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COVER: A large snowblower clears drifts from a floating road on the McMurdo Sound ice near McMurdo Station.

Photo by U.S. Navy

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With the 19th SAE at Vostok Station, 1973-1975

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Each year one American scientist is traditionally invited to winter at one of the Soviet Union's antarctic stations, and a Soviet, in turn, is invited to winter at a U.S. station. U.S. participants in recent years have described their experiences in MacNamara (1969), Maish (1970), Vane (1973), and Grew (1975). The precedent for scientist exchange between the United States and the Soviet Union was set during the 1957-1958 International Geophysical Year (IGY) and is very much in the spirit of Article III of the Antarctic Treaty.

I became interested in the scientist exchange in 1964 when I wintered with Soviet exchange scientist Veniamin S. Ignatov at the United States' Byrd Station. Coincidentally, Dr. Ignatov returned to Antarctica last year as chief of all Soviet antarctic stations during the 19th Soviet Antarctic Expedition (SAE), on which I was to become the American exchange scientist. I became interested in high-latitude geophysical and geomagnetic phenomena during the 1964 austral winter at Byrd and, as station science leader, during the 1966 winter at Plateau Station. I therefore felt very fortunate to be selected as an exchange scientist by the National Science Foundation and by the National Oceanic and Atmospheric Administration, and to be invited by the Soviet Arctic and Antarctic Institute to spend the 1974 winter at Vostok Station (78°28′S. 106°52′E.), high on the plateau of East Antarctica. I thus became the 17th American to winter with the Soviets in Antarctica.

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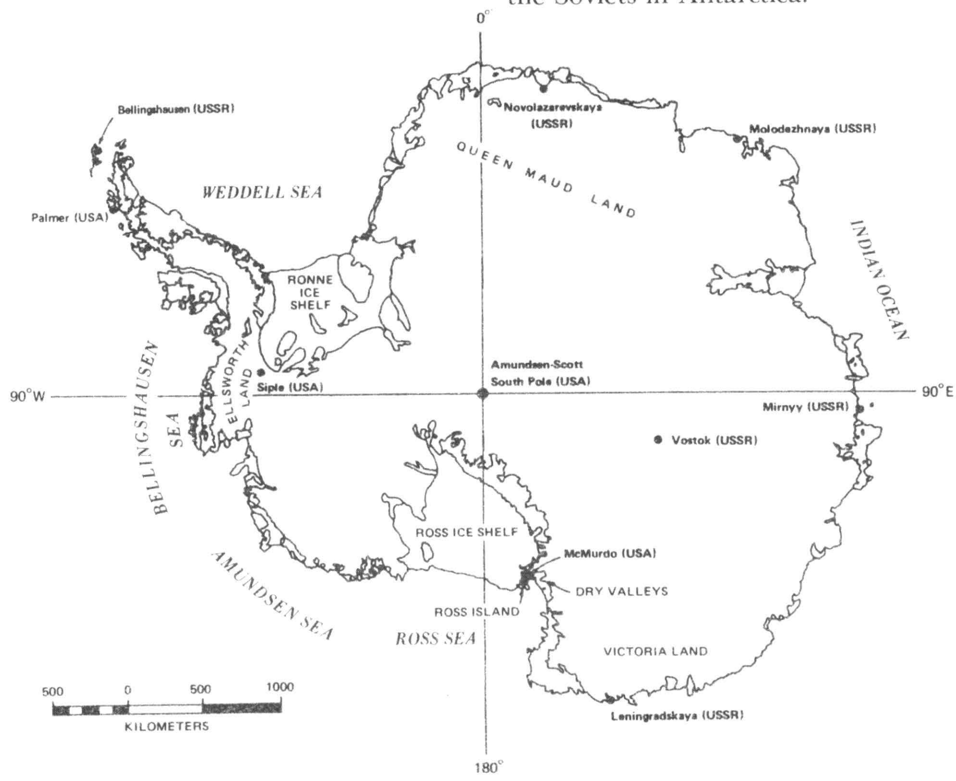
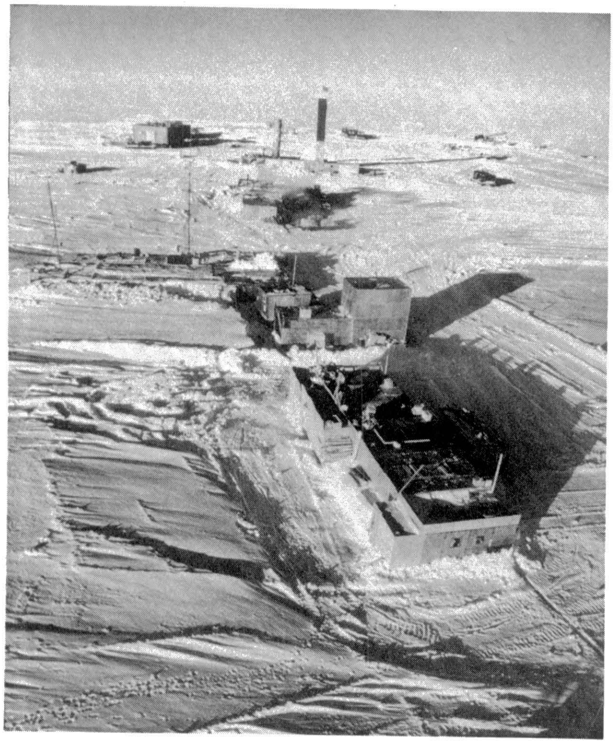


Figure 1. U.S. and U.S.S.R. antarctic stations.



Photos by author

Figure 2. Vostok Station, showing (from the foreground) the hospital, the inflation shelter, the old main building, the generator building, the drilling complex, and the new buildings.

The Soviet Union has pursued an active research program in Antarctica since 1956. In addition to Vostok, six stations are maintained today year-round: Molodezhnaya (67°41'S. 45°51'E.), the largest station and headquarters of Soviet efforts on the continent; Mirnyy (66°33'S. 93°01'E.), the previous chief station and still the coastal terminus of overland and air supply routes to Vostok; Novolazarevskaya (70°46'S. 11°50'E.); Leningradskaya (69°30'S. 159°23'E.); Bellingshausen (62° 12'S. 58°56'W.), on the Antarctic Peninsula. Of these, Vostok is the only inland station, the only one at high altitude, and the only one supported long distance from the coast by tractor train and airplane. Vostok, which translates to "east" in English, is named after one of two ships of Thaddeus von Bellingshausen, the great 19th century Russian explorer who, in 1820, was among the first to sight Antarctica. Vostok Station was established at the south geomagnetic pole by tractor train in December 1957, as part of the Soviet IGY program. Except for 1 year, it has been occupied year-round ever since. In recent years the station's programs, physical structures, and power generating capacity have been greatly expanded. The altitude of the station, 3,488 meters above sea level, makes it the highest presently occupied station in Antarctica. It also is the coldest inhabited spot on earth.

On 14 December 1973 I was flown aboard a U.S. Navy Antarctic Development Squadron Six ski-equipped LC-130 airplane from McMurdo Station to Vostok, a flight of about 3 hours. U.S. airplanes have visited Vostok every year since 1964, and the visit of Americans is eagerly awaited by the *Vostochniki* (men of Vostok). As before, we Americans were superbly received with excellent Russian food and drink, accompanied by toasts expressing fellowship and friendship, sentiments which seem especially appropriate in the middle of the world's only international continent. During the 2 hours that the plane was on the ground, gravity measurements were made for Charles Bentley, Geophysical and Polar Research Center, University of Wisconsin, Madison. As the U.S. airplane disappeared over the horizon, I received a large Russian bear hug with the words, "Now you are one of us!," and thus found myself a full-fledged member of the 19th SAE.

By previous arrangement, four men who had wintered at Vostok in 1973 returned to McMurdo on this flight for a week tour of U.S. stations. They were headed by Peter Astakhov, the wintering leader at Vostok, who wintered in 1967 as an exchange scientist at Amundsen-Scott South Pole Station. Included in the group were Volodya Ponomarev, a station physician, Alex Kalesnikov, an aerologist, and Vitali Kovalenko, chief of the deep-drilling crew at Vostok in 1973. Meanwhile, I became acclimated to the high altitude following a week of intermittent headaches and an occasional awakening from sleep gasping for breath. (By contrast, my acclimation at Plateau Station had been much easier, perhaps due to a short period spent at South Pole Station on the way.)

Four Americans had wintered at Vostok before: John Jacobs in 1964, John Taylor in 1966, F. Michael Maish in 1969, and Dale L. Vance in 1971. U.S. experiments have been operating continuously at Vostok since 1964; Soviet operators have maintained the equipment when an American has not been present. The U.S. experiments are housed in two small buildings, a Jamesway and a small rectilinear hut. In addition to seven instrument racks of equipment for U.S. experiments, the huts contain two bunks, a small electronics workshop, a small library of English-language books, and a crude but workable running water system. Presently the huts are electrically heated. Snow is partly cleared away from the buildings every year, but leaving them mostly buried improves their insulation from the cold. These huts were my home for 13 months.

Besides the American Pavillion, there were five main buildings at Vostok when I arrived. The camp is arranged perpendicular to the aircraft runway, which of course is alined with the prevailing wind. Nearest the runway is the American Pavillion. Next to it is the station leader's quarters and the hospital. Beyond is the inflation shelter and tracking equipment for aerological balloons. Then comes the old main building, a sprawling complex built around the original 1958 station. Housed in this building are the meteorology, aerology, and magnetics rooms, a darkroom, a bathroom, the old kitchen, a cold food storage area, and the old dining room. Beyond this is the generator building. Finally there is the drilling site with its two tall, enclosed towers over the two deep holes. The new buildings of Vostok, of which two were built in 1974, are planned to extend farther along the same axis. Several small buildings house scientific experiments.

The season's first Soviet airplane arrived from Mirnyy on Christmas with all of the fanfare and excitement that greets the opening of any isolated station after a long winter. The second U.S. airplane arrived on 2 January 1974, returning the four Soviets and bringing a few forgotten miscellaneous supplies for the winter. On this flight Patricia Nicely of the National Science Foundation and U.S. Navy Lieutenant Ann Coyer became the first non-Soviet women to visit Vostok.

January temperatures were mild and pleasant. A record high for Vostok of −13.3°C was set on 6 January. On almost every day during which the weather at Mirnyy was good, two Soviet AN-14s (about the size and carrying capacity of a DC-3) would make a roundtrip from Mirnyy to Vostok, bringing food, equipment, and personnel of the 19th SAE who would replace the 18th for the coming winter. A construction crew erected the foundation and panels of the walls and ceilings for two new buildings; they would do the interior work during the winter. On 5 February the season's final U.S. visit to Vostok was made. By the time of the season's last Soviet airplane on 18 February, the temperature was already dropping rapidly and daytime temperatures were in the vicinity of −50°C.

The winterover complement of Vostok in 1974, excluding myself, consisted of 25 men: a fulltime leader, two doctors, a cook, a radio operator, a three-man generator and mechanical crew, two men for a balloon sounding program, a meteorologist, an aurora and magnetics specialist, an ionosonde operator, two satellite trackers, a two-man drilling crew, a geophysicist attached to the drilling program, and a seven-man construction crew with an assortment of skills. As a group, the *Vostochniki* were hard working, harmonious, and jolly. Vostok has a reputation among the Soviets of being particularly difficult duty, and there is a certain *esprit de corps* among those selected for this most isolated outpost. The high morale was also due, I believe, to the excellent leadership of Oleg N. Struin, a veteran of two previous winters in Antarctica and several in the Arctic; he is one of those rare individuals who can sense and defuse morale problems before they arise. My own good relationship and endless hours of discussion with him are among my best memories of the year.

My science program continued the four experiments that have been running at Vostok for several years. Two separate systems for measuring magnetic field variations in the ULF (ultra low frequency=less than 3 hertz) frequency band were run. Riometers at 30 and 50 megahertz were used to detect changes in ionospheric absorption at those frequencies. A broadband VLF (very low frequency) receiver was used to sample the VLF spectrum for 2 minutes each hour. On several occasions the transmitter at Siple was clearly audible on this system. In addition to the traditional programs, a field mill for measuring vertical electric fields was operated for most of the year, and some measurements were made of solar radiation. Duplicate copies of all data were made at the station so that both countries had it directly.

Soviet science programs included daily balloon soundings, six hourly meteorological observations, and continuing routine magnetic, ionosonde, and auroral observations. Two people operated a photographic system for geodetic satellite positioning. This job was particularly arduous because it required them to stand outdoors for long periods of time during the polar night. The deep-drilling program was operated on a more modest scale than in previous years because the crew had been reduced to make room for the construction crew. Periodic measurements were made in the inactive

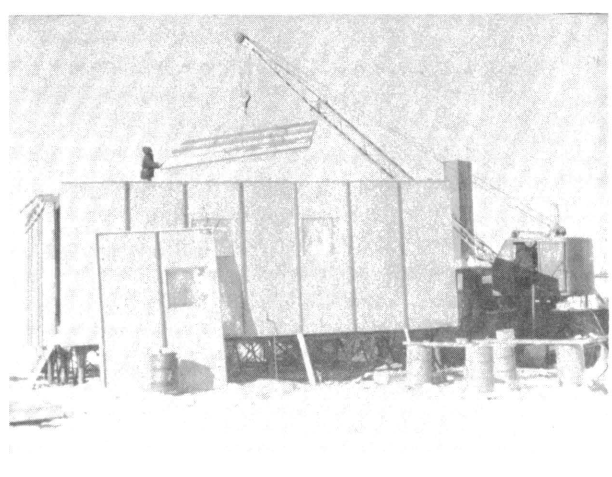


Figure 3. Construction of new buildings.

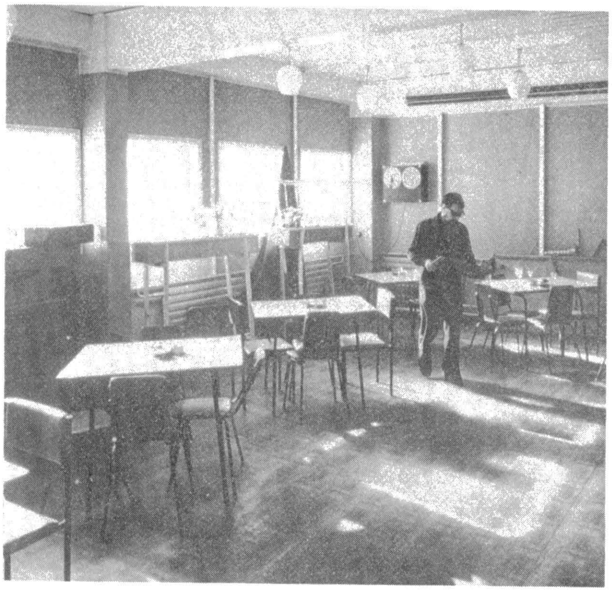


Figure 4. Interior of new dining room.

900-meter hole. The other hole was actively drilled to over 100 meters using a thermal drill. The two doctors gave everyone physical exams once a month, and from selected groups took blood and saliva samples and electrocardiogram readings at intervals. Two operations were performed during the year: an appendectomy was performed on the radio operator, and stitches were required on two fingers that a carpenter had nipped with a circular saw.

Daily routine began with breakfast at 8:00 a.m. It was non-compulsory and the number of breakfasters dropped off as the year went on. Breakfast consisted of tea with cereal, noodles, coldcuts and cheese, or a tasty salt fish. Fresh eggs were served once a week until they ran out in June. The morning work period was from 9:00 a.m. until about 12:30 p.m. The noon meal was the major meal of the day and always started with an excellent soup, followed by a meat, a starch, canned vegetables, and for dessert what the Russians called compote, fruit in a thin syrup prepared locally. After a short rest period or games, the afternoon work ran until 5:30 or 6:00 p.m. During most of the winter I spent the hour before supper at 7:00 p.m. studying the Russian language with the leader. Supper was much the same as midday dinner, except that soup was not served and that tea with bread and jam or honey replaced dessert. Occasionally supper would be all the thick tasty pancakes that one could eat. Until the fresh vegetables ran out in June, after supper a potato- and onion-peeling detail would go to work on the food for the next day. A movie from the large selection at the station was shown

Figure 5. A birthday party.

almost every night. While most of the movies were Soviet, there were several from other Eastern countries and even a few English, French, and U.S. ones with dubbed-in Russian dialogue. In midwinter a well attended class on driving rules for would-be drivers was substituted for the movie once a week.

Each day one person was "on duty." He was responsible for washing the dishes after every meal, for keeping the snowmelter full, and for sweeping

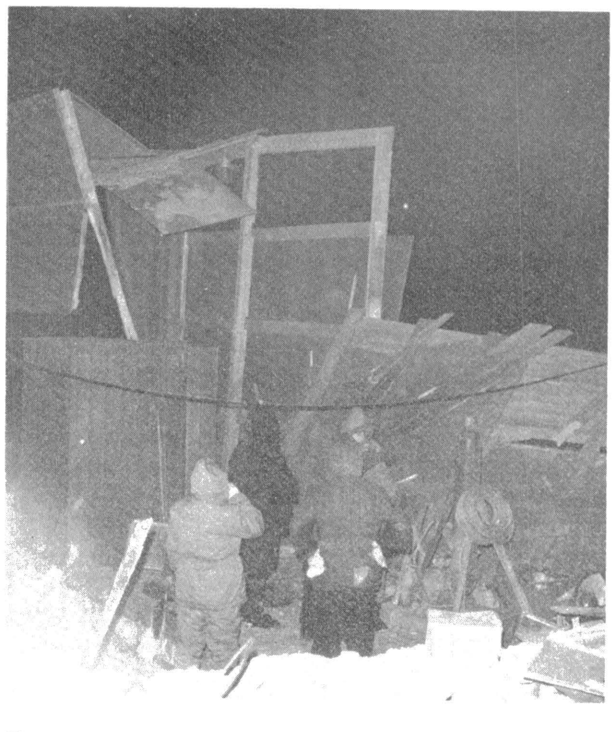


Figure 6. The inflation shelter following the 4 July explosion.

out the common areas after evening meals. By way of compensation, he could wash his clothes in the washing machine, take a sponge bath, and select the movie to be shown. If his choice was a popular one, he might find himself with much help after the evening meal in order to speed the cleanup process so that the movie could begin sooner. Snow was dropped into a melter through a hatch in the roof of the main building. Before the night began, each man was asked to cut 650 snow blocks in the clean snow area upwind of the station. The blocks then were dragged on a tractor sledge into

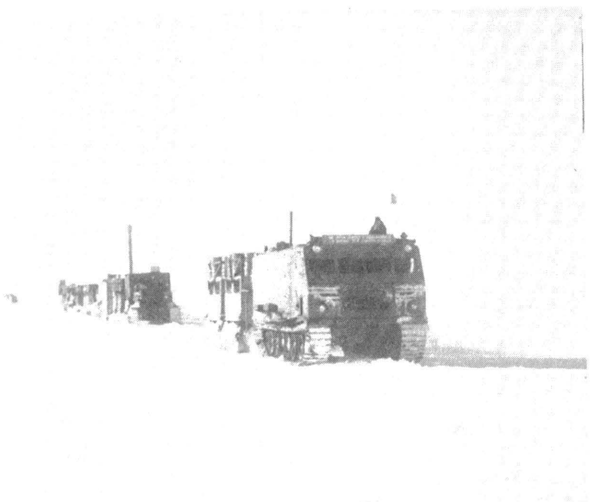


Figure 7. Arrival of the tractor train from Mirnyy.

the station and stacked on the roof for use during the winter. The supply lasted until the tractors could again be driven in the spring.

Normal weekend holidays were not observed, but at least two holidays were declared each month. One would be a combined birthday party for all who had birthdays during the month. On these occasions the evening meal was a banquet following a normal workday. Vodka and wine were served only on these occasions and were always accompanied by a wide variety of delicious *zakuska (hors-d'oeuvres)* and a special entree. Drinking was entirely in the form of toasts, always beginning with a toast by the leader. The third toast was always to our loved ones at home, and, by local tradition, the fourth became the sincere but ungrammatical reflections upon the day by the American. The following day became a holiday from normal work except for the routine observation and communication schedules.

The last sun for about 4 months appeared briefly on 23 April. Although the sun did not reappear until late August, the twilight around noon was

Figure 8. Two AN-14s on the Vostok runway.

sufficient for some outdoor work for at least another month. During full moons it was also easy to navigate outside. Because of the relatively low wind and clear skies at Vostok, it is not so uncomfortable or dangerous to walk about outdoors as one might imagine. Several of us walked the length of the runway every few days for exercise, although the average temperatures were below −65°C (−85°F) during the 8 months from March through October. But the maximum wind for the year was only 17 meters per second and the average windspeed for the year was only 5.4 meters per second. Especially during periods of extreme cold, it was frequently dead calm. Atmospheric pressure is lower than one would expect at that altitude due to a constant low pressure system over the continent. Although the altitude of the station is 3,488 meters, the average pressure altitude was 3,879 meters (626.2 millibars) and the maximum pressure altitude (minimum pressure) was 4,171 meters (602.8 millibars).

July 4 was a memorable day not only for the celebration that my hosts gave for U.S. Independence Day, but also for the year's closest brush with tragedy. We had just begun the party under a touching banner that proclaimed the congratulations of the other *Vostochniki* to me on our national holiday when an explosion shook the camp. "It's the inflation shelter!," shouted Oleg Struin, "Where are the aerologists?" In a few seemingly endless seconds everyone was accounted for, but a dash outside revealed that indeed the inflation shelter had been wrecked due to the rupture of one of the high-pressure hydrogen-generating cylinders. Apparently a safety valve had been blocked in a previous year. The power cable to the hospital and to the American Pavillion had been cut, but power was restored within an hour by the fast-working construction crew. Incredibly, over the next four days the shelter was completely rebuilt using just handtools in −75°C temperatures and in total darkness.

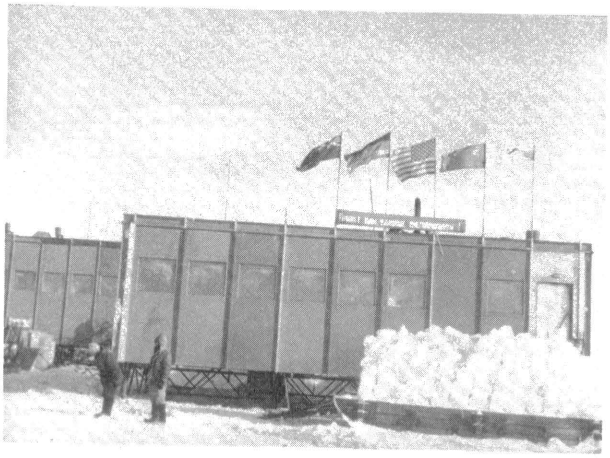


Figure 9. Exterior of the new station, showing snow blocks for water.

Figure 10. Author at Vostok Station.

The move into the new main building was made on 21 October, although the building had been officially accepted in a ceremony on 28 July. The new building included a kitchen, a dining area, a lounge, a food storage area, and the station's first flush toilet. High ceilings and double glass windows give the building a bright, airy feeling. It is noteworthy that the first winter at this replacement for the original facilities at Vostok coincided with the first year at the United States' new Amundsen-Scott South Pole Station, which also replaced buildings from the IGY era. The new buildings are constructed from prefabricated panels and are supported on a framework over the snow. They are the same as new buildings at the other Soviet antarctic stations.

The tractor train that had started from Mirnyy on 23 October arrived at Vostok 30 November. It consisted of 12 tractors pulling 16 sleds and was manned by 16 men. The newcomers, the first physical contact with the outside world since the previous February, were greeted with hugs, pistol flares, and the traditional Russian welcome of bread and salt. The load was 350 tons, including 220 tons of fuel. The ratio of weight delivered to weight of fuel consumed on a roundtrip is about one-to-one. After a week of recovery and unloading, the tractor train headed back to Mirnyy empty, making the return trip in just over 2 weeks.

The first American plane of the season arrived on 22 December, bringing resupply for the programs, New Years presents for the friends with whom I had wintered, and the first face-to-face contact with Americans in 10 and one-half months. The season's first Russian airplane did not arrive until New Year's Eve because ice conditions had delayed the arrival of the ships bringing the pilots to the coastal stations. The Vostok resupply began in earnest on 13 January, when the ships were able to reach Mirnyy. At that time Vadim Aleynikov, who would operate the U.S. projects during the following winter at Vostok, arrived. On 22 January the U.S. airplane that would take me back to McMurdo Station landed at Vostok. With characteristic Russian emotion, there were tears in the eyes of Oleg Struin as we drank a final toast to our excellent year together. It had been the experience of a lifetime.

I express my appreciation to my Soviet hosts for making the year most pleasant and fruitful, and to the National Science Foundation for supporting the international exchange and projects at Vostok (grant OPP 74-01912 to National Oceanic and Atmospheric Administration). The tradition of exchange not only provides an opportunity for a few scientists of each country to get to know their counterparts in the other country, but it is used to expand the geographical base of each country's antarctic programs toward a common goal of expanding scientific knowledge.

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U.S. Antarctic Research Program, 1974-1975

This section contains the balance of reports on U.S. programs in Antarctica and on related Stateside data analyses and support during 1974-1975. Earlier installments of such reports were in the July/August and September/October 1975 issues.

Physiological and metabolic studies of antarctic fauna, austral 1974 winter at McMurdo Station

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Physiological and biochemical adaptations of endemic antarctic marine fauna to continuous subzero temperatures are multiple and can be determined at the organismic and tissue levels. Diverse studies were undertaken from January to September 1974, and each is identified briefly here. A full account will be published elsewhere.

Holes were cut in the sea ice of McMurdo Sound (figure 1) by U.S. Navy personnel who kept them open throughout the austral winter. Ice thickness ranged from approximately 0.6 to 1.6 meters and, when formed after the austral summer breakout, permitted vehicle travel and movement of small heated houses for working through the ice. The water column ranged from 76 to 750 meters, from which 87 bottom-trap and vertical plankton-net samples were collected. Dredge and plankton samples were taken from a raft used for animal collections during the brief period of open water between 24 February and 28 March.

In anticipation of the opportunity to study seasonal characteristics of a single species, collections of the amphipod *Orchomene plebs* (identification of this species was confirmed by J. Hurley, N.Z. Oceanographic Institute) were made in the months of January, February, April, May, and July from shallow (<100 meters) and deep (>500 meters) populations. Several hundred animals were enumerated in each collection according to age, sex, stage of development, and length. The deep population showed a decline in the largest animals between January and July, with a small recruitment of juveniles (7 to 12 millimeters) from February onward, and a significant increase in females by July.

In contrast, shallow regions showed a generally younger population in early winter (April), but these animals reached essentially the same size distribution as the deep population by June/July. Females dominated the deep populations while males dominated the shallow; juveniles appeared earlier and persisted longer in the shallow populations, suggesting major species recruitment in inshore regions followed by movement to deeper waters through the winter. This results in a predominant adult population in deeper water during the summer. This study was done by Dr. Rakusa-Suszczewski.

To gain some insight into growth rates of this ubiquitous, predacious, and necrophagous amphipod, food consumption and assimilation were investigated by study of the intensity and time course of radio-activity levels in *O. plebs* that were fed pre-radio-labeled (carbon-14-leucine) fish muscle. The average food consumption of these animals (mean dry weight, 40 milligrams) was 6 milligrams of fish muscle in 24 hours; 96 percent of this food volume could be accounted for in the amphipods after an additional 48 hours of no feeding. Animals permitted to remain with labeled food for 52 hours consumed only about 24 percent more than those fed for 24 hours.

Digestion and assimilation of food appears to be very slow, as evidenced by only a 4-percent loss

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*Dr. McWhinnie was station science leader at McMurdo during the 1974 austral winter.

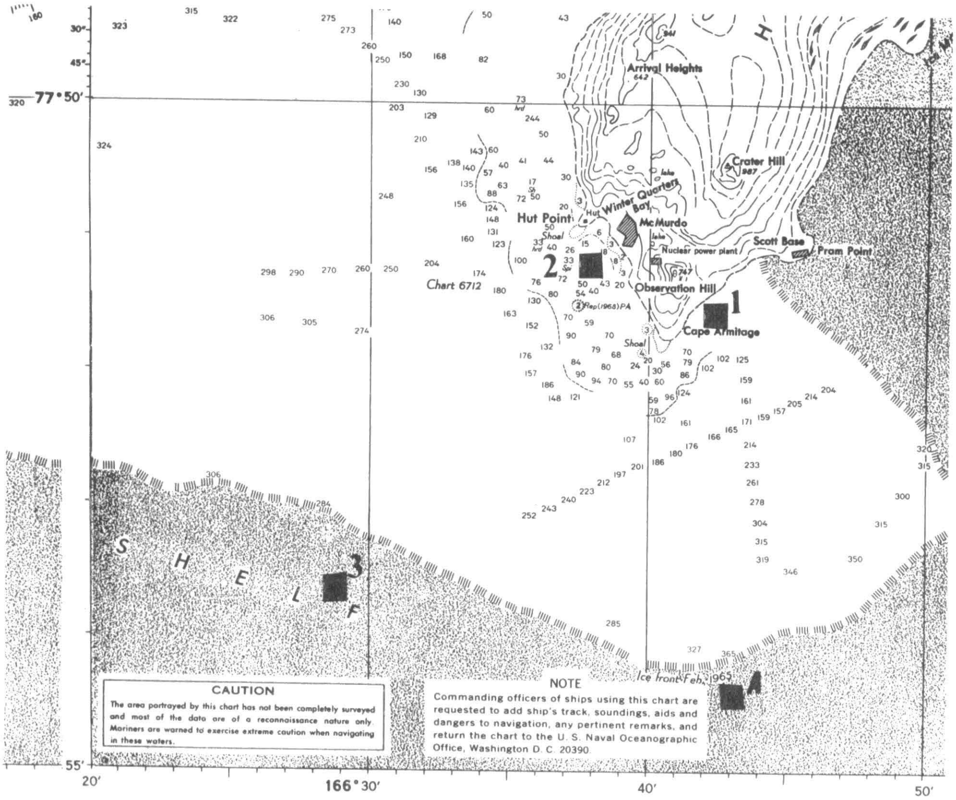

Figure 1. Locations of sampling holes cut through McMurdo Sound sea ice. The location and depth of the water column at each station was: 1, 100 meters (77°51'31.3"S. 166°42'3.2"E.); 2, 76 meters (77°51'19"S. 166°38'30.6"E.); 3, 560 meters (77°53'5"S. 166°33'34.7"E.); A, 750 meters. Ice holes A and 3 appear to have been through the permanent Ross Ice Shelf. That position, however, marked its northern extent in 1965. The ice barrier receded with the calving of icebergs since that time, and these sampling sites were through sea ice.

in radioactivity during 48 hours after feeding. This loss was accounted for by radioactivity of urine and feces in the environmental seawater. It appears that rates of food movement through the digestive tract depend upon more food becoming available for continued propulsion of digestate along the tract. Since food appears to move in a plunger-like action, intermittent feeding would result in a higher efficiency of digestion and absorption due to the longer residence time of food. It was, however, observed that 10 days of winter starvation (in July) significantly reduced the dry/wet weight ratios to about 50 percent of that in a fed population.

Table 1. Freezing point depression of body fluids of invertebrate animals collected from McMurdo Sound during the 1974 austral winter.

Species	Habitat (taxon)	Freezing point, ±s.d. Δfp, °C, body fluid
		Seawater N=(20) 1.93 ±0.17
Orchomene plebs	Primarily benthic, also pelagic (Amphipoda)	(16) 2.04 ±0.11
Rhincalanus gigas	Pelagic (Copepoda)	(2) 2.05
Euphausia crystallorophias	Pelagic (Euphausiacea)	(1) 2.13
Glyptonotus antarcticus	Benthic (Isopoda)	(10) 1.97 ±0.09
Colossendeis sp.	Benthic (Pycnogonida)	(1) 2.15
Odontaster validus	Benthic (Asteroidea)	(10) 1.98 ±0.15

Soluble nutrient absorption was investigated with several substrates and with several species. While uptake and assimilation occurred in most invertebrates, the levels are in picomoles. The nutrient contribution during periods of decreased food availability remains undefined.

Respiration studies of several species were conducted with a Gilson differential respirometer throughout the summer and winter. This measure of antarctic amphipod metabolic rates showed characteristics common to age, sex, and season known for a number of species. On a unit weight basis, juveniles, adult males, and females showed a decrease in oxygen consumption from early winter (April/May) to midwinter (July). Midwinter values for each category were essentially the same as midsummer. All age classes, excluding mature females, showed a peak in respiratory activity in early winter, and juveniles showed the highest rate of all groups. All age classes increased oxygen uptake at elevated temperatures of acclimation (1° to 4°C). Females, immature or mature, showed no respiratory acclimation at 7°C, though mixed populations survived for several days in laboratory conditions at 9°C. Acclimation to 7°C was characterized by increased oxygen consumption by juveniles and males but did not alter the water or lipid content of this species (based on dry weight).

To account for freezing resistance of animals living in seawater, which remains near its freezing point throughout the annual cycle, tolerance to excessive supercooling was evaluated for nine invertebrate species ranging from nemerteans to echinoderms. Seawater temperature was slowly reduced to between −3.9° and −7.8°C and animals were held at subfreezing temperatures for 2 to 10 hours. All invertebrates showed a high tolerance and no mortality during exposure to these temperatures. The fish *Trematomus bernacchi,* however, was more sensitive and at −4°C showed respiratory distress; some 50 percent died before ice solidification. Ice platelets formed variously but primarily on the respiratory organs of both vertebrates and invertebrates (figure 2).

The freezing points of several species' body fluids were studied with a cryoscope designed, constructed, and generously made available to us by A. L. DeVries, Scripps Institution of Oceanography. All invertebrates showed hyperosmoregulation (table 1) in normal seawater (freezing point, −1.93°C). However, higher blood concentrations often characterize pelagic species, though none exceeded a concentration of 37 milliosmoles above seawater.

Freezing resistance of a wide spectrum of antarctic invertebrates thus results from maintenance of slight hypertonicity to their medium coupled with a high tolerance to supercooling.

From limited data, a high lipid content has previously been ascribed to antarctic species in general. Similarly, some measurements have shown a low respiratory quotient (the ratio of carbon dioxide produced to oxygen consumed). Through extensive respirometric measurements, we have extended and confirmed these observations; some data are given in table 2. Levels of total lipid, among a variety of species, ranged from 32 to 50 percent of the dry weight of nonmuscle tissues; muscle of *T. bernacchi* showed the lowest lipid content measured (17 percent). Moreover, the respiratory quotients are among the lowest known (0.64 and less); very few individuals reached 0.7 or above. These values showed no variation with season.

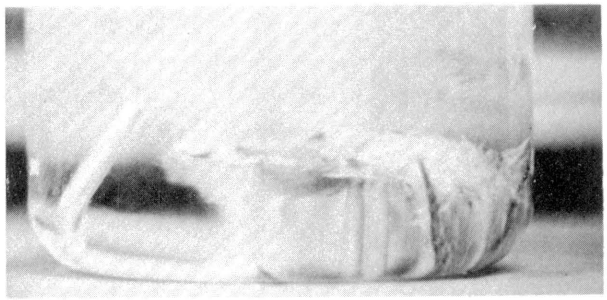

Figure 2. Ice platelets formed on the gills of the benthic isopod *Glyptonotus antarcticus* during supercooling at −6.5°C. Animal appears undamaged by such exposure.

The generalized occurrence of high lipid levels and low respiratory quotients for each of the species studied suggests a metabolic pattern that supports high lipid synthesis and reduced aerobic oxidations. Moreover, lipid reserves represent the

Table 2. Lipid content and respiratory quotient (CO_2/O_2) of selected antarctic species.

Species	Lipid (percent of dry weight)	CO_2/O_2
Urcinopsis antarcticus	N = (40) 44.93	
Linneus corrugatus	(32) 34.82	
Rhincalanus gigas		(10) 0.44
Orchomene plebs	(60) 38.80	(35) 0.64
Glyptonotus antarcticus		
hepatopancreas	(22) 50.84	(6) 0.38
muscle	(22) 39.24	(7) 0.48
Trematomus bernacchi		
liver	(31) 53.66	(27) 0.34
muscle (white)	(17) 17.24	(31) 0.64
gill	(7) 43.00	(15) 0.37

Table 3. Distribution of carbon-14-labeled glucose (C-1, C-6) in tissue fractions of antarctic fauna and carbon dioxide, including the anemone *Urcinopsis antarcticus,* amphipod *Orchomene plebs,* isopod *Glyptonotus antarcticus,* the asteroid *Odontaster validus,* and the nototheniid fish *Trematomus bernacchi.*

	Percent of total incorporated					
	CO_2		*Total lipid*		*Lipid-free, dry*	
	G-1	G-6	G-1	G-6	G-1	G-6
Mean, N = 60	0.069	0.050	58.56	63.17	41.40	36.78
Range	0.01 to 0.18	0.01 to 0.18	37.99 to 85.24	43.50 to 87.48	14.74 to 61.85	13.12 to 56.52

Table 4. Reduction of nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP) with glucose-6-phosphate as substrate.

Species, tissue	Micromoles of nucleotide reduced/milligram protein/10 minutes NAD/NADH	NADP/NADPH	Percent oxidized, via NADP
Rhincalanus gigas	N = (9) 1.91	(10) 13.96	87.93
Orchomene plebs	(3) 0.74	(4) 2.65	78.23
Euphausia superba	(5) 1.61	(11) 26.03	94.18
Glyptonotus antarcticus			
hepatopancreas	(15) 2.53	(12) 13.14	83.83
muscle	(15) 4.44	(14) 4.63	51.06
Odontaster validus	(9) 0.23	(17) 28.62	99.20
Trematomus bernacchi			
liver	(11) 4.30	(17) 54.46	92.68
muscle (white)	(9) 3.36	(13) 5.77	63.18
gill	(7) 4.05	(16) 102.96	96.21

metabolic energy available to antarctic marine poikilotherms.

To estimate the extent of substrate utilization through conventional biochemical routes (hexose monophosphate shunt, HMS), glycolysis, and tricarboxylic acid cycle (TCA), various tissues are incubated at −1.8°C in seawater labeled with carbon-14 substrates including glucose (carbon 1 or 6 being labeled). Radioactivity was traced into respired carbon dioxide, total lipid, and the lipid-free dry residue. Since all species studied showed the same pattern of carbon-14 distribution when glucose was substrate, they have been grouped for convenience (these mean values are given in table 3). It is evident that glucose undergoes very little carbon dioxide oxidation (<1 percent) in these diverse species, and that the greatest occurrence of the glucose-carbons appeared in the total lipid (38 to 88 percent). The distribution of radioactivity into these fractions was essentially the same whether the first or sixth carbon of glucose was labeled.

When coupled with the high lipid content of these animals, low carbon dioxide production provides inferential evidence for a dominant role of cellular oxidations through the HMS, and limited oxidation through the aerobic TCA cycle. Carbon dioxide (produced in the first step of HMS) appears to be utilized in lipid synthesis and may be used also in phosphoenolpyruvate carboxylation.

To obtain direct evidence for participation of HMS oxidations, reduction of nucleotides (nicotinamide adenine dinucleotide, NAD) and nicotinamide adenine dinucleotide phosphate (NADP) by tissue and organism homogenates (supernatant liquid) was studied spectrophotometrically. The nucleotide NAD is required for oxidations in the glycolytic route; NADP is required for oxidations through HMS. Some data obtained for various species studied are briefly summarized in table 4. With the exception of muscle from fish and the crustacean *G. antarcticus*, the data show that oxidation through the direct oxidative route (HMS) accounts for 78 percent or more of the glucose utilization by these antarctic species. This had been previously suggested for *Euphausia superba* (McWhinnie, 1964) based on a limited number of measurements. Other studies of selected temperate species, which had been acclimated to low temperatures, have also led to the suggestion that oxidation of glucose shifts to the direct oxidative pathway (Ekberg, 1958, 1962; Somero *et al.*, 1968), but definitive evidence has not been presented.

These investigations show that the HMS is the principal biochemical route of substrate oxidation in antarctic piokilotherms. Study of oxidation with a series of other metabolic intermediates (fructose diphosate, phosphoglyceraldehyde, pyruvate, lactate, acetate, citrate, etc.) with these species supports this conclusion.

Summarily, the high lipid content of polar species and their low production of carbon dioxide are the consequence of the biochemical characteristics of low temperature adaptation; namely, high utilization of the hexose monophosphate oxidative pathway to support synthesis of lipids that then constitute a reservoir for sustained metabolic energy production.

In vitro study of the incorporation of carbon-14-leucine into tissue protein showed exceedingly low values, which is in keeping with slow growth rates reported for antarctic fauna.

We express our gratitude to Stephen Grabacki and Dennis Schenborn, who served as field and laboratory assistants during these studies. We are also grateful to Detachment Alpha, U.S. Naval Support Force, Antarctica, whose support through the rigorous 1974 winter contributed to our studies.

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Geology and petrography of rocks from the Ross Sea near Ross Island and the mouth of Taylor Valley

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During the 1974-1975 austral summer we collected rocks that had been entangled in fish and animal traps set on the floor of the Ross Sea by A. L. DeVries, Scripps Institution of Oceanography, and his assistants. These traps were under the annual ice about a kilometer southwest of McMurdo Station where the water is about 500 meters deep. We are grateful to Dr. DeVries and his assistants for their help in collecting the specimens described below.

All of the specimens from this site were large enough (15 to 70 millimeters in diameter) to be identified megascopically. The results of our study are presented in table 1. A representative suite of clasts was studied in thin section (table 2). Our work shows that all of the clasts are rounded, indicating that they were transported and/or worked; further, all are volcanic rocks that probably were produced in the Ross Sea area.

Very similar rocks occur on volcanic islands south of the collection site. We therefore are unable to indicate the direction of transport from our studies of this collection. During the 1973-1974 season we were able to postulate some southerly transport of volcanic rocks to this locality on the basis of the occurrence of anorthoclase trachyte (Kenyte) in a similar collection (Treves *et al.*, 1974).

Table 1. Petrography of sediment sample from McMurdo Sound.

Description	Percentage
Rounded, brown, mixed tuff	14.2
Rounded, black, aphyric basalt	12.2
Rounded, light brown, laminated tuff	10.1
Angular, brown-black scoria	18.2
Rounded, black, vesicular olivine—augite basalt	8.1
Angular, black-brown scoria	20.1
Rounded, brown, volcanic breccia	6.1
Rounded, black, aphyric basalt	4.0
Rounded, black vesicular, hornblende basalt	5.0
Rounded brown, mixed tuff	2.0
	100.0

Other submarine sediment samples were collected for us by Paul Dayton, G. Roubilliard, and John Oliver, all of Scripps, while studying benthic communities of McMurdo Sound. Samples from a variety of depths were collected while scuba diving in the Cape Armitage, Winter Quarters Bay, Hut Point, Cinder Cones, Cape Evans, and Cape Royds areas off Ross Island, and offshore of New Harbor at the mouth of Taylor Valley. We are grateful to the collectors for the specimens described below.

A collection of rock fragments from Cape Armitage, averaging about 20 millimeters in diameter and ranging from 60 to 10 millimeters, is described in table 3. The collection was made at a depth of 15 meters from a bedrock surface that is an extension of the lower slopes of Observation Hill. Thinsection analyses of the various varieties are in table 4. Our data show that rocks at this site come from Observation Hill and that the rocks have been rounded probably as a result of wave action.

The next suite of specimens to be described was collected from the Winter Quarters Bay area. Specimens described in table 5 were coarse enough to be identified megascopically. Specimen 13 (table 5) was collected from a depth of 30 meters; the fragments range in size from 10 to 22 millimeters, and more than half were rounded. Specimen 14 (table 5) was collected from a depth of 20 meters; the fragments range in size from 7 to 34 millimeters in diameter, and two-thirds are rounded. Specimen 15 (table 5) was collected from a depth of 25 meters; the fragments range in size from 10 to 70 millimeters, and 60 percent are angular. Specimen 16 (table 5) was collected from a depth of 30 meters; the fragments range in size from 9 to 63 millimeters in diameter, and 50 percent are angular. Specimen

Table 2. Petrography of clasts from McMurdo Sound

Mineralogy	MS-1	MS-2	MS-3	MS-4	MS-5	MS-6
	Percentages					
Plagioclase	23.4 (An 55)	29.8 (An 50)	—	29.8 (An 50)	11.0 (An 50)	6.8
Augite	18.8	5.8	0.3	4.8	1.6	2.0
Olivine	2.4	3.0	3.0	2.2	3.8	0.5
Opaque minerals	20.6	17.8	5.0	37.6	37.0	2.8
Glass	35.0	43.6	87.2	25.6	46.6	87.6
Apatite	TR	TR	—	TR	TR	—
Rock fragments	—	—	4.5	—	—	0.3
	100.0	100.0	100.0	100.0	100.0	100.0

MS-1, olivine-augite basalt; MS-2, olivine-augite basalt; MS-3, mixed tuff; MS-4, olivine-augite basalt; MS-5, olivine-augite basalt; MS-6, mixed tuff.

17 (table 5) was collected from a depth of 25 meters; the fragments range in size from 8 to 41 millimeters in diameter, and 50 percent are angular.

Thin sections of a representative group of basalts from Winter Quarters Bay are described in table 6. Sand and granule-sized sediment samples are described in table 7. These samples are primarily volcanic sands and gravels. The depths at which they were collected follow: specimen 5, 5 meters; specimen 6, 15 meters; specimen 7, 30 meters; specimen 8, 20 meters; specimen 9, 25 meters; specimen 10, 25 meters; specimen 11, 30 meters, specimen 12, 25 meters.

The basalts, trachytes, tuffs, dunite, glass, plagioclase, olivine, augite, and kaersutite described in tables 5, 6, and 7 are similar to materials that occur on Hut Point Peninsula and so may have a very local origin. The gray granitic rocks of table 6 and the sandstone and granite fragments of table 7, however, do not occur on Ross Island except as glacial erratics. The nearest outcrop of granitic rocks of this type is in southern Victoria Land where it occurs as part of the basement complex. Sandstones like those found here occur on top of the granitic rocks and constitute the Beacon Group. To transport the granite and sandstone from the

Table 3. Petrography of sediment from Cape Armitage area.

Description	Percentage
Angular, platy, gray trachyte	5.4
Rounded, platy, gray trachyte	38.6
Rounded, platy, light-gray trachyte	6.1
Rounded, vesicular, yellow-brown to red-brown, glassy trachyte	13.3
Rounded, pumiceous, yellow-gray to brown-gray trachyte	22.1
Rounded, glassy-pumiceous, dark-brown to brownish-black trachyte	14.5
	100.0

Table 4. Petrography of trachyte clasts from Cape Armitage area.

Mineralogy	CA-1	CA-2	CA-3	CA-4	CA-5
Oligoclase	11.3	10.9	23.5	8.6	25.8
Anorthoclase	—	—	—	—	64.8
Glass	75.7	76.8	71.6	73.2	1.0
Augite	5.2	5.4	0.9	4.6	—
Kaersutite	4.3	1.5	—	—	6.4
Opaque minerals	1.7	1.8	2.2	2.9	2.0
Apatite	TR	0.9	0.9	0.9	—
Microlites	—	2.7	0.9	9.8	—
	100.0	100.0	100.0	100.0	100.0

CA-1, glassy, gray trachyte; CA-2, glassy, brown trachyte; CA-3, pumiceous, brown trachyte; CA-4, pumiceous, black trachyte; CA-5, gray trachyte.

Table 5. Petrography of sediment sample from Winter Quarters Bay.

Description	WQ-13	WQ-14	WQ-15	WQ-16	WQ-17
Black, olivine-augite basalt	16.5	—	29.9	49.1	25.6
Black, aphyric basalt	33.4	53.2	14.5	20.3	63.4
Black, augite basalt	9.6	13.6	—	13.5	—
Black, kaersutite basalt	—	—	3.7	—	—
Black, olivine basalt	—	—	24.0	—	—
Red-brown to black scoria	14.3	26.8	9.6	15.6	7.3
Gray trachyte	26.2	—	2.4	—	3.7
Brown mixed tuff	—	6.7	5.8	—	—
Green-brown dunite	—	—	—	1.5	—
Gray granitic rock	—	—	0.5	—	—
	100.0	100.0	100.0	100.0	100.0

Table 6. Petrography of clasts from Winter Quarters Bay area.

Mineralogy	Percentages WQ-1	WQ-2	WQ-3	WQ-4
Plagioclase	12.0 (AN 50)	16.7 (AN 55)	2.8	34.7 (AN 50)
Augite	15.0	32.3	4.8	17.8
Kaersutite	1.3	—	0.9	—
Olivine	—	12.6	3.8	5.1
Apatite	TR	TR	—	TR
Opaque minerals	18.0	4.7	1.9	2.5
Glass	53.7	33.9	85.8	39.9

WQ-1, augite-kaersutite basalt; WQ-2, olivine-augite basalt; WQ-3, scoria; WQ-4, olivine-augite basalt.

Transantarctic Mountains of southern Victoria Land to the vicinity of Ross Island requires ice movement from the southeast quadrant.

The mixture of angular and rounded fragments of rock in these samples probably indicates that some of the rocks were transported by ice from other parts of Ross Island (north to south ice movement) or from outcrops of similar volcanic rocks on Black and White Island, on Minna Bluff, on Brown Peninsula, etc. (south-to-north ice movement).

Two sediment samples were collected from the Hut Point area. The first, described in table 8, was collected from a depth of 30 meters. The fragments in this specimen range from 10 to 70 millimeters in diameter. All are angular and are clearly derived from outcrops that constitute the west end of Hut Point. Similar rock crops out on the submarine slope off Hut Point. The angularity of the specimens suggests little transport and a very local source. A thinsection study (table 9) of one of the aphyric basalts confirms this conclusion.

The second sample, described in table 10, was collected from a depth of 25 meters near a sponge spicule mat. The sample consisted of sand and gravel-sized fragments. Unlike the first specimen, the second sample is quite varied. The mineral component was derived from basaltic rocks. The

Table 8. Petrography of sediment sample from Hut Point area.

Description	Percentage
Angular, black to gray-black, aphyric basalt	77.4
Angular, black to gray, vesicular, aphyric basalt	10.1
Angular, red scoria	2.3
Angular, black to gray, glassy aphyric basalt	10.2
	100.0

Table 7. Petrography of sediment samples from Winter Quarters Bay.

Description	WQ-5	WQ-6	WQ-7	WQ-8	WQ-9	WQ-10	WQ-11	WQ-12
Minerals								
quartz	—	—	—	—	—	—	2.9	—
plagioclase	—	9.2	3.4	0.8	—	—	3.7	—
olivine	3.0	5.5	4.1	5.2	—	1.6	5.9	1.9
augite	5.6	5.5	8.2	3.4	—	6.0	2.9	0.9
kaersutite	—	—	—	—	—	—	0.7	—
Basalts								
aphyric basalt	6.9	3.7	12.2	3.0	8.5	7.4	53.8	17.2
olivine basalt	11.2	12.9	14.3	13.8	4.8	12.1	3.7	2.9
plagioclase basalt	25.1	11.1	18.4	24.1	16.9	28.4	5.9	3.9
plagioclase-augite basalt	11.6	11.1	4.2	3.4	37.3	17.3	4.4	36.6
augite basalt	—	9.2	8.2	0.9	—	0.8	—	7.7
olivine-augite basalt	7.9	7.3	10.2	3.0	—	0.8	—	4.8
Trachyte								
trachyte	—	24.0	2.1	15.5	10.1	6.2	5.9	9.6
kaersutite trachyte	11.5	—	2.1	2.9	—	0.4	0.7	2.4
glassy trachyte	5.9	—	—	—	—	—	—	—
anorthoclase trachyte	—	—	—	—	—	2.0	—	—
Others								
glass	6.9	3.7	6.3	27.4	16.9	17.0	4.4	11.5
sandstone	—	1.8	2.1	—	—	0.4	2.9	—
granite	—	1.8	—	—	—	—	0.7	0.4
scrap	—	—	2.1	—	—	—	—	—
schist	—	—	2.1	—	—	—	—	—
dunite	—	—	—	2.6	—	—	—	—
tuff	—	—	—	—	3.6	—	—	—
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 9. Petrography of basalt from Hut Point area.

Minerals	Percentage
Olivine	4.5
Augite	17.5
Plagioclase	24.5
Opaque minerals	22.0
Glass	31.5
Apatite	TR
	100.0

Table 10. Petrography of sediment sample from Hut Point area.

Description	Percentages	
Minerals	9.7	
plagioclase		2.0
pyroxene		3.1
olivine		4.6
Basalt	73.0	
plagioclase basalt		1.5
olivine pyroxene basalt		42.9
pyroxene basalt		28.6
Trachyte	16.4	
hornblende trachyte		8.2
pyroxene trachyte		5.6
anorthoclase trachyte		2.6
Other rocks	1.0	
granite		1.0
	100.0	100.0

basalts and trachyte, except for the anorthoclase trachyte, occur on Ross Island in many places to the north and south of the collection site, on volcanic islands to the south, and on the mainland near Mount Discovery. The anorthoclase trachyte, however, only occurs at Cape Evans, at Cape Royds, and on the flanks of Mount Erebus. Transport from north to south is thus indicated. The granite resembles the basement rocks of southern Victoria Land, indicating transport to this site from the southwest or west.

The specimen (table 11) from the Cinder Cone area, which is located on the west side of Hut Point Peninsula, was collected from a depth of 5 meters and consists of sand-sized volcanic fragments of basalt and mineral grains (phenocrystic minerals) that occur in the basalt. The fragments are clearly derived from the outcrops that constitute the Cinder Cones. No erratics occur in the sample.

A sample from a depth of 40 meters collected from the long, gentle, submarine slope in front of Scott's hut at Cape Evans consists entirely of anorthoclase trachyte (Kenyte) (table 12). It is clearly derived from surface and submarine outcrops of anorthoclase trachyte flows in this area. A thinsection study of one of the clasts (table 13) confirms this conclusion.

Seven sediment samples were collected from various depths in the Cape Royds area. Specimens CR8 through CR10 (table 14) were collected from depths of 40, 25, and 25 meters, respectively, and consist of rounded granules and pebbles of minerals and rocks that were derived from Cape Royds or the lower slopes of Mount Erebus. Thin-section descriptions of three of the clasts (table 15) confirm this observation. The shell fragments are also derived locally and represent reworked organic remains.

The long, gentle, submarine slopes that stretch seaward from Cape Royds are covered with rippled sediment, a feature that explains the high percentage of rounded clasts in these samples.

Specimens CR4 through CR7 (table 16) were collected from depths of 25, 20, 20, and 25 meters, respectively, and consist of sand-sized mineral and

Table 11. Petrography of sediment sample from the Cinder Cones area.

Description	Percentage
Glassy, vesicular, olivine-pyroxene basalt	97.1
Olivine	1.4
Pyroxene	1.5
	100.0

Table 12. Petrography of sediment sample from Cape Evans area.

Description	Percentage
Rounded, black, vesicular, porphyritic, glassy, anorthoclase trachyte	50
Rounded, black vesicular, porphyritic, anorthoclase trachyte	50
	100.0

Table 13. Petrography of trachyte clast from Cape Evans area.

Mineralogy	Percentage
Glass	61.6
Oligoclase	7.4
Anorthoclase	21.9
Augite	1.3
Kaersutite	1.8
Olivine	0.7
Opaque minerals	5.3
	100.0

rock fragments. Unlike the larger-sized clasts of specimens CR8 through CR10, the exact source of many of the fragments is difficult to determine. The anorthoclase, glass, and anorthoclase trachyte (Kenyte) are most likely local in origin, although they may have been transported to this locality from Cape Evans or the slopes of Mount Erebus. Other varieties of trachyte and some basalt types occur on the slopes of Mount Erebus, and basaltic rocks occur nearby at Cape Barne. Similar trachytes and basalts also occur at Cape Bird and on Hut Point Peninsula. Further, all of the rock and mineral fragments identified in the sediment occur as clasts and grains in the till that mantles some of the Cape Royds area. Erratics clearly derived from southern Victoria Land are also common in this till. Despite these complications, it is clear that the samples represent very local materials (anorthoclase and anorthoclase trachyte) that have been diluted by the addition of other volcanic rocks and minerals that are characteristic of the McMurdo volcanic province and which occur to the north and south of the sample sites. The erratics—orthoclase, quartz, and granitic rocks—that occur in the sample constitute the basement rocks of the Transantarctic Mountains of southern Victoria Land. To constitute a sample of this composition requires, at minimum, ice movement from south to north, or a more complex pattern of motion from north

Table 14. Petrography of sediment sample from Cape Royds area.

Description	Percentages CR-8	CR-9	CR-10
Anorthoclase	18.1	25.1	16.1
Glassy, anorthoclase trachyte	25.3	8.3	12.8
Anorthoclase trachyte	45.8	41.7	3.9
Pyroxene-anorthoclase trachyte	—	—	62.5
Trachyte	4.8	—	3.4
Vesicular trachyte	6.0	18.6	3.3
Volcanic breccia	—	6.3	—
Shell fragments	—	—	1.5
	100.0	100.0	100.0

Table 15. Petrography of clasts from Cape Royds area.

Minerals	Percentages CR-1	CR-2	CR-3
Plagioclase	49.8 (AN 65-45)	47.3 (AN 28)	17.4 (AN 25)
Anorthoclase	—	27.8	35.3
Kaersutite	—	6.5	—
Augite	16.6	8.5	11.0
Olivine	2.6	1.3	2.6
Glass	11.4	1.3	18.4
Opaque	19.6	7.5	15.3
	100.0	100.0	100.0

CR-1, plagioclase-augite-olivine basalt; CR-2, anorthoclase trachyte; CR-2, anorthoclase trachyte; CR-3, anorthoclase trachyte.

Table 16. Petrography of sediment samples from Cape Royds area.

Description	CR-4		CR-5		Percentages CR-6		CR-7	
Minerals	18.0		26.4		27.6		22.7	
olivine		6.0		0.4		0.4		0.6
augite		2.0		1.0		1.8		2.0
hornblende		—		—		0.2		—
anorthoclase		10.0		18.8		14.6		18.6
orthoclase		—		0.6		—		—
plagioclase		—		5.6		10.6		1.2
quartz		—		—		—		0.3
Basalt	44.0		60.6		53.2		27.7	
plagioclase basalt		8.0		7.8		11.8		2.0
olivine-pyroxene basalt		22.0		12.6		11.0		14.4
pyroxene basalt		—		—		—		11.3
kaersutite basalt		—		0.4		—		—
Trachyte							47.6	
anorthoclase trachyte		14.0		39.8		30.4		43.6
hornblende trachyte		—		—		—		2.0
augite trachyte		—		—		—		2.0
Others	38.0		13.0		19.2		2.0	
glass		38.0		13.0		19.0		1.7
granitic rocks		—		—		0.2		—
fossil fragments		—		—		—		0.3
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

to south and from west or southwest to the east or southeast.

Four sediment samples were obtained from the New Harbor area. These samples are described in table 17. All of the samples consist of sand-sized material and were collected from a very gently sloping to almost flat area. The depths at which the samples were taken are as follows: NH1, 45 meters; NH2, 30 meters; NH3, 45 meters; NH4, 30 meters.

All of the minerals and rock fragments of the samples, except the trachytes, have counterparts in Taylor Valley. This suggests that most of the sediment may have come from Taylor Valley. The presence of trachyte in the samples and of anorthoclase trachyte (Kenyte) in the drift of Taylor Valley indicates contributions from other source areas. Outcrops of trachyte occur on Ross Island to the east and to the north on the volcanic islands and in the Mount Discovery area. The anorthoclase trachyte, however, occurs only at Cape Royds and Cape Evans and on the slopes of Mount Erebus. To transport Kenyte from the outcrop area would require ice movement from the east to the west and invasion of the valleys by an ice sheet centered in McMurdo Sound. Of course, a more complex series of motions involving ice movement from north to south and from south to north could, over a long period, produce the same result.

Note that the granites, quartz arenites, and dolerites, and hence the sources of many of the mineral grains, also occur to the north and south of Taylor Valley; thus it is impossible to locate the exact source of this component of the sample.

In conclusion, these and similar data (Treves *et al.*, 1974) indicate that an ice sheet, probably centered in McMurdo Sound, transported materials from the north to the south of Ross Island toward the Ross Ice Shelf, and to the west of Ross Island into Taylor Valley. That some of this activity probably took place in about the last 500,000 years is indicated by a potassium-argon date of 0.68 ±0.14 million years for the anorthoclase trachyte (Kenyte) at Cape Royds (Treves, 1967, 1968).

Table 17. Petrography of sediment samples from New Harbor area.

Description	Percentages NH-1	NH-2	NH-3	NH-4
Minerals				
quartz	8.4	5.2	10.6	12.8
microcline	0.6	1.0	0.4	0.4
orthoclase	14.2	2.3	2.1	16.2
plagioclase	9.4	15.9	14.9	9.2
perthite	0.6	1.6	1.7	1.0
biotite	—	—	0.4	—
hornblende	4.0	—	—	1.4
augite	8.4	2.3	3.0	8.4
olivine	1.0	1.6	0.9	0.4
opaque minerals	5.0	—	—	1.6
Basalt				
plagioclase basalt	7.0	5.5	1.7	10.4
kaersutite basalt	0.4	0.6	0.9	1.0
olivine-pyroxene basalt	9.6	15.2	11.2	10.2
pyroxene basalt	—	1.6	6.4	—
Trachyte				
pyroxene trachyte	0.4	2.3	1.3	0.2
hornblende trachyte	—	—	3.0	0.4
Other				
granite	19.4	35.6	38.7	20.6
diabase	—	4.9	0.9	—
sandstone	0.4	1.6	—	1.0
glass	10.8	2.6	1.7	4.8
	100.0	100.0	100.0	100.0

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Rubidium-strontium ages of basement rocks recovered from DVDP hole 6, southern Victoria Land

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Data presented here are part of the Dry Valley Drilling Project (DVDP) investigation of the geologic history of southern Victoria Land. Analyzed

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samples were taken from the 300-meter DVDP drillhole 6, located about 90 kilometers west of Ross Island (figure 1) at the west edge of Lake Vida, Victoria Valley (figure 2). The stratigraphy of this valley is divided into four major units: a basement complex, the Beacon supergroup; the Ferrar dolerites; Quaternary surficial deposits.

The basement complex includes two major units: the Asgard Formation and the Admiralty Intrusives. The Asgard Formation, part of the Ross System (Harrington, 1958), crops out 3.5 kilometers west of Lake Vida, near Mount Insel (figure 2), and consists of folded and interbedded hornfelses, marbles, and schists of late Precambrian to Cambrian age (McKelvey and Webb, 1962). These rocks commonly exhibit migmatitic and gneissic textures near contacts with igneous bodies.

The Admiralty Intrusives (Granite Harbor Intrusive Complex of Gunn and Warren, 1962) are late Precambrian to Ordovician in age (Harrington, 1958) and are divided into three phases (McKelvey and Webb, 1962). The oldest phase includes the strongly foliated Olympus Granite-gneiss and the prophyritic Dias Granite, which crops out 6 kilometers south of Lake Vida. The Dias Granite exhibits a weak foliation that is generally parallel to that in the Olympus Granite-gneiss and the metasediments of the Asgard Formation. The second phase includes dikes of the Loke Microdiorite and Theseus Granodiorite, both of which cut the aforementioned units of the basement complex. The third intrusive phase is represented by the Vida Granite (Irizar Granite of Gunn and Warren, 1962) and the Vanda Lamprophyre and Porphyry. Deutsch and Webb (1964) reported average rubidium-strontium ages for the Irizar Granite of 475 ±80 million years for feldspars and

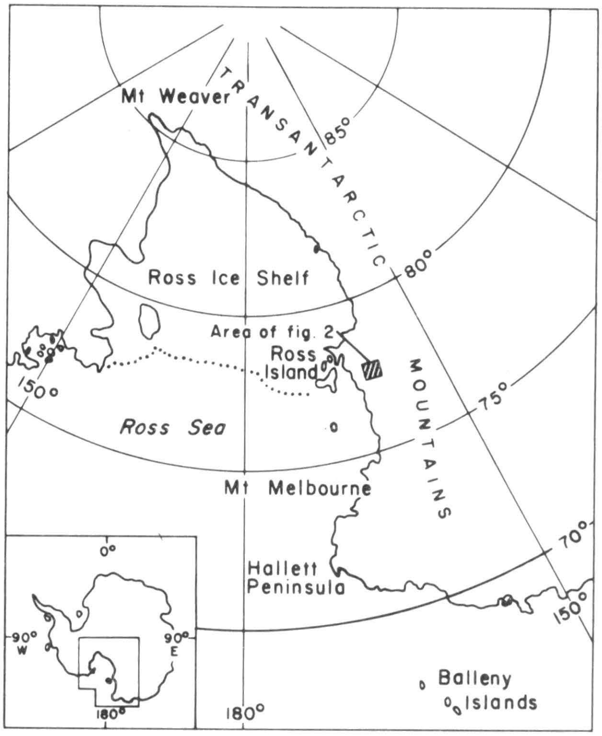

Figure 1. Index map of Antarctica showing the Ross Island and dry valley areas.

486 ±15 million years for biotites. The Vida Granite (called quartz monzonite by Smithson *et al.*, 1970) has its type locality directly south of Lake Vida and contains small xenoliths of the Dias Granite in its chilled and gneissic borders. The youngest unit of the basement complex is the Vanda Lamprophyre and Porphyry, which intrudes all of the older rocks and is exposed as dikes cutting the Vida Granite south of Lake Vida. A dike of the Vanda Lamprophyre and Prophyry also cuts

Table 1. Rubidium and strontium concentrations and strontium isotopic compositions of standards and blanks.

Sample number	Sr (ppm)	Rb (ppm)	$^{87}Sr/^{86}Sr_s$	$^{87}Sr/^{86}Sr_u$
SRM-607				
(JSS)	65.7_9	524.3	1.200_0	n.d.
(CLN)	65.70	522.5	1.200_4	n.d.
(NBS)	65.48_5	523.9	1.2003_9	n.r.
SRM-987				
(JSS)	n.d.	—	n.d.	0.7101_3
(NBS)	—	—	—	0.7101_5
W-1				
(JSS)	n.d.	21.4_5	n.d.	n.d.
(USGS)	190	21	n.r.	n.r.

s, spiked sample determinations; *u*, unspiked sample determinations; n.d., not determined; n.r., not reported; JSS, J. S. Stuckless, analyst; CLN, C. L. Niewold, analyst; NBS, recommended value, National Bureau of Standards; USGS, recommended value, U.S. Geological Survey (Flanagan, 1973).

Table 2. Rubidium and strontium concentrations and strontium isotopic compositions of crystalline basement rocks from Dry Valley Drilling Project hole 6, Lake Vida.

Sample number	Sr (ppm)	Rb (ppm)	$^{87}Sr/^{86}Sr$	$^{87}Rb/^{86}Sr$
Gneiss				
V6-37-WR	876	73.7	0.7090	0.2438
V6-37-Bi	34.9_7	410.3	0.8239	34.3849
V6-37-Fd	1125.3	76.1	0.7089	0.1958
V6-67-WR	989	61.1	0.7089	0.1789
Granite				
V6-173-WR	200	153	0.7251	2.2125
V6-300-WR	214	145	0.7231	1.968
V6-300-Bi	26.2_2	546.8	1.1390	62.9852
V6-300-Kf	225	331.1	0.7348_6	3.7737
V6-300-Pl	78.4_8	459.5	0.7134_2	0.4947

WR, whole rock; Bi, biotite; Fd, impure plagioclase; Kf, K-feldspar; Pl, plagioclase.

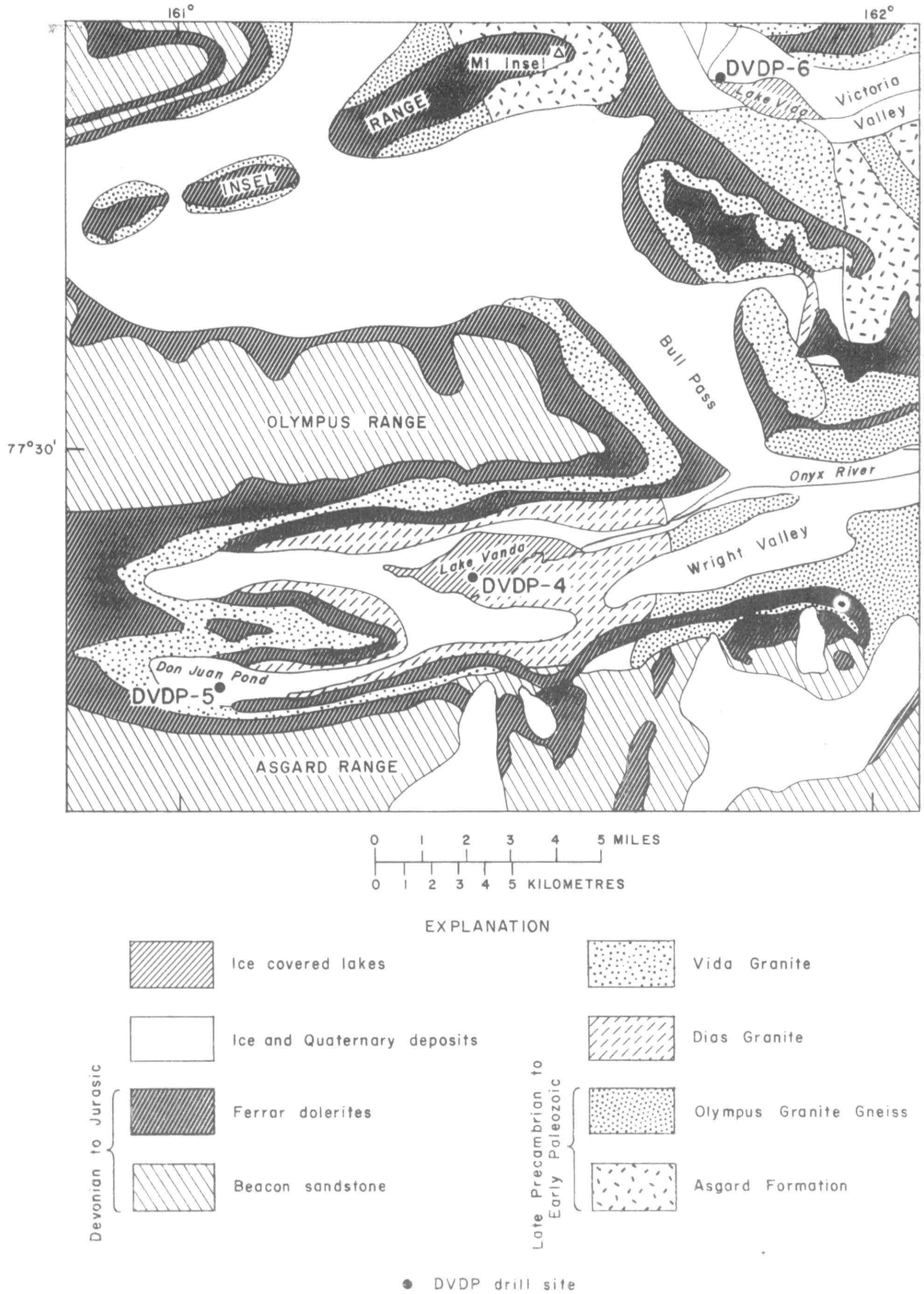

Figure 2. Generalized geologic map of Wright and Victoria valleys showing the location of Dry Valley Drilling Project (DVDP) hole 6, near Lake Vida. After Kurasawa *et al.* (1974), with modification.

the lowermost Beacon Supergroup on the south side of Victoria Valley (Smithson *et al.*, 1970).

The Beacon Supergroup unconformably overlies the basement complex and consists of essentially flatlying nonmarine strata of Devonian (or older) through Jurassic age (Barrett *et al.*, 1972). The Beacon Supergroup is composed of subgraywackes, arkoses, orthoquartzites, siltstones, and carbonaceous shales.

The Ferrar Dolerites intrude the basement complex and overlying Beacon Supergroup as dikes, sheets, and sills of tholeiitic diabase (Gunn and Warren, 1962; Hamilton, 1965). Radiometric ages that have been reported for the Ferrar Dolerites

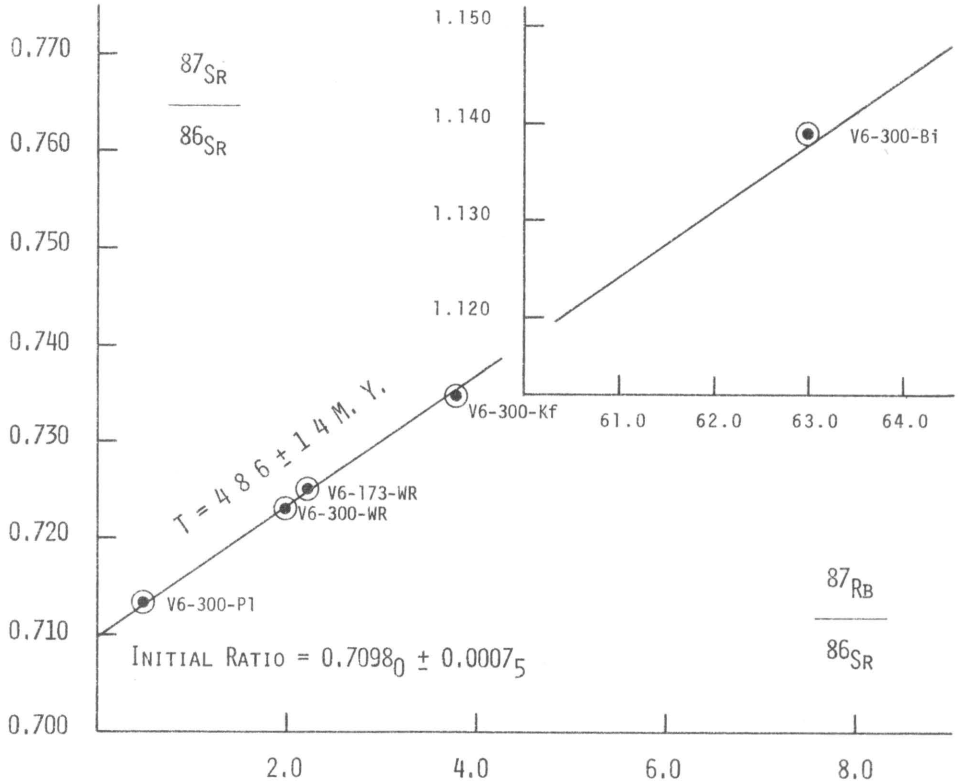

Figure 3. Rubidium-strontium, whole-rock-mineral isochron diagram for quartz monzonite (V6-173 and V6-300) from DVDP hole 6. WR, whole rock; Bi, biotite; Pl, plagioclase; Kf, potassium feldspar; sample numbers indicate depth in meters.

average 153 million years (McDougall, 1963; Compston and Lovering, 1969). Dikes of this unit intrude the Vida Granite just south of Lake Vida (Webb and McKelvey, 1959; McKelvey and Webb, 1962).

Analytical procedures

Chemical procedures employed in sample preparation are similar to those of Stuckless and O'Neil (1973), except that sample residues were ignited following dissolution. Samples were analyzed on a 15-centimeter, 60° sector, Sheilds design, mass spectrometer using a rhenium triple-filament mode of ionization. The strontium-87/strontium-86 values (tables 1 and 2) have been normalized to strontium-86/strontium-88 = 0.1194. Rubidium and strontium concentrations were determined by isotope dilution using rubidium-87 and strontium-84 enriched spikes.

Twenty-seven replicate analyses indicate a relative error for rubidium-87/strontium-86 and spike strontium-87/strontium-86 ratios of 0.95 and 0.072 percent. Analyses for rubidium, strontium, and strontium-87/strontium-86 on SRM-607 (table 1) are in good agreement with those reported by the National Bureau of Standards. Our strontium-87/strontium-86 value for 12 determinations or SRM-987 is $0.7101_3 \pm 0.0002_1$ (2σ).

Blank strontium and rubidium (table 1) were determined on reagents after passing through chemical procedures identical to those used in sample dissolutions. Blanks of less than 5 and 55

Table 3. Modal data of crystalline basement rocks from Dry Valley Drilling Project hole 6, Lake Vida, southern Victoria Land.*

Number	V6-37	V6-67	V6-173	V6-300
Quartz	7.4	7.7	39.3	19.3
Plagioclase	76.8	75.3	23.1	38.1
K-feldspar	—	—	28.9	37.4
Hornblende	1.6	2.0	—	—
Augite	tr.	0.7	—	—
Biotite	13.4	14.3	7.0	4.3
Chlorite	0.5	tr.	1.3	0.9
Apatite	tr.	tr.	tr.	tr.
Zircon	tr.	tr.	tr.	tr.
Sphene	tr.	tr.	tr.	tr.
Opaques	0.3	tr.	0.3	—
Hematite	—	—	—	—
An content	(34)	(35)	(28)	(28)

*Modes were determined by point-counting 668 to 876 points per thin section.

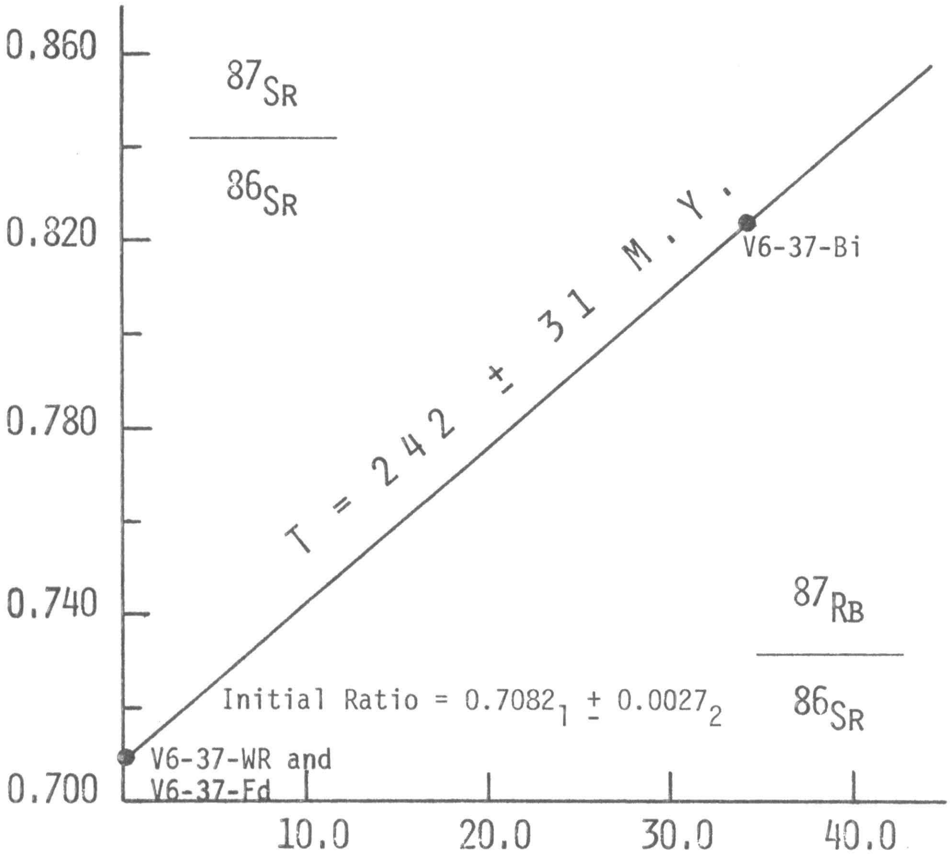

Figure 4. Rubidium-strontium isochron diagram of gneiss (V6-37) from DVDP hole 6. WR, whole rock; Bi, biotite; Fd, impure plagioclase.

nanograms for rubidium and strontium respectively contribute less than 0.1 percent to the rubidium-strontium data reported here, and no corrections therefore have been applied to the data. Ages were calculated using the computer program of McIntyre *et al.* (1966), which used a λ_β rubidium-87 of 1.39×10^{-11} per year. Ages and initial strontium-87/strontium-86 ratios are reported with errors of $\pm 2\sigma$.

Results and discussion

Modal data for the four samples analyzed here are presented in table 3. Visual examination of the core suggests that these samples are representative of the two basement units encountered in hole 6. Samples of the quartz monzonite are microscopically fresh except for minor alterations of the plagioclase to clays or sericite and minor amounts of chlorite in the biotite.

Rubidium-strontium analytical data for the whole-rock samples and mineral separates of the quartz monzonites (V6-173 and V6-300) are presented in table 2; the isochronal relationship is shown in figure 3. The apparent age for the two whole rocks and three minerals is 486 ±14 million years with an initial strontium-87/strontium-86 ratio of 0.7098_0 $\pm 0.0007_5$. This initial strontium-87/strontium-86 ratio, which is high even with respect to modern granites, may be due to: (1) a crustal origin for the quartz monzonite, (2) a large amount of crustal contamination during emplacement, or (3) partial rehomogenization of strontium isotopes and/or chemical alteration effects after emplacement. Computer reduction of the rubidium-strontium data indicates errors slightly larger than analytical uncertainties. These errors are not proportional to the rubidium-strontium ratios, and therefore are best ascribed to geologic variations such as isotopic disequilibrium at the time of emplacement of minor alteration effects. Geologic evidence suggests that the two whole-rock samples crystallized in close proximity to one another and from a single granitic magma. It therefore is unlikely that the samples were isotopically dissimilar at the time of emplacement.

Brooks (1968) studied the redistribution of strontium isotopes and concluded that K-feldspar acts as a strontium-87 donor and that alteration products of plagioclase act as strontium-87 receptors. Because the quartz monzonite samples exhibit minor alteration of plagioclase, it is likely that the plagioclase point (figure 3) is a little too high with respect to strontium-87 and the K-feldspar is a little too low, thereby: (1) lowering the calculated age, (2) raising the initial strontium-87/strontium-86 ratio, and (3) increasing the apparent error beyond the limits of analytical precision. We therefore conclude that the age of 486 million years should be interpreted as a minimum age.

The other analyzed samples are from paragneiss that contains large amounts of biotite, twinned and untwinned plagioclase, and small amounts of quartz and hornblende. Abundant clay or sericite and minor chlorite occur as alteration products. Rubidium-strontium data for the paragneiss are presented in table 2, and the isochronal relationship is shown in figure 4. As seen in figure 4, the age of 242 ±31 million years is a biotite age. Like the quartz monzonite, the paragneiss has a high initial ratio of 0.7082 ±0.0027, but a much larger uncertainty. Unlike the quartz monzonite, the paragneiss yields an apparent age that is less than half of that reported for similar rocks from Victoria Land (for example see Goldich *et al.*, 1958; Angino *et al.*, 1962; McDougall and Ghent, 1970). It is unlikely that the age of 242 million years dates any real geologic event, but rather reflects a partial loss of strontium-87 from the biotite. This may have occurred during the intrusion of the Ferrar dolerites or during the movement of hydrothermal solutions or groundwater along a near-vertical fault that cuts the core at a depth of approximately 38 meters. We conclude that the true age of the paragneiss is greater than 500 million years.

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Structure and petrology of the Scotia Arc and the Patagonian Andes: R/V *Hero* cruise 75-4

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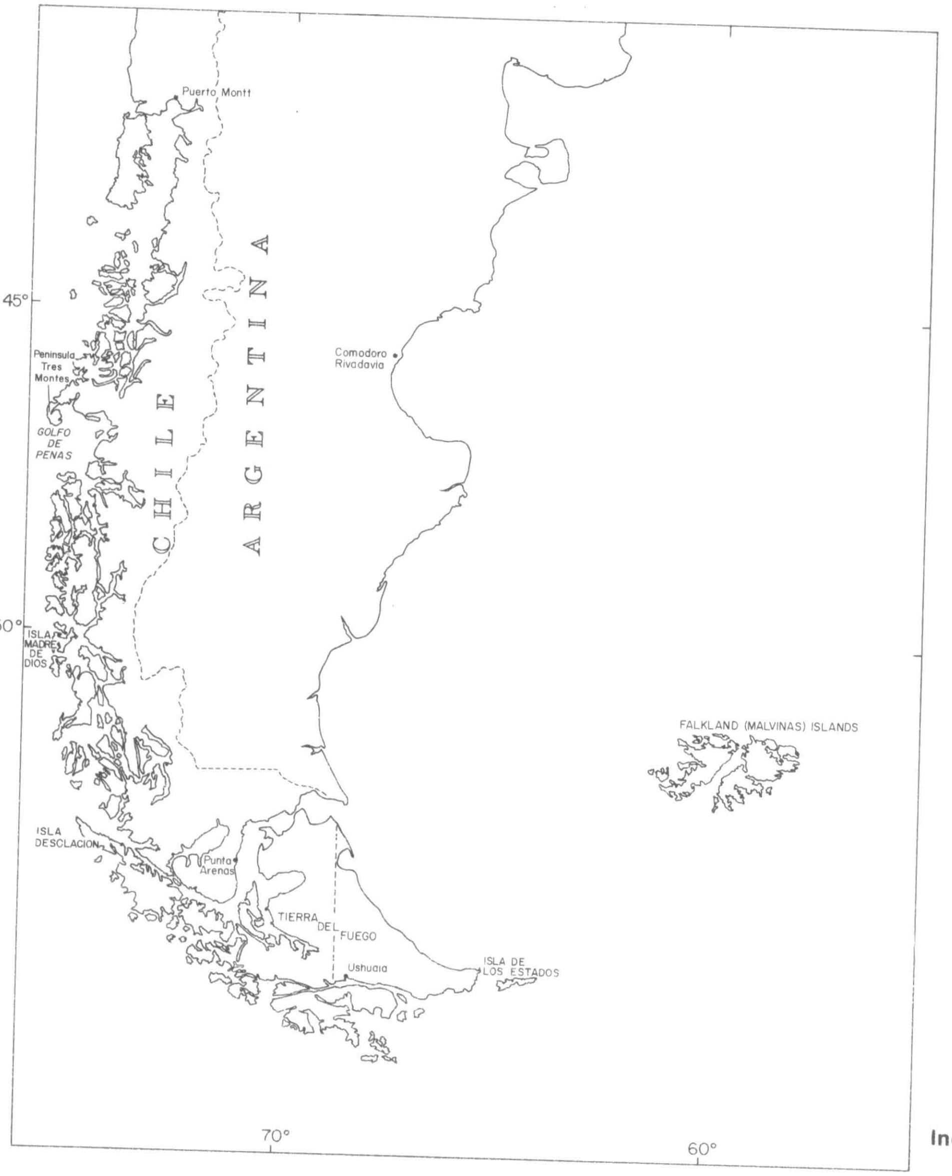
The purpose of R/V *Hero* cruise 75-4 was to study the geologic structure and history of the region between Punta Arenas and Puerto Montt, Chile, as



Index map of southern South America.

part of a continuing U.S. effort to study the tectonic history of the Antarctic Peninsula, the subantarctic islands of the Scotia Arc, and the southernmost part of the Andean Cordillera. We sailed from Punta Arenas on 14 June 1975 and arrived at Puerto Montt on 14 July 1975.

The specific objective of the cruise was to relate the geology of Tierra del Fuego and of the Chilean Andes, the Scotia Arc, and the Antarctic Peninsula south of 50°S. (all have been extensively studied by Dr. Dalziel and field associates on previous cruises since the 1968-1969 field season) to the geology of the Central Andes. The latter, of course, are relatively more accessible and have been studied by Chilean and Argentine geologists for many years. The geology of the Central Andes is in many ways more like that of the Antarctic Peninsula than that of the southernmost Andes. This has important economic implications, since major copper deposits are known to exist in the Central but not in the Southern Andes.

Randall Forsythe, Lamont-Doherty Geological Observatory of Columbia University, Sergio Cespedes, Empresa Nacional del Petróleo, Jorge Skarmeta and Hans Niemeyer, Instituto de Investigaciones Geologicas, and Estanislao Godoy, University of Chile, Santiago, were also interested in the region and participated in cruise 75-4, thus continuing a cooperative program begun in 1969 with R/V *Hero* cruise 69-6. William Taylor, University of Liverpool, England, was also aboard particularly to study the Patagonian batholith.

Our primary goal was achieved. It was possible to recognize that the so-called basement (i.e., pre to Late Jurassic) metamorphic complex of the Antarctic Peninsula, the South Shetland Islands, and the South Orkney Islands continues north into the Central Andes at least as far as 44°S. Diagnostic red cherts and associated rocks on both sides of the batholith confirmed the identical nature of the South American basement in these tectonic positions. The Patagonian batholith was thus emplaced within, and is entirely surrounded by, South American continental basement as indicated by Dalziel *et al.* (1974). Suggestions based on air photographs of basement rocks on Isla Desolación, which lies immediately south of the west end of the Strait of Magellan (see map), were confirmed. These basement rocks and those forming islands farther north (around Isla Madre de Dios) contain mafic pillow lavas underlying white, green, and red (probably manganiferous) chert deposits. They are therefore comparable to the basement rocks of the South Orkney and South Shetland islands previously studied in this project (see summary by Dalziel, 1975). We interpret them to represent Paleozoic oceanic deposits deformed in the arc-trench gap of an early Mesozoic calc-alkaline volcanic chain that lay to the east (Dalziel and de Wit, in preparation).

It was also possible to explain the essential structural difference between the Southern and Central Andes and conversely the similarity between the structural style of the Antarctic Peninsula and the Northern Andes. The ophiolitic rocks representing the floor of a Japan Sea-like marginal basin of Early Cretaceous age in the southernmost Andes (Dalziel *et al.*, 1974) clearly pinch out northward at about 51°S. The deformation involving basement reactivation in southernmost Andes is less intense and penetrative north of about 49°S. This strengthens the suggestion by Dalziel *et al.* (1974) that the deformation occurred when the marginal basin "closed" and was uplifted in the mid-Cretaceous, and that large penetrative strains at high crustal levels behind a volcanic arc are not generated by subduction alone, but may be related to a "collision" between volcanic arcs and continental foreland during the closing of marginal basins.

Slightly deformed Tertiary sediments on Tres Montes Peninsula contain vast amounts of coarse andesitic-basic volcanic detritus presumably derived from the volcanic equivalents of the batholith to the east.

Considerable rock areas previously mapped as basement were found to consist of the granitic batholith. Fiords extending east of Golfo de Penas were investigated for the first time and were found to be cut wholly in granitic rocks.

East-west traverses across the batholith indicate tonalite as the major plutonic rock type; it is associated with lesser amounts of adamellite, minor diorite, and very rare gabbro. Textures are extremely variable; equigranular, plagioclase-phyric, and strongly fabricated varieties were all observed. The main mineralogic variations involve absolute abundances of ferromagnesian minerals and presence or absence of hornblende and biotite.

Associated with the batholith are several periods of minor intrusions, commonly as thin, highly inclined dikes. Synplutonic diabase dikes were very common, displaying various stages of disruption and assimilation. Undoubtedly some shadowy inclusions observed in some tonalite bodies are partly resorbed synplutonic dikes, whereas elsewhere, especially where highly concentrated, the inclusions probably represent roof pendants. Later dikes, striking rather randomly between north and east, are dominantly diabase; local concentrations of quartz-felsite dikes, however, are also observed. These dikes postdate irregular veins and stringers of aplite and pegmatite that presumably represented the late-stage mobile components of the tonalitic magma.

Relationships between the various plutonic rocks remain poorly determined. Wherever observed, tonalite veins earlier diorite, and probably the rare gabbros predate the diorite.

In summary, the batholith appears remarkably uniform in composition, with an estimated average composition of granodiorite. North of Golfo de Penas, exposure is uniformly poor; future attempts at detailed study would best be focused on more southerly parts. There is a remarkable lack of contact metamorphism associated with the batholith, which may be attributed to the present deep level of exposure and the relatively dry nature of the magma. No clear field evidence exists for a west-east change in rock type or rock abundances. This is probably present, but involves subtle variations in K-feldspar abundance that cannot be easily observed in the field, particularly during a reconnaissance.

We are grateful to our pilot, Lieutenant Commander M. Alejandro Sepulveda Mattus of the Chilean army, Captain Norman Deniston, master of *Hero*, and to the *Hero* crew for their willingness to operate the vessel at night to help us accomplish a full program. This research was supported by National Science Foundation grants OPP 74-21415 and DES 75-04076. The Empresa Nacional del Petróleo, through its general manager General don Orlando Orbina Herrera, through its directors, and through Edwardo Gonzalez P. (Jefe de Geologia), made a generous donation of fuel for the cruise.

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Aerosol observations over the ice caps

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Greenland and Antarctica present unique cases for aerosol studies. While these are "continental" situations, the absence of vegetation and fossil fuel combustion, and the presence of continuous ice cover, result in an absence of surface sources. The only source of particulate matter over the ice caps appears to be meteorological transport from other maritime or continental regions, and chemical or photochemical reaction of gases to form particles.

Fenn and Weickmann (1958) studied aerosols over Greenland and in many instances found that the concentration was below the detection threshold of a Pollak counter. Pollak and Metnieks (1959) changed the illumination of the counter to provide a converging light beam, and were able to recalibrate the instrument to respond to aerosol levels that approach particle-free gas.

Megaw (1973) and Flyger *et al.* (1973) recently renewed interest in the study of Greenland aerosols by hypothesizing that the "background" or "end point" of Northern Hemisphere aerosol occurs over the Greenland Ice Cap. I accompanied one of these expeditions (Hogan *et al.*, 1975) and made aerosol observations at sea level and atop the ice cap near the center of the land mass.

The aerosol at sea level was similar to maritime aerosol, but a small diurnal variation was detected. The concentrations observed on the vegetated southern tip of Greenland were similar to rural aerosols in North America and Africa. These observations are included only for interest and are not typical of ice-cap observations.

The aerosol measured at Dye II, atop the Greenland Ice Cap at an elevation of over 3,000 meters, was generally of low concentration. The range of concentration was from 100 to 250 particles per cubic centimeter on clear days. At the station, slightly higher readings were generally observed from a platform 20 meters above the ice, although there is a possibility of local contamination. The highest values occurred in subsiding air with a cold front west of the station.

Extremely low values accompanied and followed a period of riming, light snow (graupel), and precipitating fog. Flow at this time was from the Davis Strait. The concentration fell to 30 particles per cubic centimeter or less during this period, and slowly returned to about 100 particles per cubic centimeter in 36 hours.

The low concentration observed is similar to that found near maritime cumulus. It would appear that the fog and liquid water cloud that accompanied this storm system were efficient aerosol collectors, thereby reducing the concentration of aerosol to a value approaching the number of liquid cloud drops. The aerosol concentration then remained at a low value because only gas reactions were available as an aerosol source in the new high-pressure system building over Greenland.

Voskresenskii (1968) first reported on antarctic aerosols. He found that typical maritime concentrations existed at the coast with northerly winds. The concentrations accompanying strong katabatic winds from the continent ranged from 60 to 400 particles per cubic centimeter. Hogan (1975) found concentrations of more than 500 particles per cubic centimeter in a strong katabatic wind at Siple Station, under conditions of subsidence over the Polar Plateau.

Experiments at Amundsen-Scott South Pole Station detected concentrations of 50 to 125 particles per cubic centimeter at the surface during the austral summer. During subsidence conditions the concentration rises considerably, sometimes to as high as 1,500 particles per cubic centimeter as shown in figure 1. These additional particles are very small and are near the threshold of detection. These particles apparently form somewhere above the strong surface inversion usually present over the Polar Plateau; they cannot be transported in because coagulation would greatly decrease the number concentration of particles of this size within a few hours. These particles come down with the subsiding air and are transported along the surface by katabatic winds. This is in agreement since the largest concentration and the smallest size occur at the Pole (midway across the continent), and the lower concentration and the slightly larger size occur at Siple (toward the coast).

Nelson continued aerosol observations through the austral winter. The aerosol concentration rapidly approaches the threshold of detection (i.e., 10 to 20 particles per cubic centimeter) following sunset, and remains at this level through the polar night. The concentration rises rapidly as the sun strikes the atmosphere prior to astronomical sunrise, and remains at this higher level (figure 2) for about a month, returning to lower levels in late summer.

Initially this increase in aerosol concentration might be attributed to photochemical conversion in the presence of sunlight; however, the polar atmosphere appears to undergo mixing in the lower layers at this time, as evidenced by a decrease in air temperature at 650 to 500 millibars. This prevents drawing the unique conclusion that the return of sunlight converts resident vapors to particles, resulting in an increased spring concentration.

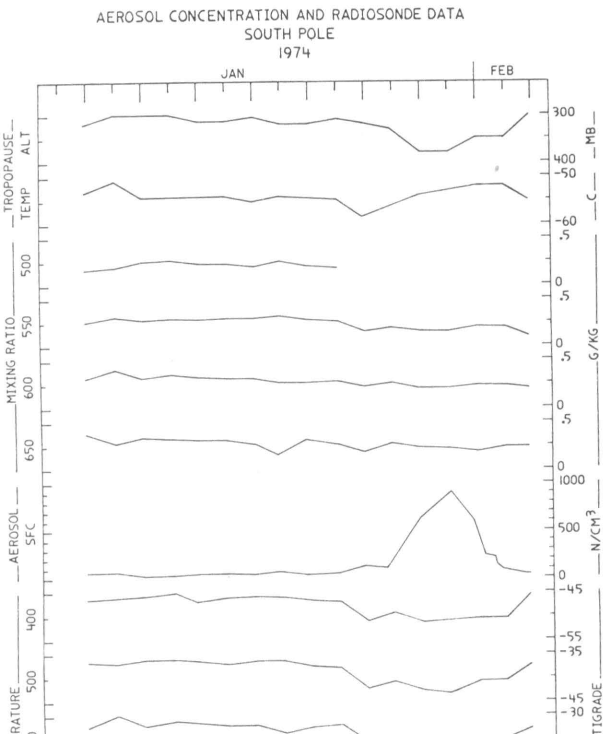

Figure 1. Chronology of aerosol observations at the South Pole. A lowered tropopause and strong subsidence increased the concentration twentyfold during 30-31 January 1974. (Reprinted with permission from *Journal of Applied Meteorology*, June 1975.)

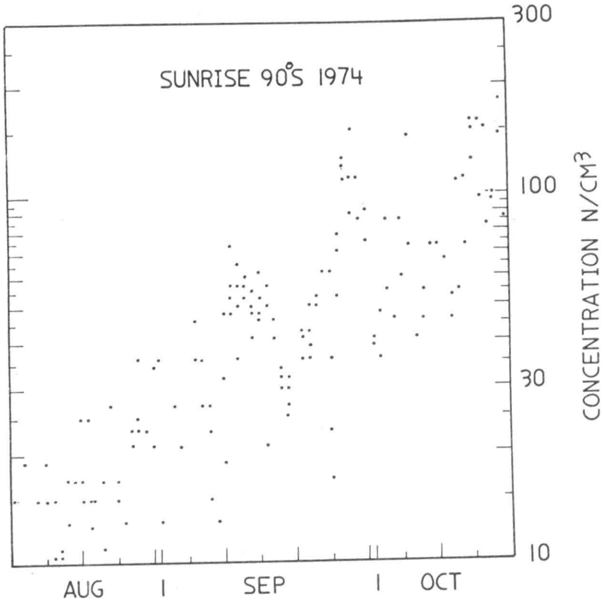

Figure 2. Chronology of aerosol observations during the period around sunrise 1974. The austral winter concentrations of zirconium, less than 30 particles per cubic centimeter, were no longer found after sunrise.

Conditions for vapor-to-particle conversion appear to be present on the polar plateau as shown by experiments with two vapors at −37°C. Terpene vapors (from citrus rind) immediately produced an immeasurably large aerosol concentration when added to surface air. Vapors from a strong oxidant (iodine crystals) produced the same results after thorough flushing of the instrument to remove all traces of terpenes.

Rasmussen (personal communication) measured aerosol concentrations aloft from an airplane in January 1975, and found concentrations of two to four times that found at the surface. Similar results were reported by Hoffman and Rosen (personal communication), who found about one particle per cubic centimeter that was large enough to scatter light aloft. This is about 1,000 times the concentration of particles this size that I found near the surface.

Those sparse data indicate that the ice caps are sinks for atmospheric aerosol. The sink only acts in the region *below* the strong near-surface inversion, and aerosol probably passes unmodified above the inversion when mixing is not present. The extremely low concentrations measured at most times over the ice caps are *not* characteristic of all polar air, but rather are characteristic only of that region below the surface inversion.

A brief description of the antarctic aerosol system is summarized as follows:

(1) A strong inversion forms near the surface during the polar night. Particles trapped beneath this inversion are removed by thermophoretic forces and turbulent diffusion, and are collected on the ice surface. Aerosols of maritime and stratospheric origin pass essentially unmodified over Antarctica above this inversion.

(2) The katabatic wind is accompanied by breaks in this inversion. Air from aloft is transported to the surface through these breaks and flows coastward with the katabatic wind. The aerosol observed in katabatic wind represents a mixture of aerosol-rich upper air and aerosol-depleted lower air.

(3) This transport continues after sunrise, and some photochemical aerosol is produced by sunlight. These quantities are small, but because of low concentration of resident aerosol these small individuals can survive for a few days without being collected by those larger particles.

(4) Although the surface inversion persists during summer, some mixing occurs due to the strong subsidence, gravity waves, and other phenomena. A decrease in the 650- to 500-millibar temperature results from this mixing and may accompany increased aerosol concentration at the surface.

The antarctic ice sheet and its accompanying low inversion are an aerosol sink. The capacity of this sink is limited by the mixing of higher level air through the inversion.

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Microparticle research at the Institute of Polar Studies

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Examination of microparticles in glaciological samples was greatly enhanced during the past year by the establishment of a clean room and the upgrading of equipment in the Institute of Polar Studies microparticle laboratory. The new facility is a class 100 clean room, as certified by the manufacturer, Weber Technical Products.

The laboratory is used only to determine micro-

OSU

Microparticle laboratory at the Institute of Polar Studies, The Ohio State University.

particle variations in snow and ice cores. The laboratory is equipped with two multichannel particle counters (Coulter Counter, model TAII, with X-Y recorder II); a Coulter 550 air contamination counter system that continuously monitors room air to record variations in the concentration of particles with diameters greater than 0.5 micrometers; a Millipore Milli-Q3 in conjunction with the Milli-Q2 water purification system that provides a large quantity of consistently high-quality, filtered, deionized water.

If one wears proper clean-room clothing, the laboratory provides ideal working conditions for measuring particle variations in ice cores. In the new laboratory we have analyzed as many as 130 samples per day, the equivalent of about 5 meters of firn core. Soon we plan to increase the number of daily analyses by adding a computer interface, thus automating the data output.

For the next few years we have established the following objectives:

(1) Develop the microparticle technique for dating cores from temperate as well as polar glaciers and ice caps. After 3 years of work, we have concluded that the microparticle technique has the greatest potential for dating deep ice cores since the annual particle layers are not subject to large-scale diffusion at depth.

(2) Determine the nature and extent of microparticle concentration and size distribution variations during past periods of climatic change. The multichannel particle counters provide more information on the actual nature of the particle population than any other current method, including the laser technique. Since deep ice cores are so expensive to drill and transport, it is prudent to obtain as much information as possible for each sample analyzed. It is particularly necessary to obtain the size distribution for the particle population since this information is valuable to the climatologist.

(3) Determine the elemental composition of microparticles stratigraphically. This also has important climatological implications.

(4) A new and very promising area of investigation is the use of deep ice cores to assess background levels for certain chemicals whose variations are being studied in the atmosphere; i.e., pH and sulfate variations. It is difficult, if not impossible, to evaluate the significance of present variations in these parameters if we do not determine the natural fluctuations of the past.

The microparticle technique will serve as one of the most important tools in future glaciological studies. The results of microparticle studies completed at the Institute of Polar Studies have been presented in three major papers, copies of which are available from us on request:

Thompson, L. G. 1973. Analysis of the concentration of microparticles in ice core from Byrd Station, Antarctica. The Ohio State University Research Foundation, Institute of Polar Studies. *Report*, 46. 34p.

Thompson, L. G., W. L. Hamilton, and C. Bull. 1975. Climatological implications of microparticle concentrations in the ice core from "Byrd" Station, Western Antarctica. *Journal of Glaciology*, 14(72): 433-444.

Thompson, L. G. 1975. Variations in microparticle concentration, size distribution and elemental composition found in the Camp Century, Greenland, and the Byrd Station, Antarctica, deep ice cores. International Union of Geodesy and Geophysics, International Association of Hydrological Sciences, Commission on Snow and Ice Symposium, August 1975, Grenoble, France. *Paper*. 17p.

The upgrading of the scientific equipment in the microparticle laboratory was made possible through National Science Foundation grant OPP 74-22274; renovation of the clean room was made possible through a grant from the Graduate School, The Ohio State University.

Technical support for systematic biology

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In January 1963 the Smithsonian Oceanographic Sorting Center (SOSC) began receiving antarctic specimen collections for processing and distribution to specialists doing systematic and other research. These collections—taken by a variety of planktonic, midwater, and benthic tows, and with grabs and dredges—are primarily marine and encompass about 6,000 samples.* Sampling locations for benthos and pelagic material are shown in figures 1 and 2. National Science Foundation contract C-864 supports the processing of these samples and other activities concerning polar

*"Sample," as used here, refers to a discrete tow or bottom grab. The number of organisms may vary tremendously from sample to sample.

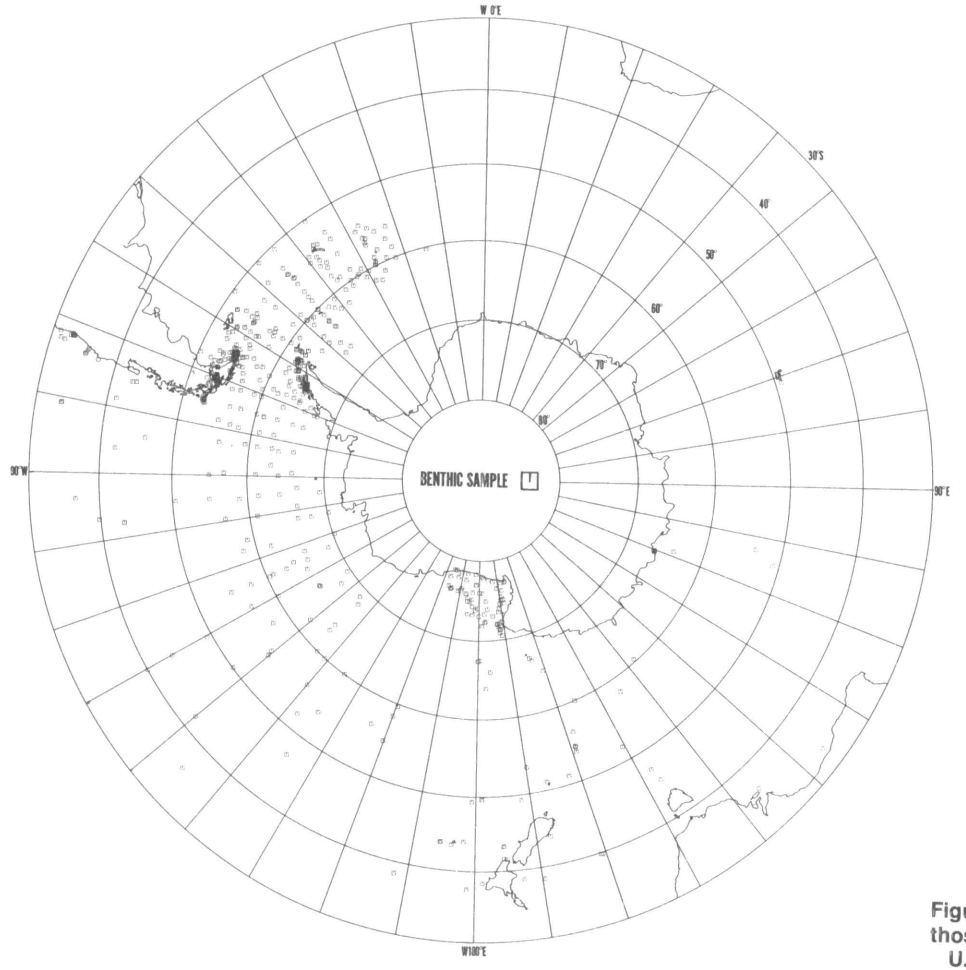

Figure 1. Locations of benthos sampling sites in the U.S. antarctic program.

biological services at SOSC, and the Foundation has designated SOSC as a national, centralized repository and distribution center for data on antarctic natural history collections obtained by U.S. investigators. SOSC stores, documents, duplicates, and distributes antarctic ocean-bottom photographs taken during USNS *Eltanin* and other research vessel cruises. We also have processed arctic biological collections since 1973; about 7,000 samples, mostly zooplankton from the Arctic Ocean, have been received.

Most polar samples are sorted into major taxonomic groups that are labeled and documented in a computer data base. Various taxa have been sent to 186 specialists who requested material for research. During 1974-1975, 12,316 processed specimens including invertebrates, larval and juvenile fishes, and marine algae were sent to 32 specialists. Recently sorted material includes 1,812,166 zooplankton specimens, 1,022,822 benthic invertebrates, 2,363 fishes, and 874 dry-mounted and wet algal specimens.

About 3,650 prints selected from 20,300 antarctic bottom photographs with corresponding station data (Simmons and Landrum, 1973a, 1973b) were shipped to 16 scientists during 1974-1975. To serve scientists who wish to study extensive areas or to examine large numbers of photographs, SOSC loans duplicate negative or positive film of entire cruises or camera stations.

We continue to augment our primary services for antarctic biology by supporting field collections in marine and terrestrial biology. Last spring, in conjunction with the benthic ecology program conducted by the University of Maine, a staffmember participated in *Islas Orcadas* cruise 0575 and sampled fauna around the South Georgia and South Sandwich islands. Benthic invertebrates were preserved and packed, and data were recorded and subsequently shipped to SOSC for further processing and distribution.

Under the program, "Cooperative systematic studies in antarctic biology" (National Science Foundation grant OPP 71-04058), SOSC provides technical and related support to scientists for systematic studies of selected taxa. This project supports studies on isopod crustaceans, copepods, cirripedia, and bacteria. Other groups being eval-

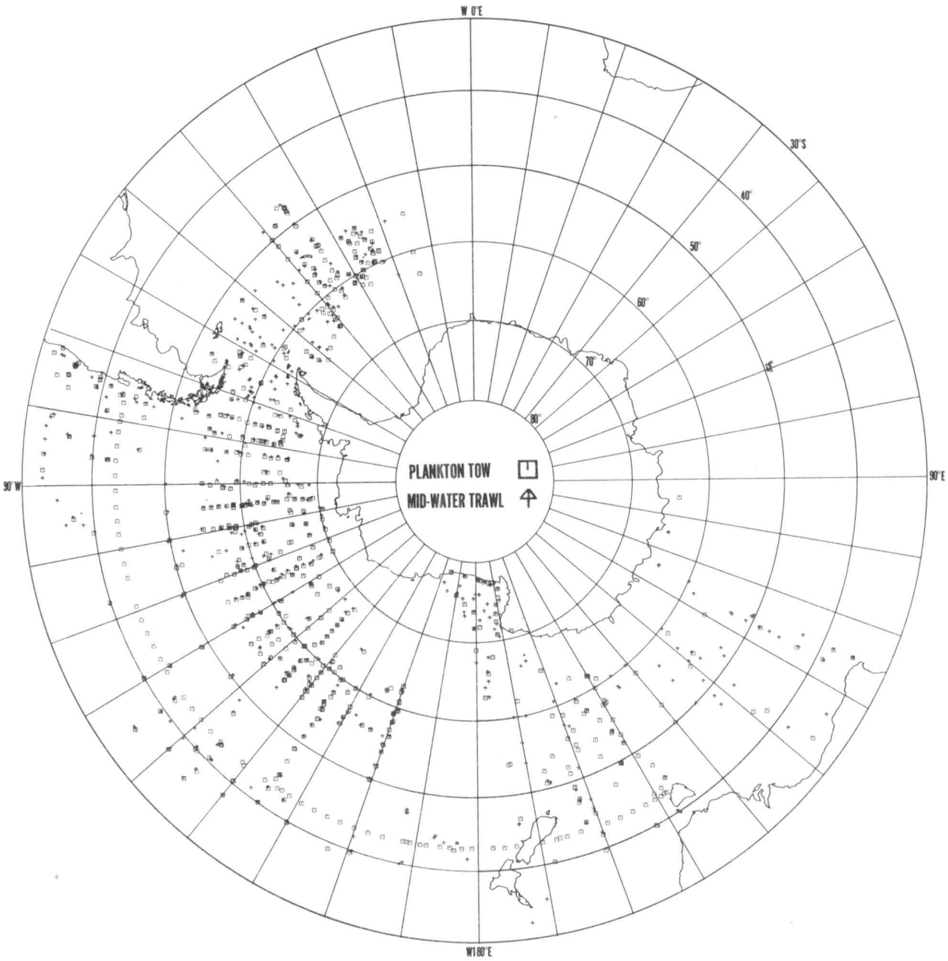

Figure 2. Locations of pelagic sampling sites in the U.S. antarctic program.

uated for study are cheatognaths, sponges, mollusks, shrimps, and euphausiids. Qualified persons interested in this program should contact the Director, sosc, Smithsonian Institution, Washington, D.C. 20650 for further details.

With the near completion of gross sorting of most available materials, we now are concentrating on classifying some abundant and complex taxa (copepods, polychaetes, and coelenterates) to lower levels. This should not only facilitate studies in progress, but it also will enable us to supply specialists with more finely classified material for further studies. For example, copepod specialists usually concentrate on certain families and do not have the time to laboriously pick these families from the tremendous quantity of available material. Trained technicians at sosc now sort to family level and thus encourage and facilitate studies of this and other ecologically vital groups. This will be an ongoing process requiring accumulation of antarctic taxonomic literature and training of technicians to recognize accurately lower-level taxa of these groups.

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Antarctic Marine Geology Research Facility, 1974-1975

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Activities for 1974-1975 at the Antarctic Marine Geology Research Facility and Core Library,

Dry Valley Drilling Project cores stored at −23°C. Rack units are modular and can be reassembled as necessary without the use of connective hardware.

Florida State University (FSU), included distribution, inventory, and maintenance of southern ocean geological specimens. We received more Dry Valley Drilling Project (DVDP) sediment cores, and we completed modifications to the low-temperature (−23°C) storage vault containing DVDP materials, and to the higher-temperature (2°C) vault containing cored, dredged, and other marine sediments retrieved aboard USNS *Eltanin* and similar research vessel cruises.

Other activities included research by Menno Dinkelman, FSU, aboard *Glomar Challenger* during Deep Sea Drilling Project (DSDP) leg 39. Independent research efforts of resident and visiting investigators also continued.

From 1 July 1974 to 30 June 1975, 5,506 piston core and 175 trigger and phleger core samples were distributed from USNS *Eltanin* materials. Also distributed were 33 *Eltanin* grab samples, 64 International Weddell Sea Oceanographic Expedition (IWSOE) piston core samples, and 404 DVDP drill core samples (from holes 4 and 4a, Lake Vanda, and from holes 8 and 9, New Harbor). Samples distributed from 238 individual *Eltanin* piston cores represented 37 of the 55 cruises; 119 individual trigger and phleger core samples represented 12 cruises; grab samples were distributed from 28 stations aboard 10 cruises. Samples were removed from 19 IWSOE piston cores obtained in 1969 and 1970 aboard USCGC *Glacier*. Samples distributed during this period represent a 289-percent increase in sampling effort by the facility over that of 1973-1974 (Cassidy and Wise, 1974). The samples were received by 35 investigators representing 20 foreign and domestic institutions.

Activities related to DVDP during 1974-1975 included the receipt of 266 boxes of frozen P, H, N, and B core (794 meters, 8,985 kilograms) retrieved from holes 10 (New Harbor), 11 Commonwealth Glacier), 12 (Lake Leon), and 13 (Don Juan Pond). Together with previous DVDP sedimentary materials from holes 4, 4a, 5, 6, 7, 8, and 9, a total of 352 boxes of core (about 1,000 meters, 10,000 kilograms) are at the facility. Awaiting shipment to FSU are 68 more meters of core from hole 14 (North Fork), presently stored at McMurdo; this will complete storage of DVDP materials recovered through 1974-1975.

Augmenting the storage capacity of the −23°C vault (figure) was the installation of more rack units with a shelf capacity of 15 cubic meters (about 700 core boxes). This brings the area's storage capacity to about 30 cubic meters (about 1,400 core boxes, presently less than 50 percent of which are in use). Completing the proposed modifications to this vault was the purchase and installation of a backup refrigeration system intended to prevent thawing of ice-cemented DVDP sediments during a power failure.

On 7, 8, and 9 July 1975, the FSU Department of Geology's Antarctic Research Facility hosted the second DVDP core sampling and inspection of materials obtained during the 1974-1975 season in Antarctica. Twelve specialists in polar studies, coordinated by Lyle D. McGinnis, Northern Illinois University, DeKalb, and by Mort D. Turner, National Science Foundation, attended the meeting. The group also included representatives of the University of Washington, Hope College, the University of South Carolina, the U.S. Geological Survey, and Australia's University of New England. Most of the assembly's effort was directed toward discussing results obtained by laboratory analysis of samples collected from the first DVDP cores shipped to the facility, and the coordination of this data with sampling needs from new drill core. Results of this and prior meetings, together with field observations, will be presented at a second DVDP seminar, 13 to 15 January 1976 at Victoria University of Wellington, New Zealand.

Research by faculty and students participating in the curatorial objectives of the FSU Antarctic Research Facility continue to stress the study of southern ocean drill and piston cores obtained during *Glomar Challenger* and *Eltanin* cruises, with emphasis being placed on micropaleontologic and sedimentologic techniques as a means of deciphering the climatologic and oceanographic history of the southern ocean as recorded in marine cores. These activities included presentation of several papers at the Third Planktonic Conference, Kiel, Germany. Paul F. Ciesielski (Ciesielski, 1974c) presented a comprehensive silicoflagellate biostratigraphic zonation for southern ocean assemblages ranging in age from early Oligocene to Recent. Also described was the derivation of a highly accurate silicoflagellate paleotemperature curve applicable to southern ocean Plio-Pleistocene assemblages (Ciesielski, 1974a; also see Ciesielski, 1974b, 1975b). This curve was instrumental in defining a Pliocene "interglacial" in Antarctica (Weaver and Ciesielski, 1974; also see Ciesielski and Weaver, 1974). Further marine evidence for antarctic interglacials, using diatoms as indicators of such events, was reported in Gombos (1974).

Studies of Neogene radiolarian and calcareous nannofossil zonations continue to emphasize correlations between biostratigraphic zones and paleomagnetic time scales (Weaver, 1975; Miyajima, 1975b, 1975c). Calcareous nannofossils have been particularly useful in dating major unconformities in *Eltanin* cores (Constans, 1975; Miyajima, 1975a), as well as in defining high-latitude paleoecological provinces (Wind, 1975). These biostratigraphic dating schemes are correlated with isotopic dating techniques being refined through a new procedure of uranium extraction from sediments, as introduced by Dysart and Osmond (1975).

Researchers at the Antarctic Research Facility are also interested in studying postdepositional diagenetic changes in antarctic marine sediments, particularly the conversion of carbonate and siliceous oozes to chalks and chert. These studies have provided insight into the interpretation of diagenetic events in the southern ocean and elsewhere (Wise *et al.*, 1974; Wise and Weaver, 1974; Weaver and Wise, 1975; Roth *et al.*, 1975).

Participation in the three antarctic cruises of the DSDP vessel *Glomar Challenger*, as well as later cruises, has been oriented toward continuation of the research and curatorial objectives of the circumpolar survey begun by *Eltanin* and resumed by ARA *Islas Orcadas*. Seventeen site reports and research papers were contributed to Volume 28 of the *Initial Reports of the Deep Sea Drilling Project* for *Glomar Challenger* cruise 28 in the Ross Sea and to the south of Australia (Hayes *et al.*, 1975). Topics include diatom, silicoflagellate, and palynomorph biostratigraphy of the southern ocean, and a variety of sedimentary studies. Research papers on cruise 35 (Bellingshausen Sea) are in press, and research investigations aboard cruise 36 (Falkland Plateau and South Georgia Basin) are in preparation.

Of particular importance to our curatorial program has been research by three members of the Antarctic Research Facility that involves drill core sediments retrieved aboard DSDP cruise 36, which was in the area that is to be charted by the first marine geology coring cruise of *Islas Orcadas*. These studies, together with similar studies of sedimentary materials recovered in this area by *Eltanin, Vema,* and *Conrad* cruises, have provided a basis for the selection of piston coring stations to be attempted by *Islas Orcadas*.

Supplementing the Antarctic Research Facility's collection of cores from the Falkland Plateau area will be several piston cores that are to be taken from aboard the British vessel *Shackleton*. These cores will be a valuable asset to existing materials; samples will be available upon request to all researchers.

This work was supported by National Science Foundation contracts C-564 and C-1059.

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Cartographic activities, 1974-1975

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The first objective of topographic mapping in the U.S. Antarctic Research Program is to produce 1:250,000-scale maps with 200-meter contours for all the mountainous and coastal areas of West Antarctica. To date, the U.S. Geological Survey (USGS) has published 81 of these maps covering about 872,000 square kilometers. Seven more 1:500,000-scale sketch maps covering about 860,000 square kilometers have been published in an interim series to meet needs of the antarctic program.

Four maps in the 1:250,000-scale series have recently been issued; these cover the Hobbs Coast area of Marie Byrd Land, Grant Island, Cape Burks, Hull Glacier, and Mount Berlin. Five other maps—Mount Kosciusko, McCuddin Mountains, Dean Island, Mount Takahe, and Crary Mountains—have been compiled and are scheduled for publication in 1975-1976. A special-purpose map covering the McMurdo Sound region (76° to 80°S., 152° to 180°E.) at a scale of 1:1,000,000 on the International Map of the World (IMW) format also will be published during 1975-1976. Twelve maps in the 1:250,000-scale series are in various stages of compilation; work on all but the five most nearly completed sheets has been deferred because of lack of funds. Work on the Palmer Land sketch map (scale of 1:500,000) has also been deferred.

Large-scale engineering plans (1:600 scale, 2-foot contours) for the McMurdo Station complex are being compiled to support long-range planning of station needs. The 26 sheets (each about 100 by 70 centimeters) will not be published. Four manuscript maps at a scale of 1:50,000 (contour interval of 165 feet), covering the Dufek Massif and Saratoga Plateau areas, were compiled in support of the proposed USGS deep drilling project. Although none of these manuscripts are to be printed, photographic copies are available upon request at $6 each for the 1:600 sheets and at $7.50 each for the 1:50,000 sheets; ozalid copies can be supplied at about a fifth of the photocopy prices. Requests should be sent to the National Cartographic Information Center, U.S. Geological Survey, 507 National Center, Reston, Virginia 22092.

Attempts to prepare eight orthophotomaps at a scale of 1:50,000 for the dry valley area of southern Victoria Land were unsuccessful. The extreme range of relief differences is too much for available instruments to rectify without excessive image distortions. It therefore is impossible to meet the objectives of the original research proposal. Although the orthophotoimage cannot be published, the eight component topographic maps will probably be published in 1976-1977.

Under joint funding by the National Science Foundation and the National Aeronautics and Space Administration, cartographic experiments with LANDSAT-1 satellite imagery continued during 1974-1975. Products completed and awaiting publication include the following: a 1:1,000,000-scale satellite image mosaic of the McMurdo Sound region, a companion to the IMW map; a 1:1,000,000-scale satellite image mosaic of Victoria Land; single-scene satellite image maps of the dry valley region at scales of 1:500,000 and 1:250,000.

Image products currently being compiled include a 1:500,000-scale satellite image mosaic of the Ellsworth Mountains area and a 1:1,000,000-

scale satellite image mosaic of the Thurston Island-Jones Mountains area. LANDSAT imagery is also being used as a revision tool for compilation and revision of medium- and small-scale maps of antarctic coastal regions.

Polar Research Board, 1974-1975

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The Polar Research Board (PRB), formerly the Committee on Polar Research (see July/August 1975 *Antarctic Journal,* page 203), was established in 1958 by the National Academy of Sciences. It advises the United States on research in the polar regions and it adheres to the Scientific Committee on Antarctic Research (SCAR) of the International Council of Scientific Unions (ICSU) on behalf of the National Research Council. James H. Zumberge is PRB chairman and serves as U.S. delegate to SCAR. The work of PRB is supported by the National Science Foundation (NSF) and the Office of Naval Research (ONR).

The 36th PRB meeting was held in Jackson Hole, Wyoming, on 6 September 1974, and its 37th meeting was in Fairbanks, Alaska, on 1-2 April 1975. The Fairbanks meeting was followed by a field trip to the North Slope (3-4 April 1975). Five PRB panels and five *ad hoc* study groups held meetings, including four workshops. Members also participated in eight meetings of SCAR working groups, and in eight international conferences.

Major PRB activities planned for 1975-1976 include (1) preparing a comprehensive science program for the proposed Nansen Drift Station, (2) assessing NSF's role in the Arctic with recommendations for future directions, and (3) hosting an international conference on living marine resources of the southern ocean.

International activities

On behalf of the National Research Council, PRB hosted the Third SCAR/International Union of Biological Sciences (IUBS) Symposium on Antarctic Biology in Washington, D.C., on 26 to 30 August 1974, and the XIII Meeting and Plenary Sessions of SCAR in Jackson Hole, Wyoming, on 3 to 7 September 1974. Reports on the symposium and meeting were in the January/February 1975 *Antarctic Journal* (pages 30-31 and 26-29).

Symposium on Remote Sensing in Glaciology and meetings of the SCAR working group on glaciology, the International Antarctic Glaciological Project (IAGP), and the International Glaciological Society, 15 to 28 September 1974, Scott Polar Research Institute, Cambridge, England. Colin B. Bull, Charles R. Bentley, and Wilford F. Weeks represented PRB at these meetings.

International Coordination Group for Southern Oceans (IOC), 15 to 20 July 1974, Buenos Aires, Argentina. Sayed Z. El-Sayed represented PRB and SCAR at the meeting.

Second International Polar Experiment (POLEX) Planning Conference, 20 September to 4 October 1974, Norsk Polarinstitutt, Oslo, Norway. Members of the joint POLEX panel (D. James Baker, Jr., Norbert Untersteiner, William J. Campbell, Knut Aagaard, W. Lawrence Gates, Gunter E. Weller, and J. S. Winston) participated in discussions of POLEX, a subprogram of the Global Atmospheric Research Program (GARP).

SCAR group of specialists on marine living resources of the southern ocean, 6 to 8 October 1975, Cambridge, England. Dr. El-Sayed, group convener, and Donald L. Siniff participated in the meeting, which was held in response to an invitation from the Eighth Antarctic Treaty Consultative Meeting for advice on antarctic marine living resources. The meeting laid the groundwork for a larger international conference on marine living resources of the southern oceans to be held in the United States in mid-1976.

Domestic activities

Polar Research Board, 4 September 1974, Jackson Hole (36th meeting). The meeting's agenda included the following: A. N. Fowler reported on recent developments in NSF's Office of Polar Programs; U. Radok discussed the emerging NSF climate dynamics program; Dr. Weeks reported on the status of the Arctic Offshore Program; T. L. Péwé recommended that the *ad hoc* permafrost study group be disbanded and that a new standing panel or committee on permafrost be formed; Drs. Baker, Weller, Radok, and E. F. Roots reviewed the POLEX-North and POLEX-South programs, the Arctic Ice Dynamics Joint Experiment (AIDJEX), and the International Southern Ocean Study (ISOS); Dr.

El-Sayed and V. T. Neal reported on the second session of the IOC International Coordination Groups for the Southern Oceans, held in Buenos Aires on 15 to 20 July 1975; C. Craddock reported on plans for the Third SCAR/International Union of Geological Sciences Symposium on Antarctic Geology and Geophysics; R. H. Rutford and B. L. Hansen discussed the Ross Ice Shelf Project (RISP); W. S. Benninghoff and Dr. El-Sayed reported on the Third SCAR/IUBS Symposium on Antarctic Biology; Dr. El-Sayed reviewed a meeting of the SCAR subgroup on marine living resources; Dr. Benninghoff discussed the International Aerobiology Program; Dr. Bentley reported on IAGP; Drs. Bull and Zumberge discussed a proposal for disposing nuclear wastes in polar ice sheets; Dr. Weeks reported on the forthcoming Symposium on Remote Sensing in Glaciology, held at Scott Polar Research Institute on 15 to 21 September 1974.

Polar Research Board, 1-2 April 1975, Geophysical Institute, University of Alaska, Fairbanks (37th meeting). The agenda included reports on research by the University of Alaska, including the Geophysical Institute (K. B. Mather), the Institute of Marine Sciences (D. H. Hood), the Center for Social, Economic and Governmental Research (V. Fischer), the Institute of Arctic Biology (G. C. West), the Arctic Environmental Information and Data Center (D. M. Hickok), and the Naval Arctic Research Laboratories (W. W. Denner); reports on the trans-Alaska pipeline (R. Ellis, W. B. Parker, and O. G. Simpson); reports by W. B. Parker and R. Weeden on Alaska's concerns on oil and gas development; reports on Canadian programs by E. F. Roots and G. D. Hobson on the MacKenzie Valley pipeline inquiry, on the Canadian Beaufort Sea Project, and on the Polar Continental Shelf Report; report by Dr. Untersteiner on AIDJEX; reports on the Arctic Offshore Program by Dr. Weeks and J. E. Heg; a report on the Bureau of Land Management/National Oceanic and Atmospheric Administration (BLM/NOAA) Alaska Outer Continental Shelf Program by W. H. Hess; a report by Dr. Péwé on recent activities of the permafrost panel, including the formation of *ad hoc* study groups on offshore permafrost and the Alaska pipeline, and sponsoring a workshop on the trans-Alaska pipeline; reports by Drs. Baker, Untersteiner, and W. W. Kellogg on POLEX, ISOS, and on the International Study Conference on the Basis of Climate and Climate Modeling; a report by Mr. Heg on plans for the Eighth Antarctic Treaty Consultative Meeting, held in Oslo, Norway, on 9 to 20 June 1975; a report by Mr. Fowler on recent activities of the Office of Polar Programs.

In executive session, PRB was briefed on the restructuring of the National Research Council. Reorganizing of PRB was discussed, and its executive committee was asked to prepare a plan. Members were requested to submit nominations for new PRB members to replace retiring ones. Comments were heard on the permafrost panel's reports, *Problems and Priorities for Offshore Permafrost Research* and *Opportunities for Permafrost-Related Research Associated with the Trans-Alaska Pipeline System.* Concern was expressed over the apparent lack of a clear U.S. position on mineral and marine living resource exploitation of Antarctica. A report from SCAR's working group on glaciology opposing the disposal of nuclear wastes in Antarctica was approved. The executive secretary was instructed to notify the SCAR secretariat that PRB preferred the dates of 20 to 30 October 1976 for the XIV SCAR meeting. A unanimous resolution was approved that chairman Zumberge, whose term of service was due to expire in December 1975, be asked to continue as chairman for another 2 years and that National Research Council approval be sought.

Field trip, 3-4 April 1975, North Slope of Alaska. The board and its panel on permafrost participated in a fact-finding trip to Alaska's North Slope to familiarize themselves with (1) the Naval Arctic Research Laboratory, (2) the Native Arctic Slope Regional Corporation, (3) the AIDJEX main experiment (then in progress), and (4) the oil development activities at Prudhoe Bay and offshore.

Joint PRB/GARP/Committee on Atmospheric Sciences/Ocean Science Board Polar Experiment (POLEX) panel. The panel report, *U.S. Contribution to the Polar Experiment (POLEX), Part II: POLEX-GARP (South),* was issued in January 1975.

Panel on permafrost, 7 December 1974, National Academy of Sciences. The panel was organized in December 1974 in response to a request from NSF and the Interagency Arctic Research Coordinating Committee (IARCC). Two study groups were established: the *ad hoc* Alaska pipeline study group was charged with developing a document identifying permafrost research opportunities associated with the trans-Alaska pipeline; the *ad hoc* study group on offshore permafrost was charged with developing a definitive program for arctic offshore permafrost research. The panel formulated a resolution for PRB consideration, calling the attention of the Secretary of the Interior to the unique research opportunities available during construction of the trans-Alaska pipeline.

Panel on permafrost, 31 March to 1 April 1975, University of Alaska, Fairbanks. The meeting's agenda included the following: discussion of offshore permafrost studies; review and approval of the report; *Problems and Priorities in Offshore Permafrost Research;* a report on the trans-Alaska Oil Pipeline Workshop; discussion and approval of the report, *Opportunities for Permafrost-Related Research Associated with the Trans-Alaska Pipeline System;* discussion of Alyeska's archeological program associated with construction of the trans-Alaska pipeline and approaches for relating this activity to the report's recommendations; review of plans for the Third International Conference on Permafrost, Canada, 1977; resolution supporting the Building Research Advisory Board's recommendations for translating Soviet papers from the Second International Conference on Permafrost.

Ad hoc *Alaska Pipeline study group, 19 to 23 March 1975, Scottsdale, Arizona.* The ad hoc Alaska pipeline study group held a workshop and prepared a report, *Opportunities for Permafrost-Related Research Associated with the Trans-Alaska Pipeline System.* Workshop participants included representatives from industry, Federal agencies, universities, and the State of Alaska.

Ad hoc *study group on offshore permafrost, 16 December 1974, Menlo Park, California, and 20-21 January 1975, Calgary, Manitoba, Canada.* The *ad hoc* study group prepared the report, *Problems and Priorities in Offshore Permafrost Research.* It reviews the need for permafrost research in the Beaufort Sea region in light of emerging offshore oil exploration and exploitation.

Ad hoc *study group on snow research and control, 21-22 February 1975, Fort Collins, Colorado.* The *ad hoc* study group was established to formulate a general strategy for snow research and control. The study group is preparing a report stating the importance of snow research and providing a focus for future snow research in the United States and Canada. A three-person writing group met 18-19 June 1974 in Tacoma, Washington, to prepare a final draft.

Ad hoc *study group on glaciers and ice sheet sliding, 14 January 1975, Hanover, New Hampshire.* The *ad hoc* study group has been preparing a report on the research required to better understand glacier and ice sheet sliding.

Ad hoc *committee on the Fridtjof Nansen Drift Station, 11 August 1975 and 3 to 5 November 1975, Washington, D.C.* The *ad hoc* committee was established to formulate a sound and comprehensive research program to maximize the return on the proposed Nansen Drift Station, Eurasian Basin, Arctic Ocean. The committee met 11 August 1975 to consider its terms of reference and to plan for a workshop scheduled for 3 to 5 November 1975 at the National Academy of Sciences.

During 1974-1975, PRB issued the following reports:

Priorities for Basic Research on Permafrost.

Earth Science Investigations in the U.S. Antarctic Research Program (USARP) for the Period July 1, 1973-June 30, 1974.

Abstracts, Third SCAR/IUBS Symposium on Antarctic Biology, August 26-30, 1974.

Documents of XIII Meeting of SCAR.

U.S. Antarctic Research Activities, 1974-75 and U.S. Antarctic Research Activities Planned for 1975-76 (report 17 to SCAR).

Opportunities for Permafrost-Related Research Associated with Trans-Alaska Pipeline System.

Most of the above reports, including those mentioned earlier, are available from the Polar Research Board, National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418.

Antarctic Map Folio Series

VIVIAN C. BUSHNELL
Research Publications
American Geographical Society
New York, New York 10032

After the December 1974 publication of Folio 18, "Antarctic mammals," effort was concentrated on preparation of Folio 19, the final number of the *Antarctic Map Folio Series.*

Folio 19, "History of antarctic exploration and scientific investigation," was published in October 1975. One of the fifteen plates in the folio is devoted to early concepts of Antarctica dating back to A.D. 43. Eight of the plates are maps showing tracks of exploratory voyages, airplane flights, and inland traverses from 1772 to 1954. On the map plates are brief highlights of the expeditions. The six remaining plates are devoted to accomplishments from 1954 to 1975, and include maps of traverses and locations of science stations in operation each year.

A discussion of human motivations for antarctic exploration, by Henry M. Dater, opens the folio. The rest of the folio was prepared by the staff of the American Geographical Society. A bibliography of the 280 sources used is included.

All folios, except the second, are available. Folio 2, which is out of print, may be obtained on color microfilm. To celebrate the series' completion, a special discount is being offered for single purchases of five or more folios (see September/October 1975 *Antarctic Journal,* page 285). All may be purchased directly from the American Geographical Society, Broadway at 156th Street, New York, New York 10032.

Antarctic Research Series and *SAE Information Bulletin*

JUDY C. HOLOVIAK
American Geophysical Union
Washington, D.C. 20006

The first title of the *Antarctic Research Series* to be published under the new format (see November/December 1974 *Antarctic Journal*, page 328) was released last August. Papers in Volume 23, *Biology of the Antarctic Seas V*, and Volume 24, *Meteorological Studies at Plateau Station, Antarctica*, are in production.

Birds of the Antarctic and Sub-Antarctic, the first handbook in the series, was released in December.

Soviet Antarctic Expedition Information Bulletin. translations continue to provide intermittent reports from Soviet antarctic scientists. Volume 8 (bulletins 79 through 90) is in progress.

Information on subscriptions and on purchases of back volumes, for both *Antarctic Research Series* and *Soviet Antarctic Expedition Information Bulletin*, is available from the American Geophysical Union, 1909 K Street, N.W., Washington, D.C. 20006.

Publication of *Antarctic Research Series* and translation and publication of *Soviet Antarctic Expedition Information Bulletin* are supported by National Science Foundation grants GN-55 and GV-32923.

Selected titles from recent antarctic literature

GEZA T. THURONYI
Science and Technology Division
Library of Congress
Washington, D.C. 20540

Bibliographic coverage of international antarctic literature continued at the Library of Congress during 1974-1975. Publication of *Current Antarctic Literature* was maintained on a monthly schedule, with author and subject indexes issued every 4 months. *Antarctic Bibliography* Volume 7, 1975, is available from the Superintendent of Documents, U.S. Government Printing Office, for $9.15 (stock number 030-018-00016-8).

In an earlier account (Thuronyi, 1971), some of the periodicals most frequently containing papers dealing with the Antarctic were listed. That list is still largely valid. Some nonperiodical publications received and abstracted recently are listed below: technical, historical, and popular books, major reports of activities and scientific results, conference proceedings, doctoral theses, etc. Because of space limitations, the list below is limited to a sampling of original publications with 1974 or 1975 imprints. Parenthetical numbers following each citation refer to the *Antarctic Bibliography* (or *Current Antarctic Literature*), where more complete citations and abstracts may be found:

Akademii nauk SSSR, Institut Okeanologii. 1974 (in Russian). Biological research in the Atlantic sector of the Antarctic. *Trudy*, 98. 312p. (B-14978)

American Geographical Society, 1974. Antarctic mammals. *Antarctic Map Folio Series*, 18. 19+11p. (B-14792)

Brent, P. 1974. *Captain Scott and the Antarctic Tragedy*. New York, Saturday Review Press. 223p. (A-15361)

California, University of. Scripps Institution of Oceanography. 1975. *Initial Reports of the Deep Sea Drilling Project*, volumes 28 and 29. Washington, D.C., U.S. Government Printing Office. 1017 and 1197p. (E-15502, E-15136).

Cameron, I. 1974. *Antarctica: the Last Continent*. Boston, Little, Brown. 256p. (A-14893)

Cazal, F. 1974 (in French). Medical aspects of French expeditions to the Antarctic and Subantarctic. Paris, TAAF. 90p. *M.D. thesis*. (H-15071)

Driatskii, V. M. 1974 (in Russian). Nature of anomalous absorption of cosmic radio emission in the low ionosphere at high latitudes. Leningrad, Gidrometeoizdat. 224p. (K-14752)

Feeney, R. E. 1974. *Professor On the Ice*. Davis, Pacific Portals. 164p. (B-15227)

Foster, M .W. 1974. Recent antarctic and subantarctic brachiopods. *Antarctic Research Series*, 21. 189p. (B-14509)

Gram, R. 1974. Mineralogical changes in antarctic deep-sea sediments and their paleo-climatic significance. Tallahassee, Florida State University. *Ph.D thesis*. 289p. (J-15059)

Gunderson, E. K. E. (editor). 1974. Human adaptability to antarctic conditions. *Antarctic Research Series*, 22. 131p. (H-15099)

Hughes, T. 1974. Is the West Antarctic Ice Sheet disintegrating? *ISCAP Bulletin*, 3. 93p. (F-14820)

Immel, R. L. 1975. Uranium isotope geochemistry of micromanganese nodules and related sedimentary components from southern ocean pelagic sediments. Tallahassee, Florida State University, Sedimentological Research Laboratory. *Contribution*, 40. M.S. thesis. 128p. (E-15191)

Jacobs, S. S., *et al.* 1974. Eltanin *Reports, Cruises 37-50, 52-55*. Columbia University, Lamont-Doherty Geological Observatory. TR CU-2-74. 502p. (J-14700)

Karaslavov. S. G. 1974 (in Bulgarian). *Antarctica: White and Blue*. Sofia. 152p. (A-14890)

Mateev, A. K. 1974 (in Russian). *Coal Deposits Abroad: America, Antarctica*. Moscow, Nedra. 234p. (A-15496)

Mountfield, D. 1974. *History of Polar Exploration*. New York, Dial. 208p. (A-15182)

Nagata, T. (editor). 1974. Proceedings of antarctic review meeting. Tokyo, National Institute of Polar Research. *Memoirs*, special issue 3. 83p. (K-13865)

National Science Foundation. 1974. *Survival in Antarctica*. 87p. (G-14609)

Neider, C. 1974. *Edge of the World, Ross Island, Antarctica*. Garden City, Doubleday. 461p. (A-14156)

Petrov, I. G. (editor). 1974 (in Russian). 16th Soviet Antarctic Expedition, wintering research, general account and scientific results. *Trudy*, 62. 248p. (D-15269)
Savours, A. (editor). 1974. *Scott's Last Voyage—Through the Antarctic Camera of Herbert Ponting.* London, Sidgwick & Jackson. 160p. (A-14549)
SCAR/IUPS/IUBS Symposium on Human Biology and Medicine in the Antarctic. Cambridge, 1972. 1974. *Proceedings.* London, W. Heinemann. 433p. (H-14084)
Schatz, G. S. (editor). 1974. *Science, Technology, and Sovereignty in the Polar Regions.* Lexington, D.C. Heath. 215p. (M-14533)
Scripps Institution of Oceanography. 1975. *Initial Reports of the Deep Sea Drilling Project*, 28 and 29. Washington, D.C., U.S. Government Printing Office. 1017 and 1197p. (E-15502, E-15136)
Shimizu, H. (editor). 1975. Glaciological research program in Mizuho Plateau, west Enderby Land, East Antarctica. Part 2, 1969-1973. *JARE data reports,* 26. 235p. (F-15309)
Stonehouse, B. (editor). 1975. *Biology of Penguins.* Baltimore, University Park. 555p. (B-14850)
Symposium on Antarctic Biology, Third, Washington, D.C. 1974. *Adaptations Within Antarctic Ecosystems.* Washington, D.C., NAS. 98p. (volume of abstracts, full proceedings in preparation). (B-13919)
Tillson, D. D., *et al.* 1974. *High-Level Radioactive Waste Management Alternatives,* 3. Battelle Memorial Institute. 278p. (G-13847)
U.S. Navy Task Force 199. 1975. *Report of Antarctic Development Squadron Six; Operation Deep Freeze '75.* (G-14966)
U.S. Navy Task Force 199. 1975. *Report of Operation Deep Freeze '75, 1974-75.* 110p. (G-15499)

The above citations are intended as examples of the various types of nonperiodical literature available on the Antarctic. They are given here to induce some readers to a more thorough study of antarctic literature. *Antarctic Bibliography* is on sale by the U.S. Government Printing Office, and *Current Antarctic Literature* is available free to researchers or libraries with antarctic interests who ask to be on the mailing list by writing to the Office of Polar Programs, National Science Foundation, Washington, D.C. 20550.

Reference

Thuronyi, G. T. 1971. Continuing control of antarctic literature. *Antarctic Journal of the U.S.*, VI(6): 249-250.

News and notes

Third Hercules damaged at dome C

A third U.S. antarctic program ski-equipped LC-130 Hercules airplane was substantially damaged on 4 November during takeoff at dome C (74°30′S. 123° 10′E.). There were no injuries to those aboard the airplane.

The mishap occurred in the midst of preliminary efforts to recover two other LC-130s that were damaged at the same site last January (see March/April 1975 *Antarctic Journal,* page 61).

A JATO (jet-assisted takeoff) cannister apparently broke from its attachment points during the dome C takeoff of LC-130 number 148320; when it was fired, the canister charged ahead of the

U.S. Navy

LC-130 148320 at dome C on 16 November 1975, 12 days after the airplane was damaged during takeoff.

U.S. Navy

Despite a surprise squall with blowing snow whipped by winds gusting to 25 meters per second, LC-130 159130, with 14 passengers and over 6 metric tons of cargo aboard, arrived safely at McMurdo's annual ice runway on 2 September 1975. Shown above shortly after arrival, this was the 1975-1976 U.S. antarctic program's first flight to the Antarctic. This and four more "Winfly" (winter fly-in) turnaround flights between Christchurch, New Zealand, and McMurdo Station delivered a total of 146 passengers and 17,428 kilograms of fresh supplies, mail, and other cargo by 5 September. Nine passengers and 7,000 kilograms of cargo were transported north during Winfly, which each year helps to get a head start on the coming field season. The airplanes were flown by U.S. Navy Antarctic Development Squadron Six.

airplane, striking the number 3 engine and propeller. A shower of debris pierced the airplane's fuselage in several places and severed essential electrical wiring. The airplane was not airborne when the incident occurred.

The disabled airplane's crew was picked up almost immediately and returned to McMurdo Station, about 1,150 kilometers away, by one of the U.S. antarctic program's two remaining LC-130s. Left behind at the dome C camp were 14 persons associated with the planned effort to recover the two airplanes damaged earlier. These people were temporarily evacuated on 16 November.

The use of JATO at dome C is often necessary because of the site's altitude (3,214 meters), temperatures (summer average of −30°C), and snow conditions (rough, wind-hardened snow). To lessen the effects of these conditions, on 7-8 December 17 persons of U.S. Naval Support Force, Antarctica, were flown in three flights back to dome C with a snow plane with which to construct a relatively smooth skiway. Once built, the skiway would shorten the takeoff run and would alleviate the rough, airplane-jarring effects of an unprepared runway. The snow plane was originally scheduled to be delivered to dome C on the flight following that of the 320 accident in early November.

According to plans, once the skiway is completed, repair crews of U.S. Navy Antarctic Development Squadron Six (VXE-6) will replace the damaged engine and propeller and make temporary repairs to the punctured airplane fuselage. The airplane then will be flown back unpressurized to McMurdo Station, and from there on to Christchurch, New Zealand, for more extensive repairs.

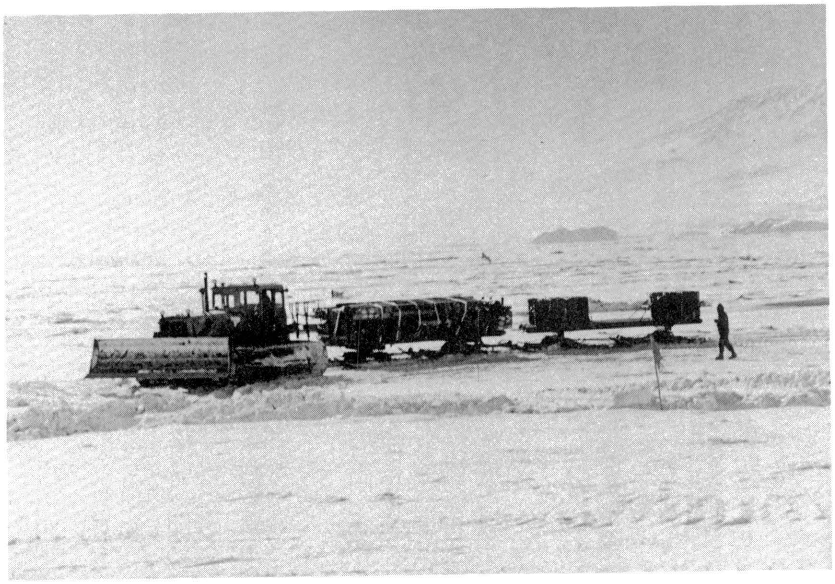
This latest dome C accident forced the cancellation of several planned 1975-1976 U.S. antarctic program field science projects, and the general curtailment of U.S. station operations. Much of the annual resupply of Amundsen-Scott South Pole Station was accomplished ahead of schedule in November, thereby permitting the two remaining ski Hercules to concentrate on the hazardous dome C recovery efforts. The season's first flight to Siple Station was made on 5 December, delivering essential supplies.

DVDP drilling stopped

Coring operations at Dry Valley Drilling Project (DVDP) site 1(a) on the west side of McMurdo Sound ended 21 November due to a combination of potentially unsafe conditions.

Having reached a total depth of 187.99 meters below the surface of the 2-meter-thick McMurdo Sound ice, drilling at site 1(a) was stopped when an international team of geologists and geochemists discovered 38 percent methane in gas obtained from some unconsolidated core, and an increase in temperature and temperature gradient. The methane was detected at 187 meters below sea level.

According to the *Manual on Pollution-Prevention and Safety in Connection with the JOIDES Deep Sea Drilling Project* (second revised edition, 4 February 1972), also used as a guide for DVDP operations, these gas and temperature factors indicated that further penetration could threaten the safety of the drill team.



U.S. Navy

Part of the second of two tractor trains that set out from McMurdo Station on 29 October 1975 to deliver equipment and supplies to Dry Valley Drilling Project site 1(a), 115 kilometers distant.

Other factors considered in deciding to stop drilling included the development of radial and a few annular cracks in sea ice near the drill site, and the development of some large working cracks in the annual ice starting at Marble Point and at Cape Bernacchi. These large cracks were traced to within 8 kilometers of the site before they passed into open water.

The decision to cease drilling was made by project manager Samuel B. Treves, professor of geology and department chairman at the University of Nebraska, Lincoln, with the concurrence of project drilling superintendent J. Hoffman, senior technical officer for the N.Z. Department of Scientific and Industrial Research's Geophysical Division, and project geologist, P. Barrett, director of the Antarctic Research Centre and senior lecturer at Victoria University of Wellington, New Zealand.

In its fifth season, DVDP is a cooperative deep-earth sampling program of Japan, New Zealand, and the United States. Its goal is to to better understand the Cenozoic geologic history of the Murdo Sound region. Fourteen earlier sites yielded core from land-based locations in the ice-free valleys of southern Victoria Land and on Ross Island. Site 1(a) was the project's first seafloor operation, using the annual ice (so called because it forms and dissipates annually) of McMurdo Sound as a platform for the drill rig and 20-person camp. Drilling at site 1(a), which began on 7 November, revealed new information on the area's subsurface geology, bottom fauna, bathymetry, and characteristics and behavior of annual ice.

The drill rig was dismantled, and essential components of the rig and camp were returned by helicopter to McMurdo Station, about 115 kilometers from site 1(a). This operation was complete by 1 December.

DVDP is partially supported by a contract from the National Science Foundation, with logistics support in the field being carried out by the U.S. Naval Support Force, Antarctica, by the Navy's Antarctic Development Squadron Six, and by Holmes and Narver, Inc. The 15-person N.Z. drill team is furnished by the N.Z. Antarctic Research Program, and the United States purchased the drill rig and all field equipment and supplies. Japan supplied the analytical instruments used to evaluate the core at McMurdo Station.

Update on Erebus

The lava lake in Mount Erebus' inner crater has increased in size since the 1974-1975 austral summer. This observation was made by four N.Z. scientists who camped near the volcano's 3,794-meter summit on Ross Island from 30 November to 7 December 1975.

Last season the lava covered only part of the northern half of the inner crater, moving along a curved path originating at the eastern end and disappearing in a tunnel at the western end. A 14-person French-N.Z.-U.S. team made the observations during 1974-1975, and actually attempted unsuccessfully to enter the inner crater.

According to P. R. Kyle, Victoria University of Wellington, New Zealand, and W. F. Giggenbach, Chemistry Division, N.Z. Department of Scientific and Industrial Research, lava now fills the entire northern half of the inner crater with the previously circular movement having been replaced by a series of overlapping areas where lava is welling up. An average of about two explosions per day were heard in the camp area; they appeared to be less violent, and were characterized by a more prolonged, whooshing noice compared to the short, sharp bangs heard during last season's visit.

Only small pools of lava were observed 3 years ago. Since then a steady expansion in the area of exposed lava has taken place. Each year the field teams have been flown to the summit in UH-1N helicopters operated by U.S. Navy Antarctic Development Squadron Six.

Notice to readers

With its next issue (Volume XI, number 1), ***Antarctic Journal*** **will be published quarterly rather than bimonthly. Issues will appear in March, June, September, and December of each year. This change is expected to reduce production costs, particularly in binding and mailing. There is no planned reduction in content. Subscription rate adjustments will be announced in the March 1976 issue.**

Correction

The second paragraph in "Snow accumulation along the Mirnyy-Vostok profile, 1970 through 1973" (March/April 1975 *Antarctic Journal,* page 57) is corrected to read as follows: "Snow accumulation sharply decreases inland, from 170 centimeters of snow at kilometer 25 to 25 centimeters of snow at about kilometer 230; it persists at this level until about kilometer 370, when it begins to increase to 40 centimeters by about kilometer 430 and then gently decreases to 7 centimeters in the Vostok area. The average density of snow decreases inland from 0.36 to 0.32 grams per cubic centimeter."

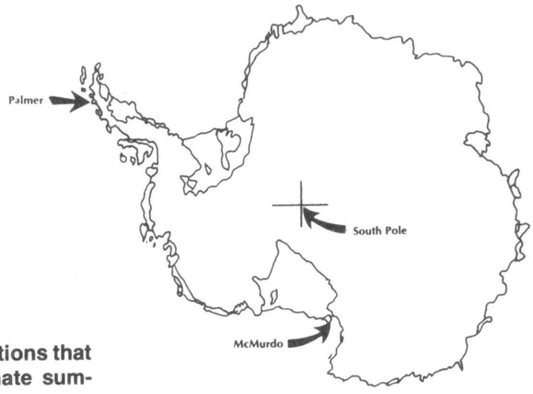
U.S. Navy

A University of Maine, Orono, field party member emerges from the group's camp in the dry valleys during the 1975-1976 austral summer. Under the direction of George H. Denton, the team is studying the Late Cenozoic glacial history of East Antarctica.

Monthly climate summary

Feature	September 1975 McMurdo (date)	September 1975 Palmer* (date)	September 1975 South Pole (date)	October 1975 McMurdo (date)	October 1975 Palmer* (date)	October 1975 South Pole (date)
Average temperature (°C)	−25.4	−4	−59.9	−22.3	−1	−49.8
Temperature maximum (°C)	−12.2 (9/18)	4 (9/26)	−38.9 (9/10)	−10.6 (10/24)	7 (10/4)	−38.3 (10/7)
Temperature minimum (°C)	−40.0 (9/3)	−14 (9/2)	−75.0 (9/1)	−37.8 (10/7)	−13 (10/12)	−67.2 (10/1)
Average station pressure (mb)	975.28		673.55	977.65		675.58
Pressure maximum (mb)	989.16 (9/18)		685.07 (9/8)	995.94 (10/16)		688.45 (10/17)
Pressure minimum (mb)	954.62 (9/5)		663.39 (9/13)	965.80 (10/2)		666.10 (10/5)
Precipitation (mm)	11.94		trace	13.46		trace
Snowfall (mm)	119.38		trace	134.62		trace
Prevailing wind direction	115°		45°	115°		45°
Average wind speed (m/sec)	6.7		4.8	4.9		6.7
Fastest wind speed (m/sec)	27.7 180° (9/26)		12.9 25° (9/19)	19.7 180° (10/4)		15.4 0° (10/10)
Average sky cover (tenths)	8.0		5.3	6.3		5.6.
Number clear days	0		9	7		14
Number partly cloudy days	21		14	8		4
Number cloudy days	9		7	16		13
Number days with visibility less than 0.4 km	4		8	0		10

*Temperature data unverified.



Index map of U.S. antarctic stations that report data for "Monthly climate summary" (above).

The Director of the National Science Foundation has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this agency. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through September 30, 1979.

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