4.0 Antarctica—Past and Present

Antarctica history is rich in adventure and science, yet human activity in the region extends back in time only about 200 years. In fact, most of what is known about Antarctica has been discovered in the present century.

4.1 Early Antarctic Activity

4.1.1 Exploration Remote, inaccessible, and inhospitable, Antarctica was the last continent to be discovered, and knowledge of the south polar region was accumulated slowly. Until the present century the interior of Antarctica was unknown, and even the continental margins had been seen in only a few places. Of the world's 61,000 nonfiction papers and books published about the Antarctic since the earliest papers dating from the 1600s, 91 percent have been published since 1951. However, the historian Kenneth J. Bertrand (*Americans in Antarctica 1775-1948*, American Geographical Society, 1971) writes that "the success of recent operations in unveiling Antarctica with the aid of modern technology does not negate the importance of earlier efforts. Present accomplishments have been built on the past, developed step by step since 1674, sometimes haltingly and sometimes failing."

Explorations have been conducted for a variety of motives and sometimes accidentally, as was the case of the first discovery south of the Antarctic Convergence (where temperate and polar waters meet) — of South Georgia in the 1670s when a commercial ship was blown off course. The true nature of the Antarctic as a frigid region of ice and snow was convincingly proved for the first time by the second voyage of the English navigator, Captain James Cook, between 1772 and 1775 (Exhibit 9). Until then, there was general belief in a large, still undiscovered continent in the southern hemisphere suitable for European settlement. Cook circumnavigated Antarctica, much of his course south of 60°S, and crossed the Antarctic Circle in three places. He failed to sight any part of the Antarctic continent, but disproved conclusively the existence of the mythical continent "Terra Australis Incognita" at latitudes north of 60°S. Mariners who followed Cook into high southern latitudes were attracted to the harsh environment by his reports of great numbers of whales and seals, particularly the latter.

In 1820-1821 the American sealer Nathaniel B. Palmer of Stonington, Connecticut, saw the Antarctic Peninsula from his sloop *Hero* and met the Russian Captain Thaddeus Bellingshausen commanding the two ships *Vostok* and *Mirnyy* on a major national expedition that circumnavigated Antarctica eastward. Three other great national expeditions were made between 1819 and 1843 by the French Admiral Dumont d'Urville, who discovered the Adélie and Clarie coasts in 1840; by U. S. Navy Lieutenant Charles Wilkes, who mapped 1,500 miles of Antarctica's coast south of Australia in 1839-1840, proving Antarctica a continent; and by Britain's Sir James Clark Ross, who discovered the Ross Sea, Ross Island, and the Ross Ice Shelf in 1841.

Historians have not settled the question of who was first to see land in Antarctica. British, Russian, and U. S. ships all were in the Antarctic Peninsula area in the early 1820s, and the first sighting occurred during that time. The first documented landing on the continent was on 24 January 1895, when the Norwegian whaling ship *Antarctic* landed a party at Cape Adare on the northern Ross Sea. The party consisted of Captain Leonard Kristensen, second mate Carstens Borchgrevinck, and H. J. Bull, who wrote a book about their adventure. Bull called being first on the Antarctic mainland "both strange and pleasurable," although he thought the crew would have preferred to find a Right Whale "even of small dimensions."

In 1895 a resolution by the Sixth International Geographical Congress in London promoted Antarctic exploration and set into motion a series of expeditions known now as the "Heroic Era." Before World War I halted this activity, 16 exploring expeditions from Australia, Belgium, England, France, Germany, Japan, Norway, Scotland and Sweden (but not the U. S.) had visited Antarctica. This activity is exclusive of whalers, discussed below. The magnitude of this activity was unprecedented for Antarctica, and, considering the state of technology and size of the world's population and wealth, it probably was greater than that of the mechanical age that followed and comparable to the operations initiated with the International Geophysical Year (IGY), 1957-1958. The best known of the Heroic Age expeditions were those led by Roald Amundsen (Norway) and Robert F. Scott (England), who separately reached the geographic South Pole (and were the first to do so) a few weeks apart on 14 December 1911 and 17 January 1912, respectively (Exhibit 10).

U. S. Antarctic activity in this century began with Richard E. Byrd's hugely popular, privately financed, expeditions in 1928-1930 and 1933-1935. Byrd's success led to Congressional appropriations of $10,000 in 1939 and $340,000 in 1940 (totaling about $4.1M in 1997 dollars) for the U. S. Antarctic Service, organized as a civilian entity under four cabinet agencies. Intended to be permanent but curtailed to a single winter and two summers because of World War II, the field work in 1939-1941 nevertheless was the largest Antarctic expedition up to that time, and it produced discoveries in a number of research disciplines.

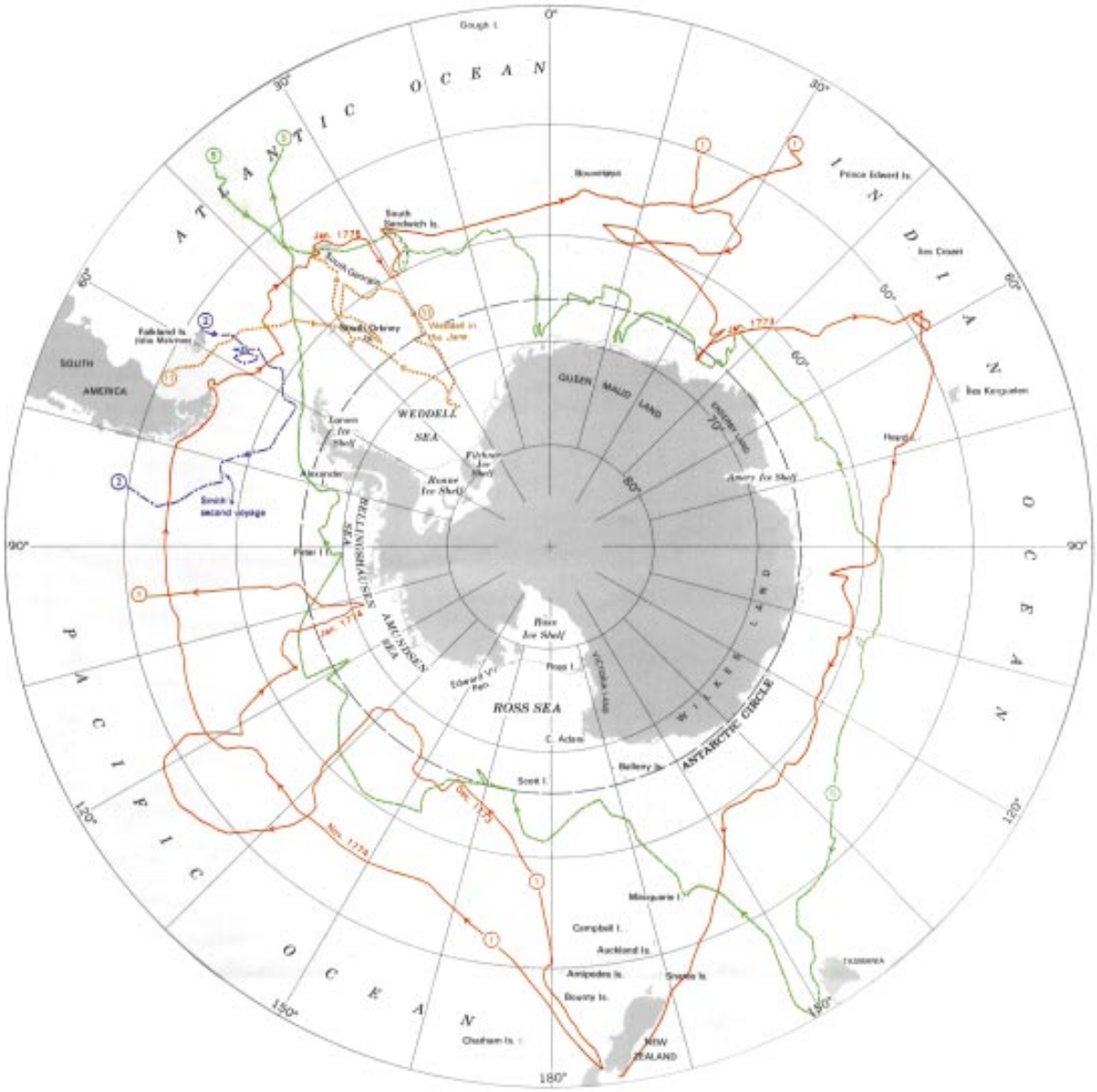


Exhibit 9

Cook's voyage. Between 1772 and 1820 explorers neared but did not discover the Antarctic continent. Of greatest significance were the three expeditions of Captain James Cook, Great Britain, who in 1772-1775 established that a continent must exist south of his southern-most penetrations. "That there may be a Continent or large tract of land near the Pole, I will not deny," he wrote on 5 February 1775. "On the contrary I am of the opinion there is, and it is probable that we have seen a part of it. The excessive cold, the many islands and vast floats of ice all tend to prove that there must be land to the South." Shown are the cruise tracks of (1) Cook; (2) Captain William Smith, Great Britain, 1819; (5) Captain Thaddeus Bellingshausen, Russia, 1820; and (11) Captains James Weddell and Matthew Brisbane, Great Britain, 1823. Source: Antarctic Map Folio Series, 1975.

Exhibit 10

Attainment of the South Pole. Roald Amundsen's and Robert Scott's teams' arrivals at the South Pole in December 1911 and January 1912 concluded humankind's quest for the highest southern latitude, which had begun centuries earlier with the voyages of Drake, Cook, and others. Personal and national prestige motivated both Amundsen — whose tent and flag stand here — and Scott, whose party this is. "Thus we plant thee, beloved flag, at the South Pole," Amundsen said, "and give to the plain on which it lies the name of King Haakon VII's Plateau." Scott and his party, arriving second, were bitterly disappointed to miss "the reward of priority." They died on the return trek to the coast, having carried 31 pounds of geological specimens to the very end. The photograph shows, left to right, Evans, Wilson, Oates and Scott.

After the War the U. S. Navy Antarctic Developments Project (Operation Highjump) in 1946-1947 was then (and remains) by far the largest Antarctic expedition, with more than 4,700 naval and marine personnel, 44 observers, 13 ships, and a number of aircraft. The expedition sighted more than 1.5-million square miles of Antarctica, half of it previously unexplored, and took 15,000 aerial trimetrogon (mapping) photographs. The following season the U. S. Navy Second Antarctic Developments Project (Operation Windmill) used ship-based helicopters to get geodetic ground control for the Highjump photographs. The expedition contributed to production of the first medium-scale maps of the region and influenced decisions regarding locations of stations for the International Geophysical Year the following decade. At a time when other nations had embarked on programs of permanent bases, the U. S. Navy Second Antarctic Developments Project also was a vehicle for continuing the U. S. presence in Antarctica.

4.1.2 Sealing, Whaling, and Fishing British sealers first crossed the Antarctic Convergence in 1778, and Americans in about 1792. Profits were enormous. Around 1797 the *Neptune* of New Haven, a ship worth perhaps $3,000, gathered 45,000 skins at the Falklands and Juan Fernandez, sold them for $90,000 in Canton, bought Chinese goods there and sold them for $260,000 in New York. As subantarctic seals were decimated the sealers pushed farther south. In 1820-1821, at least 30 American, 24 British, and 1 Australian vessels were hunting seals in the South Shetlands. The next year the numbers were perhaps doubled. Landings were said to have been made on the Antarctic Peninsula, the South Orkney Islands were discovered, and at least one and maybe three Americans traveled as far south as 66°S on the west side of the Antarctic Peninsula. James Weddell (British) discovered the Weddell Sea. Fur seals and then elephant seals (for their oil) were reduced almost to extinction by the mid-1800s, at which point the sealers for all practical purposes abandoned this activity. In 1978 the Antarctic Treaty nations agreed to prohibit the taking of fur, elephant and Ross seals, and to limit the annual catch of various other species. No seal hunting has taken place in the Antarctic since 1964 and the populations of fur and elephant seals have significantly regenerated themselves in the last half of the 20th century.

Whaling began in Antarctic waters in the 19th century. The industry enlarged greatly in the early 1900s, when steamships, harpoon guns, and shore processing stations (notably at South Georgia) were introduced. During the 1912-1913 season 10,760 whales were caught. After that time nearly all the whales caught in the world were taken in Antarctic waters. In 1931, the peak year, 40,199 whales were caught in the Antarctic, while 1,124 were caught in the rest of the world. The whaling industry declined after 1960. In the 1980-1981 season fewer than 6,000 whales were caught in the Antarctic; all were Minke whales, a relatively small-sized species. In 1994 the member nations of the International Whaling Commission declared Antarctic waters a whale sanctuary in which no commercial whaling is allowed (Exhibit 11).

Commercial fishing was begun by the Soviet Union in 1967, and in 1971 a Soviet fleet of 40 trawlers and support ships in the southern ocean landed an estimated 300,000 tons — mostly cod, herring, and whiting. In 1995-1996 ten nations landed 115,188 tons, of which 91 percent was krill and the rest finfish. Japan was the principal participant with more than half the catch; the other substantial fishers were Poland and Ukraine. This catch continued modest annual increases since 1993, but well below those taken during the years up through 1990-1991, when the Soviet Union disbanded its long-distance fleet.

Two American firms have engaged in crabbing in recent years, but the unfavorable economics of this activity have resulted in both companies abandoning their efforts.

The Antarctic fishery, a tiny fraction of the world's total annual catch of about 80 million tons, is regulated

Exhibit 11

The biggest environmental impact? In whaling's record year, 1931, that deliberate human action in the Antarctic managed to remove about two million tons of living whale biomass from the marine ecosystem. It is an ironic measure of humans' global reach that this amount is estimated to have been exceeded threefold by that resulting from the existence of the ozone hole, which was caused unintentionally by natural atmospheric transport of industrial chemicals to the Antarctic stratosphere. Because of the ozone hole, enough additional ultraviolet radiation from the Sun reaches the ocean surface to reduce the productivity of marine microorganisms in Antarctic waters by an amount estimated by experimental work to be seven million tons of carbon fixation annually. Here, an instrument that monitors the amount of ultraviolet radiation reaching the surface is operated at Palmer Station.

by the Antarctic Treaty's 1982 Convention for the Conservation of Antarctic Marine Living Resources.

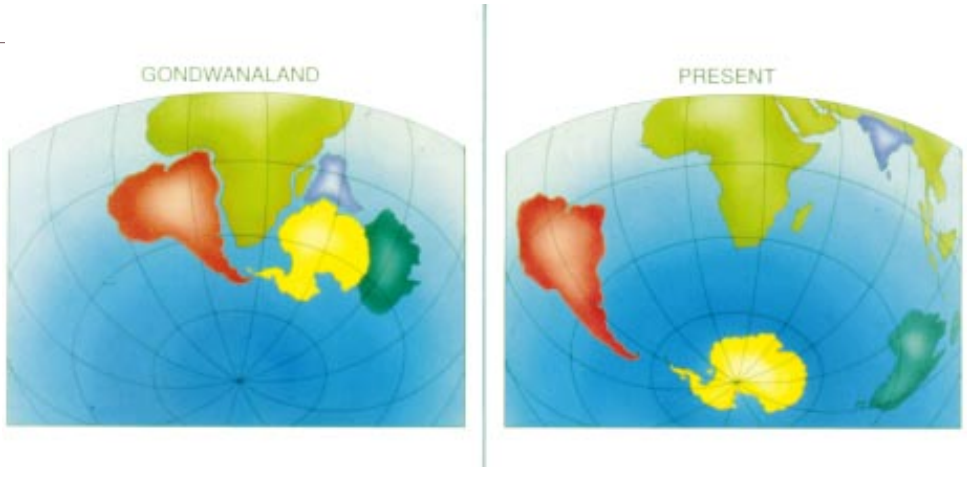
4.1.3 Mineral Resources The issue of exploitation of mineral resources in Antarctica is addressed in Article 7 of the Protocol on Environmental Protection to the Antarctic Treaty: "Any activity relating to mineral resources, other than scientific research, shall be prohibited." U. S. Public Law 104-227, the "Antarctic Science, Tourism, and Conservation Act of 1996," implements the provisions of the Protocol. President Clinton signed it into law on October 2, 1996. The Protocol will enter into force when all nations that signed it in 1991 deposit their instruments of ratification. There is no assurance that some nations will not challenge the agreement in the event of a major discovery of mineral reserves in Antarctica.

Based on current knowledge of the continent's geological setting, the chance that valuable mineral deposits exist in Antarctica appears reasonably high. Prior to approximately 200 million years ago, Antarctica was the centerpiece of a large Southern Hemisphere supercontinent, Gondwana, that included what is today South America, Africa, Madagascar, peninsular India, Antarctica, Australia, and New Zealand (Exhibit 12). The wide distribution of mineral resources across these other Gondwanan continents, including base metals and precious stones, implies that similar deposits probably exist in Antarctica. But with rare exception, the areas that are most likely to contain mineral deposits are covered by the ice sheet. The occurrence of major hydrocarbon deposits in Antarctica is uncertain because deep drilling has not been conducted on the continental shelf; however, the geological evolution of the Antarctic continental margin has resulted in the development of large sedimentary basins with known source rocks for hydrocarbons and likely reservoirs to store these hydrocarbons. Given the prevailing conditions, it is improbable that *chance* discoveries of mineral deposits will be made in Antarctica. Rather, exploration for mineral deposits would require a dedicated, costly program, including in many cases the development of new technologies.

In his book *Cold: The Record of an Antarctic Sledge Journey*, Dr. Laurence M. Gould states that he "had rather go back to Antarctica and find a fossil marsupial than three gold mines." It is unrealistic to think that this philosophy will always prevail, especially if the global demand for mineral resources continues to escalate. Scientific research will undoubtedly lead to better assessment of Antarctica's resources and to better technology for exploiting these resources. To date, the U. S. has played a key oversight role in evaluating geological and geophysical research in Antarctica and in encouraging the exchange of geophysi-

Exhibit 12

The pivotal position of Antarctica in the ancient supercontinent Gondwanaland can be seen in these illustrations. The supercontinent began to rift and break up 180 million years ago.



cal and geological data, all while precluding the commercial exploitation of Antarctica.

4.1.4 Territorial Claims Seven nations have asserted claims to pie-shaped sectors of Antarctica bounded by longitudinal lines: Great Britain (claim made formally in 1926), New Zealand (1923), Australia (1936), Norway (1939), Chile (1940), Argentina (no formal date), and France (1924). The initial claims were based on discovery, adjacency, or decree, and all but one of the claims extend from north of the coast to the South Pole. Three claims overlap. One sector is unclaimed. The claims occasionally have led to conflict; on 2 February 1952 the Argentine navy fired on the British when they tried to land at Hope Bay. Conflicts over other remote areas have not been unknown, including the U.K./Argentina war over the Falklands as recently as 1982. Other nations have acted to make claims, but not asserted them; for example, Germany sent an expedition for this purpose in 1938, and in 1939 Lincoln Ellsworth, heading his second Antarctic expedition (the first was a transantarctic flight in 1935), dropped from his plane a brass cylinder containing a note claiming territories for the U. S. "so far as this act allows."

Other than the claimant states, most nations do not recognize Antarctic claims. U. S. non-recognition, a cornerstone of the nation's Antarctic policy, dates to 1924, when Secretary of State Charles Evans Hughes wrote that discovery of lands unknown to civilization "does not support a valid claim of sovereignty unless the discovery is followed by an actual settlement of the discovered country." In 1934 the Assistant Secretary of State added: "I reserve all rights which the U. S. or its citizens may have with respect to this matter." President Franklin D. Roosevelt reaffirmed the U. S. stance in 1939: "The U. S. has never recognized any claims of sovereignty over territory in the Antarctic regions asserted by any foreign state." In 1947 Dean Acheson, then Under Secretary of State, wrote that the U. S. "has not recognized any claims of any other nations in the area and has reserved all rights which it may have in the area."

Despite the Antarctic Treaty provision that "no acts or activities taking place while the present Treaty is in force shall constitute a basis for asserting, supporting, or denying a claim to territorial sovereignty in Antarctica," some signatories have taken what appear to be assertive steps. For example, both Argentina and Chile publish their claimed Antarctic sectors on their official national maps, and both have established hotels and post offices. Chile has placed whole families in residence at its Antarctic stations, with schools, banks, and other evidence of "effective occupation," including the birth of a child. An Argentinian child was born at Argentina's Esperanza Station in the late 1970s.

4.1.5 International Geophysical Year The IGY, 1 July 1957 to 31 December 1958, was a cooperative endeavor by scientists throughout the world to improve their understanding of the Earth and its environment. Much of the field activity took place in Antarctica, where 12 nations established some 60 research stations. Laurence M. Gould, who was Richard E. Byrd's chief scientist in Antarctica in the 1920s and 1930s and later chaired the National Academy of Sciences Polar Research Board and served on the National Science Board, called the IGY the most comprehensive scientific program ever undertaken and the first attempt at a total study of the environment. "No field of geophysics," he wrote in 1958, "can be understood or complete without specific data available only from this vast continent and its surrounding oceans."

The U. S. established six Antarctic IGY research stations: Little America (on the Ross Ice Shelf), Hallett (in Victoria Land), South Pole and Byrd (in Marie Byrd Land), plus Wilkes (on the coast of Wilkes Land, East Antarctica) and Ellsworth (on the Filchner Ice Shelf). Naval Air Facility, McMurdo Sound (now McMurdo Station), was set up as a logistics base from which to supply South Pole. Studies were directed toward geophysics and upper atmospheric physics and complemented simultaneous observations around the globe. Long traverses were made to collect data in glaciology, seismology, gravimetry, and meteorology. Geological and biological samples were also collected, although these disciplines were not formally part of the IGY (Exhibit 13).

4.1.6 Antarctic Treaty International cooperation in the IGY stimulated the Antarctic Treaty, signed by the 12 Antarctic IGY nations at Washington, D.C., in 1959 and entered into force in 1961. The treaty establishes a legal framework for the area south of 60°S, which includes all of Antarctica. There are two types of Antarctic Treaty parties. Consultative nations, now 26 in number (Exhibit 14), are empowered to meet periodically and to influence operation of the treaty. Acceding nations, of which there now are 17, agree to abide by the treaty, but, not being among the original signatories and not having substantial programs in Antarctica, do not participate in the consultative process.

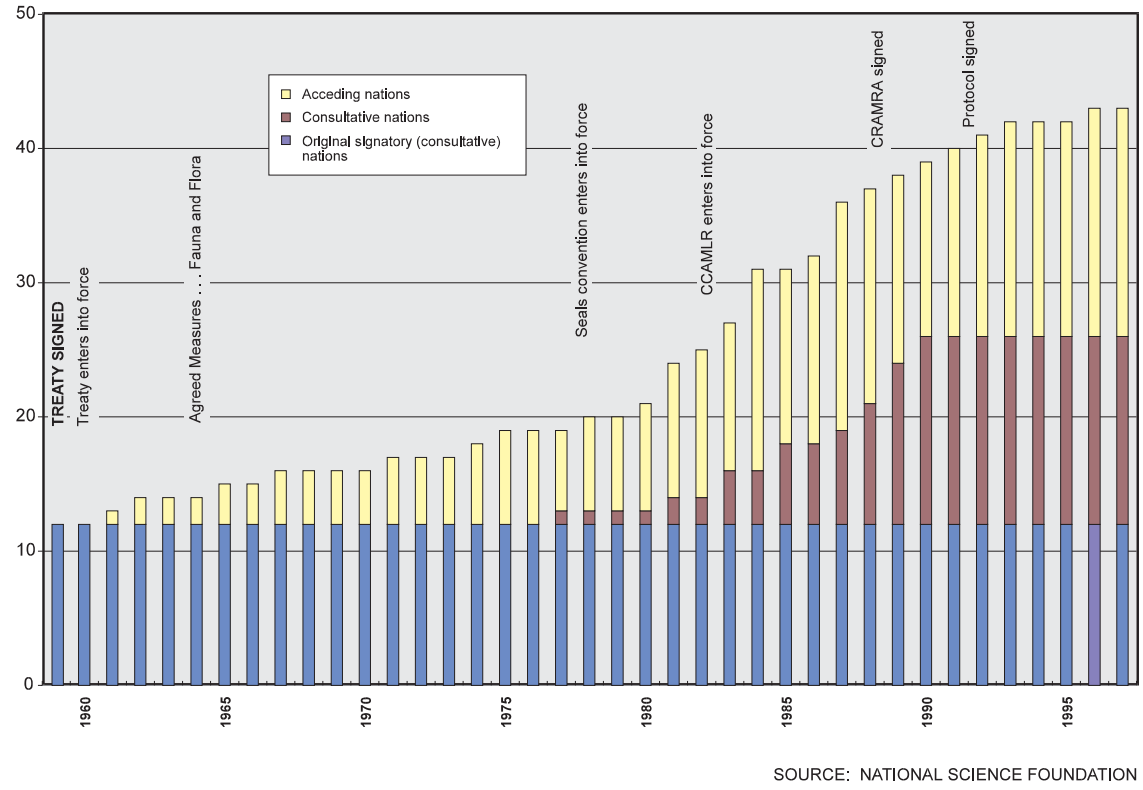
The treaty provides that Antarctica shall be used for peaceful purposes only; it prohibits military operations except in support of peaceful activities. It provides that freedom of scientific investigation and cooperation shall continue and that nations shall exchange program plans, personnel, observations, and results. The treaty seeks to resolve the issue of territorial claims by simply not recognizing, disputing, or

Exhibit 13

Year-round stations serve as research and data collection centers and as support depots for temporary summer camps, traverses, and airborne data collection. In 1995, a typical recent year, 17 nations operated 37 year-round stations. During the intensive 18-month International Geophysical Year (1957-1958), 12 nations operated about 60 year-round stations in Antarctica. Most stations receive their personnel and supplies by ship. Only Marambio (Argentina), Frei (Chile), Rothera (U. K.), McMurdo (U. S.), and Mirnyy (Russia) can land wheeled airplanes. Most Antarctic stations have been established on the coast. Only Russia and the United States have operated year-round stations in the interior over the long term. Russia has closed all but three stations since the breakup of the former Soviet Union.

establishing claims; and it prohibits assertion of new claims. It prohibits nuclear explosions and disposal of radioactive waste. It guarantees access by any treaty nation to inspect others' stations and equipment. Appendix VI further summarizes the treaty.

The consultative meetings provided for by the treaty have generated a series of recommendations, most of which have been formally adopted by the treaty nations, that provide rules for operating on and around the continent. One of the most significant is the Agreed Measures for the Conservation of Antarctic Fauna and Flora, ratified by the U. S. as Public Law 95-541, the Antarctic Conservation Act of 1978. Other advances have included the Convention for the Conservation of Antarctic Seals and the Convention on the Conservation of Antarctic Marine Living Resources. A failed recommendation of significance is the 1988 Convention on the Regulation of Antarctic Mineral Resource Activities, which would have permitted mining if the proponent were to demonstrate that the environment would not be damaged. Instead, a 1991 Antarctic Treaty meeting adopted a protocol for improved environmental protection that prohibits mining; the U. S. signed this protocol into law (PL104-227) in October 1996 and is preparing to deposit its instrument of ratification with the Antarctic Treaty system. The U. S. and other Antarctic Treaty nations are complying with the protocol on a volun-



SOURCE: NATIONAL SCIENCE FOUNDATION

Exhibit 14

Number of Antarctic Treaty nations, 1959-1997. Of the 43 nations that have signed the Antarctic Treaty, 26 are consultative (voting) nations because either they are original 1959 signatories or they perform substantial scientific research in the Antarctic. The 17 acceding nations participate in the annual Antarctic Treaty consultative meetings as observers. The treaty nations represent two-thirds of the world's human population and four-fifths of its economic output.

The 12 nations that performed Antarctic field research during the 1957-1958 International Geophysical Year signed the treaty at Washington, D. C., in December 1959. The treaty entered into force in June 1961 after these nations had deposited their instruments of ratification with the U. S. Department of State.

The 1964 Agreed Measures for the Conservation of Antarctic Fauna and Flora was particularly significant; it is only one of approximately 160 recommendations affecting management of Antarctica that have been adopted over the period covered by this graph. Another significant addition was CCAMLR, the Convention on the Conservation of Antarctic Marine Living Resources, which regulates the Antarctic fishery. CRAMRA, the Convention on the Regulation of Antarctic Mineral Resource Activities, did not achieve ratification; it was replaced by the Protocol on Environmental Protection, signed in 1991, which prohibits mining and strengthens environmental protection generally. As of early 1997, the Protocol appeared likely to achieve ratification by all 26 signing nations, after which it will enter into force.

tary basis pending its entry into force, which will occur only after all 26 of the nations initially signing the 1991 agreement ratify it.

4.1.7 National Programs Twenty-eight nations are now conducting Antarctic research programs. The activities range from summer-only seaborne expeditions that focus on particular science questions to year-round operations that span the research disciplines relevant to the Antarctic. In 1995 there were 37 year-round stations in operation: Argentina 6, Australia 3, Brazil 1, Chile 3, China 2, France 1, Germany 1, India 1, Japan 2, South Korea 1, New Zealand 1, Poland 1, Russia 5, South Africa 1, United Kingdom 4, United States 3, and Uruguay 1. Many of these nations, and other nations, operated additional summer stations and camps for research field work that is feasible only in summer.

4.2 Current U. S. Antarctic Program

Each year the USAP deploys approximately 3,500 scientists and support personnel to Antarctica and its surrounding seas to support basic research in many disciplines, including aeronomy and astrophysics, atmospheric chemistry, biology, Earth sciences, ocean and climate systems, glaciology, and environmental science. Although a far smaller effort, Antarctica also

offers a promising environment for the conduct of certain types of applied research and technology development. In FY95 and FY96, U. S. researchers came from institutions in 26 states and the District of Columbia.

The budget for the (NSF) U. S. Antarctic Program is $193.5M in FY97. Of this amount $30.5M consists of grants to scientists at research institutions, $41.0M is spent on direct field support of these research projects, and the balance of $122.0M is spent on logistics and operations that provide the infrastructure enabling the U.S. presence and science. These figures reflect the high costs of working in so remote a location. Additionally, in FY97, a separate NSF account is funding a $25M emergency safety and environmental upgrade at South Pole Station.

The history of spending for the USAP is shown in Exhibit 15. Exhibit 16 presents research and operations costs assignable to each U. S. location in Antarctica. Exhibit 17 categorizes the research funding according to function.

The NSF funds and manages the following major facilities as an integrated system for the support of research and related activities in Antarctica:

4.2.1 McMurdo Station, the principal U. S. facility, on Ross Island, coast of Antarctica (peak summer population capacity 1,258; 1996 winter, 232)

The largest Antarctic station, McMurdo (Exhibit 18) is built on the bare volcanic rock of Hut Point Peninsula on Ross Island, the most southerly solid ground that is accessible by ship. It is located just 20 miles south of Mt. Erebus, an active volcano that steams continually and erupts frequently though not violently.

The station, established in December 1955, is the logistics hub of the USAP, with a harbor, landing strips on sea ice and shelf ice, and a helicopter pad. Its 85 or so buildings range in size from a small radio shack to large, three-story structures. Repair facilities, dormitories, administrative buildings, a firehouse, power plant, water distillation plant, wharf, stores, and warehouses are linked by above-ground water, sewer, telephone and power lines. The water and sewer lines are heat-taped and insulated.

The Albert P. Crary Science and Engineering Center at McMurdo was dedicated in November 1991. The laboratory is named in honor of geophysicist and glaciologist Albert P. Crary (1911-1987), the first person to set foot on both the North and South Poles. The laboratory contains state-of-the-art instrumentation to facilitate research and to advance science and technology. It contains personal computers and workstations and a local area network. It has laboratory space, analytical instrumentation and staging areas for a range of scientific disciplines. The laboratory also supports studies of snow and ice mechanics, meteorology and special activities, including environmental monitoring and enforcement. The lab has five pods built in three phases to provide 46,000 square ft. of working area. Phase I has a two-story core pod and a biology pod. Phase II has Earth sciences and atmospheric sciences pods. Phase III has an aquarium. Other facilities are maintained for atmospheric sciences and other disciplines.

Williams Field, a skiway ten miles from McMurdo on the Ross Ice Shelf, is the aerodrome for ski-equipped airplanes. Wheeled airplanes use a harder, smoother runway on sea ice in October,

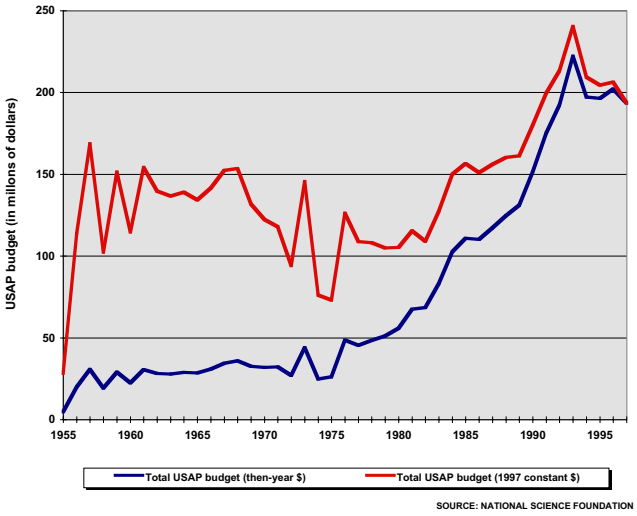


Exhibit 15

U.S. Antarctic Program funding, 1955-1997. In 1955 the U. S. began preparing for the International Geophysical Year, which took place officially from 1 July 1957 to 31 December 1958. After the IGY, the decision was made to support a continuing, or post-IGY, research program; some facilities were closed, and others were added. Budget volatility in the years 1957-1962 reflects this transition.

Fluctuations in the period 1973-1977 are caused by LC-130 procurement and budget-base transfer of costs from DOD, a continuing multi-year result of DOD's action to quantify and transfer Antarctic costs pursuant to the 1970 decision to consolidate funding for the U. S. Antarctic Program at the National Science Foundation. Part of the rise in the 1980s is attributable to completion of this process; for example, the NSF began paying the Antarctic-attributable share of military retirement costs in 1985.

The years 1990-1994 contain a five-year $85M safety, environment and health initiative. The 1993 spike contains $49M for LC-130 procurement.

This graph includes DOD, USCG, and NSF Antarctic spending for all the years shown. The graph does not include research spending by other agencies; in FY96, other agency research accounted for about three percent of the U. S. Government's total funding of Antarctic research and research support. Years shown are fiscal years.

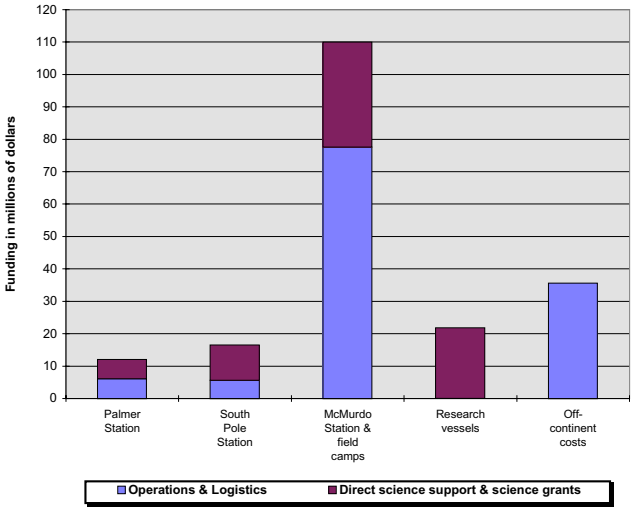


Exhibit 16

USAP FY95 funding (totaling $196M) by facility. Most of this money is spent in the U.S. for acquisitions, salaries, equipment, planning, and follow-up research at home institutions. All science-grants funds are assigned to Antarctic locations even if the research was done entirely at home institutions. The $35.5M in "off-continent costs" is for contractor and military headquarters operations in the United States and for staging facilities in Christchurch, New Zealand, and Punta Arenas, Chile.

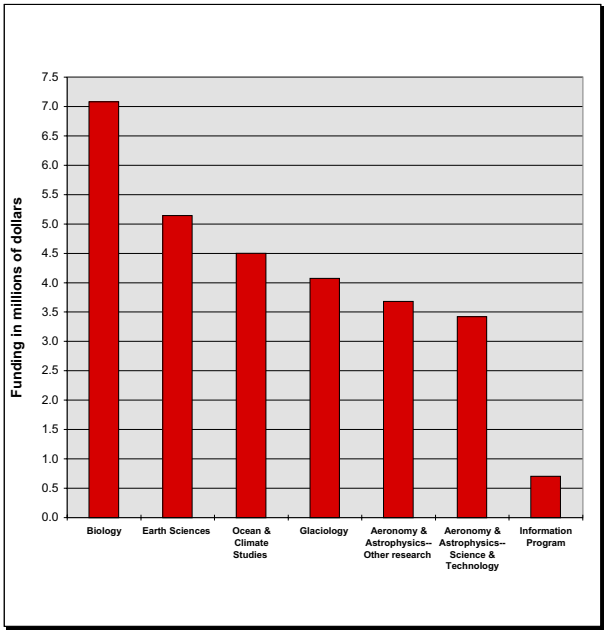


Exhibit 17

USAP FY 95 science grants to research institutions (totaling $29M) by discipline. These amounts do not include operational support in the Antarctic.

Exhibit 18

McMurdo Station. McMurdo, Antarctica's largest station, has airports and a seaport, research laboratories and support facilities. The light-colored building at the center of this photo is the Albert P. Crary Science & Engineering Center. A Coast Guard icebreaker in Winter Quarters Bay is tied to the pier, which is built of ice.. The small hut on Hut Point in the background was built by Robert F. Scott in 1902 and is protected as a historic site under the Antarctic Treaty.

November and into December, at which time the sea ice usually softens and becomes unusable. A permanent, hard-ice runway for wheeled planes, the Pegasus site on the Ross Ice Shelf, completed in 1992, can be used in all but the warmest (and, unfortunately, busiest) months (mid December to late January). Although the surface is available during the winter months, there is currently no lighting or other airfield support planned to enable winter operations.

Low and high recorded temperature extremes at McMurdo are -58°F and 46°F, respectively. Annual mean is 0°F; monthly mean temperatures range from 27°F in January to -18°F in August. Drifting snow can accumulate about four ft. per year, although the station becomes snow-free in summer. Average wind is about 11 miles per hour with a gust of 116 miles per hour having been recorded in July 1968.

Research is performed at and near McMurdo in marine and terrestrial biology, biomedicine, geology and geophysics, glaciology and glacial geology, meteorology, aeronomy, and upper atmosphere physics. Air transportation to New Zealand is frequent between October and February— the Antarctic summer. The winter population is isolated from late February to late August (Exhibit 19).