The United States Antarctic Research Report to the Scientific Committee on Antarctic Research (SCAR): Number 32 - 1990

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United States Antarctic Research

Report No. 32 to the Scientific Committee on Antarctic Research (SCAR)

1 April 1989 - 31 March 1990

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United States National Committee for Antarctic Research
POLAR RESEARCH BOARD
U.S. NATIONAL COMMITTEE FOR SCAR
COMMISSION ON GEOSCIENCES, ENVIRONMENT, AND RESOURCES
NATIONAL RESEARCH COUNCIL

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Introduction

The Scientific Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions (ICSU) requests that each of its National Committees produce and distribute on an annual basis a report on its national antarctic research programs. These annual reports are exchanged within the antarctic research community to help foster international cooperation and coordination of antarctic research.

This report is prepared and distributed by the Polar Research Board, acting as the U.S. National Committee for SCAR, in response to SCAR's request. It contains information on the United States Antarctic Program and other U.S. research conducted in antarctic waters completed during the period April 1989 through March 1990 and planned for the period April 1990 through March 1991.

The U.S. Antarctic Program is funded and managed by the National Science Foundation's Division of Polar Programs (NSF/DPP). In 1958, the National Academy of Sciences (the U.S. organization adhering to ICSU) established the Committee on Polar Research, subsequently designated the Polar Research Board, in response to a request from the Director of the National Science Foundation for assistance in formulating national scientific programs in Antarctica and in promoting international collaboration. Logistics are provided by the U.S. Navy, U.S. Coast Guard, U.S. Air Force, U.S. Geological Survey, and contractors.

The data for this report have been compiled by the Polar Research Board staff in close cooperation with staff from the NSF/DPP. For example, the section on "Highlights of Science Activities" is prepared based on materials supplied by the NSF/DPP. The section on "Future Activities Planned" is supplied by representatives from the NSF/DPP. The entries in the section on "Prospectus of Planned Activities" are written by the principal investigators for various publications of the National Science Foundation. All three sections are reproduced here with minor editorial changes.

The United States Delegate to SCAR is Robert H. Rutford, and the Alternate Delegate to SCAR is Charles R. Bentley. The SCAR Secretariat is located at the Scott Polar Research Institute, Lensfield Road, Cambridge CB2 IER, United Kingdom.

Robert H. Rutford
Chairman
Polar Research Board

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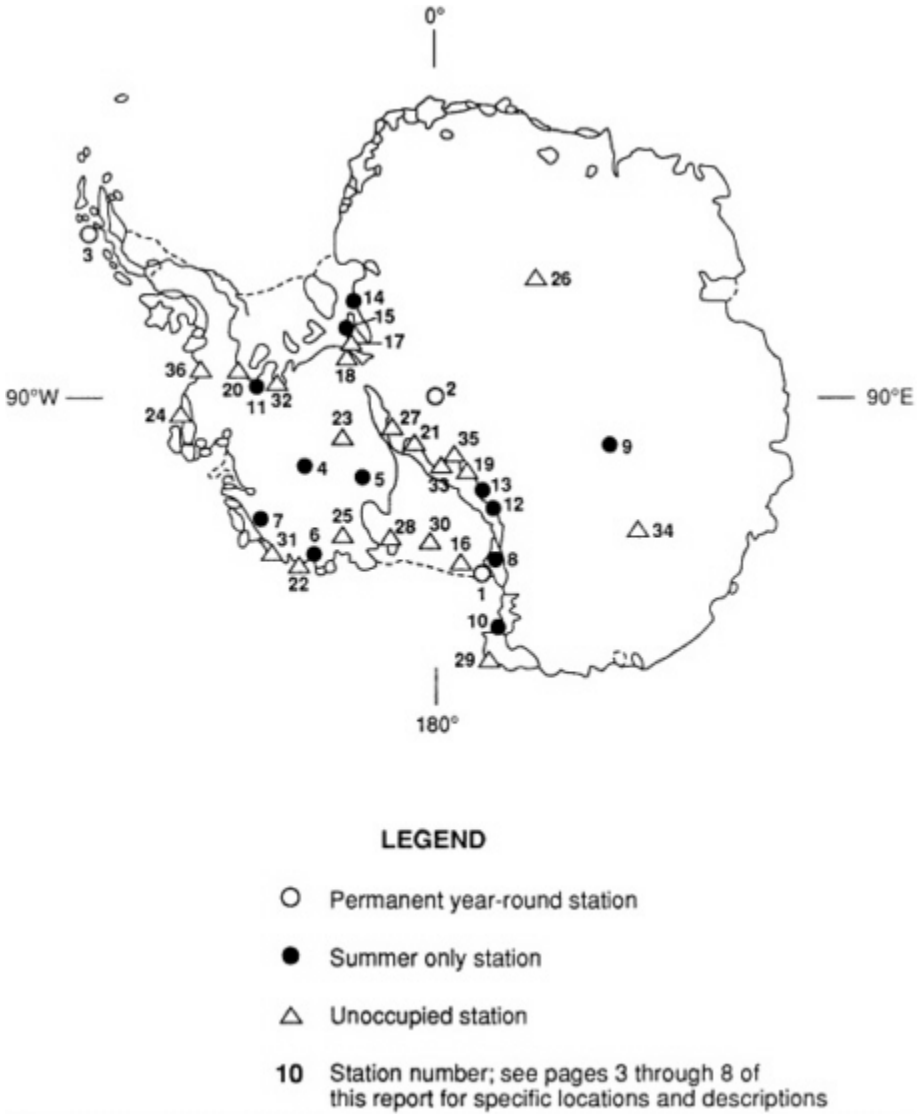
Map of Stations



Map A: Antarctica

Locations of U.S. Antarctic Research Stations [See Maps A and B]

PERMANENT YEAR ROUND STATIONS [MAP A]

1. *McMURDO STATION*

Location:	Hut Point Peninsula on Ross Island, McMurdo Sound 77°55'S Latitude 166°39'E Longitude
Annual Relief:	03 October 1989

2. *AMUNDSEN-SCOTT SOUTH POLE STATION*

Location:	90°S Latitude
Annual Relief:	31 October 1989

3. *PALMER STATION*

Location:	Anvers Island near Bonaparte Point 64°46'S Latitude 64°05'W Longitude
Annual Relief:	07 October 1989

SUMMER ONLY STATIONS [MAP A]

4. *BYRD SURFACE CAMP*

Location:	80°01'S Latitude 119°32'W Longitude
Open:	02 November 1989
Close:	03 February 1990

5. *SIPLE COAST: UPSTREAM BRAVO*

Location:	83°29'S Latitude 138°5'W Longitude
Open:	20 November 1989
Close:	26 January 1990

6. *MARIE BYRD LAND: FOSDICK MOUNTAINS*	
Location:	76°30'S Latitude 144°W Longitude
Open:	08 December 1989
Close:	22 January 1990
7. *MARIE BYRD LAND: EXECUTIVE COMMITTEE RANGE*	
Location:	76°30'S Latitude 126°W Longitude
Open:	23 December 1989
Close:	25 January 1990
8. *MARBLE POINT CAMP*	
Location:	77°25'S Latitude 163°40'E Longitude
Open:	16 October 1989
Close:	30 January 1990
9. *VOSTOK STATION (USSR)*-(site of a U.S. field camp)	
Location:	78°28'S Latitude 106°48'E Longitude
Open:	02 December 1989
Close:	15 January 1990
10. *CAPE WASHINGTON*	
Location:	740°44'S Latitude 163°45'E Longitude
Open:	28 October 1989
Close:	02 January 1990
11. *ELLSWORTH MOUNTAINS*	
Location:	78°25'S Latitude 86°30'W Longitude
Open:	21 November 1989
Close:	26 December 1989

12. *TRANSANTARCTIC MOUNTAINS: GEOLOGISTS RANGE*	
Location:	82°30'S Latitude 155°E Longitude
Open:	29 November 1989
Close:	11 December 1989
13. *TRANSANTARCTIC MOUNTAINS: MILLER RANGE*	
Location:	83°15'S Latitude 157°E Longitude
Open:	21 December 1989
Close:	03 January 1990
14. *PENSACOLA MOUNTAINS: ARGENTINA RANGE*	
Location:	82°45'S Latitude 44°W Longitude
Open:	26 November 1989
Close:	11 December 1989
15. *PENSACOLA MOUNTAINS: NEPTUNE RANGE*	
Location:	83°46'S Latitude 54°W Longitude
Open:	11 December 1989
Close:	03 January 1990

UNOCCUPIED STATIONS [MAP A]

Data on unoccupied United States facilities in Antarctica are listed here although such facilities are not considered usable as refuges. Some are so deeply buried in snow as to make them relatively inaccessible, while others are difficult to locate. Information provided: (1) position and description of location; (2) dates established and deactivated or last visited; and (3) estimate of available accommodation, food, fuel, and supplies of other kinds.

16. *BYRD AURORA SUBSTATION*

(1) 79°26'S, 188°4'W, approximately 40 miles from present Byrd Station
(2) March 1963 -October 1963
(3) Prefabricated shelter, 16 man/months food and supplies, 2,500 gallons diesel fuel

17. *CAMP NEPTUNE*

(1) 83°31'S, 57°15'W, Neptune Range of Pensacola Mountains
(2) November 1963 -January 1966
(3) 16' × 24' Jamesway building, 32 drums fuel, 4-6 man/months food, 250 lbs. explosives

18. *PATUXENT CAMP*

(1) 84°54'S, 63°W, Patuxent Range of Pensacola Mountains
(2) November 1962 -December 1965
(3) 16' × 16' Jamesway building, 4 drums fuel, 458 man/days food plus cooking utensils

19. *PREBBLE GLACIER CAMP*

(1) 84°15'S, 164°10'E, at mouth of Prebble Glacier, Queen Alexandra Range
(2) November 1966 -February 1967
(3) 16' × 16' Jamesway building, 4 drums fuel, 1 man/month food supplies

20. *CAMP GOULD*

(1) 78°57'S, 85°45'W, East Heritage Range
(2) November 1962 -February 1967
(3) 16' × 16' Jamesway building, 48 drums fuel, 8-10 man/months food

21. *AMUNDSEN GLACIER CAMP*

(1) 86°18'S, 160°55'W, adjacent to Amundsen Glacier on the Faulkner Escarpment
(2) November 1963 -January 1964
(3) 16' × 16' Jamesway building, 4 fuel drums, 400 man/days food, cooking utensils

22. *BYRD COAST CAMP*

(1) 76°55'S, 144°W, in Edsel Ford Range at Mount Farley
(2) October 1966 -January 1967
(3) 16' × 16' Jamesway building, 2 man/months food and fuel

23. *CAMP OHIO*

(1) 84°52'S, 114°20'W, Ohio Range, Horlick Mountains
(2) November 1961 -January 1967
(3) 16' × 16' Jamesway building, 7 drums fuel, cooking utensils, 2 man/weeks food supplies

24. *CAMP MINNESOTA*

(1) 73°30'S, 94°30'W, in northwestern side of Jones Mountain
(2) November 1961 -January 1965
(3) 16' × 16' Jamesway building, unknown quantity of food and fuel

25. *LITTLE ROCKFORD*

(1) 79°30'S, 147°19'W, (relocated in 1959 from 79°35'S, 156°46'W)
(2) December 1958 -February 1965
(3) 3 Wannigans, 1 improvised shelter, food and fuel unknown

26. *PLATEAU STATION*

(1) 79°15'S, 40°30'E
(2) December 1965 -January 1969
(3) Main building 70' × 25' van; emergency station separated from main building consists of 30' × 8' van attached to 16' × 26' Jamesway; 3-16' × 28' and 1-16' × 16' Jamesway huts with limited supply of DFA and mogas available; however, access may be difficult owing to snow cover; 100 man/months of food plus cooking utensils

27. *CAMP OHIO H*

(1) 86°S, 127°W, near crashed R4D aircraft
(2) November 1962 -January 1965
(3) 16' × 24' Jamesway, 4 drums fuel, 2 man/months food plus cooking utensils

28. *ROOSEVELT ISLAND HUT*

(1) 80°11'S, 161°39'W
(2) 1969
(3) Provisions for 25; no radio

29. *HALLETT STATION*

(1) 72°19'S, 170°13'E
(2) January 1957 -February 1973
(3) 18 buildings (including Jamesway), 58,000 gallons fuel

30. *BROCKTON STATION*

(1) 80°01'S, 178°02'W
(2) October 1965 -February 1972
(3) 4 buildings, 14 drums fuel, and 1,100 gallons bulk fuel

31. *MARIE BYRD LAND CAMP*

(1) 75°45'S, 135°W
(2) October-December 1977
(3) 5 Jamesway huts, bulk DFA, food

32. *ELLSWORTH MOUNTAINS CAMP*

(1) 79°07'S, 85°39'W
(2) November 1979 -January 1980
(3) 1 Jamesway hut

33. *McGREGOR GLACIER HUT*

(1) 85°08'S, 170°50'E
(2) 1982-83 season
(3) Full provisions for 7; no radio

34. *DOME C CAMP*

(1) 74°39'S, 124°10'E
(2) Camp active summer seasons through 1981/82; last visited January 1984
(3) 8 Jamesway huts, 1,000 gallon POL, 6,000 lbs. food

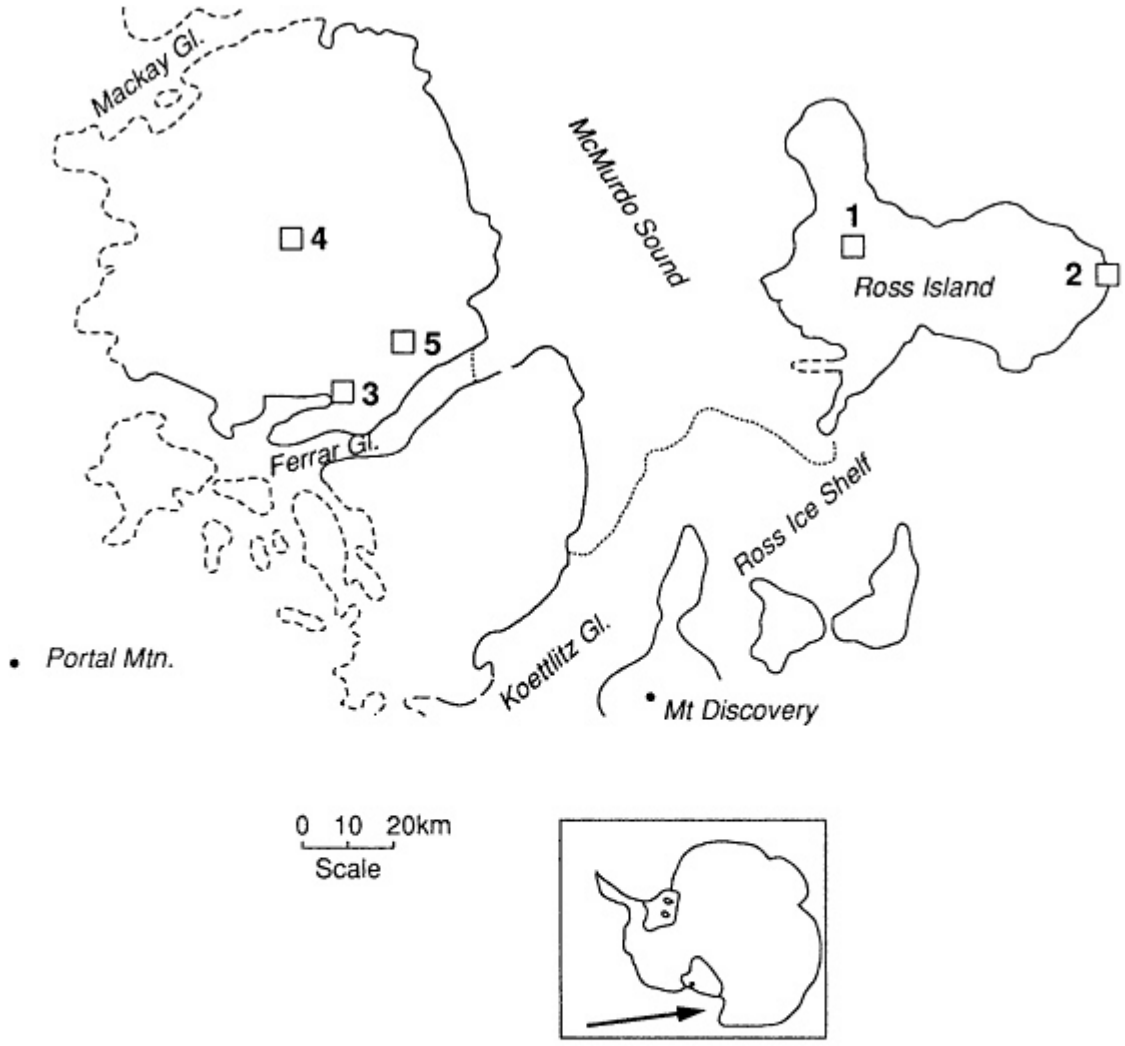
35. *BEARDMORE SOUTH CAMP*

(1) 85°2'S, 164°15'E
(2) October 1984 -February 1986
(3) 1 wooden module, DFA, mogas, JP4 available, 2 man/months food plus stove and fuel

36. *SIPLE STATION*

(1) 75°56'S, 84°15'W
(2) January 1979 -February 1988
(3) An unsafe under-the-snow enclosed area, and Jamesway huts on the surface

Map of Stations



LEGEND

☐ Refuges and survival caches

3 Station number; see page 10 of this report for station names, locations, and descriptions

Map B: *McMurdo Sound Region*

MCMURDO AREA REFUGES AND SURVIVAL CACHES [MAP B]

Information provided: (1) position and description of location; (2) accommodation, food, fuel, and supplies of other kinds. "Full provisions" indicates sleeping, eating, and cooking utensils.

1. *MT. EREBUS HUT AND CACHE*

(1) 77°30'S, 167°10'E
(2) **Hut**: partial provisions for 3 (no sleeping bags), oxygen, radio during summer
Cache: full provisions for 6, located 150' from hut

2. *CAPE CROZIER*

(1) 77°30'S, 169°40'E
(2) **Hut**: partial provisions for 4; no radio; hut located at approximately 1000' elevation, south of "the Knob" and south of the ice edge
Cache: full provisions for 6, located 100' uphill from hut

3. *LAKE BONNEY CACHE*

(1) 77°43'S, 152°25'E
(2) **Hut**: full provisions for 6, 30 man/days food; no radio
Cache: located on southeastern shore of Lake Bonney, approximately 100' from lake

4. *LAKE VIDA CACHE*

(1) 77°20'S, 162°E
(2) **Hut**: full provisions for 6, 30 man/days food; no radio
Cache: located approximately 600' from lake on southwestern shore

5. *LAKE HOARE HUT*

(1) 77°38'S, 162°57'E
(2) **Hut**: partial provisions for 4 (no sleeping bags); full food provisions in hut; no radio; hut located approximately 100' from Lake Hoare, near base of the Asgard Mountain Range
Cache: no survival cache box established

Permanent Stations, Regular Observations, and Long-Term Monitoring

MCMURDO (ELEVATION: 24 M COORDINATES: 77°55'S, 166°39'E)

AURORA AND AIRGLOW	
Photometer observations of aurora	S.B. Mende
COSMIC RADIATION	
Super multisection neutron monitor	M.A. Pomerantz
SYNOPTIC OBSERVATIONS	U.S. Naval Support Force, Meteorological Officer

Surface observations

Temperature

Three-hourly;** thermograph, thermometer

Atmospheric pressure

Six-hourly;** Hg barometer, microbarograph

Wind direction and speed

Three-hourly;** aerovane system

Precipitation

Six-hourly; eight-inch rain gauge

Visibility, clouds, ceiling

Three-hourly; visual

Upper-air observations

Pilot balloons

As needed; nonscheduled

Radiosondes and rawinsondes

At 0000 GMT February-October; at 0000 and 1200 GMT October-February; AN/AMT-4A 1680-MHz flight equipment and GMD-1A tracking equipment

** Continuous recording

ATMOSPHERIC CONSTITUENTS	
Atmospheric water vapor and trace gas concentrations Occasional; atmospheric emission spectrometer	D.G. Murcray
ASSOCIATED RESEARCH PROGRAMS	
Blowing snow Three-hourly; visual	U.S. Naval Support Force, Meteorological Officer
Surface weather observations Continuous; automatic weather stations	C.R. Stearns
Atmospheric aerosols Intermittent; impaction filters, CN counter	W.D. Komhyr; G.G. Lala
Ozone profiles 15 balloons/month	D.J. Hofmann
SPRINGTIME OZONE STUDIES	
Balloon-borne measurements of aerosols and ozone	D.J. Hofmann

PALMER (ELEVATION: 7.5 M COORDINATES: 64°46'S, 64°05'W)

SYNOPTIC OBSERVATIONS	
Climatological surface observations: temperature, atmospheric pressure, wind direction and speed, precipitation, visibility	U.S. Naval Support Force, Meteorological Officer
Six-hourly synoptic: thermometer, barometer, wind gauge, rain gauge	

SOUTH POLE (ELEVATION: 2800 M COORDINATE: 90°S)

AURORA AND AIRGLOW	
All-sky camera for photography of aurora	F.T. Berkey; S.B. Mende
Photometer observations of aurora	T.J. Rosenberg
ASTRONOMY	
Solar seismology	M.A. Pomerantz
Ultra high energy gamma ray astronomy	M.A. Pomerantz

COSMIC RADIATION	
Super multisection neutron monitor	M.A. Pomerantz
SYNOPTIC OBSERVATIONS	Contract Meteorological Observation Team

Surface observations

Temperature

Hourly;** thermograph, thermometers

Atmospheric pressure

Hourly;** Hg barometer; microbarograph

Wind speed and direction

Hourly;** aerovane system

Precipitation

Six-hourly;* visual

Visibility, clouds, ceiling

Six-hourly;* visual

Hydrometers and other obstructions to visibility

Six-hourly;* visual

Upper-air observations

Radiosondes and rawinsondes

At 0000 GMT February-October; at 0000 and 1200 GMT October-February; WB 1680-MHz flight equipment and GMD-1A tracking equipment

ENERGY-BALANCE MEASUREMENTS	J.T. Peterson

Direct solar-radiation on a surface

Continuous (summer); Eppley normal-incidence pyrheliometer on equatorial mount

Total solar and sky radiation on a horizontal surface

Continuous (summer); Eppley hemispherical pyranometer

Reflected solar radiation

Continuous (summer); Inverted Eppley hemispherical pyranometer

Diffuse solar radiation

Continuous (summer); Eppley hemispherical pyranometer shielded from direct solar radiation by an adjustable shade ring

Net radiation

Continuous; Wisconsin NET radiometer

** Continuous recording

* Observations taken at three-hour intervals from October to February

Simultaneous observations with rawin and ozone soundings

Intermittent

ATMOSPHERIC CONSTITUENTS	
Total ozone	W.D. Komhyr; J.T. Peterson
Daily at 0900, 1200, and 1500 GMT as sky conditions permit; Dobson spectrophotometer	
Twice per month (more frequently during spring); ozonesondes	
Surface ozone	W.D. Komhyr; J.T. Peterson
Continuous; electrochemical concentration cell	
Carbon dioxide sampling	W.D. Komhyr; C.D. Keeling; J.T. Peterson
Bimonthly, continuous; evacuated flasks, infrared gas analyzer	
Trace metals and halogens samplings	J.T. Peterson
Sufficient samples for analysis; evacuated flasks, filters	
Atmospheric turbidity*	J.T. Peterson
0900, 1200, 1500 GMT; Linke extinction turbidity meter	
Atmospheric trace gases	J.T. Peterson
Spot measurements; gas chromatograph and evacuated flasks	
Atmospheric water vapor and trace gas concentrations	D.G. Murcray
Occasional; atmospheric emission spectrometer	
Radiation and snow albedo	S.G. Warren
Occasional; solarimeter, spectrophotometer	
Ice crystals	W. Tape
Occasional; photography, camera, crystal replication	
ASSOCIATED RESEARCH PROGRAMS	
Snow accumulation	Contract Meteorological Observation Team
Monthly	
Radioactivity monitoring	H.L. Volchok; J.T. Peterson
Continuous collections	
Carbon-14 analysis	J.T. Peterson
Semi-weekly samples	
Atmospheric aerosols*	W.D. Komhyr; G.G. Lala

* Observations taken at three-hour intervals from October to February

Atmospheric constituents	D.G. Murcray
GEOPHYSICAL MONITORING FOR CLIMATIC CHANGE (GMCC) COOPERATIVE PROJECTS	
Carbon dioxide	C.D. Keeling
Nitrous oxide	R.A. Weiss
Radionuclides	R.J. Larsen
Aerosols	A. Hogan, G.G. Lala
Trace gases	R.A. Rasmussen; L. Heidt; R.J. Cicerone
14_C	M. Poindexter

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GROUND-BASED ELECTROMAGNETIC OBSERVATIONS	
South Pole; McMurdo	R.A. Helliwell; A.C. Fraser-Smith; U.S. Inan
Passive ELF/VLF observations	
CONJUGATE PROGRAMS	
South Pole; McMurdo; Lake Mistissini (Quebec, Canada)	T.J. Rosenberg
Riometer studies of the ionosphere	
South Pole; Lake Mistissini	F.T. Berkey
Ionosonde studies of the ionosphere	
South Pole and five stations in the north [Girardville (L = 4.4) and lac Rebours (L = 4.0), Quebec, Canada; Pittsburgh (L = 3.5), New Hampshire; Durham (L = 3.2), New Hampshire; and Frobisher Bay, NWT]	
Three-axis fluxgate magnetometer measurements of micropulsations to investigate the magnetosphere, ionosphere-magnetosphere coupling, and latitudinal conjugacy shifts	L.J. Lanzerotti; A. Wolfe
South Pole; McMurdo; Sonde Stromfjord (Greenland)	
Three-axis u-metal-core magnetometer measurements of PC-1 micropulsations	R. Arnoldy; L.J. Cahill, Jr.; M.J. Engebretson
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Palmer; McMurdo; South Pole; Ushuaia (Argentina)	
Scanning spectroradiometer measurements of UV radiation	C.R. Booth

AUTOMATIC WEATHER STATIONS	
Climatological surface observations	C.R. Stearns
one unit at Byrd Station, Dome C, Rothera Station, Siple Station, Byrd Glacier, Franklin Island and Inexpressible Island; five units in the McMurdo area; four units near Dumont d'Urville; and six units on Ross Ice Shelf	
REMOTE SITES	
Katabatic winds	T. Parish; D.H. Bromwich; C.R. Stearns
Continuous readout by Tiros N satellite; automatic weather stations at Dome C and upslope from Dumont d'Urville	
Surface weather observations	C.R. Stearns
Continuous readout by Tiros N satellite; automatic weather stations at Byrd Station, Ross Ice Shelf, Byrd Glacier, Franklin Island and Inexpressible Island	

Highlights of Science Activities 1 April 1989-31 March 1990

ATMOSPHERIC SCIENCES

Astronomy

When the inward gravitational pressure of a star exceeds the outward radiation of energy, the star's core collapses. Violent shock waves, moving from its core to the surface, blast away the outer layers of the star. This spectacular release of energy is a supernova.

Supernovas, which briefly give off amounts of energy that can rival the energy output of an entire galaxy, may trigger the birth of other stars, provide the energy and physical environment needed to synthesize elements that are heavier than iron, and have a part in redistributing heavy elements in the interstellar medium-gaseous and dust materials between stars.

At the time of the "Big Bang," the event that many believe formed our universe, only hydrogen, deuterium (heavy hydrogen), and helium formed. All other chemical elements, according to theory, must have been formed by processes occurring in stars, but a star that is in equilibrium does not generate enough energy or have conditions extreme enough to cause the synthesis of heavy elements. Only tremendous amounts of energy and extreme conditions like those resulting from a supernova can complete nucleosynthesis-the various processes by which the nuclei of new elements are formed from other elements.

In February 1987 the first observations of Supernova 1987A were made. This supernova is the first to occur close to Earth since the invention of the telescope. To learn more about this event, astronomers and astrophysicists launched a high-altitude, instrumented balloon from McMurdo Station in 1988. They selected Antarctica because the southern continent offered advantages not found at other sites. An important advantage is that radiation levels in the atmosphere above Antarctica more closely approximate those in space than levels above northern areas.

The success of this project encouraged the launching of a second instrumented balloon during the 1989-90 austral summer. A 26.4-million-cubic-foot, high-altitude balloon was launched near McMurdo Station. Investigators hoped that the balloon would stay aloft for 14-20 days. After two failed launches, a 28-million-cubic-foot balloon was launched in December 1990 and followed a circumnavigation of the South Pole at approximately 78°S latitude and an altitude of 120-130 km.

Supernova 1987A appears to be a Type II supernova, which occurs when the core of a star with a mass eight times greater than the mass of the Sun has been fused to iron. The energy generated causes gravitational collapse. Astrophysicists believe that the core becomes a neutron star and that as the external layers are blasted away, isotopic nickel-56 and nickel-57 are produced. Because each radioactive isotope produced by explosive nucleosynthesis has a unique gamma-ray signature, investigators hope to be able to trace gamma-ray emissions that show the decay of nickel-56 to cobalt-57 to iron-57. By tracing this path, they will be able to better determine whether Supernova 1987A is typical of events that cause galactic nucleosynthesis. They will also search for X-ray emissions from Supernova 1987A to determine if it has become a neutron star as many scientists anticipate it will.

The balloon flight offered opportunities to study phenomena other than the supernova. Focusing on cosmic rays, investigators attempted to define better the

isotopic composition of nickel, iron, manganese, and cobalt in cosmic rays. Such information will help astrophysicists to understand the structure and composition of the interstellar medium, the acceleration of cosmic rays, and the conditions under which heavy elements are formed in supernovas and other astrophysical objects.

Ozone-Depletion Studies

Continuing research begun in 1986, three science teams monitored changes in the ozone layer above Antarctica during the late austral spring. Work in previous years has enabled scientists to determine that atmospheric chlorine, derived from man-made chlorofluorocarbons, is a principal component of the chemical cycle that is eating away the antarctic ozone layer. At McMurdo Station, one group launched instrumented balloons to take profiles of ozone and temperature from the ground to an altitude of 29 kilometers (18 miles) to identify where in the air column ozone is being destroyed. A second group measured solar spectra during the spring at McMurdo Station to determine the amounts and concentrations of such atmospheric compounds as hydrochloric acid, nitric acid, nitrogen dioxide, chlorofluorocarbons, ozone, methane, and nitrous oxide in the stratosphere. At Palmer Station, a third group continued to use balloonborne ozonesondes to record changes in depth, vertical extent, ozone-loss rates, and seasonal variations.

At Amundsen-Scott South Pole Station, a lidar-a laser infrared radar with an intense pulsing beam that measures atmospheric discontinuities-was used to determine the vertical motion of the sodium layer about 90 kilometers (56 miles) above Earth. This information will be related to the processes causing the ozone depletion, particularly the dynamics of the climate. A second project at the South Pole focused on the characteristics of polar stratospheric clouds. These clouds, which are made of ice crystals and form at temperatures below -80°C, provide the environment in which the ozone-destructive chemical reactions occur.

BIOLOGY

Biological Effects of UV Radiation

Global loss of protective ozone in the stratosphere allows more ultraviolet radiation to reach Earth and has raised concerns about increased human risk of skin cancer and immune-system suppression. But scientists are also worried about the effect of UV radiation on life forms, including the plants and animals that make up the highly productive marine-based food chain of Antarctica, where seasonal depletion of ozone is greatest. In all life forms, the genetic material DNA can be damaged by ultraviolet radiation, but organisms differ in the amount of damage they receive and in their abilities to repair this damage.

Ecosystem-wide effects of UV radiation in Antarctica may not be predictable any time soon. Nonetheless, laboratory studies at Palmer Station reveal nearly one-hundred-fold differences in the amount of genetic damage sustained when various phytoplankton species are exposed to certain wavelengths of light. Diatoms, phytoplankton with glass shells made from silica, were among the most abundant phytoplankton in antarctic waters in September 1988, when the seasonal ozone hole was forming. Investigators exposed nine species of diatoms to middle-wavelength UV light, or UV-B, which is most strongly absorbed by ozone, to evaluate chemical changes in the small building-block molecules of DNA, called nucleotide bases. Unrepaired damage to nucleotide base pairs within genes can impair the finely-tuned regulation and production of cellular proteins, harming or even killing an organism.

Investigators found that some species incurred more mutations to their DNA chains and that some species were better able to persevere after UV exposure. It is possible that the timing and intensity of the ozone hole and the associated increase in penetration by UV-B radiation may reduce populations of some phytoplankton species, allowing other species more resistant to UV-B damage to expand opportunistically their niches. If this happened, the incidence of secondary effects on the health of animal populations higher up the food chain-e.g., krill, fish, penguins, and whales-might depend on how choosy krill and other phytoplankton-eating animals are about the species they graze upon.

To combat DNA damage, phytoplankton, like higher plants and animals (including humans), possess DNA repair mechanisms. Diatom species appear to differ in their reparative abilities as well as their susceptibility to damage. Though UV radiation is damaging to organisms, longer wavelength UV-A light also is required by phytoplankton for one type of DNA repair, called photoreactivation. This mechanism appears to play an important role in the varied rates of DNA repair achieved by diatoms.

Because phytoplankton also require visible light to drive photosynthesis and to mend damage to their photosynthetic systems, many biologists believe that it is important to consider the amounts of all three of these wavelength bands of electromagnetic radiation when examining biological impacts of the ozone hole. The ozone hole does not affect penetration by UV-A or visible wavelengths.

Environmental Impacts of Oil

By the end of March 1989-about two months after the Argentine transport ship *Bahia Paraiso* ran aground in Arthur Harbor near Palmer Station-an estimated 150,000 gallons of diesel and jet fuel had spilled into the ocean. While small relative to major world oil spills, this event could potentially have significant impacts on the biota in the nearly undisturbed area on the Antarctic Peninsula.

A scientific team representing nine institutions from three countries was organized to study the environmental impact of the oil spill. During their month-long stay at the station, the researchers assessed the immediate impact and began a long-term research program on how the oil spill has or may yet affect the plants and animals in the area. The team's objectives were to identify and determine the fate of hydrocarbon compounds, to study the microbial degradation of hydrocarbons, and to observe and record the response of the animal and plant biota to the spill.

The research team predicted that the water-column community should show little if any long-term effects. Because oil may persist in the sediments, the long-term consequences for the benthic plant and invertebrate communities are unclear. It will take years to assess completely the effects on seabirds. Future research will focus on a long-term program of ecosystem recovery.

Ecosystems in Dry Valley Lakes

In the McMurdo Dry Valleys, the ice-free region of southern Victoria Land, freshwater lakes provide unique opportunities to study biogeochemical cycles and biota that have adapted to an extreme terrestrial environment. Scientists studied chemical and biological changes that occur seasonally in Lake Fryxell to obtain new data that can be applied to similar cycles in non-antarctic lakes.

Located in one of Earth's most arid, barren environments, this lake-unlike lakes in other areas of the world-receives minor amounts of organic material and nutrients from glacial meltwater, has an extremely simple seasonal cycle, and is stabilized by a permanent ice cover. However, during the austral summer, enough light penetrates the ice cover to sustain a community of algae and bacteria. This ecosystem is similar to

temperate lakes without plant nutrients but with plentiful amounts of oxygen. Because Lake Fryxell is a closed system, two groups of scientists would be able to determine how carbon, nitrogen, and sulfur are cycled through the lake system. They also studied how constant light in the summer and constant darkness in the winter affect the chemical and biological systems and what interaction occurs among processes that occur in aerobic, anaerobic, and benthic zones of the lake.

GEOLOGY AND SOLID EARTH GEOPHYSICS

West Antarctica and Gondwanaland

West Antarctica is a collage of small tectonic plates that reflect movement during or after the breakup of the ancient supercontinent Gondwanaland. For geologists, understanding the relationship between West and East Antarctica and between West Antarctica and former pieces of Gondwanaland is crucial for understanding ancient environments, the evolution of southern ocean circulation, and the global interaction of tectonic plates.

One team of U.S. and British geologists studied the tectonic evolution of the southern rim of the Pacific Ocean. Another group focused on the relationship between Marie Byrd Land and New Zealand to learn if these two regions were once part of the same tectonic unit. A third team worked in the Ellsworth Mountains, focusing on how and when these mountains were formed. Finally, U.S., British, and New Zealand investigators examined the glacial and volcanic history of Marie Byrd Land.

GLACIOLOGY

Ice Cores and Climate Change

Polar ice sheets contain a unique record of recent and past climate and of the interactions between climate and the biosphere that influence our environment. Ice cores taken from Antarctica and Greenland offer scientists the opportunity to study the buildup of atmospheric carbon dioxide, oxygen isotopes, methane, lead compounds, chlorofluorocarbons, and trace gases over time periods ranging from one year to several centuries.

In 1984 Soviet and French glaciologists obtained an ice core from the polar plateau near the Soviet station Vostok. This core spans 160,000 years and contains a record of atmosphere and climate change that includes a record of the last global glaciation. During the 1989-90 austral summer, U.S. investigators used samples of the Vostok core to assess, among other things, how levels of organic sulfur vary under changing climate conditions, how the climate and biosphere interacted during the Pleistocene epoch, and how concentrations of methane and nitrous oxide have changed in response to past global warming and cooling.

Scientists know that greenhouse gases (carbon dioxide, methane, and nitrous oxide) and sulfate aerosols affect climate by either absorbing incoming solar radiation or contributing to cloud formation and preventing solar radiation from reaching the earth's surface. Because methanesulfonic acid has no nonliving precursors, it gives a clear chemical signal of changes in oceanic sulfur production and the productivity of the world's oceans-a critical factor in the control of carbon dioxide levels. With data from the Vostok core, investigators will differentiate between organic and non-organic sulfur

aerosols and will determine what levels of cloud-forming molecules existed in ancient climates.

Over short intervals (100,000 years or less), climate is influenced by solar radiation levels, varying concentrations of gases, and other less-well understood factors. By determining the composition of oxygen, nitrogen, and argon trapped in the ice core to learn more about photosynthesis, respiration, and hydrologic process, investigators hope to describe global interactions among the hydrosphere, biosphere, and atmosphere, and to compare past and present measurements of atmospheric nitrogen, in order to understand climate changes that are presently occurring.

Methane and nitrous oxide can have a greater impact on the environment than carbon dioxide. Ice-core data show that during ice ages and colder periods, these gases were present at levels 50 percent lower than those before the Industrial Revolution and about 20 percent lower than today. These changes probably reflect the response of the world's ecosystems to climate changes. Because records from the last 100 to 200 years show that atmospheric levels of both gases have increased dramatically, scientists are concerned about the contribution methane and nitrous oxide will make to global warming. By studying the 160,000-year record in the Vostok core, investigators hope to record how concentrations of these two gases changed in response to past global warming and cooling.

Permits and Rationale for Entry into Specially Protected Areas (Spas) and Sites of Special Scientific Interest (SSSIs)

Investigator(s)	*Dates*	*Area(s) Entered*	*Rationale*
Polly A. Penhale	3/1/89-3/1/90	SPA No. 17 (Litchfield Island)	To document and assess the effects of the *Bahia Paraiso* fuel spill on plant and animal populations
William R. Fraser	11/15/89-3/15/90	SPA No. 17 (Litchfield Island)	To assess the impacts of the *Bahia Paraiso* fuel spill on penguins and other seabirds breeding on the island
Paul K. Dayton James P. Barry	11/1/89-12/31/89	SSSI No. 1 (Cape Royds)	To conduct surveys of the mud bottom habitat at Horseshoe Bay, search for rare samples of algae, and collect water samples
Albert F. Bennett Zoe A. Eppley	12/10/89-1/30/90	SSSI No. 14 (Harmony Point, Nelson Island)	To collect sheathbill eggs to study behavioral and physiological adaptation to cold
Jonathan H. Berg	11/1/89-2/28/90	SSSI No. 3 (Barwick Valley) SSSI No. 12 (Taylor Valley) SSSI No. 18 (White Island) SSSI No. 19 (Linnaeus Terrace), SPA No. 5 (Beaufort Island), SPA No. 7 (Cape Hallett)	To collect samples of the lower crust and mantle included in the volcanic rocks in these sites

Investigator(s)	*Dates*	*Area(s) Entered*	*Rationale*
David F. Parmalee Jean M. Parmalee	11/15/89-2/15/90	SPA No. 17 (Litchfield Island)	To locate and release previously banded birds, do additional banding, and collect salvageable specimens found dead and a few live specimens
Anne M. Grunow	12/1/89-1/1/90	SSSI No. 6 (Byers Peninsula, Livingston Island)	To collect paleomagnetic cores (Jurassic and Lower Cretaceous) to better understand the position of the Antarctic Peninsula during the opening of the Weddell Sea and motion away from South America
Lowell E. Starr Alan R. Stevens	11/1/89-1/26/90	SSSI No. 2 (Arrival Heights, Ross Island), SPA No. 5 (Beaufort Island, Ross Sea), SPA No. 7 (Cape Hallett, Victoria Land)	Geodetic surveying
Mark D. Kurz	12/4/89-1/20/91	SSSI No. 1 (Cape Royds), SSSI No. 4 (Cape Crozier), SSSI No. 19 (Linnaeus Terrace)	To collect rock samples to develop a new method of dating and using cosmic ray-produced nuclides in the rocks
Stephen L. Burns (National Geographic Society)	12/15/89-2/15/90	SSSI No. 8 (Western Shore Admiralty Bay, King George Island), SPA No. 17 (Litchfield Island), SSSI No. 32 (Cape Shirreff)	To take photographs

Prospectus Of Planned Activities 1 April 1990-31 March 1991

ATMOSPHERIC SCIENCES

Ozone-Depletion Studies

Polar stratospheric clouds at the South Pole

James M. Rosen, University of Wyoming (S-117)

The results of research since 1986 indicate that polar stratospheric clouds (PSCs) have a significant role in the annual springtime depletion of ozone above Antarctica. Scientists believe that these ice-crystal clouds, which form in the stratosphere at temperatures below -80°C, provide the environment in which the ozone-destruction cycle occurs. The objective is to study the physical, chemical, and radioactive properties of these clouds and the relationship between the clouds and the ozone-destruction cycle. To obtain data, 20 balloons carrying various instruments will be launched near Amundsen-Scott South Pole Station. The instruments will measure water vapor, ozone, temperature, winds, infrared heat flux, and on some flights, nitric acid vapor. A PSC-sonde will be used to detect the presence of polar stratospheric clouds and stratospheric aerosols and to provide information on particle size and distribution in the clouds. Data from these measurements will provide new details on dehydration and denitrification in the polar stratosphere.

Springtime measurements of ozone-related compounds in the antarctic stratosphere

David G. Murcray, University of Denver (S-270)

The springtime decrease of atmospheric ozone over Antarctica has been observed over Halley Bay, Syowa, and South Pole stations and has been recorded by satellites over a wide area of the continent. Although current photochemical models did not predict these observations, atmospheric scientists now agree that chlorine chemistry has a major role in the decrease. The effects of other atmospheric constituents, however, are still unclear. In this study, infrared techniques will be used to measure the concentrations of compounds in the stratosphere over Antarctica. The field party will service the infrared emission interferometer at Amundsen-Scott South Pole Station; this equipment records infrared solar spectra during the winter. Solar spectra, which contain thousands of absorption lines produced by compounds present in the atmosphere, can provide information about atmospheric chemistry at the time that the measurements were made. Because they respond to molecules anywhere along the optical path, this technique yields information on the total column density of compounds present in the stratosphere. These data will be used to analyze for total-column density of hydrochloric acid, nitric acid, nitrogen dioxide, chlorofluorocarbon gases F-11 and F-12, ozone, methane, and nitrous oxide to document the changes in the amounts of these compounds from late winter through early spring.

Investigation of polar stratospheric aerosols and their relation to the ozone hole

David J. Hofmann and James M. Rosen, University of Wyoming (S-289)

In this study, scientists hope to provide information valuable to two of the models proposed to explain the springtime ozone-hole phenomenon (the chemical model and

the dynamic model). Using balloonborne instruments, scientists will systematically study polar stratospheric clouds and related ozone variations. With data from earlier studies, it was established that polar stratospheric clouds are related to the annual appearance of the ozone hole. The locations in the air column where most of the ozone is being destroyed were identified. During the austral summer, 40 balloons of various sizes will be launched which are instrumented with ozonesondes to measure in detail vertical profiles of ozone and temperature, as well as aerosols and condensation nuclei, from the ground to about 29 kilometers above the surface.

Antarctic ozone profiles: Palmer Station

Arnold L. Torres, National Aeronautics and Space Administration, Wallops Flight Facility (S-293)

Sudden and dramatic decreases in atmospheric ozone occur each austral spring over Antarctica. The most detailed picture of this depletion comes from relatively high-resolution vertical profiles obtained with balloonborne electrochemical ozonesondes. Continuing the project begun in 1987, scientists will take a large set of profiles over Palmer Station from September through November 1990, a period which should include the beginning of the ozone depletion as well as the peak. These profiles will provide clues to changes in the depth, vertical extent, ozone loss rates, and seasonal behavior of this phenomenon. The integrated profiles will provide correlative performance checks on remote-measurement systems.

Climate Studies

Chlorine-and bromine-containing trace gases in the Antarctic

R.A. Rasmussen, Oregon Graduate Center (S-254)

The project objective is to collect a year-long suite of air samples at Palmer Station. With these samples, scientists will investigate seasonal trends in trace-gas concentrations. The samples will be analyzed at the Oregon Graduate Center for a number of trace components, especially chlorine-and bromine-containing species. These trace constituents, which come from both natural and man-made sources, can alter the earth's climate and have been implicated in the chemical processes that contribute to the austral spring depletion of ozone over Antarctica. The study will contribute to a better understanding of the buildup of trace constituents, particularly those of high-latitude marine origin.

Global monitoring for climatic change

Eldon Ferguson (South Pole Station), Climate Monitoring and Diagnostics Laboratory, and James T. Peterson (Palmer Station), Environmental Research Laboratories, National Oceanic and Atmospheric Administration (S-257A and S-257C)

The investigative team will continue long-term measurements of trace atmospheric constituents that may influence climate. Working at the South Pole Station observatory, four scientists during the austral summer and two personnel during the austral winter will measure carbon dioxide, surface ozone, winds, pressure, air and snow temperature, atmospheric moisture, and trace constituents from the station's clean-air facility. These data will be used to make time-series analyses of multi-year data records that focus on stratospheric ozone depletion, transantarctic aerosol transport and deposition, solar and terrestrial radiation fluxes on the polar plateau, the accumulation of and temporal variations in greenhouse gases, and the development of polar stratospheric clouds over

Antarctica. The objectives are to determine the rate at which concentrations of these atmospheric constituents change and to examine sources, sinks, and budgets. Working with climate modelers and diagnosticians, investigators will use these data to determine how the rate of change in aerosol concentrations affects climate. In support of this project, personnel at Palmer Station also will collect carbon dioxide samples.

Lidar experiment at South Pole

Giorgio Fiocco, Universita "la Sapienza", Rome, Italy (S-257B)

The lidar is designed to take vertical profiles of the upper atmosphere. From these data, scientists are able to infer the molecular and aerosol concentration of air and, under some conditions, measure such parameters as atmospheric temperature. This information, which is useful in climate studies, is relevant to studies of atmospheric radiation, structure, and composition and may help us understand the mechanisms involved in ozone depletion. This is a cooperative project between the U.S. and Italian antarctic programs.

Atmospheric halos and ice crystals

Walter Tape, University of Alaska (S-264)

The refraction and reflection of sunlight by ice crystals produce atmospheric halos. Different halos arise from different classes of crystal orientations and from different light-ray paths through the crystals. The unique atmospheric conditions of the antarctic interior frequently produce beautifully-formed simple, prismatic ice crystals that create strong, well-defined halo displays. Because these well-formed crystals typically occur near the surface, they can be collected easily for examination and comparison with the halos that they create. Extending the work performed at Amundsen-Scott South Pole Station, this austral summer investigators will photograph halos and simultaneously sample falling ice crystal at the Soviet station Vostok. By comparing computer simulations of halos with observed halos and crystals, they hope to clarify the relationship between crystal types and halo types. While sampling crystals, the investigators will measure the distribution and intensity of polarized light intensity from associated halos. Theoretically, the distinctive shapes formed by the distribution of polarized light should help define the size and orientation of the crystals. Data on crystal size and orientation obtained from the samples and from the halo simulations will enable verification and calibration of polarimetric techniques. Investigators will also conduct controlled experiments, such as seeding the atmosphere with dry ice, to produce simple, well-formed single-type crystals artificially. These artificially-produced crystals of known source, age, and growth conditions will help to clarify the special atmospheric conditions that produce the crystals for the elaborate halos in Antarctica. The research results have potential for remote sensing of atmospheric conditions.

Climate studies at the South Pole

Stephen G. Warren, University of Washington (S-265)

Investigators will conduct an integrated study of the optical and physical properties of the antarctic snow surface. The four major objectives of the study concern the processes by which global climatic variability is imprinted into the antarctic ice record. Over the course of the austral summer, investigators will measure the effect of surface roughness (sastrugi orientation) on the angular distribution of reflected sunlight to provide information necessary for interpreting satellite remote-sensing data from the Earth Radiation Budget Experiment. These measurements will also be compared with the theoretical model of atmospheric radiation. By operating instruments during the austral

winter, investigators also will assist an ongoing experiment that involves measuring the spectral distribution of thermal infrared radiation from the atmosphere. To study the mechanism of dry deposition of atmospheric aerosols in the snow surface, they will measure the flow of air in and out of the permeable upper layers of firn and in samples of hoar frost; firn and hoar frost samples also will be examined for their isotopic composition. The measurements of airflow through the firn will enable investigators to evaluate the extent to which the concentration of aerosols in the firn and ice represent contemporaneous concentrations in the atmosphere. The hoar frost samples will provide data for a comparison of isotopic ratios to ambient air temperatures.

Spectral bi-directional reflectance of antarctic snow and ice

Robert W. Carlson, Jet Propulsion Laboratory, California Institute of Technology (S-266)

Remote sensing of terrestrial and planetary polar areas is hindered by an incomplete understanding of the snow reflectance. The project objective is to contribute to a comprehensive understanding of the optical properties of antarctic snow and ice-information that can be extended to other regions. With this information, investigators hope to develop an experimental base, or "ground-truth," for remote sensing of glacial and snowpack regions. Such an experimental base will enable researchers to interpret more accurately aircraft and satellite observations to determine properties of snow surfaces, including such features as particle size and shape (properties that relate to the "age" of the snow surface), impurity content, and liquid-water content. Working near Amundsen-Scott South Pole Station, they will measure the spectral bi-directional reflectance of various snow and ice surfaces in the visible and near-infrared (0.4 to 5.0 microns), as well as the polarization effects. They will focus on how surface and subsurface grain properties influence spectral and angular variations of reflectance patterns. Antarctica provides several advantages for this type of investigation. First, the temperature of this continent, which is important to global climate, is determined largely by the optical properties of the snow and ice surface. Secondly, in contrast with temperate regions, the antarctic snow surface does not radically change during the day; consequently, lengthy measurements can be taken. Additionally, contamination from natural and manmade sources is greatly minimized in Antarctica.

Operation of an aerosol sampling system at Palmer Station

Gail dePlanque, Environmental Measurements Laboratory, Department of Energy (S-275)

In March 1990, a team from the U.S. Department of Energy installed a surface-air sampling station at Palmer Station to measure manmade radionuclides, generate data messages, and transmit these data through National Oceanic and Atmospheric Administration satellites to Department of Energy receiving stations. The sampling station is part of a global array of automated stations, and its position in Antarctica fills a significant gap in this vital global data set.

Boundary-layer dynamics over West Antarctica

David H. Bromwich, Ohio State University (S-282)

The antarctic surface wind field is highly irregular, is strongly affected by the surface slope, and has marked areas of convergence and divergence inland from the coastal margins. The interior provides large reservoirs of cold air that produce a persistent, gravity-driven (or katabatic) wind system. These convergent features appear to dominate the antarctic surface climate. This austral summer will be the first phase of this project. In October and November 1990, investigators will test atmospheric sensing equipment on

the Ross Ice Shelf near McMurdo Station at a site that has climate conditions similar to the Siple Coast. During the 1991-92 austral summer, this equipment will be moved to the Siple Coast, which offers a different dynamical setting from earlier experiments in the Terra Nova Bay region of East Antarctica. The overall objectives of the project are to describe and simulate both the downslope and cross-slope variations of the surface winds and temperatures in the Siple Coast confluence zone, to describe and model the impact of synoptic forcing along the terrain slope on the behavior of the surface winds, to investigate the interaction between the surface wind field and the potential temperature gradient along the snow surface, and to measure and simulate boundary layer wind and temperature profiles along terrain contours under the opposing factors of mass convergence and decreasing terrain slopes.

Automatic weather stations: operation and research

Charles R. Steams, University of Wisconsin (S-283)

Although information taken from satellites on antarctic weather patterns is valuable, surface data are needed for confirmation. Automatic weather stations (AWS) measure surface pressure, air temperature, wind speed, and wind direction and transmit the data to satellites for interrogation by ground stations. The weather stations are used to study the barrier wind along the Transantarctic Mountains, vertical motion and sensible and latent heat flux from the Ross Ice Shelf, foehn winds flowing from the Beardmore and Byrd Glaciers onto the Ross Ice Shelf, katabatic flow in East Antarctica, and propagating weather systems at the South Pole. The weather stations also gather continuous and reliable meteorological data that support aircraft operations at McMurdo Station. During the 1990-91 field season, existing AWS units at South Pole Station, near McMurdo Station, and at sites accessible via the U.S. Coast Guard icebreaker *Polar Sea* will be checked, serviced, and relocated.

Astronomy And Upper-Atmosphere Studies

Support for operating an extra-low-frequency/very-low-frequency (ELF/VLF) radiometer at Arrival Heights, Antarctica

Robert A. Helliwell, Stanford University (S-100)

Controlled wave injection of low-frequency radio waves into the upper atmosphere from the ground enables scientists to study magnetosphere wave-particle interactions as well as observe and analyze the behavior of these waves and the response of ionized particles in the magnetosphere. With these techniques, scientists have acquired important quantitative information on the nature of wave-particle interactions in the magnetospheric plasma (low-energy, ionized gas that permeates the magnetosphere) under conditions that cannot be created in a laboratory. During the 1990-91 austral summer, observations will be made from the Arrival Heights upper-atmosphere facility near McMurdo Station. Information will be recorded about background magnetospheric wave activity in the extremely-low-frequency/very-low-frequency (ELF/VLF) range, as well as other effects produced by or associated with magnetospheric waves and particle precipitation. These experiments provide data that further our understanding of coherent radiation from magnetospheric plasma. These data are important to laboratory plasma physics and astrophysics. The results also can be applied to communications, remote sensing of magnetospheric plasma, and modification of the magnetosphere and the ionosphere by wave-induced particle precipitation.

High-latitude magnetic pulsation studies in the Antarctic and Arctic

Roger L. Arnoldy, University of New Hampshire (S-102)

This project will continue the collection and analysis of data from magnetic pulsation sensors located at high-geomagnetic-latitude stations in the Arctic (Sondre Stromfjord, Greenland) and Antarctic (McMurdo and South Pole stations). The pulsations measured, which range in frequency from a few millihertz to a few hertz, are used in conjunction with similar data acquired from a number of satellites and are vital to scientists' understanding of the mechanism by which energy is transferred from the solar wind to the earth's magnetosphere.

Measurement of vertical atmospheric electric current at a network of sites in Antarctica including manned stations and automatic geophysical observation

Edgar A. Bering III, University of Houston (S-103)

During this field season, a network of eight atmospheric current sensors will be deployed in Antarctica-two at manned stations and six at automatic geophysical observatories. The scientific objectives of this project fall into two broad areas: atmospheric electricity and ionospheric electrodynamics. For a study of atmospheric electricity, the network will provide a measure of the power and voltage level in the global circuit and a preliminary estimate of the "geoelectric index." With the ionospheric electrodynamics data, scientists will be able to interpret the differences in the air-earth current at various sites in terms of differences in the electrostatic potential of the ionosphere above the sites. If most stations in the network are installed and operating, more or less continuous "snapshots" of the ionospheric electrostatic potential, and, therefore, convection patterns in the polar cap, should be obtained. Studies of the relationship of statistical patterns to instantaneous patterns, substorm responses, and hemispheric differences are anticipated.

Auroral imaging

Stephen B. Mende, Lockheed Palo Alto Research Laboratory (S-104)

Installed in 1982 at South Pole Station, an image-intensified all-sky camera has enabled scientists to monitor cusp auroral activity. This camera produces images of weak optical emissions at the latitude of the cusp, an important but poorly understood boundary region of the earth's magnetosphere. For data analysis, data have been used from a two-channel photometer at Siple Station, from other projects at South Pole and Siple stations for correlation, and from the auroral imagery on the Dynamics Explorer satellite (DE-1). The primary interest is in the extent to which aurora seen by DE-1 in the Northern Hemisphere mirror those observed at the South Pole. During this austral summer, a research team will inspect and service this equipment. The system will be operated and maintained by South Pole personnel during the austral winter.

Very-low-frequency sensing of thunderstorms and radiation-belt coupling

Umran S. Inan, Stanford University (S-106)

Recent research results suggest that lightning and thunderstorms may have a major role in the precipitation of trapped particles from the radiation belts surrounding Earth. By using ground-and satellite-based observations researchers have established that detectable lightning-induced electron precipitation and associated ionospheric perturbations do occur. Such precipitation is evidence of a fundamental coupling mechanism between the magnetosphere-ionosphere system and the middle atmosphere. The project focuses on the bursts of precipitation that lightning discharges induce at middle to low latitudes. The results help to determine the role of lightning and

thunderstorms in relation to magnetospheric electrons and the way in which the atmosphere, ionosphere, and magnetosphere are coupled. To study this phenomenon, scientists will use the ionospheric density enhancements that it produces. These enhancements are detected as amplitude and phase perturbations on very-low-frequency, low-frequency, and middle-frequency radio signals that propagate along geomagnetic field lines. From recent research, scientists know that such measurements are a powerful and possibly unique ground-based tool for detecting particle precipitation at mid-and low-latitudes. While working at Palmer Station, technicians will conduct simultaneous, high-resolution measurements of the amplitude and phase of subionospheric very-low-frequency, low-frequency, and middle-frequency signals to determine the spatial distribution, temporal signatures, and magnetic conjugacy of lightning-induced precipitation.

High-resolution helioseismology from the South Pole

Martin A. Pomerantz, Bartol Research Institute, University of Delaware (S-109B)

During the 1981-82 austral summer, a solar observatory about 4 miles (6.5 kilometers) from South Pole Station was utilized. With this telescope and a modified version used during the 1982-83 and 1984-85 austral summers, global solar oscillations have been observed and recorded. These observations have helped to extend our understanding of the structure and dynamics of the solar interior. During the 1981-82 austral summer, simultaneous, high-resolution photographs were obtained at two different wavelengths over protracted periods. During austral summer 1990-91, using an enhanced camera, new photographs will be taken for comparison with the earlier ones. With these data, possible changes in the level of solar activity will be investigated, as well as exploration for new solar features.

Observations of ultra-high-energy, gamma-ray sources from the South Pole

Martin A. Pomerantz, Bartol Research Institute, University of Delaware (S-109D)

Since early in this century when cosmic rays were discovered, scientists have sought to determine their point of origin. Initially, they believed that cosmic rays were energetic electromagnetic radiation. More recent data have shown that cosmic rays are electrically charged particles, mainly hydrogen nuclei and more particularly protons. The circumpolarity of the sky over South Pole Station makes this site one of the few from which continuous observations can be made for 200-teraelectronvolt gamma-rays from a large number of X-ray binaries and related compact objects-potential emitters of primary cosmic rays. Because of the station's location, scientists will be able to search for regularities of what are, in the few cases confirmed to date, somewhat episodic sources. The continuous exposure, coupled with the favorably high altitude, will also enable the discovery of weaker sources in the southern sky where there is a preponderance of potential ultra-high-energy, gamma-ray sources. To obtain directional data, an array of detectors that respond to extensive air showers produced by ultra-high-energy, gamma-rays incident on the earth's atmosphere will be used.

Antarctic neutral thermospheric and mesospheric dynamics and thermodynamics

Gonzalo J. Hernandez, University of Washington (S-110)

The dynamics and thermodynamics of the antarctic mesosphere and thermosphere-those regions above the stratosphere beginning at 50 kilometers altitude and extending to the outer edge of the atmosphere-will be studied through the use of a high-resolution, high-luminosity spectrometer near Amundsen-Scott South Pole Station. The station's location in relation to the south magnetic pole makes it possible to study the southern

hemisphere cusp during three months in the winter season. Because of the greater degree of symmetry between the geographic and geomagnetic poles in the southern hemisphere, solar ultraviolet radiation and solar-wind particle effects interact and influence the dynamics and temperature in the upper atmosphere differently than they do in the northern hemisphere. Data from this investigation will help to determine the extent of this interplay during the solar activity minimum. Other studies include the determination of the ion-neutral coupling in the upper thermosphere and its variation. The data from the optical station in Antarctica, integrated with data from other southern hemisphere locations, will give a picture of southern hemisphere thermospheric circulation not previously possible. Direct measurements of ion drifts will provide a measure of the ion-neutral coupling in the thermosphere near the station. Finally, optical measurements of the antarctic mesosphere will continue to be made to study the dynamics and thermodynamics of this very important atmospheric region.

Polar experiment network for geophysical upper-atmosphere investigations (PENGUIN)

Ted J. Rosenberg, University of Maryland (S-111)

A comprehensive investigation of the polar ionosphere at high geomagnetic latitudes in Antarctica will be carried out by using automatic geophysical observatories and selected manned stations. These arrays of instruments will be used to study the energetics and dynamics of the high-latitude magnetosphere on both large and small scales. One of the objectives is to develop a polar-cap magnetic index to provide the first continuous characterization of polar-cap variability. The research will be carried out coincident with *in situ* observations of the geospace environment by spacecraft, in close cooperation with other nations working in Antarctica, and in conjunction with conjugate studies performed in the northern hemisphere.

Cosmic background isotrophy measurements from the South Pole

Mark Dragovan, Princeton University (S-113)

The cosmic microwave background comprises thermal radiation that fills the universe. It originated about 100,000 years after the Big Bang when electrons and protons recombined into hydrogen, thereby causing the gas to become transparent to thermal radiation. Any density inhomogeneity in the universe at that time should have left an imprint on the background radiation. Detecting this imprint has so far been unsuccessful, because more sensitive equipment and longer integration times were required. The measurements taken for this project, however, will be made at wavelengths both longer and shorter than the peak in the cosmic background radiation spectrum in hopes of detecting even slight variations, which theory tells us should be present but which measurements, thus far, have failed to detect. Because these radio waves are strongly absorbed by the atmosphere, especially water vapor, South Pole Station, which is the second driest inhabited place on Earth, is the best place to make these measurements. Another great advantage of this location is that the circumpolar motion of the sky makes it possible to observe any spot in the sky through a constant thickness of atmosphere for any length of time.

South Pole studies of the cosmic background radiation

Philip M. Lubin, University of California at Santa Barbara (S-115)

Measuring fluctuations (or anistropy) in cosmic background radiation is one of the few experimental inputs available to atmospheric physicists for comparison with cosmological models. Because large-scale (greater than 10°) measurements of these variations can be disrupted by emissions from our galaxy, particularly by high-galactic latitude dust

emissions, the objective is to make observations at the 3-millimeter-wavelength level, where galactic emission is near its minimum. Atmospheric fluctuations, particularly water vapor, generally create problems for ground-based anistropy measurements, but results from earlier antarctic studies indicate that the extreme cold and low water-vapor content of the atmosphere at South Pole provide an excellent environment for this type of measurement. During the 1990-91 austral summer, investigators will again collaborate with Princeton University researchers (S-113) in their study of cosmic background radiation by using a liquid-helium-cooled detector that operates at a 3-millimeter wavelength. A 1-meter telescope, developed as a part of the balloonborne program, will allow them to make measurements on the order of 1°. Measurements will be made in an angular region that has not been well investigated, that is complementary to other experiments, and where the predicted fluctuations are expected to be near maximum. These measurements will also help scientists to understand better the atmospheric fluctuations, useful information for future millimeter and submillimeter wave astronomical investigations.

Cosmic and solar hard X-ray and gamma-ray spectroscopy from Antarctica

Robert P. Lin, University of California at Berkeley (S-116)

Astrophysicists believe that supernova explosions produce most of the heavy elements in the universe through the processes that occur as a star's core collapses and explodes during supernova. Observing and recording the spectral properties of gamma-rays appear to be the best ways to study this process because many of the heavy elements are first produced as unstable nuclei that emit gamma rays of characteristic energies as they decay. On 23 February 1987, astronomers and astrophysicists observed Supernova 1987A in the Large Magellanic Cloud, a companion galaxy to the Milky Way. This was the closest supernova to Earth in more than 300 years and offers astronomers and astrophysicists a unique opportunity to study in detail a supernova explosion, to learn more about the process of explosive nucleosynthesis, and to search for cosmic gamma-ray bursts and astronomical events that occur during supernovas. To accomplish this, investigators will participate in a multi-institute project to launch a 28.4-million-cubic-foot high-altitude helium balloon equipped with detectors. It is anticipated that the balloon will reach an altitude of between 120,000 and 130,000 feet and that it will stay aloft for 20 days.

Measurement of cosmic-ray composition and spectra using emulsion chambers-Japanese-American Cooperative Emulsion Experiment

Thomas A. Parnell, National Aeronautics and Space Administration, George C. Marshall Space Flight Center, and R.J. Wilkes, University of Washington (S-119)

Since 1979 there have been collaborations with Japanese investigators in a series of experiments to study the composition, spectra, and interactions of cosmic-ray nuclei. Although initially NASA personnel worked to develop an electronic counter and performed calculations to support data analysis, the focus during the last seven years has been to perform passive detector analysis, specifically using x-ray film densitometry and emulsion chambers. As participants in the antarctic long-duration balloon project, NASA investigators use similar passive techniques to trace and measure cosmic-ray events and perform calculations for data analysis. Over the last three years, the group has analyzed data from six balloonborne experiments and has produced unique data on nucleus-to-nucleus interactions at high energies (greater than 1,000 gigaelectron volts).

Solar and heliosphere studies with antarctic cosmic-ray observations

John W. Bieber, Bartol Research Institute, University of Delaware (S-120)

Cosmic rays provide a powerful tool for studying exotic astrophysical processes that occur on the Sun and in its far-reaching atmosphere that controls space near Earth. Antarctic monitoring stations are crucial for probing interplanetary plasma dynamics through observations of variations in relativistic (over 1 gigaelectronvolt) galactic cosmic rays. At McMurdo and South Pole stations, investigators will continue year-round observations of cosmic radiation and collaborate with the magnetospheric cusp program. To enhance understanding of the solar physical processes that control the electromagnetic conditions in the earth's environment, these data are used in conjunction with data from other ground-based instruments and spacecraft. The objectives are to explore the nature of long-term variations and North-South asymmetries of solar activity; to investigate the acceleration, coronal transport, and interplanetary transport of energetic solar particles; to learn more about the three-dimensional structure of interplanetary magnetic turbulence; and to improve understanding of the solar modulation of galactic cosmic rays.

All-sky camera measurements of the aurora australis from Amundsen-Scott South Pole Station

Frank T. Berkey, Utah State University (S-122)

Amundsen-Scott South Pole Station, located at the south geographic pole, is a unique platform from which to undertake measurements of the polar ionosphere. Because of the configuration of the geomagnetic field in the Southern Hemisphere, the station is situated in such a way that dayside auroras can be viewed for several hours each day. Research has shown that the precipitation of low-energy particles, which enter the magnetosphere by means of the solar wind, cause these auroras. The objective is to continue making winter observations of the aurora by operating a 35-millimeter all-sky camera system that has been used since 1967. The data that are acquired will be used to investigate dayside auroral structure, nightside substorm effects, and polar-cap arcs. These studies can also be used to obtain further insight into the physics of the magnetosphere, the convection of plasma in the polar cap, and winds in the thermosphere.

P. Buford Price, University of California at Berkeley (S-124)

An extraordinary amount of astrophysical information can be extracted by determining the amount of isotopes of iron, nickel, and neighboring elements in cosmic rays. Unfortunately, inadequate statistics and poor mass resolution have limited past efforts to study these isotopes. The objective is to measure isotopic composition of iron, manganese, cobalt, and nickel in galactic cosmic radiation using balloonborne instruments launched near McMurdo Station as part of the Long-Duration Ballooning Program. These measurements will provide information about cosmic-ray origin and acceleration, the structure of interstellar medium, and stellar evolution. The balloons will carry a special glass to an altitude between 120,000 (36,580 meters) and 130,000 feet (39,624 meters), where the glass will be exposed for as long as 20 days. After the glass is recovered, investigators will etch it with a strong acid. This process reveals the tracks *left* by energetic cosmic rays that penetrate the glass. By studying the etched tracks, investigators can accurately determine the mass, charge, and energy of the isotope that caused them.

Observation of very-high-energy gamma-ray sources from the South Pole

Robert M. Morse, University of Wisconsin, and James A. Gaidos, Purdue University (S-125 and S-126)

Although cosmic radiation was discovered more than 75 years ago, its origin remains a mystery. Gamma rays represent only a small fraction of the total cosmic-ray flux, but they propagate undeflected from their sources to Earth, while the dominant, electrically charged component is deflected by magnetic fields. The objective is to identify sources of cosmic radiation which, according to some theories, may have been created by a modest number of supernova. To do this, an atmospheric Cherenkov telescope will be installed near the South Pole. The telescope consists of an array of parabolic mirrors with photomultiplier tubes at their foci that can detect light from very-high-energy (VHE) interactions in a small amount of atmosphere. The geographic South Pole is an ideal site for this research because it is possible to view a single object for extended periods through a constant thickness of atmosphere. At a mid-latitude site, observations are limited to a few hours of viewing at a time.

Sodium-lidar studies of the antarctic upper atmosphere at Amundsen-Scott South Pole Station

Chester S. Gardner, University of Illinois (S-127)

The antarctic upper atmosphere is a region of diverse, complex interactions where chemistry and dynamics are greatly influenced by the tropospheric and thermospheric vortices. This region is attracting considerable attention because of the springtime depletion of ozone above Antarctica. Although the lower atmosphere has been explored for many years using various balloonborne, rocketborne, and ground-based instruments, the relative isolation of Antarctica and the paucity of suitable instruments has inhibited the study of the antarctic mesosphere (50 to 80 kilometers) and lower thermosphere (above 80 kilometers). A sodium lidar is a powerful tool for exploring upper atmosphere structure and dynamics, including stratospheric aerosols, mesospheric temperatures, gravity waves, tides, and vertical transport near the mesopause, the boundary between the mesosphere and thermosphere where there is a temperature minimum. The lidar can detect the sodium layer at about 56 miles (90 kilometers) altitude and, by measuring the height and density of this layer, determine the vertical motion of the upper atmosphere. The objective is to install and operate a sodium lidar at Amundsen-Scott South Pole Station so that information relevant to ozone depletion can be obtained, particularly data concerning the dynamics of upper atmospheric regions.

Low-frequency/high-frequency programmable frequency receiver to the antarctic automatic geophysical observatories

James W. LaBelle, Dartmouth College (S-128)

For decades, intermittent ground observations have given tantalizing hints that the Earth's high-latitude ionosphere emits radio waves in the low-frequency to high-frequency band (0.15-9.6 megahertz). Rocket and satellite observations in the upper regions of the ionosphere and magnetosphere commonly indicate the existence of such terrestrial radio signals, particularly in the lower portion of this frequency range. Theoretical studies have indicated that some of these emissions should be able to penetrate the ionosphere and be detected at ground level, but there is a need for a ground-based recording effort to study this much-neglected radio band to confirm these theories and provide insight into auroral emission and wave-propagation processes. The unmanned automatic geophysical observatories (AGOs) are ideal for this effort because the sensitivity at these frequencies is greatly affected by human-produced transmissions,

which are generally minimal in the Antarctic. Because the AGOs can be installed at locations remote from antarctic stations, interference from radio transmission is even less of a problem. To gather data about this poorly understood frequency band, investigators will use a programmable low-frequency/high-frequency receiver, an array of small ferrite-rod antennas, a power subsystem, and data compression software deployed at two automatic geophysical observatory sites.

Spectroscopic and interferometric studies of airglow and auroral processes in the antarctic upper atmosphere over South Pole Station

G.G. Sivjee, Embry-Riddle Aeronautical University (S-129)

The project will focus on the physical, dynamical, chemical, and atomic-molecular processes occurring in the upper atmosphere above Antarctica-particularly the mesopause, thermosphere, and ionosphere. Investigators will use the long, dark winters at South Pole Station for more extensive observations of semi-diurnal, diurnal, and longer period disturbances propagating through the mesopause. Investigators hope to compare the South Pole Station data with similar data from stations in the Arctic, where topological and meteorological conditions are different from those in the Antarctic, to assess the contributions of these factors to the mesopause disturbances.

Long-duration balloon test flight in Antarctica

David Stuchlik, National Aeronautics and Space Administration, Wallops Flight Facility (S-272)

In January 1988 the first large (11.6-million-cubic-foot), high-altitude helium balloon was successfully launched in Antarctica. It carried instruments which collected data on cosmic events associated with Supernova 1987A to an altitude of 115,000 feet. Although its flight was brief, the successful launch of this balloon demonstrated that large high-altitude helium balloons could be used for research in Antarctica. This austral summer, investigators will continue to develop the uses of long-duration ballooning in Antarctica. This investigative team will test the balloon instrumentation subsystems for future flights and manage flight operations. It is anticipated that the 28.4-million-cubic-foot balloon will reach an altitude between 120,000 and 130,000 feet and remain aloft for about 20 days, following a circumpolar path at about 78°S latitude.

South Pole X-ray characteristics

George K. Parks, University of Washington (S-273)

The southern polar cap region is usually associated with the geomagnetic field lines that connect to the interplanetary medium. Recently, researchers established that energetic particle precipitation occurs in the upper atmosphere above Antarctica. The disparity in energies indicates that these energetic particles come either from field lines flowing into the magnetosphere or from some other type of acceleration taking place on "open" field lines. As a result of satelliteborne, polar-orbiting imaging experiments, investigators know that various types of polar-auroral arcs are present, but the relationship between precipitating energetic particles and these arcs is not known. More information is needed to understand the morphology and mechanism of energetic polar-auroral activity. As part of the Long-Duration Balloon Program, a balloonborne X-ray imaging camera will be used. With this camera, investigators hope to be able to examine the behavior of these auroral phenomena over longer periods of time because the balloon moves more slowly than most auroral events occur. When carried aloft by the stratospheric balloon, these systems will provide data that will enable the study of structures as large as 10 kilometers with durations as short as a few seconds. Working near McMurdo Station

with investigators from the University of California at Berkeley (S-116), the team will acquire X-ray data that later will be correlated with other geophysical and solar events (e.g., solar flares and magnetospheric substorms). These results will be studied for spatial, motional, and temporal evolution of X-ray events and analyzed for energy-spectral characteristics of X-rays as a function of space and time. Additional support for the balloon launched will be provided by investigators from the National Aeronautics and Space Administration's Wallops Flight Facility.

BIOLOGY

Dispersal and diving behavior of Weddell seals determined by satellite telemetry

J. Ward Testa, University of Alaska (S-004)

Most of what scientists know about the behavior, ecology, and population dynamics of Weddell seals (*Leptonychotes weddellii*) comes from research conducted in the austral spring and summer. This study, which uses data obtained from a 20-year population study of seals in the McMurdo Sound region, focuses on the winter movements and diving behavior of adult Weddell seals near McMurdo Sound. To obtain data, investigators will attach satellite-linked, time-depth recorders to the seals. When a seal leaves the water for the sea ice or a nearby beach, the recorder will relay information on the seal's location and transmit summaries of the duration and depth of dives made by the seal. Because these seals usually return to the same area each year, the satellite time-depth recorders can be recovered. With data from this investigation and earlier studies, a better understanding of age-related differences in behavioral traits that may explain demographic features and selective pressure on the life history of Weddell seals will be gained. These data also will be used in studies of other large mammals.

The role of glycopeptide and peptide antifreezes in freezing avoidance by antarctic fishes

Arthur L. DeVries, University of Illinois (S-004)

Responding to the polar marine environment, antarctic fishes produce protein and amino-acid compounds that act as antifreeze and enable them to survive in ice-laden shallow water. Research indicates that there are eight antifreeze-like compounds capable of lowering the freezing point of body fluids below -1.9°C, the temperature of the seawater. Such mechanisms, which provide resistance to freezing, have great evolutionary and ecological importance. The objective of this multidisciplinary study is to learn how these compounds prevent ice from forming in intestinal fluids, what the biophysical interactions between ice and antifreeze compounds are, and what the molecular biology and organization of the antifreeze genes are. Also, by continuing this investigation, scientists hope to learn more about ice-crystal growth and to apply this new information to such areas as crystallography, medicine, and frozen food technology.

Biogeochemistry of antarctic dry valley lakes: seasonal and feedback processes in antarctic lakes dominated by internal cycling

Diane McKnight and Richard Smith, U.S. Geological Survey, and Brian L. Howes, Woods Hole Oceanographic Institution (S-008 and S-020)

In temperate regions seasonal environmental changes, as well as biogeochemical cycles, influence freshwater-lake ecosystems. The mixing and diluting of lakewater, however, can obscure the importance of some biogeochemical processes. The lakes of the McMurdo Dry Valleys sharply contrast with temperate-zone lakes but are uniquely suited for the study of internal production and degradation of organic material. Located in

one of Earth's most arid, barren environments, these lakes annually receive from glacial meltwater relatively minor amounts of inorganic matter, organic material, and nutrients. The seasonal cycle is simple-six months of light and six months of dark-with the permanent ice cover stabilizing the environment. During the austral summer, sufficient light penetrates the ice cover to support the algal and bacterial photosynthesis that sustains a microflora population that is similar to temperate lakes without plant nutrients but with plentiful amounts of oxygen. The project focuses on the chemical and biological changes that occur during the austral summer (constant daylight) and the austral winter (constant darkness) and on the interaction or feedback processes that occur in aerobic, anaerobic, and benthic zones of the lake. Working at Lake Fryxell (a closed ecosystem), investigators will determine the internal cycling of carbon, nitrogen, and sulfur in various environments. They also will determine how important seasonal lakewater cycles are to the biogeochemical processes within the lake and study the response of predominant biogeochemical cycles to the seasonal light-dark cycle. The study objective is to measure processes of organisms that require organic matter for life and those that synthesize organic material from inorganic elements, determine related chemical parameters, quantify lake hydrology, and develop sampling devices to operate during the winter. Data from this project will help scientists to understand internal biogeochemical cycling in non-antarctic lakes.

The impact of the Bahia Paraiso oil spill on a Southern Ocean seabird community

William R. Fraser, Point Reyes Bird Observatory (S-013)

On 28 January 1989, the Argentine supply ship *Bahia Paraiso* ran aground and sank near Palmer Station, spilling 170,000 gallons of diesel fuel, jet fuel, and lubricating oil into the marine environment. The spill, which coincided with the feeding, fledging, and migration of the area's six most abundant seabird species, exposed 36,000 to 43,000 chicks and adults to the oil. The focus of the study is to determine what impact the spill has had on the seabirds in the Palmer Station area. Studies done between 1987 and 1989 provide data on the abundance, breeding success, diets, and growth rates of many members of this seabird community, including chicks marked in 1988 (not exposed to oil) and those marked in 1989 (exposed to oil). These data will serve as baseline data in this comparative study, which is designed to assess seabird mortality and to determine the population's potential for recovery. Because baseline data with which to compare the impact of an oil spill are rarely available, this study is unique not only in terms of assessing the impact of an oil spill on a comparatively pristine polar environment but also generally as a potential source of critical data for seabird impact studies.

Energetics of adult and larval krill (Euphausia superba)

Langdon B. Quetin and Robin M. Ross, University of California at Santa Barbara (S-014)

Euphausia superba (krill) and related euphasid species are the most abundant animals in the Southern Ocean. Besides being exploited heavily by almost all antarctic marine carnivores, krill is the focus of a small but growing fishery. The study objective is to assess the impact of food availability on the total energy required for reproduction in adults and on the survival, development, and growth of larval stages of krill. Four factors affect how much food is available for reproduction-how much is ingested, how efficiently it is assimilated, what the metabolic costs are for swimming and maintenance, and how energy is partitioned for growth and reproduction. Working aboard the *Polar Duke* from late November 1990 to mid January 1991, the investigators will collect samples of live krill from waters near Adelaide Island and in Marguerite Bay, the Bellingshausen Sea, the southern Bransfield Straits, Gerlache Straits, and the Palmer

Basin. During these cruises, sonar will be used to measure and track krill populations; measure current, temperature, and salinity at selected sites; and take water samples. Divers also will observe the behavior of krill communities. The results of the project will contribute substantially to understanding aspects of krill biology that are either unknown or poorly understood.

Ecology and nutrition of invertebrate larvae in McMurdo Sound, Antarctica, and Monterey Bay, California: use of phytoplankton and non-phytoplankton food resources

John S. Pearse, University of California at Santa Cruz, Donal T. Manahan, University of Southern California, and Richard B. Rivkin, Horn Point Environmental Laboratories/University of Maryland (S-016, S-019, and S-038)

Many benthic invertebrates, including polar species, produce larvae that must survive as plankton before entering the adult population. Understanding what factors influence larval survival is critical to understanding how adult populations are replenished and maintained. The research team will focus on one of the most important of these factors-nutrition. Working in the McMurdo Sound area, these investigators will try to clarify whether larvae are nourished by particulate food, dissolved organic material, yolk provided by the parent, or a combination of these three mechanisms. Because little is known about the relative role of these nutrient sources for larvae of different types, investigators will compare feeding and nonfeeding varieties of larvae from two contrasting environments-Monterey Bay, California, and McMurdo Sound. In Monterey Bay, primary production and phytoplankton production are high throughout most of the year, but in McMurdo Sound phytoplankton and biomass production remain low most of the year with marked seasonal fluctuations. At several sites in the McMurdo Sound region, the team will sample adult animals and larvae of benthic invertebrates, along with their food. With these data, investigators will be able to characterize seasonal and daily distribution and the physiology of various types of invertebrates near Hut Point, at Cape Armitage, and along the ice edge at Explorers Cove, New Harbor, Butter Point, and sites along an east-west transect. The results of this project will help explain how different nutritional environments affect larval growth and survival, and how the need to replenish adult populations influences the evolution of larval nutritional modes.

Use of the lateral line for foraging in Antarctica

John A. Janssen, Loyola University (S-023)

Fishes of the suborder *Nototheniodei*, the dominate species in antarctic waters, have adapted to an unusually cold marine environment and are able to function in extreme darkness (during winter or under thick sea ice). Recent investigations indicate that although they can function in the dark, they have not developed special ocular adaptations. Preliminary research suggests these fish may use a mechanical sensory system called the lateral-line system. This system, which is common to fishes that live in such dark habitats as the deep ocean or caves, is made up of hair cells and supporting cells that are sensitive to changes in pressure and may have a role in feeding. The study objectives are to determine which notothenioids use lateral-line systems to feed in the dark. Working near McMurdo Station, investigators will focus on two theories-that the lateral-line system can be tuned to identify important prey and that fishes living in deeper waters have more sensitive systems. This approach combines studies of behavioral responses to live prey and artificial stimuli, physiological responses of lateral-line nerve fibers to artificial stimuli, and the anatomy of the various types of lateral-line systems. Because the role of the lateral-line system in fishes is not clearly understood, the project should contribute much new information to this field.

Photoadaptation by phytoplankton in permanently ice-covered antarctic lakes: response to a nonturbulent environment

John C. Priscu, Montana State University (S-025)

The underwater environment of the lakes in the McMurdo Dry Valleys is the exception to the usual model of the light regime for planktonic microalgae. In most ecosystems, plankton are exposed to varying amounts of light based on the rate of vertical mixing in the water column. Because the water column in the permanently ice-covered dry valley lakes is relatively stable, investigators believe that light intensity and spectral quality are constant. The study objective is to describe the photophysiology of distinct plankton populations in Lake Bonney in relation to the lake's unchanging physical regime. Investigators will examine the stability of the physical environment, habitat preferences for distinct vertically-stratified populations, the rate of physical and chemical change in relation to photoadaptation, the rhythm of photosynthesis over 24 hours, and the physiological mechanism responsible for observed photosynthesis versus the fluctuation of light intensity patterns. Because these plankton populations are spatially stable, they will be a model for studying photoadaptation as it occurs during the growing season.

Biology of King and Emperor penguins while at sea

Gerald L. Kooyman, Scripps Institution of Oceanography (S-026)

This study, which will be conducted at Cape Washington, will compare King and Emperor penguins, focusing on two behaviors of the birds at sea: diving and energetics. For studies of diving behavior, a microprocessor will be used to measure and store data on time, dive depth, and swim velocity. From these recorders, investigators will obtain the diurnal patterns of dives, prey depth distribution, and swim speeds. Time spent by the penguins at sea and at the colony will be determined by remote transmitters. For studies of energetics at sea, investigators will procure laboratory measurements of oxygen consumption and carbon dioxide production at antarctic temperatures and at various swim velocities and use those values to validate time budget estimates. Both types of studies will be used for interspecies comparisons of hunting strategy, success rates, and energy outputs, as well as to test several hypotheses regarding the physiology of diving.

Mary Putt, Old Dominion University (S-027)

Research suggests that nano-and microzooplankton, which are too small to be effectively grazed by larger zooplankton, are important in the transfer of carbon through polar food webs, but because of the large number of energy transfers involved, microbial food chains may be less efficient than food webs that are dominated by larger, physiologically more complex organisms in transferring energy to higher trophic levels. Consequently, understanding the role of these two food chains is important in developing models of energy and material flow through polar ecosystems. McMurdo Sound is representative of larger areas of the Southern Ocean that are seasonally or permanently covered by ice. Microalgal carbon enters the Sound seasonally and episodically. These inputs appear to be influenced strongly by inputs from sea-ice microbial communities and by the movement of water from the Ross Sea into McMurdo Sound. Investigators believe that the trophic role of nano- and microzooplankton reflects the episodic nature of primary production in this system. Working in McMurdo Sound, they will examine seasonal and spatial variation in the distribution of nanozooplankton (2 to 20 micrometers in size), microzooplankton (20 to 200 micrometers in size), microalgae, and bacteria. The growth rates of microzooplankton

and the impact of grazing by the nano-and microzooplankton communities on algae and bacteria also will be investigated. Dominant bactivores found in this system will be identified, and the use of dissolved amino acids and detritus as nutritional sources for individual microzooplankton species will be evaluated. Results from this study will contribute to scientific understanding of how microbial food webs function in the cycling of carbon in ice-covered areas of the Southern Ocean.

Ozone diminution, ultraviolet-B, and phytoplankton biology in antarctic waters

Deneb Karentz, University of California at Santa Barbara and Raymond Smith, Texas A&M University (S-031 and S-231)

The Antarctic is experiencing large springtime losses of stratospheric ozone. As a result, the magnitude of ultraviolet-B radiation reaching the surface now approaches that measured in tropical latitudes. Perhaps more important, while ultraviolet-B radiation in the Antarctic has increased, both ultraviolet-A and photosynthetically-available radiation have remained unchanged. In this study, investigators will make use of recent improvements in atmospheric modeling and technology in oceanographic instrumentation during a six-week austral spring field study to document the impact of ultraviolet radiation on the phytoplankton community during the ice-edge spring bloom. Special emphasis will be placed on defining biological restraints imposed by the springtime radiation changes on the balance of ultraviolet-B photodamage to photorepair as well as photoprotective and photosynthetic mechanisms operating in the Southern Ocean.

Early life history studies of antarctic fish

Richard Radtke, Hawaii Institute of Geophysics (S-034)

Although fish larvae are an important component of the zooplankton community, the ecology of larval fish has received little attention. How fish larvae function affects the dynamics of antarctic fish populations and, ultimately, the entire marine ecosystem. Before these processes can be investigated, scientists must identify which life-history stages, environmental events, or combination of these two are significant to larval growth, survival, and recruitment into the adult population. To examine the variables that influence larval fish survival, the investigators will study the microstructural patterns in fish otoliths-calcium carbonate structures in the inner ear that serve as storage sites for chronological information. With these data, they hope to develop a schedule for larval fish growth rates, hatching periodicity, and environmental histories and to understand larval fish processes better. In laboratory experiments, they will investigate otolith microstructure to determine what causes otoliths to form. The data from this part of the investigation will be combined with environmental data so that physical aspects of larval fish can be related to growth and survival. The results of the study will help to clarify what factors influence growth and mortality and, hopefully, will guide similar studies of other ecosystems. Additionally, a model developed from otolith research will be useful for studies of how fish communities maintain population levels and could improve understanding of the early life-history stages of antarctic fish.

Nematode distribution and function of antarctic dry valley ecosystems

Diana W. Freckman, University of California at Riverside (S-035)

The McMurdo Dry Valleys, the ice-free region of southern Victoria Land, are among the most extreme desert ecosystems in the world. Like other desert regions, water is limited in these valleys, and this limitation combined with extremely low temperatures has prevented the development of vascular plants. Nematodes, which are worms with unsegmented, threadlike bodies and which are often parasitic, are known to be important

for carbon and nutrient cycles in deserts because of their interaction with plants and the decomposition cycle. Little is known about their distribution and function in the ice-free regions of Antarctica. The project objective is to examine the distribution and nutritional requirements structure of nematode communities in Wright, Taylor, and Marshall Valleys. Distribution, abundance, and species composition will be related to soil physical and chemical properties, including organic carbon, nitrogen, salinity, pH, and microbial numbers and biomass. To determine if nematode numbers are limited by levels of energy or by environmental factors like soil moisture and temperature that influence activity and survival, investigators will augment the available energy supply in the soil with sugar. Under controlled laboratory conditions, they will study the organisms' adaptation to low soil moisture and low temperatures. Wind dispersal of nematodes from island and continental sources also will be studied in one of the valleys by trapping wind-dispersed nematodes and identifying the species that are endemic to these ecosystems.

Metabolic and ultrastructural adaptations to chronically cold body temperatures in antarctic fishes

Bruce D. Sidell, University of Maine (S-036)

Antarctic fish have evolved in extremely cold seawater that has little seasonal variation. Near McMurdo Station, the average temperature of the water is approximately -1.9°C and in the Antarctic Peninsula about -1.1° to 0.3°C. As part of their adaptation to the cold, most antarctic fish produce biological antifreeze compounds; however, biologists also have found that some of these fish, such as *Channichthyidae,* substantially reduce red blood cells and hemoglobin and are protected from the cold because this lowers the viscosity of the blood. The lack of hemoglobin in *Channichthyids* (ice fish) is compensated for by increasing the size of the heart, the volume of blood, and cardiac output. *Nototheniodei* fish, the most common antarctic fish, accumulate substantial quantities of corporeal lipids. Although some biologists have suggested that lipids are a primary fuel for energy metabolism, this has not been demonstrated. The goal of this project is to use a cellular/biochemical approach to describe more completely the energy metabolism of antarctic fish. Specifically, investigators will critically evaluate enzyme activity that parallels metabolic cold adaptation in tissues, assess the relative importance of carbohydrates and lipids as fuels for energy metabolism, determine the fatty-acid composition of lipid stores, evaluate the suitability of predominant fatty acids as substrates for energy metabolism, and quantify geometric relationships of cellular structure that may be required for the functioning of metabolism at severely cold body temperatures. To compare how diet and lifestyle affect energy metabolism, they will focus their investigation on benthic *Notothenia gibberifrons* and *Channichthyid* fish. To address questions of metabolic cold adaptation, they will concentrate on major energy-consuming tissues (red and white skeletal muscle, cardiac muscle, etc.). The activities of key enzymes in pathways of energy metabolism will be measured at body temperature and compared with existing data from temperate fishes to determine whether antarctic species are biochemically cold-adapted. Results from this study should help to resolve conflicting hypotheses on whether metabolic rates of these fish are cold-adapted or whether fats are primary fuels for energy metabolism. These data also will contribute to a better understanding of the role of *notothenioid* fishes in the trophic structure of the antarctic marine ecosystem.

Assembly and stability of microtubules in fish at low temperatures

H. William Detrich III, Northeastern University (S-037)

Macromolecular assemblies of proteins perform many essential cellular processes.

Cytoplasmic microtubules are tube-like, subcellular filaments composed of the major protein subunit, tubulin, and one or more microtubule-associated proteins (MAPs). The ordered assembly, maintenance, and disassembly of cytoplasmic microtubules play critical roles in cell division, nerve growth and regeneration, cell-shape determination, and cytoplasmic transport. At temperatures near 0°C the cold-labile microtubules of warm-blooded vertebrates break down rapidly into their simpler subunits. In contrast, the cold-stable microtubules of antarctic fish must be assembled and maintained at extremely low temperatures (approximately -2° to +2°C). The goal of this study is to determine the biochemical adaptations responsible for assembly, stability, and function of microtubule proteins in cold-adapted antarctic fishes (*Notothenia coriiceps neglecta, N. gibberifrons*, and *Chaenocephalus aceraturs*) at low temperatures. Experiments conducted during previous austral summers demonstrated that cold stability of microtubules from these fishes is caused by alterations in the structures of tubulin subunits and, to a lesser extent, in the MAPs. To extend the research this austral summer, investigators will determine the structural adaptations that enable antarctic fish to chemically assemble and disassemble cold-stable microtubules, characterize the structure of tubulin and MAPs that are involved in these interactions, clone and sequence the DNA messages that encode alpha and beta chains in tubulins, and determine the structure of tubulin genes from antarctic fish. From brain and reproductive organ tissues of two antarctic cods (*N. gibberifrons* and *Notothenia coriiceps neglecta*) and an ice fish (*Chaenocephalus aceraturs*), investigators will purify the microtubule proteins and nucleic acids (DNA and RNA) necessary for these studies. Experiments will be conducted at Palmer Station during the austral summer and in their laboratory in the United States.

Foraging habitats and behaviors of pygoscelid penguins

Wayne Z. Trivelpiece, Point Reyes Bird Observatory (S-040)

Penguins are major predators of krill (*Euphausia superba*) and an important component of the antarctic marine food web. To understand thoroughly the structure and function of the antarctic ecosystem, biologists must have information on population dynamics, as well as the factors that regulate the size of penguin populations, especially pygoscelid penguins, the dominant antarctic genus. The three pygoscelid penguins-Adelie (*Pygoscelis adeliae*), chinstrap (*P. antarctica*), and gentoo (*P. papua*)-nest sympatrically at Point Thomas, King George Island, near the Polish Arctowski Station. For several years, scientists have banded penguins at this site and studied their breeding and feeding ecology. Results of these studies indicate that each species responds differently to winter conditions, differs in annual survival levels, and has different age and sex requirements for maintaining population levels. During austral summer 1990-91, the investigators will work in the Admiralty Bay area. By observing banded penguins daily from October through February and by using radio telemetry and time-depth recorders, they will be able to collect data on known-age populations; to determine the relationships of sex, age, and experience to fecundity and survival; and to compare the foraging ability of young, first-time breeding birds with older, experienced breeders. With telemetry and time-depth data, their data base will be expanded to include information on how these penguins behave at sea. This information will improve significantly the scientific understanding of the trophic relationships among these penguins and will enable the investigators to test hypotheses on how age affects foraging proficiency and how foraging proficiency affects breeding and recruitment patterns.

Sources, distribution, and fate of hydrocarbons in the vicinity of the Bahia Paraiso, Arthur Harbor, Antarctica

Mahlon C. Kennicutt II, Texas A&M University (S-041)

The grounding of, and subsequent leakage of, petroleum from the *Bahia Paraiso* into the relatively pristine environment of Arthur Harbor raised the spectre of a major ecological disaster caused by human activities in the polar climates. In response to initial accident reports which stated that substantial amounts of hydrocarbons had been released, a multidisciplinary team of experts was dispatched to the area. Environmental chemists at the accident site focused on determining the extent of hydrocarbon contamination and its ultimate fate in the environment. Sampling included tissues (invertebrates and macroalgae), sediments, and water in both affected and control areas. As part of this effort, investigators will perform laboratory chemical analysis of samples collected at the site at the time of the accident and approximately one year later. The project goals are twofold: to assess the chemical impact of this accident on the environment and to evaluate, on a broader scale, the significance and impact of petroleum releases associated with mankind's activities in the polar regions.

Reproductive strategies of south polar skuas: the role of food in chick survival and sibling aggression

Gary D. Miller, University of New Mexico (S-042)

This study will examine the relation between the natural selection process and chick deaths during the nesting period for south polar skuas. Previous theories have attributed deaths to cannibalism, adoption of foreign chicks into the nest, and competition among siblings. In addition, this study will examine the roles of food availability and parental feeding behaviors as causes of sibling aggression leading to siblicide and nesting starvation. The south polar skua represents one of the few examples where sibling aggression is mediated by hunger. The investigators' hypothesis predicts that when food is plentiful for chicks, aggression will decrease and fewer deaths, higher growth rates, and increased reproductive success will result. The causes and timing of egg and chick mortality will be determined; how skuas adjust their reproductive strategies from year to year will be studied; and a quantitative description of the role of siblicide to the reproductive success of the south polar skua will be developed. The study will be conducted on Ross Island.

Test morphogenesis in a giant antarctic formaminiferan

Samuel S. Bowser, Wadsworth Center for Laboratories and Research (S-043)

The shell of the giant foraminiferan protist, *Astrammina rara*, is composed of mineral grains tightly bound by a chemically-resistant biological cement. The goal of this study is to describe the process used by this cold-adapted organism to construct its shell. Cursory observations indicate that *A. rara's* network of foot-like projections collects larger particulates from the sediment, secretes a shell matrix, then sculpts the shell. Because *A. rara* is a giant, single-celled system, general questions regarding the induction, synthesis, post-translational modification, secretion, and assembly of extracellular matrix components can be studied without the complications of cell-to-cell and cell-to-tissue interactions common to the system of larger, more physiologically complex organisms. From a theoretical standpoint, this study will help to answer a longstanding biological question; from a practical standpoint, analysis of *A. rara's* shell is likely to reveal the presence of novel cold-adapted fusogens, which may have biotechnical and commercial value.

Research on Antarctic Coastal Ecosystem Rates (RACER): microbial dynamics and carbon flux

David M. Karl, University of Hawaii (S-046)

The Southern Ocean maintains a moderate, if patchy, biological productivity in spite of the harsh environment. Primary production in coastal antarctic ecosystems is characterized by an intensive spring bloom. During this two-three month bloom, 70-90 percent of the annual organic carbon is produced, which, in turn, increases biological productivity at all levels, from bacteria to baleen whales. The precise pathways of carbon transfer, however, and the rates and mechanisms involved have not been carefully investigated. In particular, the role of microheterotrophs in antarctic foodwebs and the immediate fate of phytoplankton production need to be examined. This study will attempt to define the mechanisms, pathways, and rates of coupling between photoautotrophic and heterotrophic populations and also evaluate the coupling between the pelagic and benthic habitats. The data obtained during this expedition will add to an overall understanding of the rates of primary and secondary production and will ultimately be used to formulate a general model of carbon and energy flow in antarctic coastal ecosystems.

Mathematical models of foraging seabirds

Peter M. Kareiva, University of Washington (S-048)

Seabirds are excellent indicators of biological activity in the pelagic environment and have the special advantage that they can be easily and inexpensively studied in conjunction with conventional oceanographic sampling. The problem is that we now have an abundance of data on seabird dispersion without any theoretical framework within which to evaluate these observations. Researchers theorize that the foraging movements of seabirds are likely to be responsive to the dispersion of food resources. To analyze this hypothesis, the investigative team will contrast models of passive diffusion with more realistic behavioral models. The behavior-based modeling they plan to apply to seabirds will be useful for explaining patterns at the population and ecosystem levels, thereby enabling the definition of species-specific foraging behaviors, as well as the interrelationships between foragers and their prey.

Energetics of reproduction and foraging in Adelie penguins

Mark A. Chappell, University of California at Riverside (S-200)

Adelie penguins, *Pygoscelis adeliae*, are the most abundant of the antarctic penguins and are an important component of the antarctic marine ecosystem. The breeding ecology, behavior, and thermal physiology of Adelies have been extensively studied, but many aspects of their ecological and reproductive energetics are yet undescribed. In this study, investigators will measure rates of energy consumption and changes in body composition in breeding Adelies while simultaneously studying their foraging behavior. This will enable the investigators to determine reproductive effort and to calculate the trophic impact of breeding Adelies on the surrounding marine ecosystem.

GEODESY AND GEOGRAPHIC INFORMATION

Geodetic satellite observations

Arnold J. Tucker, Applied Research Laboratories, University of Texas at Austin (S-051)

At McMurdo Station, investigators will operate and maintain a geodetic satellite

observatory to collect dual-frequency, doppler data from polar-orbiting satellites. These satellites transmit similar data to Amundsen-Scott South Pole Station on specific orbits. The observatories at both sites record changes in electromagnetic frequencies relative to the positions of the observatory and the satellite. With these data, they can help determine spatial and time variations of the ionosphere and provide geodetic positioning controls. Data from the South Pole will be relayed via the South Pole satellite data link and then on to the United States via the University of Texas INMARSAT geosynchronous satellite communications system. Two members of the field team will winter over to support the year-round, continuous operation of the program.

Antarctic survey and mapping

Jerry L. Mullins and Lowell E. Starr, U.S. Geological Survey (S-052A and S-052B)

At Amundsen-Scott South Pole Station, two U.S. Geological Survey technicians will continue to operate electronic doppler equipment (to track overflights of Navy navigational satellites throughout the year), the South Pole seismometer (part of the Worldwide Standardized Seismology Network), and the ultra-low-period seismology equipment. In addition, a team will work in the Convoy Range as part of a joint U.S./New Zealand mapping program. The image and reconnaissance maps developed will present scientific information, such as geologic data, in an accurate manner for expert analysis and can be used in the design and execution of future expeditions.

GEOLOGY

Vertebrate paleontology and sedimentology of the Cynognathus zone (late Early Triassic), Beardmore Glacier region, Antarctica

William R. Hammer, Augustana College (S-054)

In a joint expedition, investigators from Augustana College and Ohio State University will undertake a vertebrate paleontologic-sedimentologic study of a recently discovered vertebrate locality. At the end of the 1985-86 field season, late Early Triassic fauna, including abundant amphibian and reptilian fossils, were found along the surface of an ancient stream channel which had been exhumed by recent erosion. Further collecting will greatly enlarge the numbers of taxa in this fauna. The abundance of fossils and the ideal exposure of the sediments in which they occur will permit the group to study the chemical and physical processes to which these organisms were subjected during fossilization, reconstruct the paleoecologic/environmental conditions for the late Early Triassic vertebrate community, and work out stratigraphic relations with other Gondwanaland continents. The search will be expanded for new fossil localities at the same and higher levels throughout the Beardmore Glacier region.

Sedimentology of the Permian-Triassic Gondwanaland sequence in the central Transantarctic Mountains

James W. Collinson, Ohio State University (S-055)

This study promises significant new insights into fluvial sedimentology, the evolution of the Transantarctic foreland basin, and the relationship of the Transantarctic basin with other Gondwanaland basins. The project objectives are to appraise fluvial channel and flood-plain depositional models; to determine internal (e.g., channel processes) and external (e.g., climate, tectonic activity, and basin subsidence) controls on sedimentation; to develop fluvial models for rapidly subsiding foreland basin; to achieve a better understanding of the Late Paleozoic/Early Mesozoic Transantarctic basin including

subsidence history, climate, and tectonic activity along the adjacent paleo-Pacific margin of Antarctica; and to reconstruct environmental settings for Permo-Triassic floras and Triassic vertebrate faunas in conjunction with field parties engaged in paleontologic studies. Investigators will employ techniques of detailed mapping and sampling of extensive three-dimensional plateau margin exposures.

Antarctic search for meteorites

William A. Cassidy, University of Pittsburgh (S-058)

Meteorites are useful for investigating possible changes through time in the meteoroid flux at Earth, measuring the cosmic-ray flux in past eras, searching events in which asteroid parent bodies were disrupted, and defining the abundances and characteristics of pre-solar system organic molecules. As part of the ongoing meteoritics study, during austral summer 1990-91 one team will recover meteorites, study the Lewis Cliff Glacier Tongue, and sample ice. The second team will search for meteorites in the Allan Hills region, northern Victoria Land for seven weeks.

Variation in solar flare signatures in antarctic snow

Gisela A.M. Dreschhoff, University of Kansas (S-059)

Analysis has shown that antarctic snow contains a chemical record of ionization from charged particles incident upon the upper atmosphere. The continent acts as a cold trap that effectively retains this signal in the stratigraphy of the ice. Using ultraviolet spectrophotometry, scientists will be able to detect short pulses of high nitrate concentration, which can be directly related to specific solar flares known from past records of geomagnetic activity and satellite data. Past studies using harmonic analysis have constructed a signature record that correlates with the 11- and 22-year cycles of solar activity. This project will focus on the solar activity record at Windless Bight and will enable investigators to expand the quantitative correlation between nitrate anomalies in the snow sequence and white-light flares.

The tectonomagnetic setting of Early to Middle Jurassic bimodal volcanism in the Transantarctic Mountains

David H. Elliot, Ohio State University (S-060)

The Beardmore Glacier region of the Transantarctic Mountains has the most complete Gondwanaland sequence in Antarctica. Deposits in this region give evidence to a major change in the tectonic environment of the Transantarctic Mountains from a foreland basin associated with an active plate margin to a continental rift related to the Gondwanaland breakup. The study objectives in this region are to establish a detailed stratigraphic framework for the volcanogenic rocks of the upper Falla and Prebble Formations; to investigate the paleovolcanology of this sequence; to characterize further the geochemistry of the volcanogenic rocks; and to attempt a preliminary assessment of possible source regions for silic magmas. Through these investigations, researchers hope to be able to assess the importance of geological processes in the area, understand the physical environment in which the rocks were formed, determine the relationship of rock-formation processes to the tectonic setting, and better define time-dependent changes.

Tectonic evolution of the antarctic sector of the Pacific margin: Mesozoic and Paleozoic development of Marie Byrd Land II

Ian W.D. Dalziel, University of Texas at Austin (S-063B)

The importance of the boundary between the east antarctic fragment of the Gondwanaland Precambrian shield and the west antarctic sector of the circum-Pacific orogenic belt has long been appreciated by geologists. Understanding the nature of the boundary and how the tectonic evolution of West Antarctica relates to that of East Antarctica, however, is a still a fundamental problem—one which is critical to studies of global plate interactions, paleocirculation in the southern oceans, paleoenvironment, and paleobiogeography, as well as to the processes that control the growth of the continents. This study is part of a tripartite United States-New Zealand-United Kingdom effort to examine the geology of Marie Byrd Land. The overall goal is not merely to complete geographic coverage of the antarctic section of the Pacific margin but also to develop an integrated picture of the tectonic development of West Antarctica within the framework of both the Gondwanaland and the Pacific Ocean basin evolution.

Petrogenesis and crustal structure of metamorphic rocks in the central Transantarctic Mountains: an integrated petrologic, structural, and geochronologic study

John W. Goodge, Southern Methodist University (S-064)

In the central Transantarctic Mountains of Antarctica, rocks more than 600 million years old (Precambrian era) comprise some of the only exposed, high-grade basement rocks in this range and represent a part of the ancient east antarctic craton. Understanding the origin of these rocks (particularly igneous rocks) and the tectonic evolution of the region is important for a better understanding of how the ancient antarctic craton evolved and how the supercontinent Gondwanaland formed. Because these rocks are near the edge of West Antarctica, scientists have a unique opportunity to study the relationship between tectonic elements, which are more than 100 million years old, and younger elements formed along a convergent antarctic plate boundary. The study objective is to investigate the regional metamorphism and deformation of Precambrian basement rocks in the Miller and Geologists Ranges of the central Transantarctic Mountains. The investigators will evaluate and describe the metamorphic evolution of the basement terrains within this region, including the evolving physical conditions, fluid compositions, and regional thermal gradients, as well as the history of tectonic movement, geometry, and styles of deformation within these rocks and the strain mechanisms that operated during metamorphosis. These data will be compared to structures within the adjacent lower-grade sedimentary sequences. Additionally, the investigators will determine the ages of metamorphism and deformation that pre-date post-tectonic granites, use mineral-age data to establish a crustal-thermal history, develop petro-tectonic models of Proterozoic mountain-forming processes for this area, and establish a tectonic and paleogeographic framework for evolution of the ancient continental margin.

Corridor aerographics of the southeast Ross transect zone (CASERTZ)

John C. Behrendt and Steven M. Hodge, U.S. Geological Survey, and Donald. Blankenship, Ohio State University (S-066, S-154, and S-166)

Developing a thorough understanding of the Cenozoic evolution of West Antarctica is the key to understanding the breakup of the Pacific margin of Gondwanaland; however, the nature and history of two lowland regions of central West Antarctica-the interior Ross embayment (between western Marie Byrd Land and the Transantarctic Mountains) and the Byrd subglacial basin (between eastern Marie Byrd Land and the Whitmore Mountains)-remain poorly understood. In conjunction with the Byrd Polar Research

Center of Ohio State University, the U.S. Geological Survey will conduct a combined airborne radar and aeromagnetic survey of these two regions to gather specific information about their nature and origin as well as the relationship between Cenozoic volcanism and the tectonic and glacial history in the regions. The grid spacing will be 5 kilometers and navigation will be by radio-positioning. In addition to constructing maps of subglacial topography and magnetic intensity, investigators will also try to reconstruct the position of subglacial diffractors in three dimensions. This reconstruction, especially when combined with the magnetic results, should give new information about the distribution of escarpments and, therefore, the tectonic relationships within the region.

Diversity and distribution of fossil floras from southern Victoria Land

Edith L. Taylor and Thomas N. Taylor, Ohio State University (S-068)

The research objectives of this project are to make detailed and systematic collections of fossil floras ranging from Devonian to Jurassic (between 405 million to 135 million years old) from the ice-free valleys of southern Victoria Land. Once the fossils collected from these areas are returned to the laboratory, the sites (logged at the time of collection) will be assessed for the quality of preservation, diversity and types of plants present, and the potential for further collecting. Throughout the fieldwork, some reconnaissance for additional fossil plant localities will also be undertaken.

Geological and geophysical studies in the Ford Range of Marie Byrd Land, West Antarctica

Bruce P. Luyendyk and David L. Kimbrough, University of California at Santa Barbara (S-070)

In Gondwanaland reconstructions, Marie Byrd Land is juxtaposed with portions of New Zealand and the Campbell Plateau. The breakup of the Pacific margin of Gondwanaland is reflected in well-documented Cretaceous and Early Tertiary extension and rifting in the region. A sequence of magnetic anomalies records the opening of the Tasman Sea and the splitting off of New Zealand about 85 million years ago. Events in Marie Byrd Land may relate to the tectonics of the Gondwanaland Pacific margin before and following this rifting. Although there are many geologic parallels between New Zealand and Marie Byrd Land, it is unclear whether these similarities indicate that the two regions were part of the same unit. From previous research in New Zealand's Western Province, scientists know that a sequence of Cretaceous metamorphic events that are related to the rifting of Gondwanaland exist. Through paleomagnetic studies, they also have identified a Permian terrane that formed during the Early Jurassic just before Gondwanaland broke up. By studying the tectonic history of the Ford Range in Marie Byrd Land, the investigators hope to determine whether or not similar events occurred in this part of Antarctica. Other geologists have described West Antarctica as a collage of microplates that appear to have been closely related to each other and Antarctica since the Jurassic, but the relationship of Marie Byrd Land to these microplates during this time is less clear. Paleomagnetic data for the region do indicate that Marie Byrd Land was at a higher latitude about 100 million years ago and that since this time it has rotated independently of East and West Antarctica. The project objective is to sample and study exposed Late Precambrian and Early Paleozoic metasediments, gneisses, and migmatites, carboniferous and Cretaceous plutonic rocks, and Cenozoic and Quaternary volcanic rocks. Data from petrologic, geochronologic, and paleomagnetic studies also will be used to reconstruct the tectonic evolution of Marie Byrd Land.

Geochemistry and petrology of the lower crust, Antarctica: evaluation over space and time

Jonathan H. Berg and Ruth I. Kalamarides, Northern Illinois University (S-071)

During previous field seasons, the research team has investigated the nature of the upper and lower crust in southern Victoria Land as recorded in alkaline magmas of the Erebus Volcanic Province over the last few million years. This austral summer, they want to expand their knowledge of the antarctic crust by sampling contemporaneous alkaline magmas of the Hallett Volcanic Province that extend about 600 kilometers to northern Victoria Land. Recently, they discovered that 450- to 500-million-year-old dikes, such as those found in southern Victoria Land, have inclusions of igneous rock from the lower crust and possibly the mantle. Consequently, the investigators have the opportunity to study two suites of samples of the earth's crust and mantle brought to the surface in the same location but separated by about 500 million years. By also extending the southern Victoria Land studies, they will be able to see how the upper mantle and lower crust have changed over the last 500 million years. Samples from northern and southern Victoria Land will help to understand better the geologic and tectonic history of the Transantarctic Mountains, as well as the tectonic history of Gondwanaland. Fundamental knowledge of the earth's upper mantle and lower-crust composition and evolution will be increased. Because less. is known about the lower crust than the portions above and below it, these data will enhance understanding of the earth's evolution and contribute information critical to completing cross-sections in the Global Transect Program and to geophysical studies of the Ross Sea.

Mesozoic and Cenozoic kinematic evolution of the Transantarctic Mountains

Terry J. Wilson, Ohio State University (S-072)

The study objective is to examine the crustal structures produced during two phases of uplift of the Transantarctic Mountains. Along the front of the mountains near the Ross Sea are structures from the more recent of these two uplift phases. Near the Beardmore Glacier, rock formations associated with older periods of magmatic intrusion and fracturing are best developed in and around the Marshall Mountains. Rock formations produced during the more recent phase of uplift are found in the Dominion Range and along the front of the mountains adjacent to the Ross Ice Shelf. This austral summer the field party will concentrate on measuring and mapping the orientation of faults, fractures, and igneous dike swarms (large groups of linear, parallel, or radially oriented igneous rocks that cut across or through other rocks) near the Beardmore Glacier. These observations and measurements will be compared to those that were made during the 1989-1990 austral summer in southern Victorian Land. As a result of last year's field studies, the investigators have already identified critical areas for establishing the regional significance of fault and fracture patterns.

Cosmic-ray exposure-age dating applied to antarctic glacial geology

Mark D. Kurz, Woods Hole Oceanographic Institution (S-077)

Dating surface rocks by exposure-age dating techniques has great potential for glacial geology. Although scientists have used extensively the accumulation of elements produced *in situ* to date meteorites, they have only recently begun to use this technique to date terrestrial rocks. Isotopes of helium in surface rocks are produced by cosmic-ray-induced, high-energy nuclear reactions that release large numbers of protons or neutrons. Recent studies of radiocarbon-dated lava flows have shown that measurements of helium produced this way can be used to determine exposure ages. The study goal is to use this technique, for the first time, to date glacial deposits in the ice-free areas of

southern Victoria Land, which provide an ideal testing site for this method because of uniquely exposed, well-dated glacial moraines. Investigators hope not only to resolve some questions about the helium exposure-age method but also to define better the history of the antarctic ice sheet and its relationship with global climate. Initially, they will focus on collecting samples and measuring quartz from sandstone boulders in dated moraines of Arena Valley. Extensive sampling by the field team will enable them not only to gain sufficient data to help elucidate the history of the ice sheet but also to understand better the distribution and retention of helium with quartz. Because quartz is common worldwide, the study results also should interest glacial geologists not working in Antarctica.

Degassing and crystallization of anorthoclase phonolite magma, Mount Erebus

Phillip R. Kyle, New Mexico Institute of Mining and Technology (S-081A)

Mount Erebus contains a persistent convecting lava lake of magma that is composed predominantly of alkali feldspar. The lake is the top of a magma chamber and functions as a window through which the processes operating within a magma chamber can be observed. Because of the magma's mineral composition, the activity and convection complement studies at other volcanoes such as Kilauea and Mount St. Helens. Observations of sulfur-dioxide emissions are providing new insights into sulfur solubility in this type of magma and how degassing occurs. Beautiful, large crystals of feldspar (or anorthoclase phenocrysts), often over 88 millimeters long, are well developed in older lavas and in the active lava lake. To date, no studies have addressed the nucleation and growth of such large crystals. The objectives of this study are to continue surveillance of the volcanic activity of Mount Erebus, to monitor the latest eruptive cycle, and to estimate the growth of the anorthoclase phenocrysts. Investigators will also address several fundamental questions regarding sulfur-dioxide degassing and the contribution of Mount Erebus to the nearly pristine antarctic atmosphere. By sampling the plume from the crater rim, they will be able to collect samples of volatile acid gases and trace metals.

West antarctic volcano exploration (WAVE)

Phillip R. Kyle, New Mexico Institute of Mining and Technology (S-081B)

Marie Byrd Land, one of the world's largest alkali volcanic provinces, contains a unique record of the Late Cenozoic glacial and volcanic history of Antarctica; however, investigations of this region have been limited to reconnaissance studies and recent studies of Mount Takahe and Mount Murphy. From this limited data set, investigators know that the earlier reconnaissance interpretations of the subglacial origins of these volcanoes are incorrect. The study objective is to examine the glacial and volcanic history of the region and the origin of the volcanoes. Working as part of a U.S., British, and New Zealand investigation, these scientists will study the geochemistry, volcanology, and tectonic history of these Marie Byrd Land volcanoes. During the 1990-91 austral summer, the team will focus on volcanoes near the Toney Mountain and Mount Hampton. Geochemical, tectonic, and glaciovolcanic investigations will be made using geochemical and isotopic analyses, argon-40/ argon-39 dating, scanning electron micrograph studies, and paleo-and rock-magnetic analysis.

Study of sediment, glacier ice, and silicate spherules, Walcott Névé, Antarctica

Gunter Faure, Ohio State University (S-089)

Subglacial bedrock ridges disrupt the flow of the east antarctic ice sheet and make the margin a very sensitive area. The resulting ice fields expose a stratigraphic section of

the ice sheet that includes very old basal ice, which ablates to form supraglacial moraines. The study objectives include mapping the surface elevation and thickness of ice entering the Walcott Névé and Law Glacier from the Beardmore Glacier area to document what effect bedrock topography has on local ice-flow patterns; identifying by oxygen-isotope composition the Pleistocene-Holocene boundary in exposed ice; studying selected fragments from supraglacial moraines to learn about the geology of the ice-drainage basin on the east antarctic craton; and studying the geochemistry, mineralogy, and isotopic composition of silicate spherules that are found abundantly in the area's glacial sediments. Investigators also will integrate geologic and glaciologic information to explain the occurrence of meteorites and silicate spherules along the east antarctic ice sheet margin and elsewhere in Antarctica.

Determining exposure ages and erosion rates of bedrock surfaces in Antarctica

Roy Middleton and Robert Giegengack, University of Pennsylvania (S-092)

Determination by accelerator mass spectrometry of concentrations of the cosmogenic radionuclides beryllium-10 and aluminum-26, produced by cosmic rays in quartz on exposed bedrock surfaces through high-energy nuclear reactions, has been demonstrated to provide valuable data on exposure times and rates of erosion for those surfaces. The oldest exposure times found using this method are those measured in bedrock samples from Antarctica. During the course of this study, investigators will measure concentrations of beryllium-10 and aluminum-26 in bedrock samples from previous expeditions, as well as from their own collections, and interpret those measurements in terms of exposure ages, erosion rates, and Quaternary glacial history.

Stratigraphy, paleontology, structural geology, and paleoglaciology of the late Neogene Sirius Group of the Dominion Range/Beardmore Glacier region of the Transantarctic Mountains

Peter N. Webb, Ohio State University (S-093)

Previous studies have convinced investigators that the Dominion Range/Beardmore Glacier area has a highly significant Late Neogene climate record of Antarctica. In this study, field and laboratory work will focus on determining pre-Sirius paleotopography and structural geology; taking measurements and recording observations; collecting macro-and microplant material; searching for fossil insect, crustacean, bivalve, and fish material; collecting additional samples from the Sirius Group with the aim of expanding the collection of Cretaceous/Paleogene/Neogene microfossils which were transported from the interior basins of East Antarctica during the Late Pliocene/Early Pleistocene; and continuing to test the hypothesis that Pliocene glaciation in this part of Antarctica involved high-frequency variations of relatively small ice sheets, the development of protracted warm periods, and major marine invasions of the antarctic interior associated with periodic higher sea levels.

Geochemistry of Paleozoic granites of the Transantarctic Mountains: phase 2

Donald J. DePaolo, University of California at Berkeley (S-094)

One of the most important advances in plate tectonics is the realization that the mantle of the Earth behaves like a fluid. It transports, by convection, the internal heat of the Earth to the surface. This convection drives both plate tectonics and magmatism. Since the mantle represents about two-thirds of earth's mass, understanding the fluid-like nature of the mantle is tantamount to understanding the evolution of the planet. This project, a systematic study of the portion of Early Paleozoic granitic rocks of the central Transantarctic Mountains that may have been formed from magma, seeks to increase the

body of knowledge about the mantle by focusing on three objectives: understanding the origin and structure of the granitic rocks; investigating the age and origin of the Precambrian basement rocks; and constructing tectonic-magmatic models of the Early Paleozoic evolution of the antarctic continental margin.

Quaternary climate record from the Antarctic Peninsula regions, Antarctica

David H. Elliot and Scott E. Ishman, Ohio State University (S-208)

Preliminary analyses of benthic foraminiferal distribution, sediment distribution, and water-column profiles from the Bellingshausen/Pacific sector of the Antarctic Peninsula have suggested that the observed patterns are influenced by oceanographic, glacial, and climatic conditions. This study will supplement these preliminary findings and will provide new information on the microhabitat and geochemical associations between the surface sediments and benthic foraminifera. Investigators will analyze modern sediment flux and distribution, water-column profiles, and benthic foraminiferal distribution. The faunal and environmental associations observed in the modern setting will then be used to formulate an interactive model which can be Used, in turn, to infer paleoceanographic and paleoclimatic conditions in downcore sediments, thus helping to reevaluate the Cenozoic marine records from samples previously collected in the antarctic margin region.

SOLID EARTH GEOPHYSICS

Paleomagnetic studies designed to test the Mesozoic paleoposition of the Antarctic Peninsula and test models of the Weddell Sea opening

Ann M. Grunow, Ohio State University and Ian W.D. Dalziel, University of Texas at Austin (S-063A)

Investigators will continue examining the geologic history of West Antarctica and the relationship of West to East Antarctica by collecting paleomagnetic samples from Mesozoic-age rocks on the Antarctic Peninsula. Resolving the position of the different West Antarctic crustal blocks is critical for understanding when and how the Weddell Sea opened and for understanding the resulting paleoclimatic, paleoceanographic, and paleobiological implications. By systematically collecting paleomagnetic samples ranging in age from the Triassic through Late Cretaceous, they hope that a more complete apparent polar wander path can be constructed for the Antarctic Peninsula. Such a polar wander path can help constrain the position of the Antarctic Peninsula with respect to East Antarctica and provide information on the time of opening of the Weddell Sea.

Dry valley seismograph project

Nicholas A. Orsini, U.S. Geological Survey, Albuquerque Seismological Laboratory (S-078)

Increasing the availability of high-quality seismic data from Antarctica is a long-term objective of many investigators. Such data, when combined with data from the Worldwide Standardized Seismological Network, would provide needed azimuthal control for locating seismic events in both the Northern and Southern Hemispheres. During several austral summers, investigators surveyed sites and installed equipment in southern Victoria Land's ice-free valleys. Eventually, data will be transmitted in real time via a geosynchronous satellite to the U.S. Geological Survey's Albuquerque Seismological Laboratory as part of a larger seismic data collection network. During the 1990-91 austral summer, investigators will perform maintenance on telemetry-radio equipment

and clean and check the operation of the Wright Valley station.

Support for the global seismic station at Amundsen-Scott South Pole Station

Rhett Butler, Incorporated Research Institutions for Seismology (IRIS) (S-090)

Amundsen-Scott South Pole Station is uniquely located for long-term global seismic studies. The station is a seismically quiet platform, which lies on the earth's rotational axis and can be used as a site to measure long-period oscillations of the Earth. Its location on the Great Circle Paths coincides with portions of the Mid-Atlantic Ridge and the East Pacific Rise and includes active seismic regions and other features of intense geophysical interest. IRIS, a non-profit consortium of 57 U.S. universities, creates and manages research facilities for seismology. Currently, IRIS is funding the University of California at Los Angeles to operate the South Pole seismic facility.

GLACIOLOGY

Polar Ice Coring Office drilling projects

John J. Kelley, University of Alaska (S-150)

Ice cores provide valuable information on past atmospheric constituents and climate. During the 1990-91 austral summer, the Polar Ice Coring Office will support U.S. and New Zealand investigators (S-159 and S-165) who will be conducting a seismic investigation along the boundary of East Antarctica and the Ross embayment and near the Beardmore Glacier.

Antarctic ice-sheet response to global Pliocene warming

George H. Denton, University of Maine (S-156)

Glacial geologic evidence, including high-elevation trimlines, striated bedrock, and basal tills, from strategic positions in the Transantarctic and Ellsworth Mountains, implies that massive overridings by a temperate ice sheet occurred more than two million years ago in the Late Tertiary. From other data, scientists infer numerous fluctuations with maximum ice volumes in East Antarctica greater than those existing during the last two million years. Evidence from the ice-free valleys of southern Victoria Land and near the Beardmore Glacier also indicate that a younger massive overriding by a polar ice sheet occurred in the later Tertiary. Glacial geologic and soil studies of lateral moraines suggest a less massive, later Quaternary (two million years ago) expansion that featured peripheral thickening and interior thinning in comparison to the present. The study objectives are to develop a glacial chronology, stratigraphy, and description of tectonic uplift through critical time intervals represented by these glaciations. To do this, investigators will acquire data for argon-40/argon-39 isotopic dating of McMurdo volcanic eruptive centers that simultaneously date overriding and monitor tectonic uplift, stratigraphy of dated volcanics and silty overriding tills through a wide range of elevations, radiocarbon dates of late Wisconsin moraines in eastern Taylor Valley, and uranium-series dates of moraines in Taylor Valley. This austral summer, investigators will continue sampling of volcanic deposits and interbedded glacial tills in Taylor Valley and in the nearby Asgard and Quartermain Ranges. The results of this research will improve antarctic glacial chronology and associated tectonic history of the Transantarctic Mountains and will allow numerical ice-sheet reconstructions that help scientists to develop atmospheric modeling experiments of the influence of these ice sheets on southern hemisphere climate.

Seismic investigation of the plate boundary between east and west antarctica

Uri ten Brink; Stanford University (S-159)

The Seismic Experiment-Ross Ice Shelf (SERIS) program will examine the plate boundary between East Antarctica and the Ross embayment. Investigators will first acquire a 150-kilometer-long multichannel seismic reflection line starting on the Ross Ice Shelf and entering the Transantarctic Mountains front through one of the outlet glaciers. A reversed-refraction profile and several wide-angle reflection profiles will be collected along this multichannel seismic line. Interpretation of the data, flexural modeling of the uplift and the subsidence, analysis of the seismic stratigraphy and modeling of the gravity will then be done. This cooperative experiment is designed to serve as a prototype for large-scale seismic experiments in the interior of Antarctica in the next decade.

Broadband seismic imaging of lithospheric structure: application to the Transantarctic Mountain front and Bentley Subglacial Trench

Daniel R.H. O'Connell, Ohio State University (S-165)

The tectonic relationship between the east antarctic Precambrian craton and the west antarctic assemblages of deformed Paleozoic sedimentary rocks, Jurassic granites, and Mesozoic and Cenozoic intrusive and extrusive rocks remains a fundamental problem of Gondwanaland geology. To explore this question, this study will focus on determining the lithospheric signature of the Bentley Subglacial Trench in West Antarctica. Investigators will deploy an array of portable, digital broadband seismographs at a Beardmore Glacier site and at a site close to the Bentley Subglacial Trench. Seismic waveform modeling of broadband body waveforms will be used to describe constraints on Transantarctic Mountain and Bentley Subglacial Trench lithospheric velocity structures. Further, the portable seismic packages used in this project will provide a long-term capability for studying lithospheric structure throughout the antarctic interior.

Oxygen-isotope climate record from McMurdo dome and its relation to the geological climate record of the McMurdo Dry Valleys

Pieter M. Grootes, University of Washington (S-167)

During this study, investigators will obtain a climate record of the Holocene and the last part of the last glaciation from the McMurdo dome, a small ice dome near the head of Taylor Valley in southern Victoria Land. Comparison of this isotope proxy climate record with a radiocarbon-dated proxy record derived from perched deltas, strandlines, and moraines in the nearby McMurdo Dry Valleys will provide data that could be crucial for interpreting both the isotopic oxygen-18 fluctuations observed in ice cores during the Holocene and the lake levels and ice positions during this time. These comparisons should reveal the response of the east and west antarctic ice sheets to the glacial-interglacial temperature increases and sea-level rise.

HUMAN BIOLOGY AND MEDICINE

The influence of prolonged polar residence on the cellular distribution of thyroid hormones

H. Lester Reed, U.S. Naval Medical Research Institute (S-030)

Thyroid hormones are important for maintaining basal metabolism; however, adaptations to the environment can alter the concentrations of these hormones. Data from earlier investigations have shown that thyroid activity changes after prolonged residence in

Antarctica. In a 1986 study, investigators found that after 42-weeks residency in Antarctica, the responsiveness of the pituitary that stimulates thyroid activity to the hypothalamic-releasing hormone (TRH) increased by 50 percent. Additionally, the rate of production of another thyroid-related hormone (triiodothyronine or T_3), the rate of metabolic clearance, and the volume of distribution increased by 150, 160, and 230 percent, respectively, when compared with a control group. How these changes occur and what physiological and psychological significance they have is yet unknown. By continuing the earlier investigation, researchers hope to begin answering these questions. They will investigate human circulating blood lymphocyte as a model for human-tissue response to alterations in thyroid hormones found after prolonged antarctic residency. From blood samples taken from 20 volunteers, the investigators will isolate circulating lymphocytes, which reflect accurately system-wide thyroid activity at the tissue level. Sampling will be done before, during, and after the volunteers have been in Antarctica for 42 weeks. To determine the concomitant cellular and sub-cellular changes that are associated with changes in peripheral T_3, the volume of distribution, the T_3-production rates, and the metabolic clearance rates, investigators will analyze these lymphocytes for alterations in the T_3 receptor number and affinity and in RNA.

OCEAN PHYSICAL SCIENCES

Antarctic bottom water formation

Theodore D. Foster, University of California at Santa Cruz (S-206)

This project will investigate the dynamics and processes of deep-water formation in the western Weddell Sea, combining physical and chemical oceanographic techniques to produce a coherent picture of the importance of this unique region to the structure of the world ocean. In the global context, this area is a major water mass modification site, involving open-ocean convection, the continental margin, and the ice cover. At this time, the various water types that combine to form Weddell deep water and Antarctic bottom water and the conditions under which these water masses form are not known well enough to establish direct physical links and volumetric budgets. Investigators expect that the outflow from the Weddell Sea is restricted to quite narrow boundary currents flowing near the base of the continental shelf and, consequently, could be observed with conventional current-meter moorings from the shelf into the deep ocean. Two oceanographic expeditions to the western Weddell Sea are planned as part of this study. The objectives will be to measure the flow of the newly-formed bottom water and to explore the sinking process of the near-surface waters in the open ocean to see how these affect the deep water flows.

Marine geology of the Antarctic Continental Margin

John B. Anderson, Rice University (S-207)

Since 1979, scientists have collected and described sediments that blanket the antarctic seafloor; with these data, they have related sedimentary facies to glacial and oceanic conditions. During the 1990-91 austral summer, investigators will gather seismic reflection data and collect piston core samples in the Bransfield basin (north of Palmer Station to King George Island) and along the continental margin (north of the South Shetland Islands). Working aboard the *Polar Duke*, they will use sedimentologic analysis of deposits and high-resolution seismic methods to map the distribution of marine ice sheets and ice shelves on the continental shelf during the last glacial maximum. By detailed study of lithofacies in areas representative of antarctic glacial-marine environments, scientists will increase their understanding of glacial-marine sedimentation.

Additionally, they will examine the deep-sea hemipelagic and turbidity record to see how glacial changes are manifested in deep-sea deposits and conduct high-resolution seismic stratigraphic studies of the continental shelf to learn more about tectonic and glacial evolution. This year's work and the results of studies conducted over the last 11 years will be combined and published as a folio series on the Antarctic Continental Margin.

Sinking and suspended particulate matter on the antarctic continental margin

Robert B. Dunbar, Rice University (S-216)

As much as 25 to 40 percent of silica in the southern oceans may be removed through sedimentation on the continental shelf. Despite high levels of oxygenation in the water column, organic carbon accumulates at high rates, often equal to those found in low-latitude basins lacking oxygen. The processes producing such widespread and rapid deposition are poorly understood. Surface-water production appears relatively low over most of the area most of the time. High production does occur within and below the sea ice, but few sea-ice diatoms are preserved on the seafloor. Large-scale productivity in the open ocean has been recorded from December through January but not studied in detail. The objective of this study is to resolve the major features of the carbon and silica cycles along the continental shelf in the western Ross Sea area. Investigators will examine the vertical flux and water column dissolution/decomposition of opal and organic matter as part of a multidisciplinary investigation with investigators from North Carolina State University (S-268). From the *Polar Sea*, time-series sediment traps, current meters, and transmissometer arrays deployed during the 1989-90 austral summer will be recovered. These arrays, which will be redeployed, enable investigators to measure and characterize both vertical and horizontal fluxes of particulate debris during a complete annual cycle of production and sedimentation. From these data and those obtained by other researchers, they will quantitatively assess surface-, mid-, and deep-water column processes that determine sedimentation rates on the antarctic continental shelf. The results of this study should improve understanding of the influence of antarctic shelf sedimentation on ocean chemistry, as well as our ability to interpret the shelf sediment record from the last glacial period during the Pleistocene epoch.

Sources and fluxes of biogenic and anthropogenic carbon compounds in antarctic marine sediments

M.I. Venkatesan, University of California at Los Angeles (S-219)

Preliminary organic geochemical data from antarctic sediment cores indicate that organic matter in Holocene sediments is well preserved. Information regarding the occurrence, source, and preservation of several lipid components, however, is lacking. In this project, investigators will undertake detailed geochemical analyses of free and bound lipids from sediments and particulates and of total lipids from the potential source materials. It is their goal to characterize the sources, estimate the fluxes, and to study the incorporation of organic compounds into seafloor sediments. These data should help scientists understand the paleoceanographic conditions and biogeochemical processes in the region by resolving sediment provenance; identify chemical tracers of global pollution by providing a baseline measurement for future monitoring studies; and evaluate the historical migratory routes and habitats of marine mammals (particularly, cetaceans and pinnipeds) in the region.

Significance of bacterial exoenzymes in organic matter cycling in the Southern Ocean

James T. Hollibaugh, University of California at San Diego (S-230)

Coupling of carbon flows from primary producers to bacteria can significantly influence

the patterns of vertical flux of organic matter in the ocean. Bacteria must breakdown particles and mix them with water before uptake; thus, excreted enzymes (bacterial exohydrolases) assume a central role in carbon flux from particulate organic matter into the microbial loop. Investigators hypothesize that during the austral winter, bacterial-exohydrolase production ceases in the high latitudes. Therefore, particles and polymers produced during the early spring bloom cannot be used by bacteria. Investigators will test this hypothesis in the waters off Palmer Peninsula, where they will sample the euphotic zone pre-bloom through the development and decline of the spring phytoplankton bloom. Field and laboratory manipulations will examine environmental cues that regulate enzyme activity. This knowledge should contribute to the understanding of biological production mechanisms and variability in the pathways of organic matter cycling in the Southern Ocean.

Preservation and accumulation of biogenic silica and organic carbon in a high-latitude environment: the Ross Sea

David J. DeMaster, North Carolina State University (S-268)

Antarctic deep-sea and continental shelf environments are the world's major repository for silica in the marine environment. Annually, about 75 percent of all silica deposited in the world's oceans by rivers and hydrothermal emanations occurs in antarctic waters; however, antarctic sediments account for less than 10 percent of the global organic-carbon budget. A significant element of the differences in these two global budgets may relate to how efficiently the water column and seabed preserve particulate material. Continuing an investigation begun during the 1989-90 austral summer, investigators will measure rates of production in surface waters, water-column regeneration, vertical flux, seabed regeneration, and accumulation to determine the preservation efficiency for silica and carbon fluxes in the Ross Sea. They will collect various types of cores from sediments in the northwest and southwest Ross Sea and will measure pore-water profiles of dissolved silica, total dissolved carbon dioxide, nitrate, nitrite, ammonia, sulfate, and phosphate to evaluate biogenic silica dissolution and organic matter degradation in the seabed. By using radiochemical chronologies and biogenic-silica and organic-carbon measurements, investigators hope to determine silica and organic-carbon accumulation rates. In addition to collecting and redeploying current meters and transmissometers installed last year, they will use towable seismic instruments to obtain profiles of the seafloor.

Depositional processes and stratigraphy of antarctic fjords and ice-shelf environments

Eugene W. Domack, Hamilton College (S-285)

This project is a study of sediment transport on the antarctic continental margin near floating glacier tongues and restrictive fjord environments. It is concerned with determining the importance of mid-water and deep-cold-water tongues in the transport processes, and whether precise links can be established between the observed glacial-climatic regime and the resulting depositional record. The depositional record will be reconstructed from a coring program and from high-resolution seismic reflection profiles. The expected thick Holocene sections, with pronounced internal changes in texture and composition, will be analyzed for their implications with respect to the responses of antarctic fjord glacier systems to Holocene climate changes. The field work will be carried out on the Antarctic Peninsula.

Physical properties and structural stratigraphic variation of frazil, platelet, and congelation sea ice, Ross Sea, Antarctica

Martin O. Jeffries, University of Alaska (S-290)

Frazil ice may play a key role in the complex Southern Ocean regime, yet the formation, growth, and behavior of frazil ice in both horizontal and vertical dimensions are the least understood components of the ocean/sea-ice system. Investigators will examine the physical and structural properties of antarctic sea ice to determine the quantities of frazil, platelet, and congelation ice in Ross Sea pack ice. With these data, investigators will determine whether frazil, platelet, and congelation ice have different levels of salinity, and whether observed salinity variations are related to ice structure and stratigraphy. Additionally, they will document grain size and structure variations in frazil and platelet ice, examine their relationships to ice salinity, and complete a detailed study of the substructure of frazil and platelet ice to determine how and where brine and other materials are included and subsequently lost from the ice. Ice cores will be tested for salinity and temperature, as well as analyzed by thick/thin section techniques for structural and stratigraphic variations. Ice crystal size and structure variations will be studied using optical and scanning electron microscope techniques.

Future Activities Planned

ATMOSPHERIC SCIENCES

Possessing the world's largest and most intense climate regime, Antarctica appears to be important in long-term climate variability. During this century, scientists have studied regional climate regimes and unique aspects of the continent's weather. From this research, they have come to understand the major seasonal features of atmospheric circulation, the radiation and energy balances, the nature of katabatic winds, and the transport of gases and aerosols. Such data have been essential for understanding the causes and dynamics of the recently recorded seasonal "ozone hole" that has been growing above Antarctica during the last decade. Continuing these investigations, scientists are studying the interaction of solar radiation with snow and ice surfaces find its effect on the energy budget that controls the continent's climate, the relationship between events and conditions in the antarctic atmosphere and global events, and the region's role in global climate change.

Since 1986, U.S. investigators have probed and monitored the changes that are occurring in the ozone layer above the antarctic stratosphere. Although they agree that chlorine, produced by anthropogenic chlorofluorocarbons, is a major cause of the depletion that occurs each spring, the role and impact of atmospheric phenomena, climate dynamics, and other atmospheric constituents remain unclear. These questions now are their focus: How do dynamic processes of the upper atmosphere influence the depletion, what physical properties of polar stratospheric clouds enhance the chemical reactions that destroy ozone, and what other aerosol compounds contribute to the process? Answers to these and other questions are critical not only for understanding antarctic (and arctic) atmospheric and climatic changes but also for determining the global effects of these changes and processes.

For upper atmosphere, solar, and astronomical research, Antarctica is a unique platform from which researchers probe the earth's near-and far-space environment, the nature of stellar and solar activity, and solar-terrestrial effects on humans and the environment. Because the antarctic continent encompasses a wide range of geomagnetic latitudes, scientists can study the plasmapause (the internal magnetospheric boundary), the magnetospheric cusp, and the auroral zone. For more than a decade, solar and stellar astronomers have used the geographic South Pole for observations because it combines continuous daylight (during the austral summer) and long periods of clear weather with high altitude, low humidity, and low effective day temperature. The success of these investigations has drawn more astronomers and astrophysicists to the South Pole. These investigators have found that from this site they can probe the mysteries of the beginning of the universe and the nature of cosmic radiation. Data from these studies and others help describe how solar energy enters the outer terrestrial environment and reaches the atmosphere, how disturbances associated with the transfer of energy propagate to and affect the planet's surface, and how matter in the universe formed into galaxies and clusters of galaxies.

BIOLOGY, HUMAN BIOLOGY AND MEDICINE

The vivid contrasts and unique characteristics of antarctic marine, freshwater, and terrestrial life have long attracted biologists to the southern continent and the surrounding oceans. Here, the oceans constitute one of the world's most productive

marine regions, while scattered, ice-free areas on the continent support biota of a limited number of species that have adapted to the extreme dry and cold. Because they have identified and quantified much of Antarctica's marine and terrestrial life, biologists are now focusing on the behavior, evolution, and adaptations of these biota and on special factors that drive and maintain these ecosystems. Biologists are studying how these environmental factors-particularly large, dynamic sea-ice zones, near-constant sea temperatures close to the continent, and arid cold and nutrient-poor terrestrial areas-have combined with the continent's isolation to generate special adaptations and interactions between species. With the discovery of the seasonal depletion of ozone above Antarctica, biologists are turning their attention to how marine and terrestrial organisms respond to increased exposure to ultraviolet (UV) radiation. Understanding how antarctic flora and fauna interact has taken on a new significance in the last decade. Without such information, scientists cannot evaluate how life on the continent and in the oceans is responding to such environmental changes as decreased ozone levels that enhance exposure to ultraviolet radiation. These investigations also help scientists to understand how humans are affecting these ecosystems and to hypothesize on the long-term effects of human habitation in this remote region. Conversely, other investigators are beginning to look at the physical and psychological effects of this environment on humans, since here they can find features-isolation and a harsh physical environment—that parallel life in outer space.

GEOLOGY AND SOLID EARTH GEOPHYSICS

Surveying, mapping, and description of most geologic features in Antarctica have enabled geologists during the last 30 years not only to understand regional geology and geophysics but also to address topics that apply to other areas of the world. Antarctic data have supported such theories as plate tectonics and the existence of the ancient supercontinent Gondwanaland and have helped to solve more fundamental problems, including mountain-forming processes and marginal-basin evolution. With most reconnaissance work completed, geologists and geophysicists focus on the role of the south polar region in global geodynamics, the evolutionary history of endemic marine and terrestrial biota, and Antarctica's role in the evolution of ocean circulation. Special considerations include investigating the tectonic relationship of West Antarctica and other areas of the world to learn more about the nature of Gondwanaland before it broke up, probing past environments through the study of fossil data, and collecting for further study the large number of meteorites that have been concentrated on the surface of the antarctic ice sheets.

GLACIOLOGY

Antarctica's ice Sheet covers 97.6 percent of the continent in thicknesses up to 4.8 kilometers. Its history-derived from ice cores, the terrestrial geologic record, and the marine sedimentary record-provides information about climate and atmospheric constituents and their variation over time. By studying the continent's glacial history, glaciologists, geologists, and others learn about the timing of northern and southern hemisphere glaciations, global ocean circulation, ocean boundary changes, and the dynamic response of ice to changes in the atmosphere. Deep ice cores taken from the east antarctic ice sheet have provided a 160,000-year record of climate change, while data from ice-free regions enable glacial geologists to create models of ice-sheet fluctuation and soil development. With data from radio-echo sounding and doppler-satellite

positioning, glaciologists and geophysicists have measured the thickness of the ice sheets, learned about the internal layering of ice sheets, and determined the velocity of ice movement. With such data as these, they can better understand the relationship of ice and climate, the stability of Antarctica's ice sheets, and the potential impact of these ice sheets on global sea levels.

OCEAN PHYSICAL SCIENCES

The Southern Ocean is important for understanding the history of the world's oceans, changing oceanic conditions, and climatic and glacial history. Physical and chemical processes occurring in the Southern Ocean have a central role in the composition and structure of the world's oceans. Because large-scale heat exchange at the surface overturns the water column and mixes trace constituents, these waters are major sources of the world's intermediate and deep water masses. The Antarctic Circumpolar Current, the world's largest ocean current, affects global ocean circulation, and the annual change in sea-ice cover-from one million to eight million square miles-influences energy transfer. Ocean scientists probe the relationship between oceanic and atmospheric circulation systems and the physical basis for biological productivity; determine the dynamics of formation and distribution of water masses, sea ice, and currents; and investigate the relationship between the Southern Ocean and climate. The complex structure of the seafloor presents fundamental problems in geology and geophysics. The detailed sediment record of changes in the antarctic ice sheet enables geologists to learn more about the continent's glacial history and about changes brought about by the breakup of Gondwanaland.

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The papers and books listed below have been selected from *Current Antarctic Literature*, nos. 201 (April 1989) through 212 (March 1990). They represent the contribution to antarctic research published by U.S. authors over the period 1 April 1989 through 31 March 1990.

Current Antarctic Literature is prepared by the Library of Congress, Cold Regions Bibliography Project. Criteria for selection are as follows:

1. Any paper whose first author is listed as being affiliated with a U.S. institution is included.
2. Any book or conference proceedings is included if published in the United States and written or edited by a U.S. scientist. In addition, individual papers in such a book are listed separately if they meet the other criteria presented here.
3. A paper by a scientist affiliated with a non-U.S. institution not in a SCAR nation is included if substantial U.S. field support or data were provided.
4. A paper by a scientist in a SCAR nation other than the United States is not listed, even if the author received substantial U.S. support.
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