

Courtesy Paul Popper Ltd., London.

The Terra Nova, Captain Robert Scott's ship, photographed in 1911 by Herbert Ponting from a cavern in an Antarctic iceberg. The deaths of Scott and four companions as they tried to get back to the ship from the South Pole climaxed the "heroic age" of Antarctic exploration.

Antarctica

Two hundred years ago, Captain James Cook circled Antarctica, saw that it was ice-covered, and lamented that man would “derive no benefit from it.” But European and, later, American explorers still pushed south, driven by what one of them called the “Intellectual Passion”—the pursuit of knowledge for its own sake. By the end of the 19th century, Antarctica was the last uncharted territory on Earth. Today, the geography of the continent is less mysterious; scientists probing beneath the ice have found coal, uranium, titanium, and strong evidence of oil deposits. Here, historian Peter Anderson describes the great age of exploration. Political scientist Barbara Mitchell assesses recent developments. Antarctica, she writes, has become a “giant, open-air laboratory” for experiments in science, in fisheries, and, willy-nilly, in international relations.

HOW THE SOUTH WAS WON

by Peter J. Anderson

As the age of the dinosaurs dawned 225 million years ago, the land mass of Pangaea—mother of continents—was being broken apart by earthquakes and volcanoes. Lava surged through great rifts in the Earth’s crust, and the continent was split in half. A sea began to form, separating the southern “supercontinent” that geologists have named Gondwana (comprising South America, Africa, Australia, India, and Antarctica) from its northern twin, Laurasia.

At the time, Gondwana probably lay somewhere in the vicinity of the equator, surrounded by a warm-water ocean. The portion of Gondwana that would become Antarctica—and eventually be covered by a crushing ice sheet—was once, it seems, a hospitable place. Parts of it may have resembled the Pacific Northwest, with thickly forested mountains giving way to lush

lowlands drained by meandering rivers and streams. Eruptions by Gondwana's many volcanoes occasionally spewed hot ash and lava across the countryside, possibly contributing to a gradual warming of the planet. (Antarctica today is pockmarked with extinct volcanoes.) Tall, pine-like trees flourished from the rainy uplands down to the warm, flood-prone plains. Cooler, danker locales sustained giant ferns and 30-foot-tall *Glossopteris* trees with large tongue-shaped leaves.

Wandering Continents

One of the earliest inhabitants of the land was the carnivorous *Labyrinthodont*, which appeared even before Pangaea began to break apart. These primitive amphibians probably shared their watery habitat with the *Lystrosaurus*, a vegetarian reptile and an ancestor of the hippopotamus. In 1971, paleontologists found fossil skeletons of the *Thrinaxodon*, a spry, reptilian carnivore built somewhat like a weasel. In the trees lived the *Prolacerta*, a foot-long, lizard-like reptile with powerful limbs and a supple body. It probably fed on insects and on the young of other creatures. Antarctica's exposed rock has yielded other reptile fossils, suggesting that a rich and varied history of animal life may lie buried beneath the ice. Whether Antarctica was ever inhabited by dinosaurs or their relatives is not known.

Even as the Antarctic menagerie evolved, all of Gondwana was slowly drifting south and beginning to break apart. First, South America and Africa tore away from the mother continent, the Atlantic Ocean ultimately forming between them. Antarctica, Australia, and India, still linked together, continued to move slowly to the south, arriving near the South Pole about 100 million years ago.

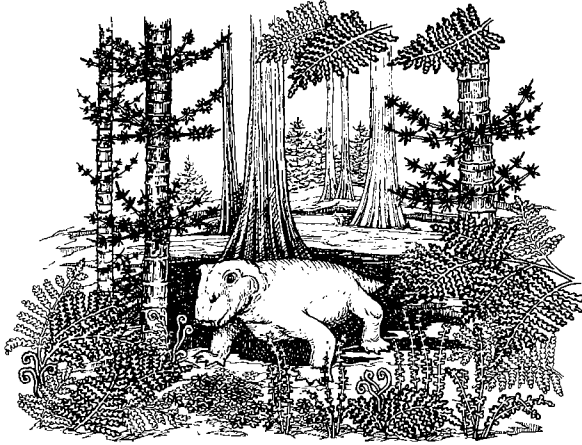
Some 35 million years later, Australia and India broke free and began edging north toward their present positions; India eventually collided with the Asian continent, plunging under it and forming the great "uplift zone" that we call the Himalayas. Antarctica was now alone at the South Pole.

The once-pleasant continent began to ice over between 10 and 25 million years ago, for reasons that are little understood.

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An artist's
conception of a
Gondwana forest,
depicting the reptile
Lystrosaurus beneath
the overhanging
leaves of a
Glossopteris tree.

From *This Is Antarctica*,
by Joseph M. Dukert.



It became a great frozen desert, larger than the continental United States and Mexico combined, with a meager annual precipitation of only two inches in the vast interior plateau. But the long Antarctic night (during the March to September winter, the sun skirts the horizon, disappearing for months at a time) and the reflective qualities of the ice cover ensured that very little ice would ever melt. So it accumulated, layer by layer.

Today, 98 percent of the continent's surface is covered year-round by ice. Only in a few coastal areas does the summer temperature rise to near freezing, and inland it commonly drops to near -100°F during winter. The coldest temperature ever recorded anywhere in the world was almost -127°F , reported by the Soviets' Vostok station in the interior in 1960. On the Antarctic Peninsula, the continent's long "tail," the climate can be far more hospitable. Balmy 40°F temperatures have been reported there in summer, and precipitation is relatively heavy.

As the ice built up, it became so heavy that the land beneath it was pushed, on average, about 2,000 feet into the Earth's crust. (Much of the original Antarctic land mass now lies well below sea level.) Mile-high mountains were buried up to their tops. Today, their summits (called "nunatuks") protrude modestly above the thick ice cover, some of them only a few feet high. Yet, in other places, mountains unconquered by the ice draw themselves up to their full height—almost 17,000 feet.

Homo sapiens evolved long after the continent froze over. But philosophers and explorers have presumed its existence since the beginning of Western civilization.

The Greek philosopher, Crates of Melos, speculated in the second century B.C. that the Earth was a sphere composed of four separate, equal-sized continents, with two in the Northern Hemisphere and two in the Southern. The Greeks already knew about one of the southern continents—Africa—but the other was unknown to them. They envisioned it as temperate in climate, a land of abundance inhabited by a peaceful people.

The first man thought to have actually approached Antarctica was the Polynesian sailor Ui-te-Rangiora in about A.D. 650. According to Polynesian legend, Ui-te-Rangiora sailed south in a large open canoe called *Ti-Ivi-o-Atea* until he reached an immense frozen ocean.

During the Middle Ages, the dream of a fabulously rich southern continent took hold in the West. European thinkers then had no contact with the Polynesians. Little by little, however, evidence supplanted supposition. In 1497, for instance, the Portuguese navigator Vasco da Gama sailed around the Cape of Good Hope at the southern tip of Africa, disproving a popular notion that the “southern continent” was really just an extension of Africa.

Dashed Dreams

Early maps typically reflect Europeans' hopes and ignorance more accurately than Antarctica's shape and position. Yet there are some mysterious exceptions. In 1532, for instance, a French cartographer named Oronce Finé published a remarkable map in Antwerp showing the Antarctic coast as it would appear today if free of ice. A terse notation says only that the continent was “recently discovered, but not yet fully known.” Possibly, then, Antarctica's glaciers had receded considerably by the 1400s, and some now unknown sailors had visited the continent.

The old dreams of riches persisted until Britain's George III dispatched his kingdom's finest navigator and explorer, Captain James Cook, to settle the issue once and for all in 1772. Cook was directed to survey the southern seas, partly to aid British merchant ships. But his “prime object,” as he saw it, was to discover the southern continent.

Between 1772 and 1775, Cook circumnavigated Antarctica, braving high winds and severe cold. But he was unable to penetrate the barrier ice packs that girdle the continent. While Cook never saw land, he realized that any continent beyond the pack ice would be no paradise and remarked that it would “afford no better retreat for birds, or any other animals, than the ice itself,

with which it must be wholly covered.”

Cook's voyage was a remarkable achievement. The southern seas are among the world's stormiest, because the continent's cold air collides with the much warmer air from the north, creating constant high winds that circle Antarctica. Closer to the mainland, the ocean is studded with icebergs, formed when slices of the permanent ice shelves that cover the continent's embayments break away. These flat-topped, "tabular" bergs may be hundreds of feet tall and the size of a small country. (During the 1970s, a tabular iceberg the size of Luxembourg was seen.) Tabular bergs in turn "calf" dozens of smaller icebergs.

An Accidental Discovery

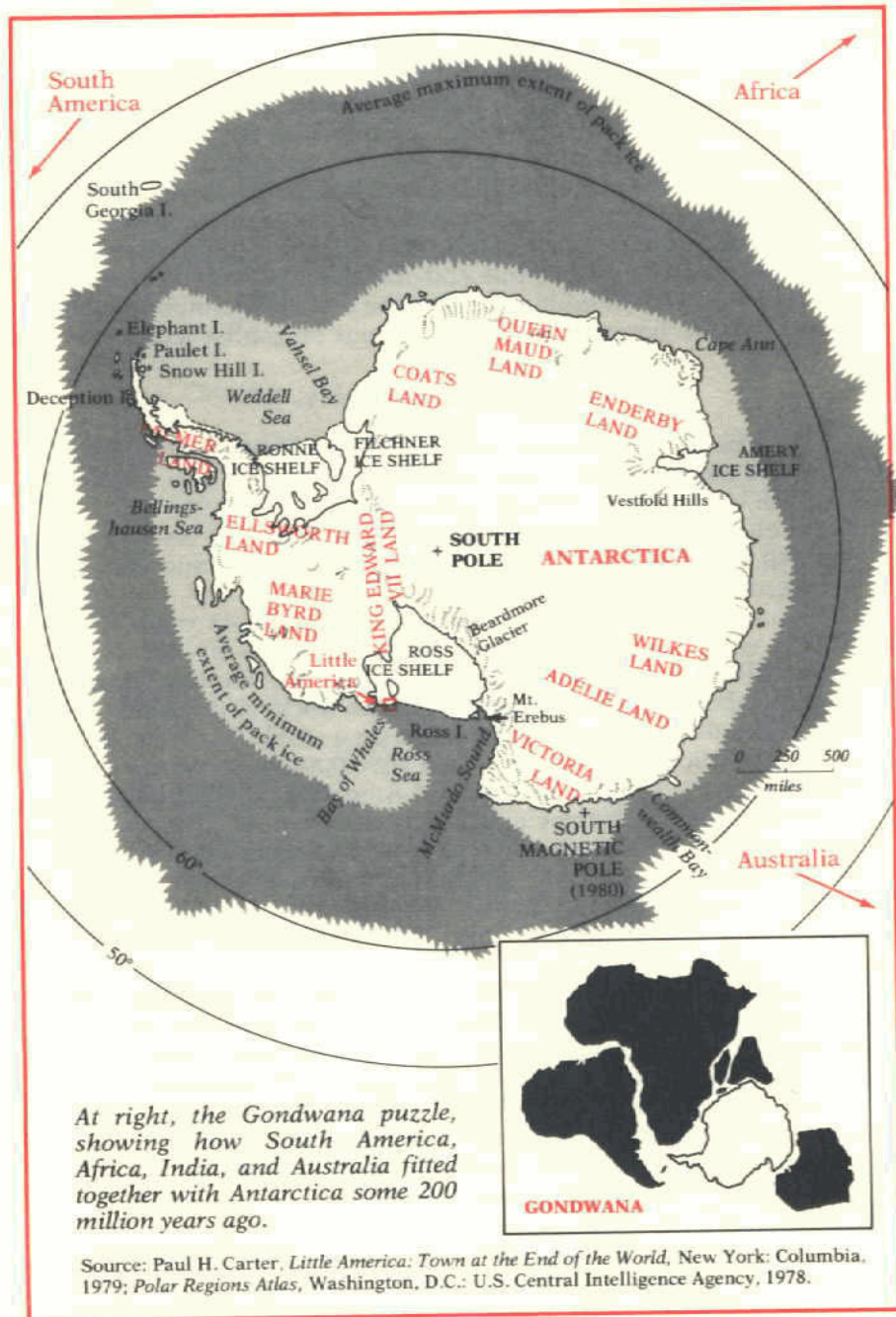
In winter, the Antarctic seas freeze over for up to 700 miles from the continent, virtually doubling its "land" area. As this pack ice breaks apart with the approach of summer, the floating bergs cluster together in the surrounding seas. The pack is inhabited by penguins and seals, who visit the mainland only to breed, and is frequented by killer whales.

Antarctica itself was not sighted until some 45 years after Cook's expedition. It seems to have happened by accident. Around 1800, American and British sealers and whalers, having depleted their quarry in the Arctic, began working the South Atlantic. Small fortunes could be made on a single trip. (The brig *Betsy* took 100,000 seal pelts worth \$680,000 in one season.) On November 17, 1820, a 19-year-old American sealing captain named Nathaniel Palmer apparently became the first man to sight Antarctica. The coastline he saw many miles distant was desolate and inaccessible: "Thought it not Prudent to Venture in ice Bore away to the Norther'd and saw 2 small Islands and the shore every where Perpendicular." The sight was of little interest to a sealer.

Actually, there are two other candidates for the honor of first to spy the continent. The Russian admiral Fabian von Bellingshausen circled Antarctica between 1819 and 1821, charting the seas and islands in the region with remarkable accuracy. He may have sighted land without even knowing it, for more than once he approached to within 20 or 30 miles of the coast. But Bellingshausen never claimed he saw land. It was not until 1949 that the Soviet Union—alarmed by new Antarctic territorial claims by other nations—asserted that he had.

Also in the region at the time was an Englishman, Sir Edward Bransfield. Like Bellingshausen, he came close to land but never claimed to have seen the continent. Bransfield sent a

ANTARCTICA



written account of his journey to London late in 1820, but the Admiralty promptly lost it, and it has not been seen since.

Whaling and sealing captains again dominated the region after Bellingshausen and Bransfield departed. The next wave of exploration did not come until 20 years later, and it was motivated as much by scientific inquiry as by commercial interests. Captain James Clark Ross, an Englishman, had sailed to the North Magnetic Pole in 1831. The German scientist, Johann Gauss, believed that if the South Magnetic Pole could be found, the erratic compass readings that plagued sailors near the ends of the Earth could be corrected. Three nations launched expeditions, almost at the same time.

The Redoubtable Ross

The first to head south, in 1837, was a French group, headed by Jules Dumont d'Urville commanding the *Astrolabe* and *Zelée*. D'Urville could not make it through the pack ice near the Weddell Sea. In 1839, he tried the Pacific side, encountered little ice, and eventually sighted land. On January 22, 1840, he stepped ashore on a small, rocky island 100 yards off the coast of Antarctica. Looking across the water, d'Urville saw an unbroken featureless shoreline terminating in sheer ice cliffs. He named it Adélie Land, after his wife. Antarctica, he wrote, "appears to consist of a formidable layer of ice, rather like an envelope, which forms the crust over a base of rock." Somewhere beyond its cliffs lay the Magnetic Pole, but he was not prepared to venture inland.*

An American expedition had been envisioned as early as 1821, with an eye to commercial prospects, but Congress dragged its feet for 15 years before authorizing one. Lieutenant Charles Wilkes, a stern and stubborn naval officer, was given the command, setting sail from Virginia in the summer of 1838. He felt, he said, "like one doomed to destruction." Under his command were 440 unhappy crewmen and five leaky ships. Two of them, the *Sea Gull* and *Flying Fish*, were refitted New York harbor-pilot boats. The *Sea Gull* later sank in a storm.

Like d'Urville, Wilkes penetrated the pack ice on his second try, sighting land on January 19, 1840. He raised the Stars and Stripes over a small offshore island 26 days later. By then, Wilkes's men were exhausted, cold, and hobbled by scurvy. But

*In 1840, the South Magnetic Pole was located at some still unknown point in the Antarctic interior. But both magnetic poles are peripatetic. When T.W.E. David reached the South Magnetic Pole in 1909, it was in Victoria Land; today, it is close to 600 miles away, off the coast of Adélie Land. The "South Pole," by contrast, is a fixed geographical point.

the lieutenant pushed on. "I considered it my duty to proceed and not to give up the cruise until the ship was totally disabled, or it should be evident to all that it was impossible to persist any longer," he later recalled. His men begged him to turn back. Wilkes did, but not before completing a month-long cruise along 2,000 miles of the coast, now called Wilkes Land.*

The third man to visit Antarctica was the redoubtable Captain James Clark Ross, a seasoned Arctic explorer. The Ross expedition was well-manned and well-equipped. Ross arrived in two specially built ships, *Erebus* and *Terror*, and bearing the British flag he had flown over the North Magnetic Pole. The ships' reinforced hulls crashed into the pack ice early in January 1840. Four days later, intact, the ships broke into open seas.

Wintering Over

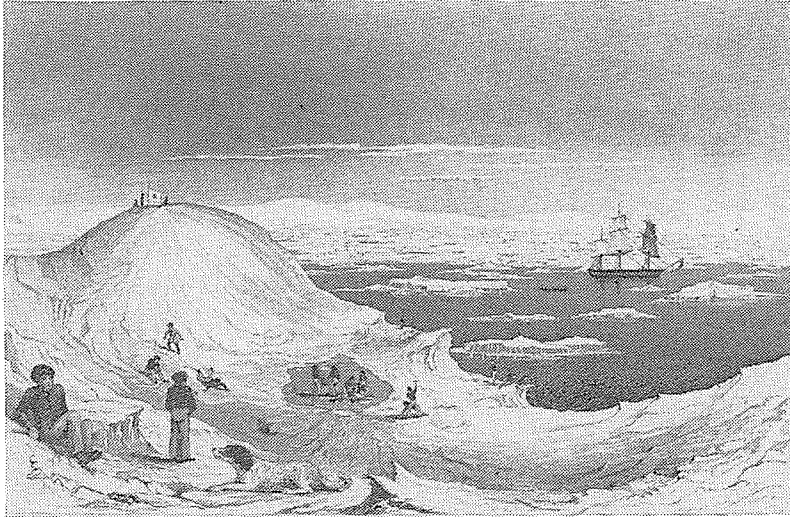
On the 11th of January, a lookout spotted a distant coastline, which Ross named Victoria Land in honor of the Queen. His two ships continued along the coast, traveling farther south than anyone yet had gone, until he reached an island with "a stupendous volcanic mountain in a high state of activity" (as one crew member put it), which he called Mount Erebus. The island, and the 400-mile-long "barrier" ice shelf along the coast beyond it, were named after Ross.

The Ross Ice Shelf would later become the "highway to the South Pole"; expeditions routinely established their base camps there. It is a floating, flat-topped piece of ice, more than a thousand feet thick in places and about the size of France. The shelf is permanently attached to the land and is fed by glaciers. Every year, it grows by about 1,000 feet along its seaward edge, but most of this growth falls off, creating tabular icebergs.

After Ross's departure, interest in the continent subsided. The next surge of exploration began after representatives to the Sixth International Geographical Conference declared at their 1895 London meeting that Antarctica represented the "greatest piece of geographical exploration still to be undertaken." Between 1897 and 1916—the period known as the "heroic age"—15 expeditions sailed for the great southern continent.

The first of them was a Belgian-led enterprise, under the command of Lieutenant Adrien de Gerlache de Gomery. In January 1898, de Gerlache's ship, the *Belgica*, reached the Antarctic Peninsula and made 19 landings. It was rough going. A small

*Wilkes was court-martialed when he went home, charged by his officers with "oppression, injustice, administering illegal punishments, falsehood, and scandalous conduct." He was acquitted, but Congress denied him the funds to publish his account of the voyage.



Lieutenant Charles Wilkes sketched members of his crew as they relaxed off-duty on an iceberg floating 75 miles off the Antarctic coast in February 1840.

party sent inland covered only one mile in seven days. The ship's surgeon, an American, Dr. Frederick Cook, reported: "On 1st of February we made another effort struggled a few hundred yards into the interior, but fog and wind and crevasses made frequent halts necessary. The sledges were difficult to drag, and altogether the work of traveling and the discomfort of camping were such that life was miserable in the extreme."

De Gerlache cruised leisurely along the coast—a bad mistake, for the brief Antarctic summer was drawing to a close. Soon, icebergs moved in, and the sea froze over, trapping the *Belgica*. Its 18 men drifted with the ice in their captive ship for 13 months. They suffered scurvy, depression, and what Cook called "polar anemia." When the sun disappeared during winter, two sailors went mad. (One recovered when daylight reappeared.) Dr. Cook wrote of life in the darkness: "The skin grows pale, muscles grow weak, and the organs are unable to function with their usual vigor. This effect is most noticeable in the action of the heart, which . . . is deprived of its regulating force, and becomes now quick, now slow, but never normal." Finally, the crew cut a channel through ice seven feet thick and reached the sea, then less than half a mile away.



Library of Congress.

In January 1912, Edgar Evans, Edward Wilson, L.E.G. Oates, and Robert Scott stand despondently beside the tent that Norway's Roald Amundsen had left behind to mark his arrival at the Pole more than a month earlier.

Another expedition faced even more extreme hardships. In February 1902, the *Antarctic* put Swedish scientist Otto Nordenskjöld and four other men ashore at Snow Hill Island, off the Antarctic Peninsula, to carry out scientific work. Nordenskjöld's men were astonished to find tiny wingless flies and mites living there—Antarctica's only year-round indigenous inhabitants apart from fleas and lice. These insects live on rocks warmed by the sun and "hibernate" for all but a few months of the year. The explorers also found fossil remains of a pre-historic penguin that probably stood between five and six feet tall.

The *Antarctic* sailed further south, planning to return during the austral spring. But in December, on its return trip, the ship became icebound. Three men were dispatched to travel over the frozen sea to reach Nordenskjöld and bring him to safety. They encountered a gulf of open water and had to turn back. But the *Antarctic* was gone.

The three men built a shelter on Paulet Island and prepared to wait out the long, dark Antarctic winter. For nine months, they huddled in a hut. Inside, the temperature hovered a few de-

grees below zero, the "warmth" sustained only by burning seal blubber, which, along with penguins, was also their main food.

By September 1903, it was clear that the *Antarctic* was not going to return. The three men set out for Snow Hill Island, where Nordenskjöld had last been seen. Although they were starving and at one point lost their tent to high winds, the trio took the time to collect rock specimens. By a lucky coincidence, they encountered Nordenskjöld, who was on a field trip. At first, the scientist mistook the men for penguins as they approached. "I am asking myself to what primitive sub-species they can belong, when one of them holds out his hand: 'You don't recognize us, do you!'" The travelers were completely blackened by blubber soot. A week later, they were all back at Snow Hill Island. On November 8, an Argentine rescue ship appeared offshore.

The Race to the Pole

The *Antarctic*, meanwhile, was at the bottom of the sea. It had been crushed by the ice, nine months before. The crew of 20 escaped and made a winter camp on the coast, subsisting, like the other scattered members of the expedition, on seals and penguins. Killing penguins was simple. With no natural land predators, the birds waddled up to a man out of sheer curiosity.

As the summer neared, the *Antarctic* crew set out for Snow Hill Island. Miraculously, they reached it on the evening of November 8, 1903, hours before the Argentinian ship was scheduled to leave with the other survivors.

Gaining scientific knowledge was but one spur to exploration during the heroic age. Above all stood the elusive, symbolic quest for the geographic South Pole, more than 800 miles inland across the highest, windiest, and coldest territory on the Earth.

The first major treks into the Antarctic interior occurred between 1901 and 1904. Robert Falcon Scott, a British Navy lieutenant with no previous experience in either polar region, had established a British Royal Geographical Society base at McMurdo Sound. Accompanying Scott was another young lieutenant, Ernest Shackleton. In November 1901, Scott, Shackleton, and Dr. Edward Wilson, a physician and painter, set out with dog sledges to cross the Ross Ice Shelf. It was a foolhardy escape, for all three men were poor skiers and novices when it came to handling dogs. In 93 days, they made a 960-mile round trip, but they also lost their 19 huskies and nearly starved to death. Shackleton, disabled by scurvy, had to be taken back to base on a sledge hauled by his companions.

During that trip, Scott and his companions encountered

ANTARCTIC FIRSTS

First Landing (1821): Boat crew from New Haven (Conn.) sealer *Cecilia* goes ashore on Antarctic Peninsula.

First Fossil (1830): American geologist James Eights discovers 30-inch fragment of petrified wood lodged in iceberg.

First Death on Mainland (1899): Nikolai Hanson, a Norwegian taxidermist, dies of scurvy while wintering over with Carstens Borchgrevink's party.

First Motorized Vehicle (1908): Bernard Day, Ernest Shackleton's automotive expert, drives four-cylinder, 15-horsepower "Arrol-Johnston" car on the sea ice.

First Book Published (1908): Shackleton's crew prints 90 copies of whimsical narrative, *Aurora Australis*, using wood from packing cases for covers.

First at South Magnetic Pole (1909): Australian T.W.E. David, age 51, leads three-man expedition 600 miles inland to magnetic pole.

First Plane Flight (1928): Australian Sir Hubert Wilkins flies single-engine monoplane *Los Angeles* along Antarctic Peninsula coastline.

First Journalist (1928): *New York Times* correspondent Russel Owen accompanies Admiral Richard Byrd to Little America, winning Pulitzer Prize for his reporting.

many of the unique hardships that make Antarctic exploration so perilous—snow blindness, caused by the unrelieved glare off the ice; "sastrugi," the rugged ridges of hard snow; and the deep, hidden crevasses that could abruptly swallow up a man and a whole team of huskies.

Some hazards they were spared. During a brief jaunt over the sea ice on a later expedition, a photographer named Herbert Ponting encountered a school of killer whales. Swimming at top speed, these aggressive predators crash through the sea ice from below, hoping to catch an unsuspecting penguin or seal. This is what happened to Ponting. The ice suddenly heaved beneath him, breaking into small chunks. "It was all I could do," Ponting wrote, "to keep my feet as I leapt from piece to piece of the rocking ice, with the whales a few yards behind me, snorting and blowing among the ice blocks." But he escaped.

Shackleton was the first to return to the continent expressly for an assault on the Pole. He advertised in a London newspa-

First Movie Shown (1929): Members of first Byrd expedition watch *Moana of the South Seas*, a 1925 Paramount romance.

First Woman on Continent (1935): Caroline Mikkelsen, wife of a Norwegian whaling captain, sets foot on coast near snow-free Vestfold Hills.

First Act of War (1941): German raider *Pinguin* captures Norwegian whaling fleet off Queen Maud Land.

First Visit by Head of State (1948): Chilean President Gabriel González Videla lands on the Antarctic Peninsula, establishes Bernardo O'Higgins Base.

First Overland Crossing (1958): British tractor expedition led by Sir Vivian Fuchs completes 99-day, 2,100-mile passage from Weddell to Ross Sea.

First Nuclear Reactor (1962): United States activates nuclear power plant at McMurdo Station; replaced in 1972 by diesel generator.

First Women at South Pole (1969): Six women—five scientists, one newspaper reporter—jump hand-in-hand from ramp of transport plane at South Pole.

First Child Born (1978): Emilio Marcos Palma, son of Argentine Army captain, born at Esperanza Station on the Antarctic Peninsula.

First Wedding (1978): Argentine 1st Sergeant Carlos Alberto Sugliano marries Julia Beatriz Buonamio at Esperanza Station.

per: "MEN WANTED for Hazardous Journey. Small wages, bitter cold, long months of complete darkness, constant danger, safe return doubtful." The response was overwhelming. As Shackleton wrote later, "It seemed as though all the men in Great Britain were determined to accompany me." In January 1909, Shackleton and three companions came within 97 miles of their goal but were forced to turn back for lack of food.

Late in 1910, three expeditions ventured to Antarctica in search of the South Pole. The first, commanded by Lieutenant Choku Shirase of the Japanese Navy, turned back because of bad weather. Scott, now a captain, left a post at the Admiralty to head up a British effort. The third was led by the Norwegian Roald Amundsen; a veteran of the *Belgica* journey and of numerous expeditions in the north polar regions. Amundsen had actually hoped to reach the North Pole, but when Admiral Robert Peary of the United States got there first, in 1909, he secretly decided to try the remaining alternative. Amundsen feinted north,

then turned around in mid-sea. "Beg leave to inform you proceeding Antarctica," he cabled Scott. The race was on.

Amundsen was a big, bluff, plain-spoken fellow with a driving desire to be first. Scott was a stiff, old-school naval officer—he maintained separate officers' quarters even at his cramped base camp—but also a complex, sensitive man. One reason he disliked using dogs in polar exploration was that the weaker ones often had to be killed to feed the stronger. Scott settled on Siberian ponies (which, unfortunately, quickly died) and man-hauled sledges for his trek to the Pole. Amundsen, who had far more experience in polar travel, used huskies—the preferred means of transport. Scott also intended to carry out an extensive program of scientific research. "Science is the rock foundation of all effort," he once said. Amundsen, by contrast, had a single mission: to get to the Pole before anyone else.

An Awful Place

Both teams established their bases near the Ross Ice Shelf late in 1910. Amundsen gambled on a site upon the ice shelf itself, near the Bay of Whales. It was 60 miles closer to the Pole than Scott's base on Ross Island. On October 20, 1911, in the Antarctic spring, Amundsen set out with four men, four sledges, and 52 dogs. Scott left four days later, accompanied by seven men, three of whom would turn back after establishing food depots for Scott's return trip (a task Amundsen's men had accomplished the year before).

Amundsen's account of his trip is almost light-hearted. The men rode on the dog sledges for the first 100 miles and were pulled along on skis for many of the next 300. They encountered the usual difficulties, but these Amundsen brushed aside. His chief complaint was frostbite: "The left sides of our faces was one mass of sore, bathed in matter and serum. We looked like the worst type of tramps and ruffians."

On December 14, 1911, they reached the South Pole. Five pairs of hands grasped a flagpole with the Norwegian colors and drove it into the ice to mark the spot. Amundsen and his party stayed there for two days, taking bearings to make certain they were at the right place. By January 25, they were back at the Bay of Whales. "The going was splendid," Amundsen recalled. "We were in high spirits and bowled along at a cracking pace."

Eight days before, after an exhausting, 86-day march, Scott himself had reached the Pole. He was not so ebullient. "Great God! this is an awful place," he wrote the next day, "and terrible enough for us to have laboured to it without the reward of prior-

ity." For there to greet his team stood the small black tent and Norwegian flag that Amundsen had left behind. "Now for the run home and a desperate struggle," Scott added. "I wonder if we can do it."

They could not. The piercing wind, the unrelenting cold, and the terrible labor of pulling the heavy sledges over sastrugi and through patches of deep, soft snow began to take their toll. Because Scott and his men traveled slowly, sometimes covering only three or four miles in a day, they had to ration their food. Though aware of their peril, they spent the better part of one day "geologising," as Scott put it.

Edgar Evans died first, on February 17, probably the result of a concussion sustained when he fell into a crevasse. Captain L.E.G. Oates was next. Frostbite had blackened his feet, and he could walk only with great pain. On March 16 or 17 (the party had lost track of dates), Scott wrote: "He slept through the night before last, hoping not to wake; but he woke in the morning—yesterday. It was blowing a blizzard. He said, 'I am just going outside and may be some time.' He went out into the blizzard and we have not seen him since." The next day, Scott discovered that his own foot was frostbitten. "These are the steps of my downfall," he wrote.

Antarctica's "Mayor"

On the 21st, Scott and his two remaining men were trapped by a blizzard only 11 miles from a supply depot and forced to stay put. About a week later, still stranded, Scott wrote simply, "Last entry. For God's sake look after our people." Their bodies were found less than eight months later.

One more journey would be made before World War I closed the book on the heroic age. In 1914, Ernest Shackleton returned to Antarctica intending to cross the continent. But his ship, the *Endurance*, became icebound in the Weddell Sea and drifted for 10 months in the floe's embrace before it was finally crushed. For another five months, the entire crew drifted on the sea ice, at last escaping by lifeboat to barren Elephant Island. From there, Shackleton and five of his men made a daring voyage in a small open boat to the whaling station at South Georgia Island, 800 miles away. They arrived in May 1916, almost a year and a half after the *Endurance* was first trapped. All of the men on Elephant Island were saved.

Antarctic exploration did not resume until 1928. Now it was the Americans who led the charge, not the British and Norwegians. The Americans brought new equipment with them—air-

planes, tractors, and radios—that would dramatically change the character of Antarctic exploration.

The most colorful figure of the period was Admiral Richard E. Byrd, the first man (along with Floyd Bennett) to fly over the North Pole. He arrived in Antarctica in 1928 with the intention of flying over the South Pole as well, making sure to erect three 70-foot radio towers from which he could broadcast news of his exploits directly to the rest of the world. (When another party visited Byrd's "Little America" base near the Bay of Whales 30 years later, they found the towers almost completely buried in snow; all that remained were three steel-girder "nunatuks" barely taller than a man).

Byrd and three others flew across the Pole on November 29, 1929, and Byrd made several other flights, traversing broad expanses of previously uncharted territory. In his 19-hour flight to the Pole and back, he saw more territory than Scott and Amundsen covered in their months-long journeys. He discovered and laid claim to Marie Byrd Land (named after his wife) and mapped 450,000 square miles of the continent using aerial photography. "I am mayor of this place," Byrd proclaimed, "until the government gets around to owning it." But the State Department never pressed the territorial claims that he made. Altogether, Byrd mounted four expeditions to Antarctica before the outbreak of World War II.

Exploration ceased in 1941, after America was drawn into the Second World War. But the accomplishments of Byrd and the small group of other prewar explorers paved the way for a new era of Antarctic inquiry. They had mapped large areas of the interior, reducing the unknowns that man would have to face. They had also established the basics of contemporary polar technology. Never again would men be forced to haul sledges across vast distances or huddle, shivering, through the long Antarctic winter.

If this was gained, perhaps something was lost as well, for the ordeals they faced forged the heroism of men like Shackleton and Cook during the first 150 years of Antarctic exploration. Yet they had set the stage for another monumental effort beginning in the years after 1945, when men would flock to the continent in the name of science. These later years would also bring a growing knowledge of the continent's hidden riches, far different from those imagined in earlier ages. For the first time, thorny questions about who would own and govern this remote land would have to be faced.

CRACKS IN THE ICE

by Barbara Mitchell

"The world is small and rapidly getting smaller," Admiral Richard E. Byrd wrote in 1935, but "the Antarctic has shrunk least of all." His observation still holds true, even though the world, driven by science and by economic and political imperatives, is steadily moving in on the continent.

Today, scientists are extracting new information from Antarctica about our planet—its past, its climate, and its inhabitants—and about the universe itself. While they have not found rubies and diamonds, today's explorers are uncovering other kinds of wealth: Coal, copper, iron ore, and uranium all exist on the continent, in quantities not yet fully known. There is also reason to believe that Antarctica's continental shelf may contain sizable reserves of oil and natural gas, perhaps matching those of Iran. And fishing fleets have already begun harvesting krill, the shrimp-like creatures, high in protein, that flourish in Antarctic waters. For the 14 nations with direct interests in the continent, the payoff may not be far away.

Politically, Antarctica was sliced up like a pie before the end of World War II, with wedge-shaped national claims radiating from the South Pole to the coast. Britain pressed the first claim, in 1908, on the basis of its early exploration of the continent. Later, it ceded territory on the continent to New Zealand and Australia, and France staked a claim in 1939. Anxious to forestall a "land grab" by Nazi Germany, Norway advanced a claim in 1939, citing the expeditions of Roald Amundsen and others. Chile and Argentina staked claims on the easily accessible Antarctic Peninsula in 1940 and 1943 respectively, both tracing their historical rights to a Papal Bull of 1493 and to the 1494 Treaty of Tordesillas, which granted all lands west of the 46th meridian to Spain. (These two claims, and Britain's, overlap.)

The Germans never did get a slice of the continent, although Nazi Reichsmarshal Hermann Goering in 1938 dispatched the catapult ship *Schwabenland* to the Queen Maud Land region of Antarctic for the specific purpose of claiming territory for Hitler's Germany. Seaplanes launched from the ship's deck mapped 350,000 square miles of the continent by air, dropping steel markers stamped with swastikas to establish the claim. After World War II, however, both East and West Germany de-

cided not to press the matter, apparently to avoid the appearance of renewed German expansionism.

Antarctica played only a minor role in the war. Beginning in 1940, Nazi cruisers operating from Antarctic waters attacked allied cargo vessels rounding the Cape of Good Hope and Cape Horn, sank the Australian cruiser *Sydney*, and mined the Australian harbors of Sydney, Melbourne, Hobart, and Adelaide. Britain responded by sending warships south to search for the German raiders, but they eluded detection. In 1944, London launched Operation Tabarin, establishing a base at Deception Island to deny use of its natural harbor to the Third Reich.

A Giant Aircraft Carrier?

The war highlighted one conflict on the continent that did not simmer down after V-E Day. During the war, British and Argentinian shore parties ripped up each others' flags and destroyed claim markers where the "territories" of the two countries overlapped on the Antarctic Peninsula. In 1952, an Argentine naval unit fired machine guns over the heads of a British party coming ashore in a disputed sector. The Argentines later apologized for the incident, explaining that the gunfire was merely a friendly greeting. A year later, the British arrested two Argentine nationals for "trespassing" on Deception Island.

Argentina, like neighboring Chile, has always considered the defense of its beachhead on the nearby continent a matter of national honor. Leaders of both countries have consistently denied the validity of claims based on discovery alone, insisting that "effective occupation" is required. To that end, in 1973, the President of Argentina took his entire Cabinet to Vicecomodoro Marambio station, on an island off the peninsula's coast, and declared it the provisional capital of his country. (It is the law of the land in both nations that all locally published maps depict Antarctic territory as part of the mother country.)

For all the postwar difficulties regarding claims and boundaries, potentially the most troublesome rivalry over Antarctica arose between two countries with no formal claims: the Soviet

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Union and the United States. Nazi Germany's marauding warships had proved that Antarctic waters could serve as a useful military base. In a war between the two superpowers, some Americans feared the Soviet Union might use the continent as a kind of giant, immobile aircraft carrier or, worse, as a base for intercontinental ballistic missiles.

Hammer and Icicle

In 1946, the United States sent 4,000 men and 13 ships south in Operation Highjump, the largest exploratory expedition ever assembled. During Highjump, the Navy mapped many small sections of the coastline, with the secret objective of establishing the basis for a U.S. claim "over the largest practicable area of the Antarctic continent." The expedition also served as an opportunity to train soldiers and try out equipment for use in polar regions. But a plan to test submarines in the Antarctic failed when the diesel submarine *Sennet*, running on the surface, was battered by pack ice and had to be towed out by an ice breaker. Since then, Antarctica has not figured prominently in the Pentagon's view of the world.

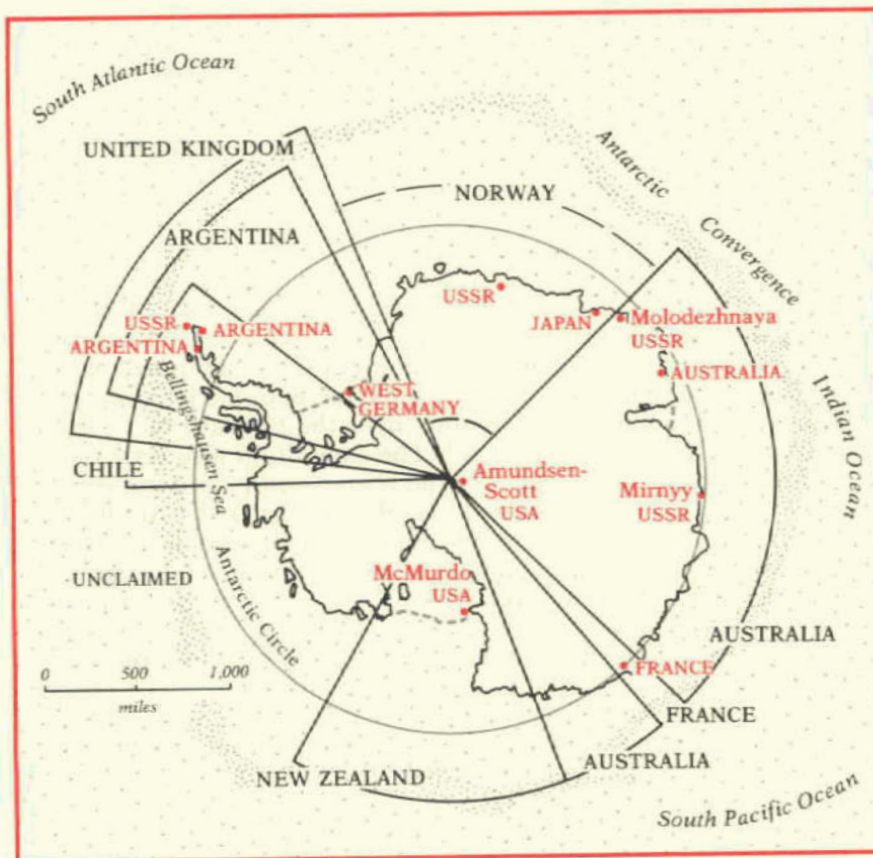
The Soviets, for their part, established a stake in Antarctic affairs by asserting in 1949 that the Russian admiral Thaddeus von Bellingshausen had been the first to sight the continent in 1820. The hammer and sickle flew over Antarctica in 1956, with the establishment of a Soviet base in the Australian sector. The Soviet presence has continued to expand, but there is no evidence that the Soviets see any more military significance in Antarctica than America does.

The 1957–58 International Geophysical Year (IGY) was a turning point for the continent. During the IGY, scientists around the world carefully coordinated their experiments and observations in many fields—climatology, meteorology, and cosmic ray research—in order to further their knowledge of global phenomena. The effort brought scientists and military support units from 12 nations to Antarctica, where they worked together without friction.

The chief lesson of the IGY seemed to be that international scientific cooperation could work, at least in Antarctica. In 1959, at the urging of the United States, representatives from the 12 countries active on the continent put together an Antarctic Treaty and signed it in Washington.* The treaty is a remarkable

*The original signatories included the seven claimant countries (Argentina, Australia, Britain, Chile, France, New Zealand, and Norway) and five others (Belgium, Japan, South Africa, the Soviet Union, and the United States).

ANTARCTICA



Source: *Polar Regions Atlas*, Washington, D.C.: U.S. Central Intelligence Agency, 1978.

The map above shows the location of stations staffed year-round by an average of 30 or more people. In all, there are 45 bases on the Antarctic mainland or nearby islands, distributed among 12 nations: Argentina (10), the Soviet Union (nine), the United States (six), Britain (five), Australia and Chile (three each), Japan, New Zealand, and Poland (two each), and France, South Africa, and West Germany (one each). Pinched financially, Norway and Belgium closed their last bases in 1959 and 1961, respectively, but retain full standing as signatories of the Antarctic Treaty. Norway has purposely left the northern and southern limits of its claim undefined; legal recognition of the "sectoral" principle could endanger its claims in the Arctic. In the unclaimed sector, where the United States has the strongest legal case for title, the United States and Soviet Union each maintain a tiny base. The Soviets have no formal claim anywhere on the continent.

agreement. It freezes the legal status quo in Antarctica, theoretically suspending the struggle over claims at least until the pact becomes subject to review in 1991. (The treaty will be reviewed only if one of the signatories requests it.) Until then, the continent is supposed to remain a kind of open-air laboratory, with free access to the whole continent guaranteed to any nation that cares to send an expedition there. Local testing of nuclear weapons and the disposal of nuclear wastes are banned, and each treaty nation has the right to inspect the others' facilities. No military activities are allowed, although military personnel and equipment can be used "for scientific research or other peaceful purposes."

There is no secretariat and no headquarters. Representatives from each signatory country simply meet every two years in a different capital to discuss plans and coordinate activities. (The most recent treaty meeting was held in Buenos Aires in June 1981.) The treaty provides that any intractable dispute be referred to the International Court of Justice at the Hague (with the consent of all concerned), but that has never been necessary.

Antarctica on \$400 a Day

The Antarctic Treaty has made the continent the province of scientists, who conduct research there in such fields as glaciology, paleontology, ornithology, and even human psychology. Approximately 900 people spent the 1980 austral winter on the continent; during the summer of 1980-81, the population rose to more than 2,000.

The accommodations have improved since the days of Scott and Amundsen. At McMurdo Station, the main American base, managed by the Navy, the summer residents can avail themselves of four saloons, a chapel, a Jacuzzi bath in the fire station, fresh kiwi fruit from New Zealand, and piña colada-flavored frozen yogurt. Windows sometimes have to be kept open in the dormitories—the rooms are heated to 85 degrees. The Annual Scott's Hut Race, a five-mile run over ice, draws many local joggers.

Antarctica even has a small tourist industry, the only commercial activity on the mainland. Two airlines began flying sightseeing tours over the mainland from New Zealand and Australia in 1976, but these tours were suspended in 1979 after an Air New Zealand DC-10 crashed into Mount Erebus. All of the 257 people aboard were killed instantly. Today, only the Australian airline offers the tours. Cruise ships have visited the continent regularly since 1966, bringing some 900 tourists to the far

south each year. A five-week tour can cost up to \$14,000. The ships visit research stations, penguin rookeries, and abandoned whaling bases.

Antarctica is no playground, however. Each of the 45 stations is a hub of research activity. About one-quarter of McMurdo's summertime population are scientists; the rest are Navy and civilian staff who provide support services.

Nature's "Anti-Freeze"

Hardly touched by man, Antarctica is remote from factories and their by-products, providing an ideal location for monitoring global trends in pollution. Scientists based in Antarctica track pollutants in the upper atmosphere and measure their accumulation as they fall on the continent's ice. Antarctica's purity serves other purposes. Last winter, a microbiologist from the University of Wisconsin used McMurdo's isolated population to test iodine-soaked "killer Kleenexes" as a cure for the common cold. (Due to their isolation, those who winter-over seldom catch colds or other common illnesses until new people arrive in the spring. Then everyone gets sick.)

Scientists studying the formation of the solar system are taking advantage of one of the continent's most plentiful resources—meteorites. In Antarctica, one can find meteorites that fell to the ice a million years ago and, thanks to the cold, remain uncontaminated. The shifting ice sheet has clustered them together in just a few locations—making Antarctica this planet's biggest known depository of other-worldly refuse. A dozen years ago, only 2,000 meteorites had been found anywhere in the world. But, since the Japanese first discovered meteorites in the Antarctic in 1969, over 5,000 samples have been collected there. In some of these specimens, scientists have discovered amino acids, leading to the conclusion that these chemicals, which are essential building blocks of life, must exist on other planets.

Researchers have also been trying to pin down precisely how Antarctica's few plant and animal species adapt to their harsh environment. For example, it appears that Antarctic fish contain glycoproteins that prevent their blood from freezing. The proteins seem to bind to the minute ice crystals that form in the blood of the fish, somehow melting them before they grow large enough to do damage. These "anti-freeze" proteins may have a number of practical applications. Transplant organs, sperm, and blood, for example, could be stored for far longer periods of time than is now possible if they could be kept at very low temperatures without freezing. A patient with failing kidneys would



Courtesy British Antarctic Survey; Library of Congress.

The 1957–58 British Transantarctic Expedition traveled in vehicles such as the “Sno-cat” (christened Rock ‘n’ Roll) above; the men of Scott’s second expedition (inset) did not have it so easy in 1911–12.

not have to wait for a donor to die if doctors could build up a supply of these organs.

Other scientists, working in Antarctica’s “dry valleys,” have discovered a completely unique form of life. Free of snow and ice, the dry valleys lie between snow-covered mountains in a few scattered locations, inland from the Ross Sea. They were probably created when the surrounding glaciers receded and have been kept clear by the winds roaring off the polar plateau. They are as dry as a desert, and their rocky brown soil seems entirely barren and forbidding.

In one of these valleys, however, near the Ross Sea, there is a frozen lake fed by the occasional summer run-off from nearby glaciers. Two American scientists burned a hole through the permanent 15-foot-thick ice covering it and dove into what one of them called “a window on the past.” In the middle of the lake, 120 feet below the surface, there is no gaseous oxygen in the water; the scientists found algae that seemed to be thriving on hydrogen sulfide instead of the oxygen that is essential to most other forms of life. The lake’s blue-green algae are extremely

primitive. They were among the first forms of life to appear on the planet and thrive in Antarctica virtually unchanged.

Antarctica's ice has provided a record of past climatic conditions. Two U.S. scientists recently put forward the controversial theory that the volume of nitrates preserved each year in the accumulating ice sheet provides a record of the sun's annual energy output. These scientists maintain that they can detect the impact of the Little Ice Age, between 1645 and 1715, when solar energy levels were lower and average temperatures declined by about 2°F.

Because the polar plateau is so high (it is a mile above sea level, on the average), and because ice is such a poor conductor, Antarctica serves as a perfect radio "tower." At one U.S. station in the interior, scientists strung a 13.6-mile-long cable on 15-foot poles to make an antenna for very low-frequency, long-distance radio experiments. Anywhere else in the world, it would have cost hundreds of millions of dollars to build towers that high above sea level. The Antarctic antenna cost only \$75,000.

Inevitably, man's extensive scientific investigation of Antarctica has also produced a growing inventory of the continent's natural resources. Ever since 1909, when Ernest Shackleton found a coal seam near the Beardmore Glacier, geologists have been aware that the continent is more than just ice and worthless rock. But Antarctica's remoteness and hostile climate make exploitation a difficult business.

Looking for Oil

Today, with the widening search for scarce resources, development is increasingly attractive. Indeed, a good deal of the scientific work being done in Antarctica today overlaps with simple resource exploration. It was "pure" science that provided some of the first indications of Antarctica's potential wealth. If the Gondwana hypothesis (the theory that some 250 million years ago, Antarctica, South America, Australia, Africa, and India were all joined together in a "supercontinent") is correct, land that was once contiguous should have similar geologic characteristics. If certain minerals are common in, say, the Andes, then there is reason to believe that they will also be found in the Antarctic Peninsula.

Oil drilling or exploration is already under way off the coasts of New Zealand, Australia, and Argentina. Not surprisingly, researchers have detected thick layers of sedimentary rock beneath the ocean floor of Antarctica's continental shelf—suggesting the presence of oil and gas. In 1972 and 1973, the U.S.

research ship *Glomar Challenger*, plying the Ross Sea, discovered methane, ethane, and ethylene, even stronger indicators. (The ship avoided drilling in the most likely locations of oil deposits, for fear of creating a blowout, which it was not equipped to control.)

No one has actually pumped a drop of oil in Antarctica—or even proved that it is there—but the evidence of petroleum deposits is overwhelming. A U.S. government report prepared for the 1976 meeting of the Antarctic Treaty nations in Paris stated that “it appears that the Antarctic continental shelf could contain potentially recoverable oil in the order of magnitude of tens of billions of barrels.” In 1979, a Gulf Oil spokesman estimated that the Ross and Weddell Sea reserves alone would come to 50 billion barrels. But there is probably oil beneath the Bellingshausen Sea as well.

A Last Resort

Over the past 12 years, a number of U.S. oil companies have made tentative inquiries at the State Department about obtaining licenses for exploratory work. The governments of Norway, Japan, and West Germany have funded offshore seismic surveys—a good example of mixed scientific research and resource exploration.

But oil and gas exploration is proceeding slowly, in part because a big strike would raise a vexing question: Who owns the deposit? Moreover, there would be environmental problems. In the event of a spill, oil would decompose very slowly in the severe cold and might damage the coastal seal and penguin rookeries and the offshore fisheries.* The environment also poses other obstacles: The great depth of Antarctica’s continental shelf, the brief summer, and the difficulty of drilling through the constantly shifting ice that covers the seas would all have to be overcome. Yet no one believed that the oil companies would be able to drill successfully in the Arctic, either.

Antarctica contains the world’s largest coal field and enough iron ore to supply the planet’s needs for 200 years. But both coal and iron are still available in great quantities elsewhere in the world, where they are more accessible and cheaper to mine. Antarctica’s coal is located mainly in the forbidding Transantarctic Mountain range, and no one is likely to consider exploiting it until coal prices climb a great deal higher.

* Such concerns led the treaty powers to conclude a very loose “gentlemen’s agreement” at their 1977 London meeting. It provides that they will delay industrial exploration or exploitation so long as negotiations on a minerals treaty, scheduled to begin next year, are “making progress.”

TO THE SOUTH POLE STATION

The longest day at the U.S. South Pole Station lasts from September 22, when the sun rises after the dark austral winter, to March 22, when the sun sets once again. This is Antarctica's summer, and the station's population swells to 70 scientists and staff. Around New Year's Day, the temperature peaks at about -18°F . But by mid-February, the weather begins to deteriorate and the last plane leaves for McMurdo Sound, 800 miles away. For the next eight months, the South Pole Station's skeleton crew of 17 will be alone, under the auspices of the National Science Foundation, continuing experiments in astronomy, meteorology, and glaciology initiated 24 years ago during the International Geophysical Year.

Americans who winter over at the Pole inhabit three buildings of modest size protected by a 52-foot-high geodesic dome. The complex, only 155 yards from the Pole, was completed in 1975, replacing a collection of steel and wooden huts that had fallen victim to 40 feet of drifted snow. (The new dome will be covered over before 1990.) Living quarters are cramped, but there is wall-to-wall carpeting, central heating, and modern plumbing. The mess-hall diet is varied: lobster Newburg, steak, cherry cheesecake—a far cry from the hard biscuits and pemmican (dried beef bars) that sustained Robert Falcon Scott.

This peculiar environment leaves its mark. Average body temperature drops to 96.6°F , and most people, for unknown reasons, are deprived of deep "slow wave" sleep. Work that takes an hour in summer may consume five hours in winter. Tedium is the main enemy; odd rituals, the main weapon against it. Thus, a tape of the Super Bowl, kept since January, is screened on Midwinter Day, June 22. In August, when the mercury first dips below -100°F , tradition requires the winter staff to sprint naked from the station sauna to the barber pole that marks the bottom of the world. (Actually, the red-and-white striped pole is some 55 yards off the mark, but by 1986 the moving ice will have positioned it precisely above the geographic South Pole.)

Despite such diversions, the isolation, monotony, and close company are exacting, and few researchers seek to prolong their tour of duty. Billiards, ping-pong, and reading pall after eight months. Insomnia, the "big eye," is common. (In the mid-1960s, one winter scientist grew irrational and violent and was temporarily confined in an improvised brig.) Small comfort that one can theoretically nudge time along by walking around the pole and crossing the International Dateline, thereby advancing Thursday, say, to Friday.

In early November, the first aircraft of the season flies in from McMurdo Sound with fresh faces from the outside world, and the cycle begins again.

Many other minerals have been found, but none (so far) in quantities large enough to spur commercial development. On the Antarctic Peninsula, there are small quantities of chromium, nickel, cobalt, copper, gold, silver, manganese, and molybdenum. Elsewhere, explorers have found titanium, platinum, lead, zinc, tin, and uranium.

The most likely site for any mineral extraction on land is the relatively hospitable peninsula, but unless a large, accessible deposit of an extremely valuable mineral is discovered, mining even there will remain too costly for a long time to come.

Palate vs. Protein

One Antarctic resource that is already being exploited is the krill, a three-inch crustacean resembling a prawn that abounds off the coast and lives nowhere else in the world. (*Krill* is a Norwegian word that means "small fish.") Antarctica, the world's most barren continent, is surrounded by what are among the world's richest seas. About 450 miles off the tip of the Antarctic Peninsula, the frigid polar waters collide with the warmer oceans, producing a strong upwelling that lifts great quantities of mineral nutrients from the ocean bottom. This Antarctic Convergence, as it is called, forms an irregularly shaped, constantly shifting ring around the continent.

The convergence is an ideal habitat for phytoplankton, and the tiny plant-like organisms turn the seas a muddy brown. When frozen into the sea ice, they produce extraordinary hues of blue and green. Krill feed on phytoplankton, and in turn serve as the main food source for the whales, seals, and birds that range about in these waters.

Until the 1960s, krill was left strictly to these gourmands. But the decline of other fisheries and the extension of coastal limits (Exclusive Economic Zones) to 200 miles encouraged countries with large fishing fleets to take a closer look at Antarctic krill. By the late '70s, the Soviet Union, Japan, Poland, Chile, West Germany, Taiwan, South Korea, and East Germany had all fished for krill in the southern ocean.

The total annual catch was probably less than 200,000 metric tons until 1979. But last winter, a West German research ship spotted a Soviet fishing fleet of about 50 vessels, including factory ships, near Elephant Island. West German scientists estimate that the Soviets alone netted 360,000 tons of krill during the 1980-81 Antarctic fishing season.

Krill are easy prey. They congregate near the surface in dense swarms up to half a mile across. (The Soviet fishing ves-

sels off Elephant Island reportedly encountered one exceptional swarm of 10 million metric tons covering several square miles.) How much krill could we harvest? Some older estimates put the possible total as high as 110 to 115 million tons each year. That would triple the world's total annual fish catch. A group of U.S. scientists has estimated that between 1 and 2.5 million tons of krill could be caught each year without damaging the convergence ecosystem. That would still place krill among the world's top 10 fish catches.

Information about krill is sketchy. Scientists are not sure how much of it is needed to ensure the survival of its predators. Because the whales, seals, and birds have no other major source of food, overfishing of krill could cause widespread starvation. A blue whale alone consumes up to five tons of krill a day.

Another problem is getting people to eat krill. It tastes something like crab and contains as much protein (15 percent by weight) as steak or lobster. It could be an extremely valuable food, but no one has figured out quite how to market it. The Japanese have been fairly successful, probably because small, whole shrimp are already a major part of their diet.

The "Iceberg Prince"

Processing presents obstacles, as well. Krill must be cooked or frozen on factory ships as soon as it is caught, for it decomposes rapidly. Because its digestive enzymes have adapted to the frigid Antarctic waters and continue to work when frozen at normal temperatures, krill is very difficult to freeze effectively.

Most of the krill-fishing nations have used it to make fish meal as feed for cattle and poultry. There have also been a number of innovative experiments. The Chileans have dipped frozen krill bars in batter, selling them as "krill fingers." The Soviets have pioneered the development of krill paste, which they use as an additive in sausages, cheese, and soup. They have even brewed a krill beer. However, none of these products has been a big seller.*

Antarctica's most abundant resource is also the one most often overlooked—its ice. The Antarctic ice sheet contains about 70 percent of the fresh water supply in the world. If it all melted, the oceans would rise by between 150 and 300 feet, submerging cities such as New York up to their penthouses.

In 1977, Prince Muhammad al-Faisal of Saudi Arabia, the "Iceberg Prince," hired the French engineering consortium

*It is worth remembering that when Albert P. Halfhill first canned albacore tuna in San Pedro, California, in 1903, local fishermen declared, "That ain't eatin' fish."

Cicero to study the feasibility of bringing Antarctic ice to Jidda. Cicero concluded that it would be possible to cut up an 85-million-ton tabular iceberg like a loaf of bread, cover the "slices" to protect them from the sun and erosion by the sea, and tow them to Saudi Arabia for conversion to drinking water. It would be cheaper than the desalinated sea water the Saudis rely on, the French predicted. This ambitious plan came to nothing when the French company went bankrupt, but the idea is still alive. Today, New Zealand, Australia, and Britain are all looking into the possibility of towing icebergs to arid lands.

Yours, Mine, or Ours?

Because of the potential wealth and political prestige that a stake in Antarctica might bring, many governments are beginning to give the continent more of their attention. In a 1975 speech to the General Assembly, the president of the UN Law of the Sea Conference, Shirley Amerasinghe, argued that the principle of "equitable sharing of the world's resources" should somehow be applied to Antarctica. The idea has not gained much public support so far, largely because Third World governments have more pressing issues to confront. Privately, however, many Third World officials regard Antarctica as the undeserved exclusive preserve of a rich nations' "club."

The parties to the Antarctic Treaty, for their part, have worked out several agreements to demonstrate that the continent is under responsible management. In 1972, they drew up a treaty on the conservation of Antarctic seals, followed in 1980 by a treaty regulating the harvesting of krill.* Their next goal is to establish a set of rules governing the development of Antarctic oil and minerals.

The twelve treaty countries have kept a firm grip on Antarctic affairs. To join their ranks, a nation must demonstrate interest in Antarctica by conducting "substantial scientific research activity" on the continent, which in effect means they must establish a scientific research station. Since 1961, when the treaty became effective, only two countries (Poland and West Germany) have joined the club. West Germany spent \$100 million to build its station.

The possibility of hidden wealth in Antarctica has aroused some dissension even among parties to the Antarctic Treaty. New Zealand, once the leading "internationalist" party to the accord (during the 1950s, Wellington offered to abandon its ter-

*The agreement on krill sets no quotas but contains an innovative provision prohibiting krill fishing that would damage the other convergence species that rely on it for food.

ritorial pretensions if the others would follow suit), has become much more interested in protecting its claim now that it is thought to include rich offshore oil deposits. Australia has become almost as intransigently "territorialist" as Chile and Argentina.

The United States has stuck to the position articulated by Secretary of State Charles Evans Hughes in 1924. Hughes, sounding much like the leaders of Argentina and Chile, declared that sovereignty over a claim is not ensured "unless the discovery is followed by an actual settlement of the discovered country." The United States has never made an official claim although Admiral Byrd and other veteran explorers and their allies tried to rally public support for such a move. The United States refuses to recognize other claims and reserves the right to advance its own if the Antarctic Treaty should lapse. On the basis of claims made by American explorers (particularly Byrd) but never formally pressed by the State Department, the United States could annex large chunks of the continent.

One reason the United States chose not to make a formal claim was that the sector where the legal foundation is strongest, Marie Byrd Land, seemed to lack promise, and its icebound coast was impenetrable to ships. (American icebreakers did not make it through the pack until 1960.) Today, geologists think Marie Byrd Land's continental shelf may prove to be among the most promising oil and gas sites. Marie Byrd Land remains the continent's only unclaimed sector.

Settling for Utopia

Another reason why Washington held back was that the State Department believed the United States had more to gain by demonstrating an interest in the *entire* continent. As State Department spokesman Herman Phleger testified during the Senate's hearings on the treaty's ratification in 1960, "If we were to make a claim right now, we might be confined to an area of 20 percent [of the continent]. . . . We would have to give up, certainly, the claim which we have maintained to date, that we have a right in all of Antarctica." Today, the State Department insists that all new agreements on Antarctic resources must provide for free international access to the entire continent.

The United States protects its interests by maintaining a considerable presence on the continent. The base at McMurdo Sound is the largest on the continent and, until recently, had Antarctica's only airstrip. The United States spent \$63 million on Antarctic programs in 1981, up slightly from the previous

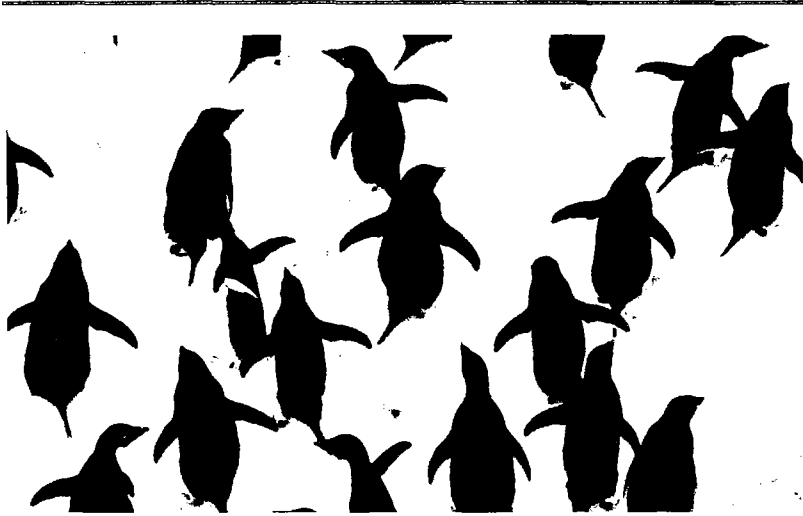


Photo William Curtsinger, courtesy United States Navy.

year. But most of the budget is consumed by the cost of providing support services, particularly air travel, which is increasingly expensive due to the rising price of fuel. Only about \$10 million of the Antarctic budget goes directly to research.

The Soviets do not publish their budget for Antarctic research, but the USSR maintains nine bases, and more than 250 Soviets winter over every year, by far the largest contingent from any nation.

The Soviet Union has one of the most extensive onshore geologic research programs in Antarctica and initially seemed very interested in offshore oil and gas, too. Publicly, however, the Kremlin has supported the idea of an indefinite moratorium on the "industrial" exploration and exploitation of minerals on the grounds that such activities could be environmentally harmful.

Sending scientists to Antarctica serves various nonscientific purposes: bolstering the treaty; defending territorial claims; supporting the grounds for free access. As Edward Todd, director of the National Science Foundation's Division of Polar Programs, said during a 1979 visit to the continent: "What we have here is a mutually beneficial symbiosis between science objectives and foreign-policy objectives. If the Antarctic Treaty ceases to be effective, our research program gives us an excuse to be here. In a free-for-all, our presence is well established."

Political considerations also affect the location of research stations on the continent. The U.S. South Pole station serves no

indispensable scientific function, but it *does* give the United States a foot in each sector of Antarctica, claimed or unclaimed. Deprived of the convenient South Pole site, the Soviets achieved a similar end by building a chain of stations along the continent's periphery in almost every sector.

Men have been trying to conquer Antarctica since the 1820s. First, they sent down explorers, now they send down scientists. Yet Antarctica remains untamed and beyond national jurisdictions. The Antarctic Treaty has proved to be a workable interim measure that sets some precedents worth preserving.

In some ways, indeed, the treaty is a utopian model. It includes the most comprehensive disarmament agreement in the world and is the only one to provide explicitly for on-site inspection. The treaty has fostered a remarkable degree of East-West cooperation: The exchange of research findings and scientists in Antarctica and the establishment of joint programs have no parallel elsewhere. A glance at the other end of the globe shows what Antarctica could be like. Arctic research is completely uncoordinated, and the exploration and exploitation of resources is going ahead with no international cooperation at all. Nor are there any limits on military activities in the Arctic.

But the success of the current treaty as a short-term solution is due precisely to its authors' failure to address the fundamental questions: Who owns Antarctica? How will Antarctica's krill, oil, gas, and minerals be exploited? Who will reap the benefits? How will the continent's environment be protected? These questions will have to be tackled before 1991, when the treaty will probably come up for review. By then, Third World governments will probably be demanding a role in the governance of the continent, and the parties to the Antarctic Treaty will have to consider that matter, too.

Conceivably, the 14 treaty powers could choose to maintain the status quo. But the stakes may be too high by 1991 to permit the perpetuation of a fuzzy legal regime. In that event, the alternatives would be either a free-for-all or the forging of an effective international agreement. There are many precedents for the former. Is it too much to hope that the latter might itself become a precedent?



BACKGROUND BOOKS

ANTARCTICA

The geologists and paleontologists and ornithologists who followed the early Antarctic explorers unlocked some of the continent's secrets. But many things about the Earth's fifth-largest land mass—its political future, its distant past—remain a mystery.

In other ways, too, it is sometimes difficult to get a fix on the continent. In *Antarctica* (Mayflower, 1979), lavish color photographs by Peter Johnson and a spare text by Creina Bond and Roy Siegfried help to establish a sense of place, even if that place is always shifting. Place a wooden stake at the South Pole, the writers observe, and it will stay there for a moment only: "Tomorrow the ice will have crept [several] centimeters."

Man got to know Antarctica slowly. One of the best accounts of the early voyages of exploration is *Quest for a Continent* (McGraw-Hill, 1957) by *New York Times* science editor Walter Sullivan. Antarctica repeatedly failed to live up to expectations. In 1820, Sullivan writes, an optimistic British Admiralty sent Lieutenant Edward Bransfield to search for land in the far south, directing him to "observe the character, habits, dresses, and customs of the inhabitants, to whom you will display every friendly disposition."

The only natives Bransfield met, however, were the seals, penguins, and skua gulls of the continent's enveloping ice pack.

For later visitors, the Antarctic held a fascination of its own. British physician Edward Wilson believed that the emperor penguin might be the missing evolutionary link be-

tween birds and reptiles and sought an emperor embryo to make his case. In 1910, Wilson set out from McMurdo Sound for a remote penguin rookery. One of his two companions, Apsley Cherry-Garrard, remembered the trip as *The Worst Journey in the World* (Constable, 1922; Chatto & Windus, 1965).

The problem: Emperor penguins breed only during winter, in almost total darkness and in temperatures far below zero. (They shelter and warm their eggs beneath their bellies while standing virtually motionless for a period of two months.) The three explorers barely survived the 36-day trek. Their sweat formed a thin layer of ice upon the skin, and their clothes froze if they stayed in any position for too long. But they got their eggs.

Such experiences were not unique. The literature of Antarctic exploration is harrowing. Two fine first-person accounts are Frederick A. Cook's *Through the First Antarctic Night 1898-1899* (Doubleday, 1909; McGill-Queens, 1980) and Edward Wilson's *Diary of the Discovery Expedition to the Antarctic Regions, 1901-1904* (Humanities, 1967).

Wilson perished with Captain Robert Falcon Scott in 1912 on the return trip from the South Pole. That fatal journey is described most vividly by Scott himself in his journal, *Scott's Last Expedition* (Smith, Elder, 1913; Dodd, 1964). Not all subsequent accounts have been sympathetic.

Roland Huntford, a former correspondent for the *London Observer*, depicts Scott as a "heroic bungler"

in **Scott and Amundsen** (Putnam's, 1980). The British captain, he says, doomed his party by providing poor organization and scant rations.

In this controversial critique, Huntford also questions the accuracy of Scott's journal as it has come down to us. He claims that Scott's heirs excised all passages that indicated bitterness toward his Norwegian rival, Roald Amundsen, or criticism of his companions, or Scott's own incompetence. But for his "martyrdom" and brisk literary style, Huntford argues, Scott would have become a symbol of ineptitude. Indeed, Scott "was a suitable hero for a nation in decline."

Huntford dismisses the importance of the 35 pounds of geologic specimens that Scott's men collected near the Beardmore Glacier and refused to abandon. Yet the rocks contained the plant fossil *Glossopteris*, also found in India and Africa, providing the first solid evidence for the existence of the prehistoric "supercontinent," Gondwana.

The Gondwana hypothesis did not win immediate acceptance. The skepticism expressed by such prominent polar researchers as geologist R. E. Priestley and ornithologist Robert Cushman Murphy in **Problems of Polar Research**, edited by W. L. G. Joerg (American Geographical Society, 1928), reflected the attitude that prevailed until the "Air Age" of Antarctic exploration produced compelling new evidence.

The airplane opened up the continent but, as Paul A. Siple observes in **90° South** (Putnam's, 1959), it didn't make staying there any easier. Siple, who accompanied Richard E. Byrd to Antarctica as a 19-year-old Boy Scout in 1928, recalls how the admiral, aware of the psychological toll the Antarctic environment could

take, once brought a morale "specialist" to Little America. The specialist, Siple writes, "equated good morale with an ability to play the ukulele. He had brought along boxes of ukuleles and was prepared to teach us how to strum the strings to keep us from growing morose or homesick. Unfortunately, the men considered it a morale booster not to have him or his ukuleles around."

Byrd himself once foolishly attempted to stretch the limits of human endurance. During the 1934 Antarctic winter night, he single-handedly manned the Bolling Advance Weather Base, deep in the interior, as he recalled in **Alone** (Putnam's, 1938; Grosset, 1961). Driven to "know that kind of experience to the full," Byrd nearly died of gradual carbon monoxide poisoning owing to a faulty stove that he was unable to repair. For two and a half months, he struggled with a steadily deteriorating mind and body before his garbled radio transmissions alarmed his colleagues and a tractor party from Little America II rescued him.

Byrd, the symbol of the early Air Age and an accomplished self-promoter, wrote several other books on the Antarctic, including **Little America** (Putnam's, 1930) and **Discovery** (Putnam's, 1935; Gale, 1971).

After World War II, air travel to and around the continent became routine. By the time Richard S. Lewis and Philip M. Smith published their wide-ranging collection of essays, **Frozen Future** (Times Books, 1973), geologists airlifted into the Transantarctic Mountains had uncovered fossil remains of the *Lystroraptor*, a prehistoric animal that was also common to Africa and India. *Lystroraptor* dispelled any lingering doubts about Gondwana. Because the now-extinct reptile could not

have crossed the oceans that today separate Africa, India, and Antarctica, scientists concluded that these lands must once have been joined.

The contributors to *Frozen Future*—Antarctic scientists, for the most part—address such topics as glaciation, climate, biological adaptation, and research policy. All of them stress the need to maintain the cooperative spirit of the 1957–58 International Geophysical Year, whatever the continent's commercial allure. Antarctica, they argue, must remain an "international laboratory."

So far, it is just that. Antarctica, and most of the writing about it, falls mainly within the scientists' domain. Specialists report on their experiments and activities in several journals. Chief among these are the *Polar Record*, published by the Scott Polar Research Institute (United Kingdom), and the *Antarctic Journal of the United States*, published by the National Science Foundation.

Not all of the research is disinterested, however. As Barbara Mitchell and Jon Tinker show in their detailed introduction to **Antarctica and Its Resources** (Earthscan, 1980, paper only), the 14 parties to the Antarctic Treaty and other nations have long had their eyes on the continent's oil, gas, fish, and mineral resources.

If the region's past experience of commercial exploitation is any precedent, Antarctica could be in for trouble. Its waters were once the world's premier whaling grounds, producing 10 times more whale oil than did all others combined, ac-

ording to the U.S. Central Intelligence Agency's data-laden **Polar Regions Atlas** (CIA, 1978, paper only). But some of the largest whale species were nearly hunted to extinction. The population of blue whales is down to 5 percent of its 1900 level; for the smaller humpback, the figure is closer to 3 percent. Only the drastic quota cuts decreed by the International Whaling Commission in the early 1970s curbed the slaughter.

Today, the focus has shifted from whales (and seals) to krill and oil. In her comprehensive **Antarctica in a Resource Age** (forthcoming), *Science* reporter Deborah Shapley argues that the United States has failed to protect its own interests in the new Antarctic resource sweepstakes.

Before the 1961 ratification of the Antarctic Treaty, she points out, the United States could have laid claim to as much as 80 percent of the continent. Today, owing to its weak resource exploration effort under the treaty's loose arrangements, America may be taking a back seat in Antarctic affairs to Japan, the Soviet Union, and West Germany, nations that are pushing ahead with plans for commercial ventures.

It is inevitable, Shapley concludes, that when the treaty comes up for review in 1991, decisions about the management and exploitation of Antarctic resources will be shaped by governments that know something about them. Hence, she argues, the United States should step up its research program and take a more active role in Antarctica.

EDITOR'S NOTE: Many of the titles in this essay were suggested by Franklin Burch, director of the U.S. Center for Polar and Scientific Archives.