TRIP REPORT

Visit to Antarctica, January 1 - 11, 1967

Dr. Wernher von Braun, Director, MSFC

Dr. Robert Gilruth, Director, MSC

Dr. Maxime A. Faget, Assistant Director, MSC

Dr. Ernst Stuhlinger, Director, R-RP, MSFC

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1. DISCOVERY AND EXPLORATION OF ANTARCTICA:

(Brief History)

1772 - 75:	James Cook, British explorer, circumnavigated Antarctica on his Second Voyage.
1819 - 21:	Bellinghausen, Russian explorer, circumnavigated Antarctica.
1820:	N. B. Palmer, American sealer, sighted land on the Antarctic Peninsula and discovered the Antarctic Continent.
1821:	J. Davis, American sealer, made the first landing on the Antarctic Peninsula.
1823:	J. Weddell, British navigator, discovered the Weddell Sea.
1840:	Lt. Ch. Wilkes, USN, sighting Wilkes Land, established existence of the "Antarctic Continent". Dumont D'Urville, French explorer, discovered Adélie Land. ("Windiest place in the world", storms up to 200 miles per hour).
1841:	Sir J. C. Ross, British explorer, discovered Victoria Land, the Ross Ice Shelf, and the volcanoes Erebus and Terror on Ross Island (named after his ships).
1897 - 99:	Arctowski, Belgian geologist and meteorologist, directed first broadly based geological and oceanographic study on the Antarctic continent as a member of A. de Gerlache's expedition. Group was forced to winter in the pack ice of Antarctica when their ship was beset (first party to winter over in Antarctica).
1901 - 04:	Captain Robert Scott, British explorer, assisted by Lt. Shackleton, reached McMurdo Sound, discovered Edward VII Peninsula, crossed the Royal Society Range, and penetrated into the high plateau area.
1907 - 09:	Sir Ernest Shackleton, in an attempt to reach the Pole with Manchurian ponies, came within 200 km (125 mi) of the Pole.
Dec. 14 1911:	Roald AmUNdsen, Norwegien explorer, and four companions reached the Pole with 4 sleds and 52 dogs.

Jan 18, 1912:	Robert Scott, British explorer, and four companions reached the Pole, pulling their sleds by hand.
March 1912:	Robert Scott and the last two of his men died on the Ross Ice Shelf 200 km (125 mi) South of McMurdo, only 18 km (11 mi) from a food depot.
1912:	W. Filchner, German explorer, discovered the Filchner Ice Shelf South of the Weddell Sea.
1915 - 16:	Sir Ernest Shackleton, after losing his ship "Endurance" in the ice pack of the Weddell Sea, made a heroic escape to South Georgia, saving all 28 men of his expedition.
1928 - 30:	Admiral Richard E. Byrd mounted first of two private expeditions. Wintering at Little America, he flew over the South Geographic Pole in November 1929.
1933 - 35:	Admiral Byrd established Little America II and explored the coast east of the Ross Sea.
1935 - 36	Lincoln Ellsworth, leading a private U. S. expedition, flew across Antarctica from the northern tip of the Antarctic Peninsula to Little America.
1934 - 37:	British expeditions explored the Palmer Peninsula (Graham Land).
1939 - 41:	The U. S. Antarctic Service Expedition explored and mapped the coast of the Ross Ice Shelf, and the mountains of Mary Byrd Land.
1946 - 47:	Admiral Byrd commanded "Operation Highjunp" which completed an uncontrolled aerial photographic reconnaissance of much of the continent.
1956:	Admiral George Dufek, USN, Commander of Operation Deep Freeze, landed at the Geographic South Pole and directed the building of Seven U S IGY Antarctic Stations. Dr. Paul Siple and 17 companions wintered at the Pole. The station has been occupied continuously since that time.
1957 - 58:	Sir Vivian Fuchs and Sir Edmund Hillary accomplished the British Transantarctic Tractor Expedition from the Filchner Ice Shelf to Scott Station.

1961:	Dr. Albert P. Grary, Chief Scientist of USARP, led a geophysical traverse from McMurdo to the Pole.
1962:	New Byrd Station, fashioned after Camp Century in Greenland as an under-ice station, was dedicated.
1963 - 65:	Eights Station, first U. S. Modular airlifted station established and occupied at 75° 14'S 77° 10'W.
1964:	Palmer Station, on Anvers Island, established.
1965:	Plateau Station, 40° East longitude and 79° latitude, was established with prefabricated units and modules at an elevation of 3626 m (12080 ft.).

2. GEOGRAPHICAL FACTS ABOUT ANTARCTICA

The Antarctic continent covers more than five million square miles, one and one-half times as much as all of U. S. A., and almost two-thirds of the North American continent. Ninety-five percent of Antarctica is covered by ice; in fact, the Antarctic ice amounts to nine-tenths of all the ice on earth. If it melted, the water level of all the oceans would rise by 80 meters. The thickness of the ice cap reaches 4200 meters (14000 ft.) north of Byrd Station, where the surface elevations are 1500 - 1800 meters (5000 - 6000 ft.), and a great sub-glacial below sea level trench is ice filled. Maximum elevation of the ice cap, south of the Russian Station "Pole of Inaccessibility" (the point farthest away from any coast line), is also about 4200 meters (14000 ft.). Elevations at the Pole, at Plateau Station, and at Byrd Station are 2912 m (9700 ft.); 3626 m (12080 ft.) and 1500 m (5020 ft.). Summer temperatures are up to +4° to 10° C (+40° to +50° F) at McMurdo and -30° to -18° C (-22° to 0° F) at the Pole; winter temperatures as low as -89° C (-127° F) have been recorded on the Plateau.

The Greenwich Meridian, passing from the Pole through Princess Martha Coast, has been declared "Grid North"; it defines an "East" and a "West" Antarctica. East Antarctica, below the ice shield, consists of igneous and metamorphic basement rocks, overlain by Paleozoic strata. A high Transantarctic Mountain Range, extending from Victoria Land in the South along the Ross Sea and the Ross Ice Shelf through the Queen Maud Range to the Palmer Peninsula in the Northwest, divides East Antarctica from West Antarctica. Uplifted since Mesozoic times, it contains Devonian and even Jurassic, Cretaceous and Tertiary formations. Many of the mountains in the Transantarctic Range reach altitudes of 3500 to 4500 m (11500 to 14500 ft.), some even in the vicinity of the coast. The highest mountains in Antarctica, the Vinson Massif in the Sentinel Range (Ellsworth Mountains), reaches almost 5100 m (16860 ft.). West Antarctica, geologically younger than East Antarctica, shows much evidence of igneous and tectonic activities. Paleozoic rocks were deformed and metamorphosed during the Mesozoic. Jurassic, Cretaceous and Tertiary strata have been found with fossils on the Palmer Peninsula. The close geological relationship between this part of western Antarctica and the Andes is evident.

3. PRESENT RESEARCH ACTIVITIES

With the conclusion of the Highjump Expedition, in 1947, basic geographical exploration was completed. Systematic scientific exploration of Antarctica began in 1955 with preparations for the IGY. Several stations were established on the continent at that time; some of them (McMurdo, Byrd, Hallett, Pole) are still in use. At the end of the IGY in 1958, the U. S. Antarctic Research Program (USARP) was created. IGY activities had been limited to geophysical and glaciological traverses, weather observations, aurora and ionosphere studies, magnetic measurements, and seismic observations; USARP extended the program to include geology, biology, glaciology, cartography, and oceanography.

USARP, as a part of the National Science Foundation, is administered by the Office of Antarctic Programs. Together with the Earth Sciences Section and the Atmospheric Sciences Section, this office is under the direction of Dr. Thomas O. Jones in Washington. Chief Scientist is Dr. Albert P. Crary; Philip M. Smith is Director of Field Planning. U. S. Antarctic goals and policies are defined by the Antarctic Policy Group which consists of the Director of NSF, L. J. Haworth; Assistant Secretary of Defense, J. McNaughton; and Assistant Secretary of State, J. J. Sisco. The scientific community takes an active part in the Antarctic science program through the Committee on Polar Research. Financial support for the scientific program is provided annually by Congress as a line item in the NSF budget (approximately 8. -M in 1967); logistic support is provided and paid for by the Department of Defense (20. -M annually). The Navy's responsibilities include construction and maintenance of the permanent stations; communications; supplying the permanent and the field stations; and transportation to and within Antarctica. By Bureau of Budget direction (A-51), all funds for Antarctica are included in either the NSF or DOD budgets; thus, the United States Geological Survey participates in the Antarctic program by way of a NSF grant, producing relief maps at 1:250000 on the basis of aerial photographs and geodetic control obtained by its survey parties. All applicants for scientific research projects in Antarctica, if successful, receive grants, travel accommodations, polar clothing, field equipment and complete personal support from NSF and DOD while in Antarctica.

In December, 1959, the Antarctic Treaty was signed by 12 nations; it went into effect in 1961. This treaty declares the area south of 60^{o} South Latitude an "International Reserve for Scientific Research", without national boundaries. It guarantees the use of Antarctica for peaceful purposes, and the free exchange of data. It encourages exchange of

4. PERSONAL ITINERARY JANUARY 1-11, 1967

When we arrived at Christchurch, the "Port of Entry to Antarctica" for American parties, on January 1, we were met by Ed Goodale, New Zealand USARP Representative at Christchurch, and his assistants Bill MacDonald, Jim McCrae, and Dave Hawkins, and also by Philip M. Smith, Director of Field Planning for the Office of Antarctic Programs, NSF, who was to be our host and escort during our entire stay in Antarctica. Our Antarctic gear, two large bags full of special clothing and equipment for each of us, was already waiting in our rooms in the White Heron Lodge. Ed Goodale helped us try on the various pieces, and advised us how and when to use the different kinds of boots, mittens, head-gear, thermal underwear, parka, inner linings, etc. In the evening, we spent a few hours in the Officer's Club, enjoying the company of members of Navy, Army, and civilian Antarctic crews. On January 2, we further tried out our Antarctic equipment, and we stored all the non-essential items of our "warm" weather travel baggage in our suitcases, which we left in the Lodge until we returned from Antarctica. Sufficient time was available on this day for a quick field trip which Phil Smith had organized with some of his New Zealand friends (Jon Hamilton, Guy Mannering, George Davison, Pat Dolan). We traveled up the fast and shallow Waimakariri River in three jet boats and even had a refreshing swim in the headwaters of the river. Later that afternoon, Rear Admiral and Mrs. F. E. Bakutis held a reception for us in the Officer's Club. Attendees included Capt. Busbee and Capt. Burky, both of whom were also to visit Antarctica; Cdr. J. McNally, and many other military and civilian members of the Naval Support Force, Antarctica, and USARP. We met Bill Mason, a Navy photographer, who remained with us during our entire Antarctic trip.

On January 3, at 9:10, we departed from Christchurch in the Constellation "Pegasus", in cloudy weather. Cape Adare became visible about seven hours later, and at 18:30 we landed at Williams Field, McMurdo, greeted by many members of the airfield and McMurdo Station. Helicopters took us to our quarters (Dr. Thomas O. Jones' Quarters #137), where we spent a very pleasant evening, talking with Jerry Huffman (Antarctic USARP Representative), Capt. Kendrick (Assistant Chief of Staff for Operations and Plans, Naval Support Force) who had arrived from New Zealand by separate plane (a C-130), Cdr. Balish (Commanding Officer of Air Devron Squadron Six), Capt. Kosciusko (Commanding Officer, Antarctic Support Activities), Cdr. Smith (Exec. Officer, Antarctic Support Activities), Cdr. Schneider (Executive Officer, VX-6), CDR. N. Vartzikos (Office of Antarctic Programs Administrative Officer),

Dr. Russ Strandtman (biologist), Dr. Ray Dillon (biologist), Mike Kulis (USARP Assistant), Graeme Johnstone (Logistics Officer), Robert Evans (Assistant), and many others who dropped in. We terminated the day with a walk in bright midnight sunshine to Scott's Hut (built in 1901), Vince's Cross, and the quay where cargo ships bringing cargo to McMurdo discharge about 6,000,000 gallons and 2500 short tons of dry cargo annually.

January 4 was devoted to a helicopter tour of the dry valley area. We left at 8:00 in two helicopters, flew 35 km (23 miles) over the Ross Ice Shelf, and landed on Brown Peninsula near the Koettlitz Glacier. Unlike Ross Island, which is entirely volcanic, Brown Peninsula and the nearby dry valley region show many old rocks of granite, sandstone, quartzite, and diorite. We continued to Lake Miers, and then across the terminus of the Blue and Ferrar Glaciers to Marble Point, along the beautiful mountain ridges of the Royal Society Range. This range, a huge fault block, has peaks of over 4000 m (14000 ft.) altitude, with glistening snowfields and glaciers, blue lakes of open water, and dark ridges of exposed rock in between. We flew in brilliant sunshine between peaks and over valleys to Marble Point, where a relatively flat, rocky beach one-half kilometer long, 100 meters wide, and 15 meters above sea level rests on a clean ice slab. The ambient air temperature this day was relatively high (about +8° C or +47° F), and we found lichens, green moss, and, in ice-free puddles of fresh water, thick growths of algae. Dr. Russ Strandtman, biologist from Texas Technological College, pointed out to us the various forms of life, and their adaptations to this unusual environment. Each rock sample which he selected with the trained eyes of the research biologist contained on its protected underside some specimens of algae, mites, or collembolas[1]; the samples which the rest of us picked at random almost never showed traces of life - a striking example of the difference in proficiency between trained scientists and automated samplers in the search for life!

Lake Bonney in Taylor Valley, our next stop, is a particularly arid area where "rain or snow never falls". The lake is frozen with the exception of a ring of blue water along the shore, but floor and slopes of the valley are completely free from ice or snow. The sandy ground is strewn with rocks and boulders up to several meters in size. Many of them are carved and polished by wind action ("ventifacts"). The dessicated mummies of seals, penguins, and skuas[2] were found in this region, some

[1] Primitive insects.

[2] The skua is a brown-white bird of herring gull size, but not related to gulls. Its nearest relatives are the Jaegers, another group of coastal birds. Skuas are excellent fliers. They feed on fish, penguin chicks, and, more recently, on the waste found near human Antarctic settlements.

of them hundreds of years old. We had lunch in the warm sunshine outside the "Bonney Lake Hut", a depot for food, fuel, and scientific equipment, used about 50% of each austral summer by various geological and biological parties. Structure and appearance of the surface in Taylor Valley, and later in Wright Valley and Victoria Valley, reminded us very strongly of the image of the lunar surface as derived from Surveyor and Lunar Orbiter pictures.

Our next stop was on a 2000 m (6600 ft.) high promontory, New Mountain, at the confluence of Ferrar and Taylor glaciers. The temperature was -28° C (-18° F), but the high winds made it equivalent to -40° C (-40° F). The rocks consist of stratified old sandstone, with volcanic intrusions. Eolic and thermal erosion have produced strange deformations of exposed surfaces. On a half-hour walk up the steep slope, we found numerous shell-like half spheres of sandstone of the size of a fist, called "ash-trays" by the Antarctic oldtimers. The view from New Mountain over the Royal Society Range, the glaciers more than a thousand feet below us, and the Asgard Range with the "Matterhorn" was perhaps the most magnificient we ever saw. The low temperature, combined with the strong dry wind, gave us at least a faint impression of the arduous work of the scientist who does field work in a hostile, but otherwise most fascinating environment.

A completely different, but no less fascinating environment was presented at our next stop, the Don Juan Lake, in a secluded portion of Wright Valley. Descending 1500 meters (5000 ft.) between high cliffs and precipitous slopes, we reached an undrained valley floor covered with white precipitations of a very concentrated saline solution. The shallow lake of bitter-tasting water had a temperature of +18° C (+64° F), although the air temperature was considerably lower. The high water temperature is probably caused by a "greenhouse" effect of solar radiation in the concentrated solution. Many large granite boulders were lying around, all of them heavily eroded by the leaching action of the saline water.

Further down in Wright Valley, we visited an Ohio State field party (Gerald Holdsworth, Lyle Irwin) near Meserve Glacier. A 60 m (200 ft.) tunnel into the glacier allows measurements of glacier movements, ice composition and temperature, and interface effects between ice and bedrock.

A last stop was made near Lake Vida in Victoria Valley. This area was particularly interesting to us because of biological observations made there by Roy Cameron of JPL. One of his recent findings is the fact that

the occurrence of protozoa, algae, and other small organisms in Antarctic areas depends, more than on any other environmental factors, on the availability of nutrients.

We returned home to McMurdo around 19:00.

On January 5, we first visited the excellently equipped biological laboratory (Russ Strandtman, Roy Cameron, Raymond Dillon, Peter McCarthy, Wulf Massell, Charles Heuser) in McMurdo with studies involving algae, protozoa, and other low organisms; lichens, mites, collembolas, crustaceans, fishes, birds, and seals. We then toured the dispensary and hospital and learned that almost no illnesses occur in Antarctica, except injuries by accidents, and short spells of common colds when personnel, material, and mail arrive from New Zealand. McMurdo Station is occupied by up to 900 persons in summer, and about 200 during winter.

We visited the diesel-electric plant (4 units with 500 kwe each; largely as standby in case the nuclear plant should suffer a shut-down); the Chapel of the Snows; the Byrd Monument; the Ships Store; the USARP Field Party Processing Center; and the motor sled garage and shop. Later, we flew by helicopter to Williams Field on the sea ice. A number of Jamesway huts house the crews and the equipment. As the sea ice recedes during the austral summer, the air field must also be moved. At 17:00, we left by ski-equipped LC-130 (Hercules), flew over the beautiful Rockefeller Range, and landed two and one-half hours later at Byrd Coast Camp #1, a temporary station for geological research at approximately 140° West longitude and 78° latitude, where we were greeted by a brilliant red poster in the snow "Welcome NASA". Station leader is Dr. Campbell Craddock, University of Minnesota. We heard five brief, very interesting talks about the geological, topographic, petrological, paleomagnetic, and biologic field work which is carried out from the Camp, mainly with turbine helicopters. A Russian, Dr. Lev Klimov, lives at the Camp as Exchange Scientist. Tom Early (Washington University, St. Louis), collecting magnetic samples from rocks, showed great interest in the NASA-developed lunar drill which provides undamaged drill cores from hard rock without need of gas or fluid for chip removal.

We took off in heavy ice fog and landed one and one-half hours later at the Byrd VLF Substation near New Byrd Station. This station, almost completely submerged under the ice and operating a 10 and a 150 kw VLF transmitter, driving a 34 km (21 mi) horizontal dipole, impressed us

because of its prefabricated construction AND its near-perfect installations for transmitter operation and maintenance, and for living comfort. Occupied by two men (George Webber, University of Washington, and Mike Boman, University of Wisconsin), it represents an ideal field unit for research work and life support.

Having crossed quickly over a number of degrees in longitude, we lost our feel for the time of day. After two lively hours at the VLF Substation, we mounted two Thiokol Trackmasters and drove, in bright sunshine, 18 km (11 mi) to Byrd Station. Each of the four of us took the driver's seat for a few kilometers; the best driver was undoubtedly Bob Gilruth, charging ahead like a seasoned polar explorer. We arrived at Byrd Station at 6:30 in the morning, had breakfast, and went to bed for three hours.

Byrd Station, built during 1961-62 completely under the snow, is a vast expanse of high archways, store rooms, tunnels, crew quarters, power stations, mess halls, communications rooms, and science buildings. We took a long and extremely interesting tour through the various facilities with Lt. Williams, Lt. Cranton, Ross Smith (Scientific Station Leader), his assistant, Robin Ehlers, and others. An Army crew (Lyle Hanson) is presently preparing the core drilling of a 2400 m (8000 ft.) hole through the ice to the bed rock; ice samples from 60 m (200 ft.) depth showed the characteristic bubbles of enclosed air under 6 atmos. pressure. When dissolved in water (or another liquid), the bubbles pop with loud crackling noise. Each of us received a small bottle of water melted from ice that had been deposited in the year 1776 $\pm$ 1, as determined by counting layers in the ice shield. In the science building, we saw the automatic recording of ionospheric layer altitudes with riometers, and we heard a tape recording of whistlers, whose frequencies covered the audio range. Signals from the Pogo satellites are received and used for ionospheric and geodetic purposes. Walking through the 300 m (1000 ft.) science tunnel and a short distance over the snow, we reached the VLF Building which transmits and receives signals in conjunction with the VLF Substation we had visited the previous day. We even enjoyed the opportunity of telephone conversations with our families through ham stations at Byrd and in the United States. Later in the afternoon, Bob Gilruth and Wernher von Braun showed films and slides of the Gemini and Apollo Projects to an audience of USARP and military men. After a very animated discussion, a LC-130 flew us back to McMurdo across the sun-reflecting snowfields and over Mt. Erebus, the only active volcano in Antarctica, with a short, but most impressive glimpse into its steam-filled crater. We arrived at 17:30 McMurdo time and turned in early after dinner at our quarters.

January 7 was spent in the McMurdo Sound area. In the morning, we drove by Dodge Powerwagon to Scott Base (2 km), the New Zealand Station on Ross Island. Colin Clark, Station Leader, showed us the various facilities and housing complexes which are connected by closed tunnels. Scientific work includes ionospheric, magnetic, and meteorological studies. The station still keeps dogs; we were given rides with two dog-sled teams, and we were greatly impressed by the strength, manageability, and mobility of dogs as prime movers. We also saw and tried out the Gnat, a low, open vehicle with three small, wide track inflatable wheels and air-cooled Honda engine. It was praised highly by its users because of a large, easily accessible loading area, and because of a convenient ingress and egress of the driver even in heavy arctic clothing. Its three wheels make it very maneuverable even in rough terrain. Among other vehicles which we saw were Tucker Sno-Cats (used by Fuchs and Hillary on the 1957-58 Antarctic Traverse), several smaller tracked vehicles, and even a common Volkswagen, adapted to snow with partial success by mounting twin tires on the rear wheels. Members of the station emphasized that a variety of vehicles from small to large sizes is very essential for efficient exploration. In extremely rough terrain, man on his feet is still by far the best mode of locomotion, at least over short distances.

After returning to McMurdo, we flew in two helicopters to Cape Royds on Ross Island where we first visited Shackelton's Hut, erected in 1907 and still equipped with the original tools, utensils, journals, books and large amounts of supplies for men, dogs, and ponies. Close on this hut is the southernmost rookery of Adelie Penguins; about a thousand birds on a rocky peninsula tend to their crude pebble nests and their fluffy chicks. We saw eggs and young penguins of all ages between newly-hatched and nearly adults; we even observed one egg just hatching. Adelies begin nesting on the bare rocks on the coasts around the Antarctic continent with the beginning of the austral summer, so that the young obtain their final "swimming" plumage before winter sets in. Father penguin does the breeding. When the young hatch, both parents share in the care for the chicks; only one goes to the water for feeding at a time, the other one guards the young against the skuas. Adelie Penguins feed mostly on krill. Penguins have a remarkable capability to navigate over long distances under and on the water, and on land. Studies of their navigational techniques (dependent on sun azimuth), of their feeding and hatching habits, of their ability to recognize their own young, of their food, their blood composition, their thermal control, their parasites, and other properties, are the objectives of numerous biological research projects in Antarctica.

We did not see the second penguin species native to the Antarctic continent, the Emperor. It has different hatching habits; the female lays one egg in the middle of the austral winter night; the rookeries are on the ice shelf, and the egg, and later the chick, rests on the feet of the male parent which does not take food during the incubation period of almost three months. When the young hatches, mother penguin returns with food for the chicks, and father goes feeding for himself. Emperor penguins live on fish and squids. By the end of December, the young are large enough for swimming, and the entire colony takes to the water until next ~~time~~ JUNE when breeding on the ice begins again.

Emperor and Adelie Penguins, and skuas are among the few birds nesting on Antarctica. Several other birds such as petrels, gulls and terns, are seen along the coast, mostly on the Antarctic Peninsula. The Arctic Tern, which nests north of the Arctic Circle, flies to Antarctica each fall to spend another nightless season near the South Pole; when the sun begins to set below the horizon, it flies back to its breeding grounds in the high north. Observations of migratory birds are part of the biological research program in Antarctica.

From Cape Royds, we flew to Cape Evans on Ross Island where Scott erected a supply hut in 1909. This hut, also, is well preserved; ice masses which had developed inside were removed recently by a volunteer New Zealand party in an effort to restore the cabin to its early 1900 state. Many of the stores of food, tools, material, books, newspapers, and equipment for chemical and geophysical laboratory research are still in fairly good condition. We were deeply impressed by the feeling of being suddenly so close to the life and work, and to the hopes and sufferings of the men whose heroic voyages have filled us with greatest admiration for many years. Equally impressive was the fact that these huts, as historic shrines of immeasurable value, are open to visitors, without fences, guards and even "Don't . . ." signs, and still do not show any marks of souvenir hunters and name carvers - certainly a convincing testimony to the wonderful spirit that permeates the Antarctic continent.

On our way back to McMurdo Station, we landed briefly on the ice in the middle of a herd of Weddell seals. The animals are quite friendly, and not too shy. They allowed us to pat them on the back and "shake hands", and to take many close-up photographs. After delivering Colin Clark to Scott Base, we returned to McMurdo where we had dinner with Capt. Kendrick, Capt. Kosciusko, Cdr. Balish and others. Later in the evening, we drove up to the Nuclear Power Plant where we received a briefing and a tour by the Officer in Charge, Lt. L. K. Donovan. The plant, built by The

Martin Company at Baltimore, Maryland, has been in operation since June, 1962. Producing up to 1.8 MW of electric power, it is now the primary source of electric power, steam, and distilled water for McMurdo Station. In a 12-month period of operation, the plant produced 16 million kwh of electric energy which would have required 1.3 million gallons of fuel if produced by diesel power. The nuclear power plant is staffed and operated by 23 Navy personnel. Besides providing these utilities, the nuclear power plant has offered a unique opportunity to test and evaluate the effectiveness of nuclear power in an isolated, hostile environment, and to acquire operational data for improved designs of future nuclear power plants.

On January 8, at 09:00, we left Williams Field by LC-130 (Cdr. Balish) and landed after a five hour flight at Plateau Station, 79° latitude, 40° East longitude, elevation 3626 m (12080 ft.). Lt. Holik, VX-6 physician, accompanied us. The weather was beautiful, temperature -25° C (-13° F), almost no wind. The station is largely covered by snow. It was built during the 1965/1966 austral summer from prefabricated and modular units. Obviously, this mode of building an Antarctic station is highly effective; all the buildings made a very functional impression. Under the guidance of Station Leader Jim Pranke, Officer in Charge Lt. Blackburn, R. Dingle, and J. Wagner, we visited several science projects; the program includes studies of micro-meteorology, aurora, ionosphere, VLF, geomagnetism, and medical research. Eight persons (4 scientists, 4 Navy personnel) will winter over at Plateau.

A 2-1/2 hour flight took us to Pole Station. The first approach to the landing field failed because of a temporary white-out; the second approach, a few minutes later, occurred in bright sunshine! After our arrival at the station, we engaged in long talks with the USARP and Navy personnel which extended through dinner (Station Leader: Dick Weininger; M. D. in charge: Lt. D. Craig Sullivan). Later in the evening, we gave presentations with films and slides on Projects Gemini and Apollo, followed by lively discussions on exploration projects in Antarctica and in space. During the summer 1966/67, 22 persons are living at the Pole Station; in winter, the population will be smaller. Toward midnight, we took a steam bath, followed by an invigorating "run around the Pole", clad only in shoes and towel, at a temperature of about -28° C (-18° F) and no wind. The next morning, January 9, we visited several scientific stations (cosmic ray laboratory operated by the Bartol Research Foundation, with largely automated measurements of mesons and neutrons; earth magnetic field measurements; forward scatter measurements; VLF, aurora, ionosphere, meteorology, riometer, and ozone measurements; studies

of sleeping habits; and we walked through a 300 m (1000 ft.) long ice tunnel to the seismic station). We then took a hike to the "True Pole", about 500 m (0.3 mi.) away from the "Old Pole", and on the basis of recent geodetic studies, correct within less than 100 m. On the way back, we tried out a motor tobbogan, a one to two man tracked vehicle with remarkable maneuverability and ease in handling. Around noon, the LC-130 arrived and took us back to McMurdo, on a beautiful 1300 km (800 mi.) flight over the sun-glistening ice cap and Beardmore Glacier, probably the largest glacier in the world. Back at McMurdo, we met in the "Chalet" with Capt. G. Busbee, Cdr., U. S. Naval Construction Batallion, Atlantic Fleet, and Capt. J. Burky, Command Officer, CBC, for a very interesting discussion on support functions and problems. After dinner, Bob Gilruth and Wernher von Braun gave presentations with film and slides on our manned space programs in the helicopter hangar. About 350 USARP and DOD personnel attended, and again very lively discussions developed after the formal talks. Later that evening, some of us walked up on Observation Hill behind McMurdo and enjoyed the magnificient view over the station and McMurdo Bay, Scott Station, the Ross Shelf, Mounts Erebus, Terra Nova and Terror, and the Royal Society Range, all lighted by the brilliant midnight sun. On return, we found a discussion between Phil Smith, Russ Strandtman, and the VX-6 helicopter pilots in progress, and we observed once again the very close, pleasant, and successful interface between the pilots and their scientist passengers.

Our last day on Antarctica, January 10, was cool and cloudy. Some of us walked again up on Observation Hill; we then packed our gear; had a very interesting talk with Mr. Tillman Durdin, New York Times Australia Desk, and met with Adm. Bakutis, Capt. Kendrick, Capt. Busbee, Capt. Burky, Maj. Gen. Hayes (Corps of Engineers), Maj. Gen. Curtin, USAF (Director of Civil Engineering), Dr. M. Britton, ONR, and Dr. H. Dater, Naval Support Force Antarctica, who had just arrived from Christchurch. We discussed our experiences and impressions of the past seven days, and particularly the relationships between Antarctic exploration and space exploration. In both cases, the objectives are primarily scientific research, but the efforts can succeed only when adequately supported by a long, complex, and costly line of logistics. In both cases, the potential values of the research programs are invaluable, but they cannot be counted at the end of each fiscal year in dollars and cents. In both cases, the profits will not be limited to scientific knowledge, but will extend far into the areas of technology, organization, program planning, and management. In both cases, one of the most valuable products will be a group of men, motivated by the spirit of exploration,

and experienced in the handling of large and complex science-industry-DOD projects. And finally, in both cases, this country is not alone in its endeavor to accomplish a program of challenging exploration; we should not be willing to play the role of a second rate nation when successes are accomplished.

That evening, when we finally walked to the helicopter which took us to Williams Field, we met briefly with Ed Goodale who had just arrived from Christchurch. Jerry Huffman, Ray Dillon, Wulf Massell, Mike Kulis, and several others waved us goodbye when our Constellation "Phoenix" left McMurdo shortly before midnight. After arriving in Christchurch at 09:30 on January 11, we first sorted and returned our Antarctic gear, and then met with the press for a one-hour TV interview. During the remaining hours, we took a car trip to downtown Christchurch and saw Scott's monument, the Canterbury Cathedral, and Lyttleton Harbor. Shortly before midnight, we said goodbye to Phil Smith, who had been a most wonderful escort and friend during our Antarctic trip, to Bill Mason, the tireless and always cheerful photographer, and to Bill McDonald and Dave Hawkins, who took such good care of us in Christchurch, and we boarded the Constellation "Pegasus" for the long trek back to the United States.

5. IMPRESSIONS AND OBSERVATIONS DURING ANTARCTIC TRIP

Our one-week stay on Antarctica was made particularly successful through the presence of Mr. Philip M. Smith, Director of Field Planning, OAP, NSF. His knowledge of every facet of Antarctic exploration and research proved almost limitless; his organization of our trip was perfect; and all his actions as a host and travel companion could not have been surpassed. In many discussions with him, and with other scientific leaders such as Jerry Huffman (USARP), Roy Cameron (JPL), Russ Strandtman (Texas Tech NOLOGICAL College), Wulf Massell (North Star Research and Development Institute), Ray Dillon (University of South Dakota); with the Station Scientific Leaders; with airplane and helicopter crews, among them Cdr. Balish, Commanding Officer, Gene Van Reeth, VX-6 Operations Officer, Group Captain Fred Tucker, RNZAF; Lt. Cdr. Jim Koloc, Cdr. Tarzikos, Lt. (jg) Art Nash, Lt. Cdr Jim Bolton, Lt. Cdr Bill Furey; with Logistics Officer G. Johnstone and USARP Assistants Mike Kulis and Bob Evans, we obtained an insight into Antarctic operations which was not only extremely interesting, but also most valuable to us with regard to the space project planning in which we are involved.

The following impressions were gathered during our stay in Antarctica:

a. Logistics Support - During summer (October till February) the U. S. program occupies about 2000 support personnel (DOD and USARP) and 200 scientists (USARP, universities, government installations, and research laboratories) in Antarctica. Logistic support includes transportation of men and material between USA and Antarctica, and within Antarctica; building and maintenance of permanent stations; supply of field stations; communications, mail, food and kitchen services, medical services; electric power, heating, water supply; maintenance of vehicles; clothing; and shipment of scientific equipment and collected specimens. Scientists are responsible only for their own housekeeping. At the smaller inland stations the scientists voluntarily help in snow shoveling for water melting, etc, often sharing a "watch" with one of the Naval personnel.

This very comfortable situation for the scientists has evolved during the past 10 years; it is considered by USARP directors as an important factor contributing to the success of the scientific program, because it allows the scientists sufficient time for scientific work.

b. Life in Isolation - We found the scientists invariably in high spirits, and filled with strong motivation for their work. They read much (scientific books, travel, fiction), hear music, and tend to their scientific activities. Support personnel, also in a pleasant spirit, enjoy being in Antarctica, but many are longing for their trip home.

A single, although small, room for each man is considered far preferable to bedrooms for larger groups. Privacy at least for several hours per day seems to be of great importance. Living conditions within the quarters should be "as comfortable, and as much like home, as possible".

c. Man-in-Charge - Each station has a Station Scientific Leader, directly responsible to the Office of Antarctic Programs. He coordinates activities of the scientists, and also the support of these activities by the DOD personnel. The Officer-in-Charge at each station is the representative of the Commander, Naval Support Force, Antarctica. He is responsible for the safety and welfare of all persons assigned to the station, and for the support of their activities. In a case of emergency, the Officer-in-Charge will direct the station activities; it may be necessary in such cases that scientists participate in non-scientific activities. The Officer-in-Charge and the Station Scientific Leader will jointly determine when this participation is required.

This mode of operation, decided upon at the start of the IGY and practiced during the past years, has proven to be a highly workable arrangement.

d. Construction of Stations - The first stations were built about 10 years ago, mostly out of raw material such as wood and steel beams, corrugated sheet metal, and plywood panels. Newer stations, particularly Eights and Plateau Stations, were prefabricated either in modules, or in entire units. There is no doubt that the prefabrication method is far superior because it saves transportation effort, construction work in a hostile environment, waiting periods, and impractical or otherwise unfavorable designs. Thorough checkout before shipment is mandatory.

e. Vehicles - Besides the obvious requirements of reliability, maneuverability in rough terrain, and operability in cold weather, the following properties are highly desirable: the vehicles should be easy to load and to unload; driver and riders should have convient access to their seats, even when hampered by heavy clothing; major parts (engine, tracks) should be easily exchangeable under field conditions; it

should be possible to tow, lift, or turn the vehicle manually or with another vehicle after it becomes stuck between boulders or in crevasses, or after turning over. Different vehicles are required for different purposes (short, medium, long distances; light, medium, heavy loads; easy, medium, difficult terrain). A one-man, load carrying, short-haul vehicle is of great utility.

f. Nature of Research Programs - The various research projects fall into two categories: the survey-type measurements (cosmic ray, ionosphere, radio wave propagation, weather), and the exploration-type studies (geology, paleontology, biology). Survey-type observations are mostly carried out by young scientists with pre-built equipment in close contact with their professors at home. The objective is the operation of the equipment and the recording of data; analysis and evaluation are performed mostly at the home university. The exploration-type studies are carried out by senior scientists in the field. The success depends largely on the ability of the scientist to reach the areas of interest, to look for the right objects, to recognize important specimens and facts, to draw conclusions while exploring, and to continuously develop his research program as his exploration proceeds. Laboratory facilities in the base station, as in McMurdo, are of great value, but without the important field research they would be of little value.

Undoubtedly, both types of research projects are of greatest importance in Antarctica, and both should be continued for many years to come. In both the survey and exploration studies, the accumulating data are suggesting specific experiments (e.g. the VLF antenna and the paleontological research) which are being incorporated in the program. As new studies are added, outgoing studies are terminated.

g. Energy Supply - Besides food and shelter, the most important utility is power. It is needed for heating, cooking, housekeeping, transportation, construction work, scientific equipment, communications, water distillation, snow melting, repair work. Electric power in the stations is produced by diesel electric generators, and by a nuclear-electric plant in McMurdo. As an average figure, 5 to 10 kw of electric power per man is needed at the stations. Transportation, and to some extent also heating, requires fuel (aviation gasoline and diesel oil). Fuel is by far the largest single item in the transportation budget of the Antarctic program.

We heard repeatedly the statement that a dependable, inexpensive, compact, transportable nuclear-electric power unit of approximately 50 kwe with a lifetime of two to three years would be extremely valuable (reactor-thermionics type).

h. Modes of Exploration - In geological, glaciological, and biological research, it seems that the optimum approach consists of two phases. First, a very thorough, high resolution photographic survey from the air should be made. Second, after evaluation of the photographic survey, field parties should go to the places recognized as promising research sites, and on-the-spot scientific work by experienced scientists should begin under comfortable life support conditions. A third phase, comprising the above-mentioned experimental biological studies following phases one and two, is just beginning in Antarctica. It will undoubtedly continue a number of years after the general exploration has been completed.

i. Use of Lunar Instrumentation - It appears to us that the lunar drill (5 cm hole, 30 m depth) may be of use in Antarctica for geologists and petrologists who wish to secure core samples from hard, dry rocks. The drill could be transported by helicopter, and could operate without water or other lubricants at temperatures as low as -60° or -80° C.

Another possible instrument of interest is the radar altimeter developed for lunar use. The ice fields with their extremely low ground conductivity may serve as testing areas. Also, lunar radar and laser altimeters may prove useful on airplanes and helicopters in Antarctica.

j. Use of Satellite Data - The Nimbus and Essa meteorological data are regularly being used at McMurdo and Christchurch for flight forecasting. These data will also be used for weather and ice forecasting in the Antarctic Peninsula research ship operations. Pogo, Transit, and Pageos programs are or will be of use to USARP. Navigation satellite data are regularly used on the research ship Eltanin. Future manned and unmanned polar satellites are expected to be of interest to USARP. Two IRLS signatures have been assigned to the NSF Office of Antarctic Programs.

k. Similarities between Antarctic and Space Programs - The subject of primary interest on our trip to Antarctica was the intricate relationship between the scientists in the field and their support organizations. The field scientists constitute small, highly specialized work teams with well defined scientific objectives, operating at remote places under extremely unusual, often hostile environmental conditions. The support organizations include the Office of Antarctic Research and its sub-offices in Washington; the "home bases" of the scientists (universities and research

5. We were greatly impressed by the high cost effectiveness of the Antarctic Program. A large number of field parties, some of them even wintering over, are doing research work in about 15 major scientific disciplines, among them geology, aeronomy, physics, biology, medicine, glaciology, oceanography, astronomy, and geophysics. For all of them, Antarctica represents an open frontier with vast opportunities to acquire new scientific knowledge and, perhaps even more important, to create new scientists well trained in scientific research work. The steady increase of scientific capabilities is certainly one of the most important objectives a nation can have. When compared to the rich scientific harvest which the Antarctic Program is yielding, the yearly expenditures of $8. -M for science projects, and $20. -M for the total logistic support of the program, certainly look modest, and exceedingly well spent.

6. The broad, reconnaissance-type exploration of the Antarctic continent is practically completed. The phase of detailed research studies of many subjects, and at many places, has begun. It is to be expected that this second phase will yield even more striking results, particularly in such areas as geology, paleontology, climatology, biology, radio physics, and solar physics. In particular, it is to be expected that this second phase of Antarctic research will produce results which are presently unexpected and even unknown. Scientists all over the world are looking forward to this phase with greatest anticipation. The United States, with its well-organized USARP program, is excellently prepared to play a major role in this phase of scientific research.

1. Possible Uses of Antarctica in Space Programs - Although it would be premature to discuss here projects that USARP and NASA may like to carry out jointly in Antarctica, a few areas of possible interest to NASA will be indicated. The subject of prime importance is undoubtedly the interface between science and logistics support discussed in the previous paragraphs. The technical projects of joint interest include tracking stations for polar satellites. Tracking and monitoring of such satellites as Pogo, Pageos, and Nimbus from Antarctica significantly increase the area for data collection on weather and ice conditions, and also for triangulation of the earth's surface, and for measurements of the earth's gravitational field. Since 1965, a Doppler tracking station at McMurdo has recorded some 700 satellite passes every month.

When a manned polar satellite is orbiting the earth, a monitoring station near the South Pole may be of value because this station can contact the satellite once during each orbit.

Satellite measurements on ionospheric densities, which require a ground station network spread out over as large a portion of the earth's surface as possible, profit greatly from Antarctic stations. At Byrd Station, data are regularly collected from Alouette I and II, Explorers XX and XXII, Pogo, and others. VLF stations on Antarctica also produce data on ionosphere and exosphere electron densities. Cosmic ray laboratories at various Antarctic stations monitor neutron, meson, and proton activities; these data are useful for comparisons between satellite and ground measurements of cosmic ray intensities. Possible future observations from Antarctica include monitoring of the sun during the austral summer for flare activities, an observational program in which NASA is greatly interested in connection with manned space flight.

Although environmental conditions in Antarctica are extreme as compared to other areas on earth, they are still vastly different from those we must expect on another planet. And yet, the search for microorganisms in the Dry Valley area near McMurdo has some striking similarity with a search for life on Mars. It appears quite logical that some of the life-detection instruments to be built for unmanned and manned use on Mars may be tested out in the ice-free areas on Antarctica. Likewise, it would seem appropriate to include a six-week field trip through the Dry Valleys, with search-for-life experiments, in the regular training program for astronauts being prepared for flight to Mars.

The use of instrumentation presently under development at NASA for lunar exploration, such as lunar surface drills, thermal and radiation probes for drill holes, laser altimeters, laser and radar surveying equipment, seismometers, and nuclear isotope electric power supplies, has been under discussion between USARP and NASA for some time. These instruments, if found applicable, would be of immediate use to USARP projects; at the same time, their use in Antarctica would provide NASA with very valuable test data acquired under harsh and at least semi-realistic environmental conditions. Cooperation between USARP and NASA in this area has been underway for several years.