended scientific operations and hastened toward the island. During the evening of the seventh, information was received that the crisis had passed. The ship resumed her oceanographic work, but on February 10, as *Eastwind* was passing near the island, her commanding officer took the opportunity to fly ashore for a brief stay.

In turn, Palmer Station received visits from other expeditions. Personnel from the Chilean naval vessel *Yelcho* visited the station on December 31, and others from the naval vessel *Piloto Pardo* stopped on February 2. The British Antarctic Survey ship *John Biscoe,* with Sir Cosmo Haskard, Governor of the Falkland Islands, aboard, called on January 22, and after the last United States vessel had departed, another British ship, *Shackleton,* stopped briefly to deliver mail to those wintering over.

Visitors of a different category also called at Palmer Station to inspect the facilities under provisions of the Antarctic Treaty. Official inspections were carried out by Argentina on January 31 and by the United Kingdom on February 22. Another group that was encountered consisted of a tourist party aboard the Argentine naval transport *Lapataia.* A projected visit to Palmer Station had to be cancelled because of ice conditions in Arthur Harbor, but the tourists were entertained aboard USNS *Wyandot.*

From McMurdo Station, LC-130Fs on two occasions flew to the Soviet's Vostok Station. These flights, made in connection with exchange of scientists between the two expeditions and the maintenance of United States equipment installed at Vostok during 1963-1964, allowed the Commander, U. S. Naval Support Force, Antarctica, his deputy, and the USARP Representative at McMurdo Station to visit briefly with their Soviet colleagues.

On November 11, a ski-equipped C-47 of the Argentine Air Force landed at McMurdo. It was one of a three-plane detachment that had flown to the South Pole by way of General Belgrano Base on the Filchner Ice Shelf. The other two, Beaver aircraft, remained at the South Pole while the C-47 proceeded to McMurdo. The Naval Support Force furnished supply support to all three planes, and naval personnel at McMurdo repaired an engine and replaced a wheel strut on the C-47 before the return flight.

A month later, on December 10, three Sno-Cats of the Argentine Army, also coming from General Belgrano, arrived at the South Pole after a 45-day journey. The machines were serviced and repaired with the assistance of Navy personnel at the station, and the traverse party was entertained for a period of five days.

The close cooperation with New Zealand continued during the 1965-1966 season. As in the past, New Zealand made a tanker available to the United States for transport of fuel to McMurdo. Also used for resupplying New Zealand's Scott Base, HMNZS *Endeavour* made two trips from New Zealand to McMurdo Station last season, ferrying over one million gallons of fuel and 21 tons of dry cargo. This year, for the first time, New Zealand aviators flew from their country to Antarctica and landed at Williams Field. On the three RNZAF C-130H flights, they transported almost 75,000 pounds of cargo for the United States and New Zealand stations.

In return, the United States expedition transported, aboard its aircraft and ships, New Zealand cargo and personnel between Christchurch and McMurdo Sound, and supported New Zealand field parties. The two United States destroyer escorts, USS *Calcaterra* and USS *T. J. Gary,* regularly made stops at Campbell Island on their trips between New Zealand and "Ocean Station" (60°S. 170°E.) and delivered supplies and mail to the remote island. *Calcaterra* also provided transportation for 13 members of the 1966 New Zealand Auckland Island Expedition. They were landed at Port Ross and Carnley Harbor on January 15 and 16 and picked up on February 4.

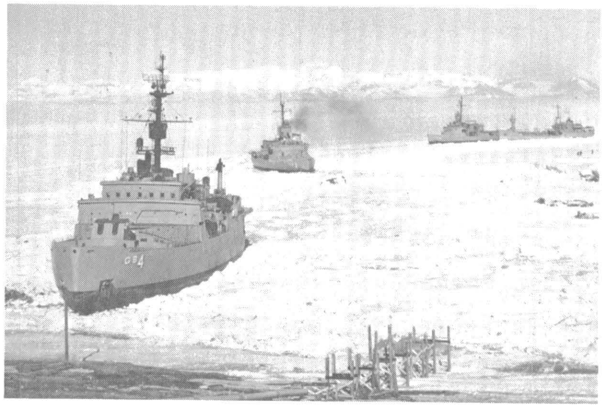
Beginning in 1955-1956, the United States has invited foreign governments to exchange representatives. This year the invitations were accepted by seven countries. Their representatives were Captain Enrique Ferrari, Argentine Air Force; Mr. John Béchervaise, Australian Ministry of Foreign Relations; the Honorable Alfred van der Essen, Director, Ministry of Foreign Affairs, Belgium; Mr. Victor Dezerega, Chilean Antarctic Institute; Mr. Shunichi Nomiyama, First Secretary of the Japanese Embassy in New Zealand; the Honorable J. S. F. Botha, South African Minister to the United States; and Mr. L. M. Forbes, Scott Polar Research Institute, United Kingdom. In return, the United States sent out only one official exchange representative, Lieutenant F. R. Myers, of the U. S. Naval Oceanographic Office, who participated in the Belgium-Netherlands expedition.

Ship Operations

The resupply of Palmer Station was carried out by the icebreaker *Eastwind* and USNS *Wyandot*. *Eastwind* delivered about 30,000 gallons of diesel fuel and about 10 tons of miscellaneous cargo early in January. *Wyandot* arrived at Palmer Station on January 26 and left two days later. Because Arthur Harbor was ice-filled at the time, *Eastwind*'s helicopters off-loaded the greater part of the cargo, about 30 tons. The remainder, about 7.5 tons, largely made up of bulky articles, was carried ashore in *Wyandot*'s landing craft, an LCM, manned by *Eastwind* personnel. When *Wyandot* left Palmer Station, she proceeded directly to McMurdo Sound and became the last United States ship to reach the Ross Sea area.

On the whole, ice conditions in McMurdo Sound were less favorable this year than last. When *Glacier*, the first icebreaker to arrive, reached McMurdo Sound on November 23, she found about 25 miles of fast ice blocking the way to Winter Quarters Bay. Because of a casualty to her No. 1 propulsion generator, *Atka* was delayed in New Zealand for repairs, and the channel to Hut Point was begun by two icebreakers, *Glacier* and *Burton Island*, rather than three. They attacked the ice on a narrower front than would have been used if three ships had been present. A second factor leading to a difficult situation was lack of southerly winds to blow the brash out of the channel. As a result, the channel tended to refreeze and constantly had to be reworked to keep it open. Finally, the fast ice several times broke off in great sheets which blocked the channel and had to be cut before the channel could be used.

When the first resupply vessel, the tanker *Alatna*, arrived on December 12, she was forced to lie off the channel entrance for six days while the icebreakers sought to prepare the way. It then required all three icebreakers to work *Alatna*, towed by *Burton Island*, into Winter Quarters Bay. While



(U.S. Navy Photo)

this was perhaps the most difficult ship operation of the season, escorting and towing continued until mid-January, almost a month longer than the previous year. In the course of the operation, *Alatna* and *Endeavour* delivered to McMurdo Station almost 5,700,000 gallons of petroleum products, while the cargo vessels, *Towle, Petrarca*, and *Wyandot*, discharged 5,474 long tons[1] of general cargo to the same destination. The difficult conditions encountered early in the season had not prevented the ships from accomplishing their mission.

The icebreakers in the Ross Sea, like *Eastwind* off the Antarctic Peninsula, were able to contribute to the scientific program. *Burton Island* left McMurdo Sound on December 29, with a party of biologists on board. The ship stopped at Hallett for several days, where the ship's helicopters also flew scientists from that station to several points of interest in the vicinity. From Hallett, she proceeded up the coast to Cape Adare and Robertson Bay and put biologists ashore or on ice floes to carry out their studies. The ship made a radar survey of the coast and took soundings. Returning by way of Hallett, *Burton Island* arrived back at McMurdo Station on January 13, having steamed 1,217 nautical miles in support of the scientific program. Her helicopters had made 49 flights, accumulating 74.6 flight hours, for the same purpose.

Atka carried out a fathometer survey of previously uncharted waters along the west side of McMurdo Sound from February 13 through 16. For this work, she embarked representatives of the Naval Oceanographic Office. The actual soundings were made from the ship's Greenland Cruiser. On February 21, *Atka* left McMurdo for the last time to go to Hallett Station. En route the oceanographic per-

[1] A long ton is 2,240 pounds.

sonnel took 28 ice prediction stations. *Glacier*, the heaviest and most powerful of the icebreakers, which had led the way in channel breaking, set out on February 6 for the coast of Marie Byrd Land to support the aerial photography program. She would report weather conditions, and her helicopters would reconnoiter to the limit of their range and report the extent of cloud cover. After rounding Cape Colbeck, it was found that the ice was much thicker and more consolidated than earlier reconnaissance had indicated. On February 18, while maneuvering in heavy ice, *Glacier* damaged her rudder and, two days later, was ordered to New Zealand for repairs, which terminated her participation in *Deep Freeze* 66.

Season's End

Even before *Glacier* departed the Ross Sea, *Deep Freeze* 66 was drawing to a close. The last airplane flight to Plateau Station occurred on February 10, and to the South Pole seven days later. Byrd Station received its last visit on February 26. The following day the last of the aircraft left the Antarctic, and *Atka* arrived at Hallett to take off the last personnel from that station. She lingered there because *Wyandot* was still in the area, and there existed the remote possibility that icebreaker assistance might be needed. *Wyandot* left McMurdo Station on March 2, with the last of the summer support personnel and scientists and with 2,820 tons of cargo for the United States. *Atka* departed Hallett the same day. The season was over and those remaining in Antarctica settled down for the winter.

ORGANIZATION

Support operations in Antarctica are conducted by Task Force Forty-Three, United States Atlantic Fleet. This force is composed of the United States Naval Support Force, Antarctica, and assigned units from the Army, Navy, Air Force, and Coast Guard. Rear Admiral Fred E. Bakutis, USN, acts both as Commander, Task Force Forty-Three, and Commander, U.S. Naval Support Force, Antarctica, and the staff of the two organizations is the same. The following list indicates the principal groups and units of the Task Force for *Deep Freeze* 66.

UNITED STATES NAVAL SUPPORT FORCE, ANTARCTICA, AND TASK FORCE 43 ORGANIZATION FOR *DEEP FREEZE* 66

Commander, U.S. Naval Support Force, Antarctica, *and* Commander, Task Force 43—*Rear Admiral F. E. Bakutis, USN*

Commander, U.S. Naval Support Force, Antarctica, Representative, Washington, D.C. (Operating season only)—*Captain P. Lewis, Jr., USNR.*

Officer in Charge, Naval Support Force, Antarctica, Detachment One (Christchurch, N.Z.)—*Commander W. H. Withrow, USN.*

Officer in Charge, Naval Support Force, Antarctica, Detachment Two (Davisville, R.I.)—*Lieutenant D. R. Goodmon, USN.*

Commander, Antarctic Support Activities—*Captain H. M. Kosciusko, USN.*

Officer in Charge, Antarctic Support Activities, Detachment A (McMurdo Station)—*Commander J. G. Ballou, USN.*

Officer in Charge, Antarctic Support Activities, Detachment B (Mayport, Fla.)—*Lieutenant Commander H. J. Orndorff, USN.*

Officer in Charge, Antarctic Support Activities, Detachment C (Norfolk, Va.)—*Lieutenant Commander V. G. Law, USN.*

Commanding Officer, Naval Air Group *and* Commanding Officer, Air Development Squadron Six—*Commander M. E. Morris, USN.*

Commanding Officer, Army Aviation Detachment—*Major W. C. Hampton, USA.*

Commander, Air Force Task Unit—*Lieutenant Colonel R. D. Coffee, USAF.*

Officer in Charge, Mobile Construction Battalion Six, Detachment W—*Lieutenant C. V. Ripa, USN.*

Commander, Ross Sea Ship Group—*Commander J. S. Blake, USN*

USS *Atka* (AGB-3)—*Commander J. S. Blake, USN*

USS *Glacier* (AGB-4)—*Commander F. P. Faughman, USN*

USS *Burton Island* (AGB-1)—*Commander C. L. Gott, USN*

USNS *Pvt. J. R. Towle* (T-AK-240)—*A. W. Webb, Master*

USNS *Pvt. F. J. Petrarca* (T-AK-250)—*R. A. Wilson, Master*

USNS *Wyandot* (T-AKA-92)—*C. D. Henry, Master*

USNS *Alatna* (T-AOG-81)—*R. W. Coulter, Master*

Commander, Antarctic Peninsula Unit—*Captain W. M. Benkert, USCG*

USCGC *Eastwind* (WAGB-279) — *Captain W. M. Benkert, USCG*

USNS *Wyandot* (T-AKA-92)—*C. D. Henry, Master*

Commander, Ocean Station Unit—*Lieutenant Commander W. C. Earl, USN*

USS *Calcaterra* (DER-390)—*Lieutenant Commander W. C. Earl, USN*

USS *T. J. Gary* (DER-326)—*Lieutenant Commander R. C. Smith, USN*

STATISTICS

The following statistics provide general measures of the magnitude of the logistics effort of operations in Antarctica during the 1965-1966 season. Without aircraft, the prevailing pattern of operations would be impossible. Most personnel, both logistic support and scientific, are carried to and from Antarctica by air. Both passenger and cargo transportation inland and support of scientific field parties remain wholly dependent upon airplanes. It should be noted, however, that fuel, food, supplies and building materials, upon which the entire effort relies, arrived aboard ships except for select priority items. In the case of Palmer Station, ships provide both resupply and relief of personnel.

LC-130F INTRA-ANTARCTIC CARGO AND PASSENGER STATISTICS

Station	Tonnage * Delivered	Tonnage * Backhauled	Passengers Transported	Number of Flights
Amundsen-Scott South Pole	1,611	74	361	190
Byrd	1,662	157	390	214
Byrd VLF	223	3	7	25
Eights	4	23	6	2
Hallett	7	0	28	2
Plateau	519	46	80	53
Brockton	113	69	37	22
Little Jeana	64	32	41	13
Field Party Support	315	58	156	57
TOTALS	4,518	462	1,106	578

* Includes passenger weights.

OCEAN TONNAGE TO ANTARCTICA

Ships	Measurement Tons(1)	Long Tons(2)	Gallons
USNS *Towle*	7,850	2,868	None
USNS *Wyandot**	2,943	1,183	None
USS *Glacier*	162	33	None
USS *Burton Island*	35	13	None
USCGC *Eastwind*	24	5	30,000
USNS *Petrarca*	3,944	1,661	None
USNS *Alatna*	None	None	4,737,687
HMNZS *Endeavour*	None	None	1,130,913

* *Wyandot* back-loaded 2,820 measurement tons from Antarctica to the United States.

(1) *A measurement ton is an expression of volume equal to 40 cubic feet.*

(2) *A long ton is an expression of weight equal to 2,240 pounds.*

CARGO AND PASSENGER STATISTICS FOR DEEP FREEZE 66

	United States to New Zealand			New Zealand to McMurdo			Intra-Antarctica			McMurdo to New Zealand			New Zealand to United States			TOTALS		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
AIR FORCE																		
1501 ATW	....	*	....	238	*	136	....	*	....	217	*	31	....	*	....	455	*	167
1611 ATW	296	*	8	....	*	....	....	*	....	....	*	....	5	*	3	301	*	11
EASTAF	728	*	56	....	*	....	....	*	....	....	*	....	1,004	*	20	1,732	*	76
WESTAF	6	*	14	....	*	....	....	*	....	....	*	....	93	*	1	99	*	15
63 TCW	13	*	57	13	*	15	....	*	....	3	*	4	27	*	26	56	*	102
NAVY (VX-6)																		
LC-130F	12	2	10	273	33	113	1,106	134	4,384	438	54	36	16	4	11	1,845	227	4,554
C-121J	179	22	14	879	132	78	10	1	4	341	53	47	196	24	38	1,605	232	181
LC-47/117	*	*	*	*	*	*	68	9	22	*	*	*	*	*	*	68	9	22
U-1B	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
LH-34	....	....	....	....	....	....	5,936	*	95	....	....	....	....	....	....	5,936	*	95

* *Not calculated*

ARMY
UH-1B

Cargo and passenger statistics not available. The Army Unit flew 219 flights with 580 flying hours. Of this, 204 flights and 536 flying hours were in direct scientific support.

ICEBREAKER HELICOPTERS

Cargo and passenger statistics not available.

	Flights	Hours
USS *Burton Island*	266	315
USS *Glacier*	210	186
USS *Atka*	230	259
USCGC *Eastwind*	140	208

(1) *Numbers of passengers moved.*

(2) *Weight in tons for number of passengers. This is computed as 250 pounds per man within Antarctica, and 300 pounds per man in all other VX-6 flights. USAF weights extracted from its report.*

(3) *Cargo tonnage transported. Does not include passenger weights.*

Air Operations, *Deep Freeze* 66

MARION E. MORRIS
Commander, USN
Commanding Officer, Air Development Squadron Six

The summer support air operations for *Deep Freeze* 66 began with the departure of Air Development Squadron Six (VX-6) from its home base at the Naval Air Station, Quonset Point, Rhode Island, on September 18, 1965. The Squadron's two C-121J aircraft had already assisted U.S. Air Force C-135 jet transports in positioning several hundred naval support personnel at the main staging area in Christchurch, New Zealand. While pausing at Hickam Air Force Base, Hawaii, VX-6 flight crews tuned up their aircraft for the arduous months ahead, and, on September 21, the Squadron reported to the operational control of the commander of Task Force 43, Rear Admiral Fred E. Bakutis, USN. At that moment, VX-6 became Task Unit 43.3.1, the main component of the Antarctic Air Group (TG 43.3) which also included a three-helicopter Army aviation detachment from the U.S. Army Transportation Center, Fort Eustis, Virginia. This aerial task group would supply all of the inland air support for the logistic and scientific programs in the coming season. During the months of October and November, an Air Force unit with three C-130Es from the 1501st Air Transport Wing (MATS)[1] would join naval aircraft to provide transportation for personnel and high-priority cargo between New Zealand and McMurdo Station.

The traditional "kickoff" date of antarctic operations, October 1, found the four ski-equipped Lockheed LC-130F Hercules on the skiway at Williams Field, McMurdo Station. In the lead aircraft was the Commander, U.S. Naval Support Force, Antarctica, Rear Admiral Bakutis, whose arrival signalled winter's end and the beginning of a new and vigorous effort of air support for science.

Little time was spent in greetings. The aircraft refueled and immediately began the first of their many flights. While two of the Hercules commenced turnaround trips between New Zealand and the ice to fly in additional personnel, the other two LC-130Fs proceeded to establish Little Jeana and Brockton Weather Stations, located on the air routes to South Pole and Byrd Stations, respectively. These tiny, but vital, outposts were manned by aerographers, radiomen, and mechanics of Antarctic Support Activities (ASA), the Navy organization that maintains the seven permanent and seasonal United States antarctic stations.

Byrd Station received its first aircraft on October 4. The initial flight of the C-121 Super-Constellation on the following day to McMurdo's ice runway, located annually on the hard sea ice adjacent to Ross Island, brought 68 passengers and cargo of mail and fresh vegetables. At the same time, the helicopter operations got under way with a flight to the penguin rookery at Cape Royds. Early the next morning, a Hercules flew personnel to Hallett Station, and air operations were in full swing. In just a few short days, the silent continent was alive with the roar and whine of aircraft probing further inland as the temperature slowly rose.

It was during these early days of *Deep Freeze* 66 that the first aircraft accident of the season occurred. A Douglas LC-47 Skytrain, more familiarly known to the veteran airmen of the ice as a "Goon," encountered extremely hard sastrugi on takeoff from Williams Field and suffered collapse of its left main landing gear. A second LC-47 was to be lost on December 5 in the Horlick Mountains when its landing gear also failed under the repeated stress of open-snow landings. In this remote location, it proved impossible to repair the aircraft, and after valuable parts were removed, it was abandoned.

The first half of October, which saw an ever increasing tempo of air operations, was climaxed by the earliest fly-in on record to Amundsen-Scott South Pole Station. Rear Admiral Bakutis stepped from the aircraft on October 23 at 0016Z and greeted the men of the southernmost outpost with praise and admiration for their accomplishments during the seven and one-half months of isolation. Soon regular resupply shuttle flights were established. By the time the season was over, a total of 190 Hercules flights had been made to Pole Station. Operating in temperatures as low as −53°C.

(*U.S. Navy Photo*)
LC-130F at South Pole.

[1] Now the 60th Military Airlift Wing (MAC).

(−63°F.), the aircraft delivered 1,567 tons of cargo and 361 passengers.

Field Support by Army Helicopters

In support of the USARP programs in the Pensacola Mountains, a buildup of fuel and other supplies by LC-130F commenced in the final days of October. As soon as the 1963-1964 season's camp had been dug out and reactivated, the three Bell UH-1B helicopters of the 14-man Army Aviation Detachment were loaded aboard the Hercules at McMurdo and flown the 1,040 miles to the camp where they were off-loaded, assembled, and put into immediate operation to assist the scientific party conducting a geologic-topographic-geophysical survey of the area. The talent of the Army maintenance personnel and the skill of the pilots provided an availability and usage of the "choppers" that resulted in a most complete exploitation of the versatile and capable turbo-powered helicopters. By the time the Detachment was picked up in early January, the three helicopters had flown an impressive 178 flights totaling 455 hours in support of these scientific programs. A phenomenal 100 percent availability testified to the professional ability of the Army men. In addition to the Army helicopters, the scientific party in the Pensacolas received support from a Navy LC-47 that between December 8 and 15 carried out an airborne magnetometer survey.

November—Maintenance Problems Overcome

Early in November, two of the LC-130F aircraft suffered stress cracks in the supporting beams of their main landing gear. Field fix-kits were engineered and fabricated by the Lockheed Aircraft Co. plant at Marietta, Georgia, and dispatched over the 12,000-mile route to McMurdo, but the damaged aircraft finally had to be flown to Christchurch and repaired. Meanwhile, on the ice, nose strut difficulties and cracked windshield panels took an even deeper bite into the LC-130F air effort. Rising to the occasion, maintenance personnel of the naval air unit replaced the damaged nose strut by supporting the front of the aircraft on great rubber balloons. At the same time, a shelter of cargo parachutes was constructed around the cockpit and the cracked windows were replaced. Both feats had previously been considered beyond the capabilities of maintenance on the ice, for aircraft the size of the Hercules, but the ingenuity and determination of the Navy airmen proved more than a match for the situation.

Fortunately, the LC-47 "Goons" were able to continue with their missions, and the LH-34 Sikorsky helicopters kept the skies around McMurdo filled as they shuttled the many small scientific parties onto the ice shelf, into the dry valleys, and to the various penguin rookeries. The rotary-winged aircraft provided a major portion of the direct air support tendered to the scientific parties. As the season progressed and the icebreakers penetrated the deteriorating sea ice, the helicopters of VX-6 were often joined by those attached to the ships. Thus, maximum utilization of all available air power was efficiently realized.

Although maintenance difficulties continued to plague the Squadron during this second month of air operations, cargo from New Zealand continued to arrive on the Air Force C-130Es and the Navy "Super-Connies." Assistance was also received from the Royal New Zealand Air Force which flew three LC-130Hs to McMurdo with 75,000 pounds of cargo. The well-constructed ice runway on the annual sea ice was the center of activity on many November days. It was during this period that the final three aircraft, two LC-47s and an LC-117, arrived at McMurdo Station after a trying and exasperating 67-day, 12,000-mile trip from Quonset Point. It was a tired group of aviators that finally completed what is probably one of the most difficult transpacific flights on record.

On November 22, one of the LC-130Fs touched down on the polar plateau of East Antarctica at the Pole of Inaccessibility to position personnel of the South Pole-Queen Maud Land Traverse. During the season, the steadily plodding vehicles were resupplied by skillfully executed airdrops that included spare parts, mail, and even fresh eggs.

December—Plateau Station Operations

On December 13, a carefully planned operation, which was to become a milestone in the concept of air operations in Antarctica, commenced. After a precision aerial search to locate the crest of a high ridge running from the Pole of Inaccessibility towards the Queen Maud Land coast, an LC-130F Hercules, piloted by the Squadron Commander, glided cautiously to the surface of the polar plateau some 600 miles beyond the South Pole from McMurdo, and the American flag was planted at the site of the newest United States station, Plateau. The elevation was 11,890 feet (3,624 meters). Once the initial camp was established and the first few personnel were secure in their tents with their equipment and rations, the aircraft prepared to return to McMurdo. The soft snow which had yielded so readily to the flag now became a clinging mass on the Teflon-covered skis of the straining LC-130F. In addition, the thin air at this high elevation could not satisfy the power requirements of the aircraft's turbo-prop engines. Repeated takeoff attempts were made until finally the rapidly diminishing fuel load reached the point where one more try would tell the tale. If not successful, the newly established Plateau Station might very well be provided with an all-aluminum, ski-equipped building. The pilot taxied 14,000 feet downwind, turned around and lined up with his tracks. After an agonizing, fuel-consuming, 15-minute wait to allow the tracks to solidify, full flaps were lowered and all available power applied to the engines. Using full throw of the controls to steady the aircraft as it began to "lope" in its tracks, accelerating ever so slowly, the pilot called for jet assistance take off (JATO) as the airspeed crept past the 60-knot mark. Instantaneously, the eight JATO bottles fired to give an additional 8,000-pound thrust, and the Hercules was muscled free of the snow at 75 knots, far below its design performance of over 100 knots required for a normal takeoff.

With the technique established, a second supply flight followed the first. Soon, the small group of SeaBees positioned at the camp had smoothed and packed a 12,000-foot skiway. The remainder of the 53 flights into this highest and most remote United States station were accomplished almost without incident. By the final flights, the skill of the aircrews had developed to the point where they were loading and flying out the heavy traverse vehicles without the costly use of JATO.

In late December, to make up for time lost, crews flew "back-to-back" schedules. Bulk diesel-oil cargo flights were flown around-the-clock from McMurdo, oftentimes without shutting down the engines between trips. On December 28, the four dependable Lockheed Hercules amassed a total of 85.5 flight hours in the 24-hour period. Included was a flight to the Soviet station, Vostok, and a record-setting delivery of 267,000 pounds of cargo to the inland stations.

January—All Out Effort

January was the month of the successful completion of the aerial support requirements for *Deep Freeze* 66. With the deterioration of McMurdo's annual sea-ice runway in the first half of the month, the wheeled C-121Js could no longer operate. Yet, no slowdown of resupply occurred. As the men of Cargo Handling Battalion One joined those of Antarctic Support Activities in off-loading the ships which arrived at McMurdo Station, the air team flew the vital supplies inland. Returning aircraft were met with new loads that were only minutes out of the cargo holds of the moored ships. So efficiently did the aerial resupply progress during January that the Squadron was still able to meet its commitments in back-loading the scientific party from the Pensacola Mountains, make a second flight to Vostok, maintain an uninterrupted schedule to Plateau Station, and meet all of the scientific support requirements programmed for the period.

The helicopters worked more feverishly than ever before around Ross Island. Little Jeana, the summer weather station, was disestablished, and its buildings and equipment were flown back to McMurdo. Time was even found for a final flight of the single-engined DeHavilland U-1B Otter which has outlived its usefulness in Antarctica and was retired with honors. In this same period, a total of 1,486.3 hours was flown by the Hercules, an all-time high, while other aircraft flew an additional 600 hours. Having overcome early-season setbacks, the Squadron entered February with an air of optimism and a feeling of satisfaction that a difficult and extensive mission was on the verge of accomplishment.

February—Tragic Accidents

On February 2, as it approached the Mile 60 camp in the vicinity of Little America, an LC-47 encountered severe icing during its letdown and, while in its landing approach, suddenly spun into the snow surface obscured by a whiteout. The crew of six perished. As the stunned shipmates of the lost crew continued their air effort without pause, the elation of success gave way to sober realization of the price which must sometimes be paid for the knowledge being obtained on the Antarctic Continent. As if in emphasis, another navyman died from injuries suffered during aircraft unloading operations at South Pole Station 11 days later.

Despite these tragic events, the closing air operations were accomplished as planned. Brockton, like Little Jeana before it, was disassembled and flown back to McMurdo. On February 17, Rear Admiral Bakutis paid a last visit to South Pole Station on a flight that delivered mail and final supplies to the men preparing for the long antarctic night. Byrd Station received similar consideration and, on the morning of the twenty-seventh, the departing aircraft dipped their wings over McMurdo Station as they pulled up and away towards New Zealand.

There is no question of the success of air operations during *Deep Freeze* 66. Air support goals were accomplished, and new techniques of operation were proven. The maximum-load takeoffs accomplished at Pole Station during *Deep Freeze* 65 were routinely repeated in the establishment of Plateau Station during *Deep Freeze* 66. The previous year's exploratory flights over the polar plateau opened the entire continent to extended air operations during this most recent season. The United States exploration of the Antarctic Continent is limited now only by the amount of emphasis which is placed on it. Air operations have opened the door to the vast storehouse of knowledge in Antarctica.

Design For Survival
The Story of Plateau Station

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and

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On December 13, 1965, an LC-130F of Air Development Squadron Six (VX-6) landed at 79° 15′S. 40°30′E., to leave six men alone high on the polar plateau. Thus began the execution of a construction project many months in planning.

Eleven months before, to the day, the National Science Foundation set forth its detailed requirements for support of research programs at a station on the polar plateau in East Antarctica. The research was to be much like that at Eights Station in West Antarctica. In addition, it was expected that the vehicles being used on the South Pole-Queen Maud Land Traverse would be overhauled at the new station. To satisfy these requirements, the Foundation suggested a station composed of vans similar to those at Eights and manned by 12 men.

Like Eights Station, the proposed Plateau Station would have to be wholly dependent on Navy airlift, working at extreme ranges and altitudes. The air operations officer of the U.S. Naval Support Force, Antarctica, made a rough analysis of the logistics required to place the materials for such a station at 80°S. 40°E. He found that there were not enough flight hours available to support other scientific programs if a station of the proposed size were to be built. Only half the flight hours needed to place and support an Eights-size station could be allocated to the new project. The scope of the station had to be restricted without loss of capability to support the scientific programs. Within reason, funds were available to develop a smaller station and provide labor-saving devices which would cut the effort necessary to establish and support it, as well as reduce the number of people necessary to operate it. The original wintering-over complement had been fixed at 12, six scientists and six Navy support personnel. With a smaller station and cross-trained personnel, it appeared possible to hold the number to eight. For a time it was thought seven would be enough, if everyone shared the cooking, but experienced men believed a trained cook was essential for health and morale under the expected rigorous conditions.

All aspects of support were considered in the effort to reduce airlift requirements. An expensive energy-conservation system was proposed. The building would be heated by circulating engine coolant from the diesel generators, thus saving an estimated 10,000 gallons of fuel per year, more than 20 percent of the projected normal fuel usage. Eighty LC-130F flight hours, about 5 percent of the total hours available during *Deep Freeze* 66, could be saved.

Like Eights, Plateau Station would probably be composed of vans. Each van would necessitate one flight to Plateau Station. Distance dictated that aircraft payloads be no more than 16,000 pounds unless the aircraft could refuel en route. The vans used at Eights had been 27 feet in length, although the cargo bay of an LC-130F was about 40 feet long. It was found that longer vans could be loaded into the aircraft, and those finally decided upon measured 36 by 8½ by 8½ feet, with a maximum weight of 23,000 pounds. Using longer vans, fewer were needed, and a reduction in the number of flights could be made even though refueling at Pole Station would be required. Two additional flights were, thus, required to Pole Station to deliver aircraft fuel for every flight to the Plateau Station site. Even so, this was a more efficient arrangement than direct flights with reduced payloads. Such planning brought the construction and support of a station on the polar plateau within the realm of feasibility, at least in theory. The concepts were refined, committed to paper, and sent to the Bureau of Yards and Docks (now the Naval Facilities Engineering Command) for conversion into plans and specifications, the basis for procurement.

Design

The design problem was not routine. The Bureau of Yards and Docks' engineers and architects had to design for survival at the highest and coldest location yet occupied by the United States in Antarctica, 11,890 feet (3,624 meters), with temperatures expected to drop to -90° C. (-130° F.).

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The designers had to make the station as livable, as capable of supporting complex scientific equipment, and its operations as free of physical labor as possible, without sacrificing reliability and simplicity. While low temperature was a problem, wind was not expected to be. The designers were informed that the location of the station was thought to be such that high wind conditions, similar to those prevailing at most other United States antarctic stations, would not be encountered. In addition to the cold, concern was felt about the rarity of the air. This condition is exaggerated in the polar areas where atmospheric pressures are considerably lower for a given altitude than in the temperate and equatorial zones. For example, the pressure at 12,000 feet in Antarctica is the equivalent of about 13,500 feet at the Equator. Since, at the time, no one knew the exact height at which the station would be located, the designers had to plan for extreme conditions. An examination of the existing literature on the ability of the human body to function for long periods under such conditions revealed considerable differences of opinion. Some mountain climbers reported having slept with oxygen masks to be able to sleep at all. Indian soldiers died of pulmonary edema, a pneumonia-like affliction, in the high Himalayas. Pressurizing the bunk rooms was considered, but rejected as unnecessary and expensive. The Soviets at Vostok occupy a site nearly as high and cold as it was expected Plateau would be, and have experienced similar conditions without needing pressurized facilities, although several cases of altitude sickness have been reported. Lieutenant Commander Paul Tyler, the Naval Support Force Medical Officer, decided, after a review of the available literature, that the answer lay in high physical and psychological standards and gradual acclimatization of the personnel. They would stage at South Pole Station for 10 days to accustom their systems to low oxygen intake. Located at an elevation of 9,184 feet (2,800 meters), Pole Station was ideally suited for this purpose.

The design concept—compact, prefabricated vans—emphasized ease of construction. Plumbing and electrical connections between vans were minimized. Assembly of the vans into a station had to be simple. Shipping schedules and austral summer temperatures dictated the beginning and end of the construction season: the job had to be done in January. Because of support problems, the station construction crew was limited to 10 men and the period to assemble the vans to 14 days.

To meet all these requirements, a decision was made to use four van units, which would, when completely assembled and connected with an interior "permawalk," comprise the main station building. A small balloon-inflation tower and an aurora tower were also to be attached.

The vans were to be prefabricated of a wood framework and plywood wall construction. The outside was to be covered with sheet aluminum. Rigid polyurethane insulation, three inches thick, would be used between the wood studs to insure very low heat transmission. Careful attention was paid to the nailing so that there would be no through connection of any kind between the outside and the inside walls. A strip of ¼-inch cork was to be placed between each stud and the plywood panel to help eliminate the possibility of thermal conductivity and preclude frost buildup on cold spots.

The first van was to contain the meteorology laboratory, observation dome, doctor's office, and two bunk rooms (fig. 1). The meteorological observation domes previously used in Antarctica turned on ring mounts and they were not airtight. A fixed-mount, clear plastic dome, 4½ feet in diameter, was chosen to permit the observer unlimited vision in any direction. Frosting of plastic domes had been a problem in the past, but at Plateau a heat duct, similar to a defroster in an automobile, was designed to distribute hot air over the inner surface to keep it clear.

The doctor's office was made very small and is not suitable for any major surgery. Hindsight shows that this space should have been larger, with more room for equipment and supplies. After the design was finished, the Navy decided on a research program to investigate the physiological and psychological effects occasioned by high elevation and very low temperatures.

Two of the four bunk rooms were planned to be in the first unit. The bunk rooms presented special architectural problems. Privacy in sleeping quarters at stations of this type was something to be desired, but difficult to attain. One man to a room would have been preferable, but space limitations would not permit it. Designing for two men to a room partially solved the problem. In an effort to make available space more enjoyable, the built-in double bunks were made of prefinished wood, with the finest mattresses obtainable, and with curtains which could be closed for privacy. Vinyl wall covering was chosen for its easy cleaning characteristics and continued attractiveness. The color combinations were carefully selected to create a pleasant, unobtrusive atmosphere, one that could be endured for long periods.

The second unit was planned to include all the rooms which required plumbing: the darkroom, kitchen, and bathroom with complete sanitary and laundry facilities. The communications room was also placed in this unit. The kitchen was designed to resemble a residential kitchen, with stained wood cabinets and a brightly colored counter, a counter-top range, a household refrigerator, and an under-counter dishwasher. The idea was to avoid the look of a typical stainless steel Navy galley, and to make it, instead, like a kitchen at home. Further, the use of domestic furnishings rather than industrial kitchen installations reduced the electrical requirements.

The communications room in this unit would house ham radio equipment for contact with the outside world, and that ever-important phone "patch" home. Official communications equipment, and an ultra-high-frequency (UHF) homer, were also included. This equipment was taken from Eights Station and installed in the van at McMurdo before the van was flown inland.

The aurora laboratory, with an aurora tower above it, and the very-low-frequency (VLF) radio research receivers were located in the third unit. The aurora tower was designed to be entered through the laboratory. Colors for laboratory spaces were carefully chosen. The walls in these rooms were also covered with vinyl wall covering, and all the cabinets were made of stained and prefinished wood. The aurora-VLF laboratory had more area than any of the other scientific spaces. The space requirement was not clearly stated during the design stage, and it now appears that perhaps too much area was allotted. Some of it, however, is being used for medical research.

The fourth unit, the mechanical van, was to contain power, heat, and water sources for the main camp. The total-energy concept for the mechanical-electrical system advocated by the planners was adopted by the Bureau of Yards and Docks' mechanical engineers. Normally, diesel generators use about one-third of the heat from the fuel burned for power generation, the rest being lost. The total-energy concept makes it possible at Plateau to reclaim about 40 percent of this "waste" heat. To recover the heat and still protect the engine cooling system, the engine coolant, upon leaving the engines at 82° C. (180° F.), is passed through a liquid-to-liquid heat exchanger. Using a closed primary system like this, the danger of loss of pressure in the cooling system is reduced. The secondary liquid heated in the exchanger is then circulated through a liquid-to-air heat exchanger in the van heating ducts. Heat from this exchanger can be supplemented by electrical heat. The heating ducts were to be run in the floors to help warm them, a luxury in Antarctica. Air from the ducts forced into the rooms at floor level would help relieve the air stratification normally encountered in antarctic buildings. A humidifier was included to add water vapor to the virtually moistureless antarctic air. Plateau Station is the first of the United States antarctic stations in which adequate attention has been given to humidification.

Heat generated by the engines was also used to keep the fuel warm and to provide the station's water. Unless warmed, the fuel stored outside in 25,000-gallon rubber bladders would turn to jelly should winter temperatures drop as low as −90°C. (−130°F.). Heating the fuel is accomplished by circulating it through a heat exchanger warmed by the heat from the engine coolant. Water is obtained by melting snow in a tank through which the engine's exhaust pipe is run.

The two 75-kilowatt Caterpillar diesel generators were specified to be supercharged because of the high elevation. These generators and the rest of the mechanical and electrical equipment, including pumps, fans, switchgear, heat exchangers, and tanks, were designed to fit into a small area. There is no waste space in this unit, although it might have been better to have reduced the size of the workshop and increased the size of the mechanical room. This complete system was designed so that each of its functions could be performed by other, independent systems in the case of failure. Important functions affecting safety would have at least two backups.

The "permawalk" area, which is formed by putting floor and roof panels between the two rows of vans, was planned as a recreation and living space. The floor panels, each 36 feet long, were designed like the floors of the van units. The roof of the "permawalk" was designed in 8- by 8-foot insulated panels, to insure that the SeaBees could easily handle them during construction. "Camlock" connectors were specified to provide ease of erection and allow the builders to make connections with a simple, large Allen wrench without removing their gloves, another example of the effort to simplify construction.

In addition to the main station, an emergency camp, to be located 1,000 feet from the main buildings, was designed and built. It will be available in event of fire, generator failure, or fuel loss, and will also provide accommodations for summer support personnel. It consists of a single van containing a generator room, kitchen, and toilet room connected to a special 16- by 32-foot Jamesway hut designed by the Naval Civil Engineering Laboratory. Provision was also made to supply power from this source for scientific programs at the main station if the generators there should fail.

In addition, Bureau of Yards and Docks engineers designed a ramp of structural aluminum for the specific purpose of unloading and loading the vans from LC-130 aircraft. Built on runners, these

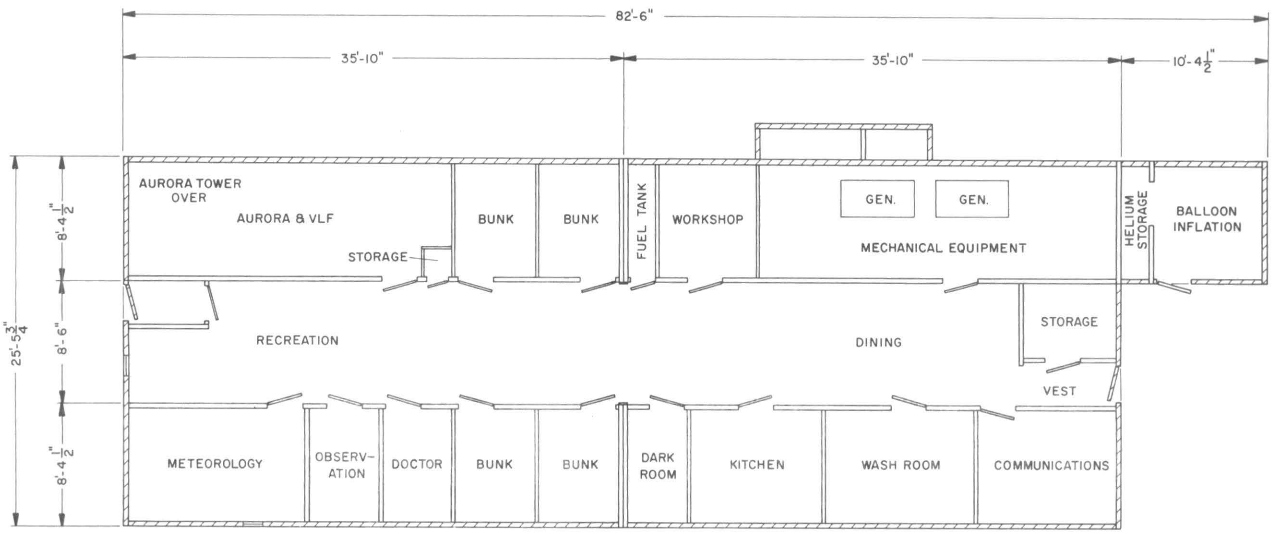


Fig. 1. Plateau Station Floor Plan

ramps could be towed with a van on them by a 955 Traxcavator to the construction site, thereby greatly facilitating the unloading operation.

Procurement

With the completion of the design, the technical officer at the Naval Construction Battalion Center, Davisville, Rhode Island, took over. Negotiations were begun with the Alberta Trailer Company (ATCO) for manufacture of the vans. The Naval Support Force, Antarctica, insisted that a single point of responsibility be established for supplying every item of material and equipment necessary for a reliable station, and further, that the workability be proven before shipment to Antarctica. ATCO, the same company that had built the Eights Station vans, assumed this responsibility and, as evidenced by the results, discharged it successfully.

Training

Mobile Construction Battalion Six (MCB-6), recognizing the necessity for intensive planning and training to insure success in the construction phase, appointed, in May 1965, Ensign David Ramsey, CEC, USNR, as prospective Officer-in-Charge of the construction. He and his senior petty officer, now Chief Builder Gerson Hyatt, picked a vigorous and capable crew who trained together, studied plans, made their schedules, and looked for unforeseen problems. A trip to the manufacturer at Calgary to participate in the factory erection and test of the station was included in the training.

Consumable supplies were ordered especially for Plateau Station and delivery was monitored by using a machine- and computer-oriented system. The list of supplies was checked and cross-checked to insure that nothing was forgotten. Final checking took place just before all the necessities for construction and living were loaded on USNS *Towle* in November for shipment to McMurdo.

On November 29, 1965, a final planning conference took place at McMurdo Station. Each job that remained to be done at McMurdo was assigned to one man as his responsibility. The passenger movement schedules were made for the group going to the South Pole for acclimatization and then onward to the construction site. The equipment, including two 10-ton Traxcavators, vans, supplies, and fuel, was to be shipped in accordance with previously prepared construction schedules. Training, refinement of planning, and constant checking continued.

Execution

On December 13, Captain V. Donald Bursik, Deputy Commander, U.S. Naval Support Force, Antarctica, planted the United States flag at 79° 15′S. 40°30′E. The advance party, including Lieutenant J. L. Gowan, MC, USN, prospective Officer-in-Charge; Robert Flint, Station Scientific Leader; Charles L. Roberts, of the U.S. Weather Bureau; Arthur Weber, architect from the Bureau of Yards and Docks; E. C. Horton, Jr., a Navy electronics technician cross-trained as a radio operator; and Robert Faul, ABC-TV, erected a tent camp and later a Jamesway hut. They determined the prevailing wind direction and insured that the site was satisfactory from a scientific point of view. The test of months of preparation had begun.

Shortly before January 1, 1966, a number of things began to happen at once. The SeaBee construction crew arrived and set up additional temporary camp facilities at Plateau. *Towle* arrived at McMurdo and the vans, which had been deck-loaded, were off-loaded onto the fast ice in front of McMurdo Station. The vans were put on sleds and carefully hauled to Williams Field for final inspection by MCB-6, installation of the communications gear by electronic technicians from the 14th Naval District Industrial Manager's Office, and final loading in LC-130F Hercules aircraft for shipment to Plateau. At Williams Field, the ramp designed by the Bureau of Yards and Docks was not used; the vans were loaded directly from the sleds into the aircraft. The ramp was used at Plateau Station to unload the vans, however, and proved very successful after a few minor difficulties had been overcome.

(U.S. Navy Photo)

Unloading Van at Plateau

At Plateau, the vans were placed on a timber foundation made of a grid of 2- by 12-inch and 6- by 8-inch timbers placed on firmly compacted snow. The snow at Plateau was extremely soft, but was compacted by running the Traxcavator back and forth over the area and then allowing the snow to harden. Placing the vans was accomplished by constructing a small ramp from the snow surface to the top of the foundation and using the winch on the Traxcavator to pull the units into place. The total construction time was a little over three weeks, including the installation of the fuel bladders and piping system, and delivery of 50,000 gallons of arctic diesel fuel in bulk and an emergency supply of fuel in 55-gallon drums sufficient for 16 weeks.

Few unanticipated problems arose. In fact, the entire Plateau operation is a model of what can be done with thorough planning and clear assignment of responsibility for the ultimate delivery to the site of every single item needed. It is interesting that while every effort was made to fix responsibility for getting material to the site, a different management concept, common to United States operations in Antarctica, was employed for the actual construction. At United States stations, independent authority exists for scientific and logistic support programs, integrated only by the concern of the individuals for the success of their mutual endeavor. At Plateau Station, there were seven men on location, each of whom felt himself significantly responsible, in one way or another, for the successful consummation of all of the previous efforts. These included the naval Officer-in-Charge of the station, the Station Scientific Leader, the National Science Foundation representative, the Bureau of Yards and Docks representative, the manufacturer's technical representative, the SeaBee Officer-in-Charge, and the Naval Support Force representative. To attempt to integrate the feelings of responsibility of all these strong and dedicated men on a formal basis in the usual hierarchy of command appeared impossible. It was felt that to do so would have diminished their individual feelings of responsibility and dedication and reduced the effectiveness of the group as a team. Captain Donald R. Pope, CE, USA, the Naval Support Force on-site representative, was instructed that he was in residual charge of establishing the station, but that he would not take over full responsibility unless the informal relationships started to break down. Planning and preparation had been so thoroughly done, and the cooperation was so good, that the construction, supply, and fueling of the station proceeded without a hitch, giving Captain Pope no occasion to exercise his authority.

On January 30, Rear Admiral Fred E. Bakutis, USN, Commander, U.S. Naval Support Force, Antarctica, officially dedicated Plateau Station. That the station was built and works as originally conceived in the minds of the planners, is a tribute to every man who participated in this project. Each of them should find in its successful completion a sense of satisfaction for a formidable job well done.

Mobile Construction Battalion Six, *Deep Freeze 66*

RICHARD D. WHITMER
Lieutenant Junior Grade, CEC, USN

Detachment *Whiskey* of Mobile Construction Battalion Six, composed of 5 officers and 104 enlisted men, deployed from Davisville, R.I., to the Antarctic in October 1965. The detachment, with a few antarctic veterans among largely young construction men, was led by Lieutenant Carl V. Ripa, CEC, USN, with Lieutenant Junior Grade Richard D. Whitmer, CEC, USN, as assistant Officer-in-Charge.

A majority of the construction projects assigned Detachment *Whiskey* involved the replacement or renovation of existing facilities. It seemed natural then to adopt the popular slogan of "Urban Renewal" for its motto when the personnel mobilized on site at McMurdo Station. The Detachment was organized into companies following the standard mobile construction battalion pattern. Senior petty officers were named as company commanders with Chief Builder John D. Becker as Operations Chief and Chief Electrician James L. Hanson as Chief Master at Arms.

Priority projects at McMurdo included completion of a 10-bed dispensary with the most modern facilities possible. Another major effort was to rework nearly a mile and a half of the McMurdo water system, installing new heating tape, and placing the saltwater distillation plant in operation. Approximately half of the foundation pad for the new personnel quarters building was to be completed. During the first few weeks of the deployment, the dispensary represented the only available inside project at McMurdo, and the majority of the SeaBees had to work outside in subfreezing temperatures with biting winds and blowing snow. Under these conditions, several projects were carried on, such as completion of the earth sciences laboratory building, preparation of a foundation pad for a VX-6 warehouse, installation of carbon dioxide fire extinguishing systems for two radio communications buildings, installation of new shutters for the diesel generator plant, preparation of the petroleum, oil, and lubricants (POL) system, and final modification of the senior scientists' quarters. Other early season projects at McMurdo were the water system, the flushing of the POL system, and the demolition of two Quonset and two Butler-type warehouses to make room for the personnel building foundation pad.

In late November and early December, weather at McMurdo improved to such an extent that additional work was taken on by the Detachment. The floor and sub-floor for a new public works and transportation building, including access ramps and parking areas, were completed on Christmas Eve.

Inland Station Construction

The number one priority project for the season was the construction of a station high on the polar plateau. In mid-December Lieutenant Junior Grade James D. Ramsey, CEC, USNR, Chief Builder Gerson Hyatt, and a subdetachment of 13 men went to the South Pole for a period of acclimatization. While there, they accomplished several pieces of needed construction. At the end of the month, they moved to the site of Plateau Station and commenced work. The construction was completed and turned over to Antarctic Support Activities for operation on January 31.[1]

During the same month, a second subdetachment led by Ensign Stephen E. Warwick, CEC, USNR; Equipment Operator First Class Richard H. Gern; and 20 men went to Byrd Station to accomplish several minor projects and to construct a facility at the site of the very-low-frequency antenna located approximately 13 miles from Byrd Station. This facility was of the same type as Plateau Station, but consisted of only three vans and differed further in that the complex was covered with a

(U.S. Navy Photo)
New Dispensary at McMurdo Station

[1] See S. K. Kauffman and A. M. Weber, "Design for Survival," in this issue for details.

metal arch 100 feet long and 35 feet wide to prevent damage from snow accumulation. This VLF facility was completed in mid-February.

In early February, an explosion occurred in the balloon inflation shelter at Pole Station and rendered it unusable. Quickly, 10 SeaBees, under the supervision of Builder First Class Charles M. Austin, were flown to Pole Station to build a new balloon inflation shelter and enable the station to continue the valuable work of gathering weather data. The remnants of the damaged structure were removed and a new building was completed and ready for use on February 13.

Completion of Construction at McMurdo Station

In late January, the McMurdo water system was placed in operation and the first flush toilets at McMurdo were tested in the new dispensary. The dispensary itself was completed in mid-February.

A major responsibility of Detachment *Whiskey* during *Deep Freeze* 66 was to receive, inventory, and stage 2,700 tons of construction material for *Deep Freeze* 67 projects. The most significant portion of this cargo included the complete structural materials for the prospective McMurdo personnel quarters building. This building, 315 feet long and 165 feet wide, will contain comfortable barracks, wash rooms, mess hall and galley, ship's store, and laundry facilities under one roof. The building will have 67,693 square feet of floor area. Ensign Henry A. Vroman, SC, USN, the Detachment Supply Officer, supervised the staging of all construction materials and provided outstanding supply support to all projects, including outlying stations, with only two rated storekeepers.

As the season neared its end, in mid-February, the water system was delivering unprecedented quantities of pure, fresh water to McMurdo Station. It was then closed down and drained, to be ready for full use beginning with *Deep Freeze* 67. Even though only half of the earth work for the personnel quarters building had been scheduled for completion this season, it was completed in its entirety, requiring 6,024 cubic yards of fill. The foundation pad, including a ramp and culvert system, for a VX-6 warehouse, which represented another 4,156 cubic yards of fill, was also finished.

During the period November 1, 1965, through January 31, 1966, a three-man crew, led by Equipment Operator Third Class Denwood L. Fairley, was assigned to assist the Naval Civil Engineering Laboratory (NCEL) on several research projects, such as snow-compacted roads and runways on the permanent shelf ice adjacent to Ross Island.

Philatelic Mail For 1966-1967

Philatelists may send covers to be postmarked at Amundsen-Scott South Pole and Byrd Stations in Antarctica and aboard *Deep Freeze* ships which operate a post office, during the 1966-1967 antarctic season. Collectors are limited to one cover per person to be postmarked at Byrd Station and South Pole, and three covers per person from each ship. Byrd and South Pole postmarks can be obtained by placing two addressed covers bearing United States postage at the letter mail rate in an envelope and mailing them to:

DEEP FREEZE Philatelic Mail
U.S. Naval Construction Battalion Center
Davisville, Rhode Island 02852

International Reply Coupons may be used by collectors from foreign countries to defray postage costs on covers.

One cover will be sent to Byrd Station and the other to the South Pole for postmarking. If a cancellation is desired from only one station, the word "Byrd" or "Pole" should be written in the lower left corner of the cover. Philatelic mail to be postmarked at Byrd or South Pole Station must reach Davisville not later than September 1, 1966, in order to be processed during the *Deep Freeze* 67 antarctic winter. The postmarked covers should be received by the collector between October 1967 and April 1968.

Cancellations from participating ships can be obtained by sending covers to:

DEEP FREEZE Philatelic Mail
(Name of ship from which postmark is desired)
(The Fleet Post Office Address)

The following *Deep Freeze* 67 ships operate a post office:

SHIP'S NAME AND ADDRESS	*CUTOFF DATE FOR COVERS*
USS *Mills* (DER-383) FPO New York, 09501	Aug. 1
USS *T. J. Gary* (DER-326) FPO New York, 09501	Sept. 1
USCGC *Glacier* (WAGB-4) FPO San Francisco, 96601	Sept. 15
USCGC *Eastwind* (WAGB-279) FPO New York, 09601	Sept. 15
USCGC *Westwind* (WAGB-281) FPO New York, 09501	Nov. 1

Philatelic mail will be returned unprocessed when more than the authorized number of covers is submitted, if it appears that a commercial motive is involved, if covers are received after the cutoff date, or when covers are submitted to *Deep Freeze* ships or units which do not operate a post office.

Emergency Medical Evacuation

On June 1, 1966, at McMurdo Station, Robert L. Mayfield, Utility Pipe Fitter, second class, reported to the dispensary with a ruptured bladder suffered in a fall. When he failed to respond to treatment and a rising white corpuscle count indicated an infection, it was decided to attempt an air evacuation to New Zealand.

This decision set men in motion from the United States to the South Pole. Air Development Squadron Six (VX-6) at Quonset Point, Rhode Island, prepared an LC-130F Hercules for the flight. Airports along the route were alerted that the aircraft would spend minimum time on the ground. In Christchurch, New Zealand, Detachment One of the U.S. Naval Support Force, Antarctica, commenced arranging for communications, flight weather data, and aircraft servicing, and its Officer-in-Charge informally approached the New Zealand Air Force and Naval Board for assistance. Since VX-6 had only one Hercules immediately available, the New Zealand Air Force was asked for a stand-by aircraft for search and rescue operations. A ship was requested from the Naval Board to take ocean station at 60°S. 170°E. for weather reporting and possible rescue service. Both New Zealand groups replied favorably, and the Naval Board ordered HMNZS *Taranaki* to Dunedin to refuel and prepare to get under way. Messages to the Australian and New Zealand meteorological services asked for supplementary weather observations from Macquarie and Campbell Islands and other pertinent information to be sent directly to Christchurch. Detachment One reactivated its weather facilities.

In the Antarctic, Byrd and South Pole Stations also augmented the usual weather observations and prepared their navigational aids and skiways for use as alternate landing facilities. At McMurdo Station, crews from Antarctic Support Activities' Detachment Alpha began to level the skiway, service the navigational aids, and bring fuel for the aircraft to Williams Field even while the emergency evacuation was in the talking stage. The men of VX-6's Detachment Alpha readied a helicopter, both to test the skiway's navigational equipment and to transport Mayfield the six miles from the dispensary to Williams Field when the hour came.

The Hercules had left Quonset Point at 1552 hours on June 3, with Commander Marion E. Morris, Commanding Officer of VX-6, as pilot. It stopped briefly in Washington to pick up Rear Admiral Fred E. Bakutis, Commander, U.S. Naval Support Force, Antarctica; Commander Arthur C. Kranz, staff meteorologist; Lieutenant Commander Paul E. Tyler, staff medical officer; and J. W. Hammond, Aerographers Mate, first class. From Washington the aircraft proceeded by way of Alameda Naval Air Station, California; Hickam Air Force Base, Hawaii; and Nandi, Fiji Islands; to Christchurch, where it arrived at 0930 on June 5. Of the 39 hours required for the 12,000-mile flight, 35 were spent in the air.

With favorable weather forecasts and preparations completed at McMurdo, the aircraft took off again after only 10 hours in Christchurch. Heavy winds were encountered at altitude, but on the ground winds were light and visibility was good. No difficulty was experienced in landing at 0416 hours on June 6.

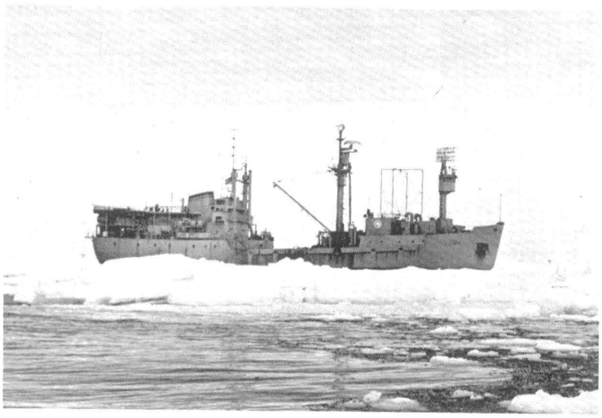
The accumulated mail and fresh provisions for McMurdo, put aboard the airplane in Christchurch, were unloaded while the helicopter brought Mayfield to the skiway, and the aircraft took off at 0720 hours. The same winds that had slowed the flight south, aided the return journey, which was made in seven hours. At 1422 hours, the aircraft was back in Christchurch, where a waiting ambulance took Mayfield, accompanied by Dr. Tyler, to a hospital. A successful operation was performed shortly after arrival.

Commander Morris permitted his crew a rest of 18 hours before beginning the return flight. The Hercules retraced its route and arrived back at Quonset Point at 0200 hours on June 9. The 24,000-mile round trip had been made in the remarkable time of 5 days, 10 hours, and 42 minutes.

(U.S. Navy Photo)

USNS *Eltanin*: Four Years of Research

K. G. SANDVED
Office of Antarctic Programs
National Science Foundation



(NSF Photo)

Fig. 1. USNS Eltanin

In 1961-1962, the National Science Foundation had the arctic resupply vessel, USNS *Eltanin,* converted into a floating laboratory for antarctic research. This expansion of the United States Antarctic Research Program represented a significant departure from the established pattern of research activity in Antarctica and made possible the extension of multidisciplinary research programs away from the Antarctic Continent and into the bordering seas, one of the least explored areas of the Earth.

Located after several months of search for a suitable vessel, *Eltanin* (fig. 1) attracted attention because she had been built specifically for use in arctic waters. Ice-strengthened, with a double hull and a cutaway bow, she also had an ice-pilot station on the foremast and protection of the screws against floating ice. Since the northern stations were being supplied by other means, *Eltanin* was made available to the Foundation by the Military Sea Transportation Service.

The vessel underwent extensive modifications at Mobile, Alabama, and Staten Island, New York, during 1961-1962. Her cargo spaces were converted into laboratories, scientific workshops, and scientists' staterooms. Above the main deck several laboratories were constructed, anti-roll tanks were installed, and protective bulwarks were added to permit work on deck during bad weather. After two shakedown cruises in the North Atlantic, the ship departed New York for Valparaíso, Chile, at the end of May 1962.

The National Science Foundation sponsors *Eltanin,* and the Military Sea Transportation Service (MSTS) operates the vessel and arranges for her resupply in ports of the Southern Hemisphere with funds from the Foundation. When the Foundation became the vessel's sponsor in February 1961 and for the next three years, the Atlantic Area Command of MSTS was in charge of the ship's operation. In February 1964, the responsibility for *Eltanin* was transferred to MSTS's Pacific Area organization, to facilitate crewing, resupply, maintenance, and operations during the South Pacific work. Throughout these five years, the cooperative attitude of the Service and the high quality of performance at all levels of the Command have permeated the operation of the vessel and contributed to the success of the scientific program.

A vertical cross section of *Eltanin* is shown in fig. 2, accompanied by a description of the vessel and its scientific laboratories as of May 1966.

THE SCIENTIFIC PROGRAMS

Eltanin is the only vessel extant devoted exclusively to antarctic research, and it supports a wide diversity of research interests during each of the cruises, including programs of both educational and governmental institutions. The scientific complement of 38 persons includes a representative of the National Science Foundation and a support party which performs the maintenance and operation of the major marine collecting gear and electronics equipment under a contract with the National Science Foundation. The Military Sea Transportation Service runs the ship with a civilian crew of 48.

The principal programs carried out aboard *Eltanin* have been hydrographic stations, piston and gravity coring, dredging, plankton tows, bathythermograph tows, continuous surface-water temperature recordings, bottom and mid-water trawling, bottom photography, large-volume water sampling, bottom grab sampling, precision depth recordings, sediment heat-flow measurements, magnetic recordings, meteorological upper air (radio-, rawin-, and ozonesonde) soundings and surface observations, seismic reflection recordings, incident and net radiation measurements, very-low-frequency and high-frequency recordings, cosmic ray monitoring, and auroral observations.

The following United States agencies and institutions have had scientific programs aboard *Eltanin* for varying lengths of time during the past four years:

University of Alaska
Bartol Research Foundation
Bernice P. Bishop Museum
University of California
Columbia University
DePaul University
Florida State University
Georgia Institute of Technology
University of Miami
National Bureau of Standards
University of Pittsburgh
Smithsonian Institution
University of Southern California
Stanford University
Texas A & M University
United States Weather Bureau
Virginia Institute of Marine Science
University of Wisconsin
Yale University

In addition to the personnel of these United States institutions, there have been a number of foreign representatives aboard. This development is the result of a desire on the part of the National Science Foundation to perpetuate the spirit of international cooperation prevalent in the programs on the Antarctic Continent. To date, representatives of some 10 countries have been accommodated aboard. These foreign scientists and technicians have either carried out projects of their own, or they have participated in the regular work of some United States institution. Foreign scientists will continue to be accommodated aboard *Eltanin* whenever possible.

Certain special studies aboard *Eltanin* can be completed during one or two cruises but, because of the nature of the area, most of the programs are long-term propositions. Some of these programs have produced such large quantities of samples or specimens that special arrangements have had to be made for their handling, preservation, and study, in order to assure optimum benefit to the scientific community. An example is the marine biological sampling program of the University of Southern California. Under this program, an unprecedented collection of marine organisms from all depths has been made which, in some instances, is unique to certain parts of the antarctic seas. The problem of receiving, sorting, accessioning, and distributing these huge collections in an orderly and expeditious manner has been solved by channeling the collections through the Smithsonian Oceanographic Sorting Center of the Smithsonian Institution. After the collections have been processed, the Center sends the specimens on to the original collecting agency, distributes them to specialists for study, or deposits them with the United States National Museum. During the first year of this agreement between the National Science Foundation and the Smithsonian Institution, nearly two million specimens from *Eltanin* were sorted at the Center. By June 1, 1966, the number had reached 5,350,000 specimens. More recently, the Center has also assumed the task of indexing, copying, and distributing *Eltanin* bottom photographs.

Another large sampling operation is the marine geological program of Florida State University. It has been estimated that *Eltanin* piston coring operations may produce nearly 40,000 feet of bottom cores during the next decade, and means must be found to preserve these cores for study by contemporary scientists and future generations. A new building, designed and constructed especially for this purpose under a grant from the National Science Foundation, was officially opened on January 24, 1966, at Florida State University. The one-story, 13,000 square-foot Antarctic Marine Geological Facility contains a section where 12,000 ten-foot long cores can be stored under controlled temperature conditions, as well as a smaller, refrigerated room for storing frozen sediments. The structure also has laboratory facilities for studying the cores. The core material is made available for study at other institutions.

A NEW NAVIGATION SYSTEM

A systematic survey at sea is only as good as the accuracy of the vessel's navigating system. In the absence of any major, land-based electronic navigational system, such as Loran and Decca, in the present area of operation of *Eltanin,* and with almost continuously clouded skies and long periods of darkness in the antarctic seas, positioning of the vessel with the desirable degree of accuracy was an impossibility during the early cruises. Strong winds and unpredictable surface currents in the relatively uncharted operations area were further hazards to accurate navigation. When, therefore, the opportunity arose in 1965 to install a prototype of a new satellite navigation system aboard *Eltanin,* it was *gefundenes Fressen* for the ship's navigators as well as the scientific programs.

Using the new navigating system, the vessel's position can be determined at frequent intervals and in any type of weather, and with an accuracy not known during the early cruises. The fully computerized system was installed during a regular port call at Auckland, New Zealand, in September 1965, between Cruises 19 and 20. Although there have been occasional problems with the system, it has already proved its value as one of the most important pieces of equipment aboard the vessel.

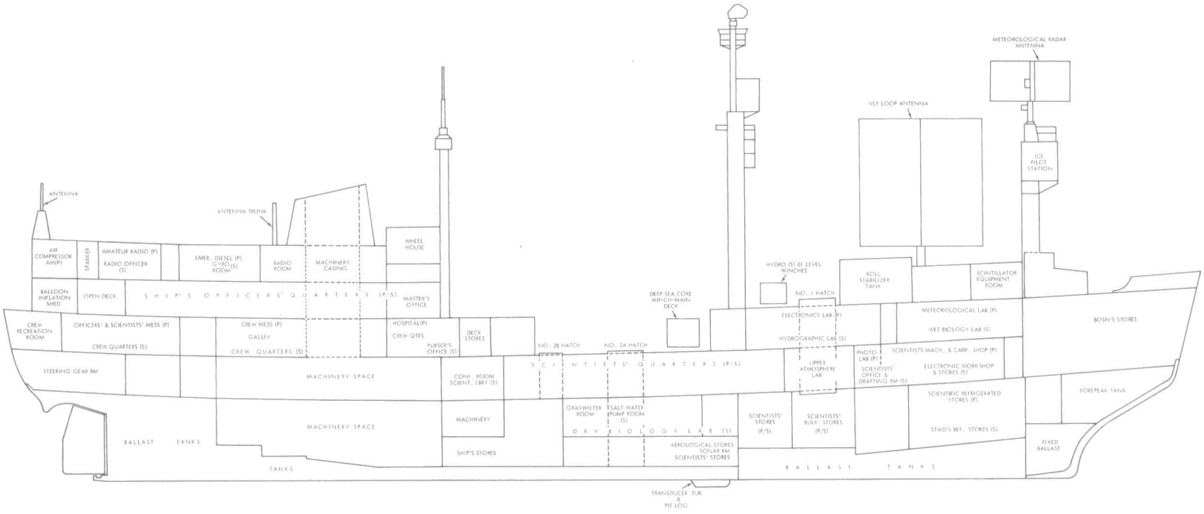


Fig. 2. Inboard Profile, USNS Eltanin

Constructed: 1957, converted: 1962
Hull: All welded steel with raked icebreaker bow, modified cruiser stern, and two continuous steel decks.
Length overall: 266 feet, 2 inches
Maximum beam: 51 feet, 6 inches
Draft: 19 feet, 9 inches
Displacement: 3,886 tons on full load
Tonnage: Gross 2,703 tons; Net 1,356 tons
Speed: Cruising 12.5 knots
Maximum 13.5 knots
Minimum 2.0 knots
Cruising range: 10,000 miles at 12 knots
Endurance: 90 days
Complement: 48 crew; 38 scientists
Propulsion: Diesel-electric
Power: 2,700 s.hp. continuous
Propellers: Two fixed pitch
Navigation equipment: two radar sets, Loran, radio direction-finder, echo sounder, and satellite navigation system.

Laboratories:

Biology Dry Laboratory—476 square-foot floor space. Equipage includes incubator, sterilizer, distillation unit, glasswasher, fume hood, refrigerated centrifuge, horizontal and vertical freezers, Warburg apparatus, and Beckman spectrophotometer. Compressed air and uncontaminated sea water available.

Biology Wet Laboratory—220 square-foot floor space.

Hydrographic Laboratory—418 square-foot floor space. Equipage includes Nansen bottle racks, Auto-Lab inductive salinometer, Beckman spectrophotometer, core examination bench, distillation and water storage units, and sink.

Electronics Laboratory—526 square-foot floor space. Equipage includes precision depth recording system, surface-water temperature recorder, sub-bottom sparker, proton magnetometer, Timesfax chronometer, dead-reckoning tracer system, seismic profiling recorder, and seismology darkroom.

Gravimeter Room—199 square-foot floor space located center of ship's motion.

Meteorological Office—248 square-foot floor space. Equipage includes 72.2 mc./s. rawinsonde receiver-recorder, hygrometer recorder (sensor installed on the ice-con station), barographs, barometers, anemometers, psychrometers and PPI and A scopes, and controls for the AN/SPS-28 tracking radar.

Cosmic Ray Laboratory—154 square-foot floor space. Equipage includes a high counting rate, plastic-scintillator, meson telescope.

Atmospheric Physics Laboratory—160 square-foot floor space. Equipage includes three magnetic tape recorders for recording whistler emissions, digital clock, electronic counter, motor-driven amplifiers for tape recorders, four-channel chart recorder, HF signal generators, and such test equipment as oscillators, vacuum-tube voltmeters, oscilloscopes, a tuneable VLF receiver, a wave analyzer, VLF phase-tracking receivers, and a frequency standard.

Photographic Darkroom—66 square-foot floor space. Equipage includes print washer, dryer, enlarger, and associated sinks, benches, etc.

Seismic Profiling Installation—74 square-foot floor space. "Sparker" room equipage includes 10,000 joule Rayflex Electra-Sonic profiling system. Sixty square-foot floor space, air-compressor room contains 3,000 PSI Ingersoll-Rand model 4R15X intermittent-duty air compressor and 3,500 PSI Rix type K continuous-duty air compressor.

Facilities supporting scientific programs:

One Alpine Geophysical Associates model 600 deep-sea trawl winch, diesel-engine driven, with a drum capacity of 25,000 feet of ½-inch wire, located midships on the main deck and oriented for starboard operations.

Two New England Trawler Equipment Company hydraulically operated hydrographic winches with a drum capacity of 30,000 feet of 3/16-inch wire, located midships and oriented for starboard operations.

One U. S. Navy E6/D bathythermographic winch, drum capacity of 30,000 feet of 3/32-inch wire, located on starboard quarter.

Machine/Carpenter Shop—402 square-foot floor space. Equipage includes Rockford 16-inch by 6-foot gearhead lathe, Bridgeport model J milling machine, South Bend floor-model drill press, DoAll model 16-3 band saw, Lincoln SAE 200-1 welding machine, tool racks, and workbenches.

THE CRUISES

Eltanin departed the United States in May 1962, and commenced her first antarctic cruise from Valparaíso, Chile, in July. Since that time, Valparaíso, and Auckland, New Zealand, have been the chief staging ports, but the ship has also called at Punta Arenas, Puerto Williams, and Talcahuano, Chile; Ushuaia, Argentina; Montevideo, Uruguay; and Wellington, New Zealand. Since late February 1962, *Eltanin* has made 23 cruises, 20 of which were in antarctic waters. Since Cruise 4, the first antarctic cruise, the vessel has spent 1,135 days at sea and has sailed over 150,000 nautical miles. She has penetrated the fringes of the ice pack on several occasions and has worked stations as far south as 70°26′S.

The tracks of Cruises 4 through 23 are shown in fig. 3. The cruises are generally 60 days in length with 10 days in port for refueling and resupply. As a rule, work at the stations commences between 45° and 55°S. While on a southerly or northerly course, stations are usually worked at every degree of latitude and, while on an easterly or westerly course, every four degrees of longitude. A working station, generally including a hydrographic station, bottom photographs, a piston core, mid-water and bottom trawling, and plankton tows, takes 15 to 30 hours to complete. The number of these full stations worked on a cruise is usually between 20 and 36. Some details of the individual cruises follow:

Cruises 1-3

Following the completion of the conversion at a New York shipyard in early 1962, *Eltanin* made two shakedown cruises in the Atlantic Ocean. The first of these, made to test the performance of the ship and the scientific and supporting equipment, took place off the east coast of the United States during February 23—March 9. The tests were continued on the second cruise, March 15—April 10, 1962, in the North Atlantic and the Labrador Sea.

Cruise 3, lasting from May 23 till June 27, took *Eltanin* from New York through the Panama Canal and along the west coast of South America to Valparaíso, Chile, her base of operation for the first series of antarctic cruises. Continued testing of equipment and techniques was carried out on this cruise simultaneously with the conduct of several scientific projects. A particular aim was to trawl at great depths in the Peru-Chile Trench, where a total of 17 specimens of the relict *Neopilina* was obtained, representing the world's largest, single collection of monoplacophorans.

Cruise 4

Cruise 4 was the first of *Eltanin*'s antarctic cruises and took place between July 5 and September 1, 1962. The programs were conducted in the waters between Cape Horn and the Antarctic Peninsula, with considerable work done en route to and from Valparaíso. Major deck operations, performed by a group from Texas Instruments, Inc., consisted of 29 mid-water and beam trawls, 21 piston cores, 18 bottom camera stations, and four current-meter buoy stations.

Cruise 5

Cruise 5 took place between September 10 and November 16, 1962, in the western Drake Passage, reaching a farthest south position of 67°33′S. at 74°34′W. This cruise was hampered considerably by illness and injury aboard, which forced the vessel to return to Punta Arenas on three different occasions. The scientific work included 254 stations for bacteriological analysis and 118 for the collection of marine organism, 28 hydrographic stations and 122 bathythermograph observations, and the collection of 30 piston cores and 14 rock-dredge hauls.

Cruise 6

Eltanin left Valparaíso, Chile, on November 24, 1962, to begin Cruise 6. The first part of this cruise was conducted in the northern part of Drake Passage and its main portion, between 56°W. and 59°W. Considerable work was done in Bransfield Strait and stops were made at Deception Island. The farthest south position reached was near 64°16′S. at 62°59′W. The cruise ended at Punta Arenas on January 23, 1963.

One interesting aspect of Cruise 6 was that, for the first time, women scientists were accommodated aboard. The pioneers were two marine biologists from DePaul University, who stayed on for Cruise

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Fig. 2. (Cont.)

Electronics Workshop—377 square-foot floor space. Equipage includes spare parts storage racks, cabinets, and workbenches, Sears Craftman bench-model drill press, Dumont 304 AR scope, Lambda 50 R power supply, SIE model N-1 audio oscillator, Tektronix type 321 oscilloscope, Ballantine VTVM 302 B, Ballantine VTVM 305, General Radio model 1330A impedance bridge, General Radio type 1001A signal generator, Brush BL-262 dual oscillograph, Kay "Missilyzer", Triplitt model 630 test sets, Hewlett-Packard model 2020 audio oscillator, Krohn-Hite 300-M bandpass filter, and Freed type 2030 megohmmeter.

Scientists' Office/Drafting Room—236 square-foot floor space. Equipage includes desks, chairs, filing cabinets, a light table, and chart table.

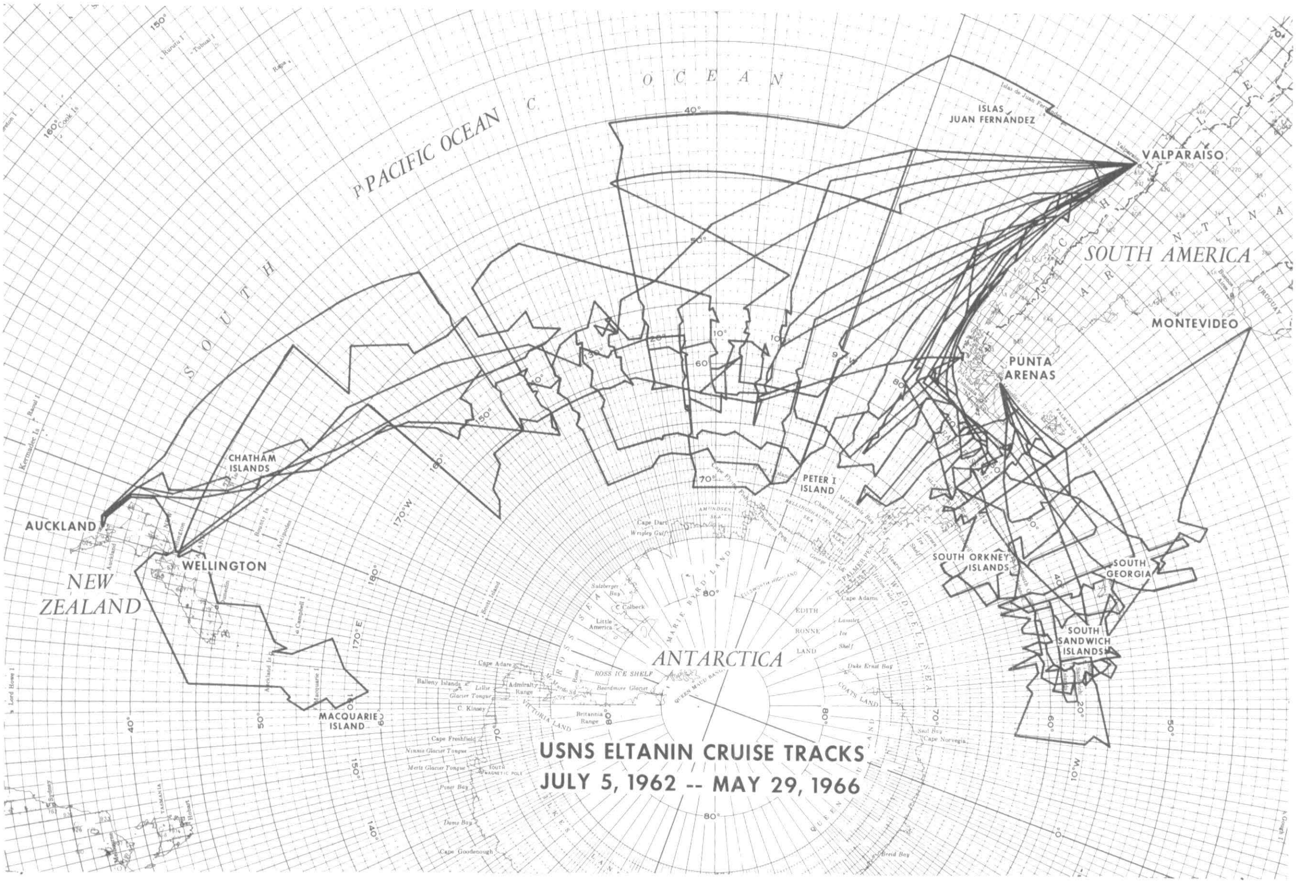


Fig. 3. Eltanin *Cruises 4-23*

7, at which time they were joined by two women colleagues from the University of Chile. Once the precedent had been established, female investigators aboard *Eltanin* were to become the rule rather than the exception.

The number of specimens collected is indicated by the 126 sample collections of the University of Southern California's marine biological project that were preserved for shipment to the United States. Representing 400 gallons of material, these collections included, among other organisms, 1,000 specimens of bottom fishes.

Cruise 7

Cruise 7 took place between February 4 and March 19, 1963. Twenty-six major scientific stations were occupied, including two near the Antarctic Circle in the Weddell Sea. Searches made south of the South Orkney Islands for the Barth and Tretten Banks, were unsuccessful, but an excellent sediment profile was obtained on the southern flank of the Scotia Ridge. At the end of the cruise, the ship docked at Montevideo, Uruguay, for resupply.

On invitation and as part of a bilateral exchange program, a U.S.S.R. oceanographer, N. F. Kudriavtsev, participated in Cruises 7 and 8. His specific research project was a study of the conditions under which water layers of different densities form, as related to the vertical structure of the current patterns.

Cruise 8

Cruise 8 began with *Eltanin*'s departure from Montevideo on April 1, 1963, and it ended on June 19 at Talcahuano, Chile, for a month's overhauling and refurbishing in dry dock. This 80-day cruise, the longest attempted during the first year of antarctic operations, was concentrated in the area of the South Sandwich Islands. A systematic investigation was conducted of the South Sandwich Trench, followed by a southward sortie to latitude 63°26′S., where further penetration was prevented by the pack ice. A visit was made to South Georgia in response to a request for medical aid.

Cruise 9

Having completed the overhaul, *Eltanin* made a shakedown cruise to Valparaíso, from where she departed again on August 1, 1963. The first part of Cruise 9 consisted of a survey of the Argentine

Basin area, roughly between 47° and 50°S. and 35° and 40°W. Bathymetry and hydrographic work were stressed and several full stations were made in the area. Upon leaving the Argentine Basin, the ship proceeded to Bird Island, where some scientific personnel visited a small, temporary biological research facility of the Johns Hopkins University and the Bishop Museum. From there, the ship cruised southward along the 38°W. meridian to approximately 59°12′S., where further penetration was halted by heavy ice.

Eltanin then sailed eastward for several days before turning north. In the vicinity of South Georgia again, various studies were made in the transition zone from deep water to continental shelf around the island. Upon completion of these studies, *Eltanin* proceeded toward Valparaíso, making several trawl collections in the vicinity of Cape Horn and Valparaíso. The 9,339-mile cruise, which ended on September 27, 1963, was the longest sailed by *Eltanin* up to that time.

During the subsequent period in port, Alpine Geophysical Associates, Inc., relieved Texas Instruments, Inc., as contractor for the provision of technical support to the scientific party.

Cruise 10

Cruise 10 began at Valparaíso on October 6, 1963. Stations were taken at standard 60-mile intervals along the 83°, 79°, and 75°W. meridians, with the southernmost stations at 66°, 64°, and 65°S. latitude, respectively. The cruise ended on December 6, 1963, with *Eltanin*'s return to Valparaíso after a 7,000-mile voyage lasting 61 days.

Thirty-three complete oceanographic stations were taken south of 55°S., and a total of 320 hydrographic casts was made during the cruise. Additional work included intermediate plankton sampling between stations in the pack ice, two hydrographic casts and plankton samplings at the northern and southern boundaries of the Antarctic Convergence, and the investigation of a submarine slide area off the coast of Chile at 39°25′S. 73°53′W. A brief search for the Pactolus Bank in the area bounded by latitudes of 56°20′ and 57°S. and longitudes of 74° and 75° 40′W. was unsuccessful.

Cruise 11

After leaving Valparaíso on December 17, 1963, *Eltanin* sailed southwestward to 55°S. 115°W., where the major work of Cruise 11 began. Fifteen complete stations were occupied between 55°S. and 70°S. The ship then cruised eastward along 70°S. to approximately 90°W., stopping for a station at every four degrees of longitude. The southernmost point in *Eltanin*'s operations to date, 70°26′S. 99° 52′W., was reached on January 22, 1964.

Heavy pack ice was encountered in the vicinity of Peter I Island and attempts to reach the island were unsuccessful. Six stations were occupied between Peter I Island and 62°S. 87°W., after which *Eltanin* proceeded to 62°15′S. 80°30′W. for VLF studies in an area magnetically conjugate to Annapolis, Maryland, site of the Navy transmitter, NSS.

A notable feature of this cruise was the length of the bottom cores obtained in the Florida State University marine geological program. In all, 35 cores were recovered; of these, the 30 that were taken in deep water averaged over 12 meters (39 feet) in length, the highest average so far for any *Eltanin* cruise.

Between February 5 and 7, 1964, marine biological studies were conducted west of the Strait of Magellan. After a three-day port call at Punta Arenas, the ship made a brief trip into the South Atlantic for marine biological studies and then returned to the Pacific through the Strait, arriving at Valparaíso on February 21, 1964.

Cruise 12

Eltanin Cruise 12 began on March 3, 1964, when the ship left Valparaíso, Chile, for the northwestern part of the Weddell Sea and the Scotia Arc area between the South Sandwich and South Orkney Islands. The first major station was occupied north of the South Shetland Islands on March 13. Station 2 was occupied at approximately 63°S. 52°W. as *Eltanin* entered the Weddell Sea. Three more stations were occupied between that point and the ship's southernmost point of 66°03′S., reached on March 18. Station 8 was completed by March 21 as the vessel worked northeastward to begin a series of six north-south profiles along the east-west axis of the Scotia Arc. Between March 22 and April 12, 12 stations were occupied in this region.

Working westward past the South Orkney Islands toward the Drake Passage, which was reached on April 19, *Eltanin* accomplished her last five full stations of the cruise. In the Drake Passage, hydrographic casts were made and three special piston core samples were taken at the Antarctic Convergence. The vessel then proceeded directly to Valparaíso, arriving on April 30.

Cruise 13

On May 13, 1964, *Eltanin* departed Valparaíso on Cruise 13, the first transpacific crossing for the ship. The first full station was made near 55°S. 90°W. on May 19. A series of 13 stations was then accomplished along 90°W. until the ice pack was encountered near 66°50′S. 89°50′W. From here, the ship turned west and seven stations were taken along latitude 65°30′S., between 90°W. and 130°W. On July 20, the ship began her northbound leg and seven stations were taken along 130°W. Stations were discontinued on June 30 near 55°S. 130°W. and *Eltanin* proceeded towards Wellington, New Zealand, arriving on July 13 after cruising a total of 7,286 nautical miles. This was *Eltanin*'s first visit to New Zealand, and special meetings and a science seminar had been arranged by the New Zealand hosts for the occasion.

Among the highlights of this cruise was the recovery of a 26-meter (86-foot) sediment core, the longest obtained on any *Eltanin* cruise.

Cruise 14

The plans for Cruise 14 called for *Eltanin* to occupy stations along the 160°W. meridian between 55°S. and 62°S., across the 62°S. parallel to 125° W. and north along this meridian to the usual northern boundary of operations at 55°S. The scientific work of the cruise began with a series of bottom profiles over the Hikurangi Canyon in eastern Cook Strait as the ship sailed from Wellington on July 29. Five days after leaving port, *Eltanin* was on her first ocean station at 50°S. 160°W. Two more stations were taken (52°S. 160°W., 54°S. 160°W.) before the regular program of full stations at 60-mile intervals went into effect.

The twelfth station was made at 63°S. on August 17, with fringes of pack ice visible to the south and east. From this point, the ship steamed northeasterly through forming sea ice until at 60°S. she was free of the ice and could proceed eastward with stations each four degrees of longitude. After completing station 21 at 60°S. 125°W. on August 29, *Eltanin* turned north, reaching the edge of the operational area at 55°S. on September 3. During September 3-8, extensive bottom profile records were made in several crossings of a fracture zone near 55°S. between 124°W. and 127°W. In addition to this special study, extra hydrographic casts were taken in the Antarctic Convergence zone on the western leg of the cruise, and supplementary bottom profiling was done over the Pacific-Antarctic Ridge at 62°S. 160°W. On September 13, *Eltanin* steamed toward Valparaíso, Chile, crossing a seamount at 43°13′S. 97°41′W. The area of this submarine mountain's summit was defined by bottom profiling and samples were taken of bottom fauna and rocks. An emergency medical case forced diversion from the planned course to evacuate the patient to Talcahuano, Chile, on September 18. The cruise ended at Valparaíso on September 19.

Cruise 15

Cruise 15 had several objectives, viz.: locating the Antarctic Convergence between longitudes 90° W. and 155°W. and sampling the waters, ocean bottom, and marine life in the area; collecting geological and biological bottom samples from a seamount reported at 55°S. 130°W.; surveying the trend, bottom topography, and extent of the so-called "Eltanin Fracture Zone" between 123°W. and 135°W.; obtaining marine biological collections in the coastal waters of Chile and on the New Zealand continental shelf for comparison with organisms of higher southern latitudes; and traversing an area centered at 54°09′S. 156°03′W., which is geomagnetically conjugate to Jim Creek, Washington, for recording artificially stimulated emissions during echo activity of the VLF transmitter, NPG.

Delayed departure from Valparaíso (October 1), engine trouble, and rough seas necessitated readjustments of the schedule throughout the cruise. Mid-water trawling, for instance, was accomplished chiefly while cruising toward a station and terminating upon arrival, or while steaming away from the station following operations from the drifting ship. Utilizing two winches simultaneously for over-the-side work also reduced time on stations.

The cruise terminated at Auckland, New Zealand, on December 4, where a major overhaul and refit of the vessel were undertaken. Equipment for seismic and magnetic profiling was installed and modifications were made to *Eltanin*'s electrical system to reduce radio interference to the upper atmosphere program.

(NSF Photo)

Fig. 4. Retrieving Hydrographic Equipment

Cruise 16

This cruise was planned primarily to check out the new submarine geophysical equipment before another Pacific Ocean crossing was made. *Eltanin* left Auckland on January 28, 1965, and returned to Wellington on February 25. The route was south along the eastern side of the North Island, then through Cook Strait into the Tasman Sea. Near 44°21′S. 162°00′E., the vessel proceeded south across the Southeast Australian Basin to the Macquarie Ridge, then along the Ridge to Macquarie Island. Here she turned due south to the Hjort Seamount, then southeast to 59°00′S. 161°51′E., the southernmost point of the cruise and just short of the Antarctic Convergence. A northeasterly direction was then taken across the Emerald Basin to Campbell Rise, then over the New Zealand Plateau towards Dunedin, and northeast to Wellington.

Cruise 17

On March 12, 1965, *Eltanin* departed Wellington on Cruise 17, which ended at Valparaíso on May 13. Thirty-six stations were occupied along the 135°W. and 95°W. meridians and along the ice front between them at about 68°S. latitude. En route, some special studies were made of the continental shelf and slope off Valdivia, Chile, near 39°S. 74°W.

Near 54°S. 135°W., the track was altered from the planned cruise to obtain additional bathymetric data on the fracture zone that crosses the South Pacific Rise. This zone is known to continue east towards the Drake Passage, and considerable bottom relief was noted along the 95°W. meridian over about two degrees of latitude.

Cruise 18

Cruise 18 was terminated early because of problems with the main generator. The ship left Valparaíso on May 24 and returned to Talcahuano for repairs on June 16. During the curtailed trip, four complete ocean stations were taken between 55°S. and 58°S. along 99°W. A good collection of marine organisms was obtained except for fish specimens, which were scarce.

Cruise 19

Eltanin left Talcahuano, Chile, on July 6, 1965, to begin Cruise 19 across the South Pacific. Unfortunately, there were major difficulties with the coring winch and very little deep-water and bottom sampling was accomplished during the latter part of the cruise. Some of the work was salvaged, however, by improvised equipment using the hydrographic winch and a cargo winch, while other programs less concerned with the deep sampling benefitted by the additional time available. The cruise ended on September 3 at Auckland, New Zealand.

Scientific programs carried out during Cruise 19 included plankton sampling, the physiology of crustaceans, a study of cephalopods, a lipid program, primary productivity studies, marine biological collecting, meteorological observations, physical oceanography, submarine geophysics including seismic and magnetic profiling, bottom photography, marine geology, cosmic radiation, and VLF recording.

Cruise 20

The cruise began with the ship's departure from Auckland on September 13. From Auckland, the route extended to 45°S. 145°W., where station work started due south along the 45°W. meridian. Near 60°10′S. 45°W., pack ice was encountered. After pushing through for several miles in an unsuccessful attempt to find open water, the ship stopped and a shallow hydrographic station was taken at 60°20′S. 45°W. She then steamed north out of the pack ice and headed to the east and then to the southeast. A station made at 62°10′S. 112°30′W. marked the southernmost point of this cruise.

After reaching 52°S. 100°W., *Eltanin* turned to the northwest and crossed the South Pacific Rise, concentrating on submarine geophysical work. At 44°15′S. 122°W., the ship turned back east for another crossing of the Rise, after which she proceeded northeast to Valparaíso, crossing the Chile Rise en route, and completing Cruise 20 on November 12.

Cruise 21

After refueling and provisioning at Valparaíso, *Eltanin* departed November 23 on Cruise 21. Members of the Chilean—United States Botanical Expedition to the Juan Fernández Islands were put ashore on Más Afuera Island on November 26, after which the ship continued to the west, reaching 32°55′S. 87°57′W. on November 30. From 90°W., the ship sailed southwest to 40°S. 97°W., occupying four regular stations plus two special sediment-core and heat-flow stations on a traverse of the Chile Rise. The track was then west to 120°W., with two regular stations and two special core and heat-flow stations on a traverse of the East Pacific Rise. The ship then sailed south to 61°S., making six regular stations, two special core and heat-flow stations, one special primary-productivity station, and a second crossing of the East Pacific Rise as well as crossings of the "Eltanin Fracture Zone" and the Antarctic Convergence. From 61°S. 120°W., *Eltanin* sailed eastward, reaching Punta Arenas on January 7, 1966.

Cruise 22

The track for Cruise 22, which began at Punta Arenas on January 19, extended from the Strait of Magellan to about 59°S. 52°W., crossing the West Scotia Basin in a southeasterly direction. The vessel then turned due north across the Basin to about 51°S. 52°W., then east along the Falkland Rise to about 51°S. 40°W., thence south to about 62°S. 40°W. From here, *Eltanin* followed the South Scotia Ridge to Thule Island, then took a southeasterly course across the South Sandwich Trench to about 63°S. 15°W. Proceeding due north along the 15°W. meridian to 55°S. and along a great circle route to Zavodovski Island, the vessel crossed the Scotia Basin and the Burdwood Bank to the Strait of Magellan and returned to Punta Arenas on March 17.

Cruise 23

Cruise 23 began at Punta Arenas on March 31. A particular purpose of this cruise was to crisscross the Antarctic Convergence on both sides of the East Pacific Rise, over which several profiles were made. From South America, *Eltanin* took a southerly course to about 65°S. 81°W., before heading west in the direction of New Zealand. The cruise terminated at Auckland on May 29, 1966.

SUMMARY

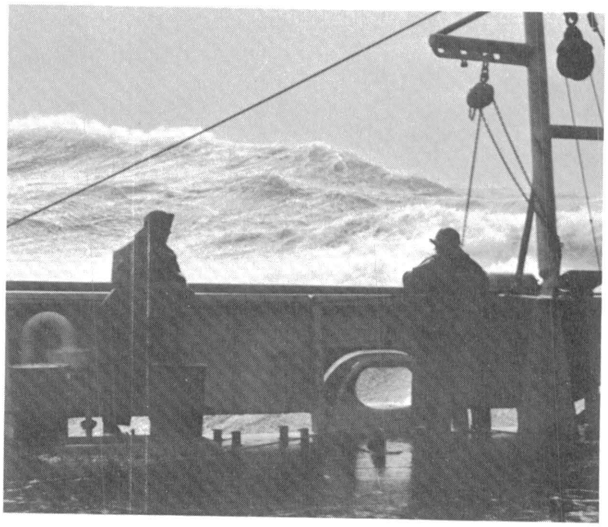
USNS *Eltanin* is a national research facility engaged in a systematic survey that is expected to take the vessel into all areas of the seas surrounding the Antarctic Continent over the next decade. Although many programs aboard are more or less continuous, special scientific programs of any discipline pertinent to the area of the antarctic seas are welcome.

Since *Eltanin* started work in antarctic waters, the principal programs have been marine biology and geology, physical oceanography, meteorology, and upper atmosphere physics. The main areas studied have been the Scotia Sea and Drake Passage, and several crossings of the southern Pacific Ocean have been made between Chile and New Zealand. Upon completion of dry docking and repairs at the end of Cruise 15, seismic profiling equipment, using both sparker and air-gun techniques, was installed. The new geophysical studies include seismic, magnetic, and heat-flow programs, presently with two broad objectives: the delineation of the East Pacific Rise and studies of the antarctic continental shelves. A major objective since the beginning of the antarctic cruises has been the study and delineation of the Antarctic Convergence.

USARP Representatives aboard *Eltanin* during the past four years are shown below with their respective cruises. These Representatives have all been members of the staff of the Office of Antarctic Programs, National Science Foundation, except where otherwise indicated.

NAME	AREA	CRUISE NO.
Crary, A. P./Crowell, John T.	Mid Atlantic	No. 1
Crary, A. P./Crowell, John T.	North Atlantic	No. 2
Toney, George R.	U.S.-Chile	No. 3
Toney, George R.	Drake Passage	No. 4
Toney, George R.	Drake Passage	No. 5
Llano, George A.	Drake Passage	No. 6
Llano, George A.	Scotia Sea	No. 7
Seelig, Walter R.	Scotia Sea	No. 8
Colson, John G., Jr.	Argentine Basin-Scotia Sea	No. 9
Mason, Robert W.	Southeast Pacific	No. 10
Smith, Philip M.	Southeast Pacific and Bellingshausen Sea	No. 11
Moulton, Kendall N.	Weddell-Scotia Seas	No. 12
Moulton, Kendall N.	Trans-Pacific	No. 13
Mason, Robert W.	Trans-Pacific	No. 14
Toney, George R.	Trans-Pacific	No. 15
Smith, Philip M.	Tasman Sea	No. 16
Dawson, Merle R.	Trans-Pacific	No. 17
Dawson, Merle R.	Southeast Pacific	No. 18
Dawson, Merle R.	Trans-Pacific	No. 19
Crary, A. P.	Trans-Pacific	No. 20
Toney, George R.	Southeast Pacific	No. 21
*Wells, Harry W.	Scotia Sea	No. 22
**Roberts, Charles L., Jr.	Trans-Pacific	No. 23

*National Academy of Sciences
** Environmental Science Services Administration



(Photo: W. A. Steffan)

Fig. 5. Eltanin *in Rough Weather*

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