



*A New Survey of Universal Knowledge*

# ENCYCLOPÆDIA BRITANNICA

Volume 2

ANTARCTICA TO BALFE



ENCYCLOPÆDIA BRITANNICA, INC.

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# ENCYCLOPÆDIA BRITANNICA

## Volume 2

### ANTARCTICA TO BALFE

**A**NTARCTICA, the continent lying concentrically about the geographic south pole. Antarctica increases in importance as it becomes better known, and it is also significant as an area of large-scale international co-operation.

This article is divided into the following sections:

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#### I. GENERAL SURVEY

**1. Location and Description.**—Antarctica lies in unique isolation in the triangle formed by the southernmost extension of South America, Africa and Australia. The nearest oceanic approach to a neighbouring continent is about 600 mi. across Drake straits from Tierra del Fuego to the tip of the Graham-Palmer peninsula. (Because of disputes over priority of discovery the British call this peninsula Graham Land and Americans call it Palmer peninsula; the hyphenated form used in this article recognizes the dispute. Argentina calls it San Martin and Chile, Tierra de O'Higgins.) Surrounding the continent is the Antarctic (or Southern) ocean, which is merely the confluent portions of the

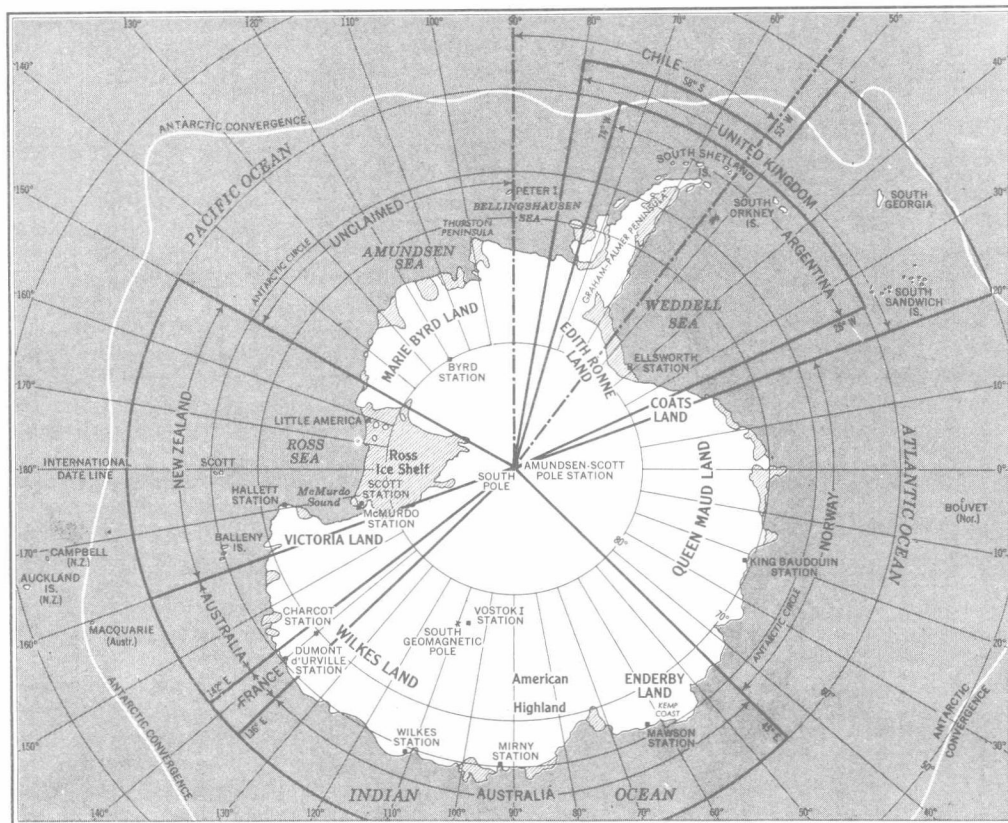
Pacific, Atlantic and Indian oceans; it is notoriously the stormiest in the world, for there is nothing to break the force of the persistent west winds. Warmer tropical waters meet with cold antarctic waters in a remarkably permanent girdling line ranging between latitude 45° and 65° S. known as the Antarctic convergence. This line, which varies considerably with longitude but generally within and not more than a degree or two of latitude per year, establishes a boundary between subtemperate and subantarctic zones. South of the convergence the waters are characteristically ice-laden and abound with subpolar aquatic life. It is a feeding region for myriads of pelagic sea birds and is the location of Antarctica's principal industry—whaling.

The continent itself is essentially circular in form except for the Graham-Palmer peninsula and the inward bights of the Ross and Weddell seas. The great mile-thick layer of continental ice thins toward the coasts and discharges flat-topped icebergs into the surrounding seas from piedmont glaciers, ice tongues and shelf-ice systems (*see also* GLACIER). Along the periphery of the continent are rugged mountain peaks left bare by the skirting and receding ice. Farther inland the rugged landscape is generally drowned by ice cover, although gentle rolling surfaces and crevassed regions in places reflect its hidden character.

The continent is asymmetrically divided into two parts by a high upthrust mountain range exceeding 15,000 ft. elevation. This antarctic cordillera runs from Victoria Land on the New Zealand side toward Coats Land on the Atlantic side. Its central relationship with the Andean type ranges of the Graham-Palmer peninsula is still uncertain for lack of adequate exploration. The geological formations of this central range seem to bear little resemblance to the Andean type, however, and its flat-lying, uplifted sedimentary rocks are in part carboniferous. Extensive low quality bituminous coal outcrops to within 200-300 mi. of the south pole yield fossils which portray an earlier age when the continent was once forested. Whether this former warmer climate was due to climatic change, polar wandering or continental drift is still a matter of intensive conjecture and investigation.

West Antarctica, the lesser of the two major subdivisions of the continent, lies almost entirely within the western hemisphere, facing toward the Pacific ocean. Ice soundings have shown this region to be largely an ice-covered archipelago. Ice thickness be-





ANTARCTIC TERRITORIAL CLAIMS. TO REMAIN STATUS QUO UNDER THE TERMS OF A TREATY SIGNED BY 12 NATIONS ON DEC. 1, 1959. THE TREATY DEDICATES ANTARCTICA FOR PEACEFUL PURPOSES ONLY AND IN EFFECT INTERNATIONALIZES THE ENTIRE CONTINENT. (ICE SHELVES INDICATED BY LINED AREAS)

tween the islands ranges to 14,000 ft. with elevations 4,000–6,000 ft. above sea level. West Antarctica is bordered by the bights formed by the Ross and Weddell seas. Its most thoroughly studied regions include Marie Byrd Land and the Graham-Palmer peninsula.

East Antarctica is nearly twice as large as west Antarctica and lies mostly within the eastern hemisphere. It appears to be more contiguously a continental mass. The subsurface beneath the ice is extremely rugged except west of Victoria Land, where it appears to be an extensive plain close to sea level; the internal ice cover forms nearly featureless domes rising to elevations above 1,200 ft.

Taken as a whole, with its lofty mountains and ice cover, Antarctica averages about 8,000 ft. in elevation, the highest of all the continents.

In sharp contrast to the lushness of sea life, the continent is virtually lifeless. Seals and birds that frequent the coasts and off-lying islands of Antarctica depend upon the sea for food and do not go farther inland than necessary to find breeding grounds. Aside from microscopic forms of life sparsely detectable in the snow and melt ponds, the only permanent life on the continent are lichens, mosses, fungi, a few grasses and one diminutive flowering plant. Tiny insectlike creatures find shelter and livelihood in the more luxuriant clumps of these hardy plants.

**2. Knowledge of the Region.**—Surrounding islands were discovered during the 18th century, but until 1820 sea ice prevented even the most daring navigators from seeing the continent itself. Positive recognition of a land mass of continental proportions was achieved in the mid-19th century, but, aside from relatively insignificant landings, the first fruitful efforts to explore the interior were initiated near the beginning of the 20th century.

Deep penetration by Ernest Shackleton, R. F. Scott and Roald Amundsen culminated in Amundsen's reaching the geographic south pole first in Dec. 1911, about 31 months after the north pole was reached by Robert E. Peary. It was not until the advent of new technical advances, such as aircraft, radios and aerial photog-

raphy, that the bulk of the coast lines and interior were first crudely mapped in the late pre-World War II period. Afterward much improved technical developments further stimulated interest in exploring the continent. Foremost was the appearance of powerful ice-breaking vessels which could shepherd cargo vessels through pack ice; the coast guard icebreaker "Northwind," leading vessel of the U.S. navy's Operation "Highjump" in 1947, was the first of its class to approach Antarctica. Advances in aircraft, aerial cameras, communications, weather forecasting and navigation systems and aids improved the ability to reach icebound coasts and inland areas denied to earlier expeditions.

A further significant change was in personnel. Early visitors to Antarctica, except for crews of sealing and whaling vessels, were unpaid volunteers who went exploring for adventure. In the post-World War II period there was an abundance of available military and civil service personnel, as well as excesses of usable military supplies, ships, aircraft, vehicles, foods and instruments, making logistics less difficult. All members of exploring parties be-

came well-salaried employees; nominal leaders were administrators who themselves could not afford the time to remain in the antarctic during winter and in some cases not even in summer. Stations therefore became more like agencies receiving instructions from outside the continent. Nevertheless, the new approach provided longer continuity, and systematic long-range surveys and scientific programs became possible.

The continent can be said to be permanently inhabited since 1943, even though its personnel is usually exchanged annually. There was a marked increase of scientific exploration of Antarctica in the period 1955–60 associated with the International Geophysical year (*q.v.*) of 1957–58, and after IGY an intensive co-operative scientific program continued. Nevertheless, of the continent's 5,100,000 sq.mi., approximately one-fifth had not been seen by the eyes of man as of 1960.

**3. Ownership.**—Declared ownership of parts of Antarctica is confused and controversial among seven claimant nations. The United Kingdom, New Zealand, Australia, Norway and France agree basically among themselves in laying claim to the bulk of the continent, with the notable small central portion of west Antarctica conceded to the United States. Norway's claims were the most modest, extending only to their coastal discoveries facing the Atlantic between longitude 45° E. through the Greenwich meridian westward to longitude 20° W.

France's claim of Terre Adélie, which is the smallest segment of any claimant, is bounded by longitudes 136° E. and 142° E. and flanked on either side by Australian claims. France also claims the Crozet and the Kerguelen islands in the southern Indian ocean.

The United Kingdom formerly made extensive claims but has bequeathed large portions of them to New Zealand and Australia. The New Zealand claim includes the wedge-shaped segment extending from longitude 150° W. westward past the international date line to 160° E., bordering the Australian claims in Victoria Land. The French-split Australian claim is the largest national claim, extending from 160° E. westward to 45° E., adjoining the Norwegian claim. This region lying south of Australia and the

Indian ocean includes Wilkes Land, an important American discovery in 1847. Australia also claims the Macquarie, Heard and other islands.

The British claim retained for itself the Falkland Islands dependencies (see FALKLAND ISLANDS). It incorporates the best-known portion of Antarctica, the Graham-Palmer peninsula and the numerous islands of the South Shetland and South Orkney archipelagos. South Georgia (*q.v.*), the important whaling centre, is also included in the claim area, which extends in a segment to the pole lying between longitudes 20° and 80° W.

Argentina and Chile make conflicting claims of most of this same area, originally and primarily on the basis of the extension of their national longitudinal boundaries south to the pole, although after World War II both nations maintained numerous small bases under military sponsorship. The Argentine claims of 1943 extend between longitudes 25° and 74° W., including the Falkland Islands and South Georgia. The Chilean claims extend southward to latitude 60° S. between longitudes 53° and 90° W. British efforts to take the conflicting claims case to the International Court of Justice in 1947 and 1955 were ignored by Argentina and Chile.

Although U.S. citizens have laid claim to portions of Antarctica, the United States government has never made any formal claims nor recognized the assertion of other claimants. It has, however, conserved its rights without defining them. Other nations that have taken part in the exploration of Antarctica without laying claims include the U.S.S.R., Belgium, Japan, Germany, Sweden, Poland and South Africa.

The bases of the various claims and the related question of the future status of Antarctica are discussed at greater length in following sections of this article. (PL. A. S.)

## II. PHYSICAL CHARACTERISTICS

**1. Meteorology.**—The weather and climate of Antarctica are the result of several factors: (1) its location near the south pole of the earth, with the implied astronomical influences; (2) its great elevation, which intensifies the polar climate; (3) its perpetual snow cover with strong reflective and radiative characteristics that also intensify the polar climate; (4) its complete isolation from all other continents by a completely surrounding ocean of relatively warm water.

The antarctic atmosphere has the same composition as that of the rest of the world, except that the principal variable gaseous component, water vapour, has only about one-tenth the concentration, on the average, that it has in middle latitudes. Excluding the Graham-Palmer peninsula, the monthly mean temperature during the warmest month is around 32° F. in the coastal region and from -30° to -4° F. in the interior; the water-vapour concentration can be no higher than about 2.4 and 0.2 gr. per cubic foot, respectively. In winter the coldest monthly mean temperature is from about -22° to -4° F. in the coastal region and from -94° to -40° F. in the interior; the water-vapour content is less than 0.4 and 0.001 gr. per cubic foot, respectively. The carbon dioxide content is between 310 and 315 parts per million, about the same as other parts of the world. Ozone observations are insufficient for a complete determination, but there is an indication of a wintertime maximum. Since there is no formation of ozone *in situ* during the dark season, there must be a transport of ozone, as well as other properties of the atmosphere, from sunlit latitudes. Dust and other pollutants are practically unknown. Nuclear radiation, also, is at the very lowest levels observed on earth.

The total of the incoming direct and diffuse solar radiation reaches values of 75%–85% of the solar constant, depending upon the altitude of the station. The high values are partly due to the earth's being at perihelion—that point of its orbit nearest the sun—during the southern hemisphere summer, but the clear, dry atmosphere and high elevation of Antarctica are important factors. However, as much as 80%–90% of the incoming short-wave radiation is reflected by the snow surface. Only the upper three to five feet of the snow cover absorb appreciable amounts of the solar energy, and it is quickly lost again in the dark season because the dry atmosphere has little blanketing effect. Small

amounts of cloud do not appreciably reduce the total amount of solar radiation reaching the surface, since there is a high multiple reflection caused by the snow surface and the underside of the clouds. In some cases this can even raise the total of the direct and diffuse radiation reaching the surface to a value higher than that of the solar constant; *i.e.*, the amount of radiation from the sun reaching the top of the atmosphere. The albedo, or reflectivity of the snow surface, varies from about 75% to 90%; values tend to be lowest after periods of ablation (*e.g.*, sublimation, melting, evaporation) and wind erosion and highest after fresh snowfall. The albedo has a seasonal as well as shorter period variation.

The isotherms of mean annual temperature over Antarctica generally approximate the terrain contours; the warmer temperatures are found near the low-lying coast and the coldest temperatures are found on the high plateau in the interior of east Antarctica, which averages between 2,600 and 3,600 ft. higher than the pole elevation of 9,200 ft. The annual mean on the plateau is about -68° F. and temperatures below -125° F. have been reported.

Although it is the world's coldest continent, Antarctica is not uniformly cold. Variations in the atmospheric circulation bring about considerable differences in temperature, both in time and in space. The minimum temperatures at one place do not always occur during the same month from one year to another, and places several hundred miles apart may be under completely different temperature regimes at the same time. A rise and fall of as much as 15° F. in the monthly mean temperature can take place in successive months during the winter. Under conditions of large-scale flow of air from the oceans to the continent, increased cloudiness will inhibit the loss of heat by radiation from the snow surface as well as increase the amount of heat radiated downward to the snow surface; a rise of as much as 25° F. in one day can occur.

In winter the main supply of heat to Antarctica is the warm air carried by the atmospheric currents. The first strong radiational cooling in winter causes an early winter temperature minimum, but the atmosphere reacts to this by changing its circulation so as to bring in the warmer air; finally, at the end of the winter, radiational cooling again becomes dominant and late winter minimum temperatures are noted, usually just before the return of the sun.

The cyclonic storms that move around Antarctica often pass across the west Antarctica highland, and even across the south pole, but only rarely over the higher plateau of east Antarctica. The exchange of air horizontally in the levels from about 8,000 to 15,000 ft. is such that a temperature fall of only about 15° F. is noted in the monthly mean values from summer to winter. The very lowest layers of the atmosphere lose heat by radiation and by contact with the snow surface. The result in these cases is inversion—that is, the temperature increases with height, and a gradient of 50° F. in 1,000 ft. is not uncommon.

Cyclones on the polar front attain great intensity and size; the air trajectory and the contrast between ocean and continental underlying surface are the principal factors in the development of weather at a given spot. The great storms and blizzards of long duration are related to deep disturbances extending in many cases from sea level to the tropopause (the boundary between the troposphere and the stratosphere), a height of about five miles in summer and six in winter. This seasonal variation of tropopause height is opposite to that of the arctic regions. Storms of blowing snow accompany the disturbances and even persist for some hours after the passage of the initial storm. The shallow storms tend to move quickly around the periphery of the continent and are not related to the large-scale planetary waves in the atmosphere. The large storms move in arclike, clockwise trajectories, generally from the northwest to the southeast, and remain north of the coast line in most cases.

The high level of the continent, the strong gravitational outflow of the cold air in contact with the surface and the procession of storms act against the formation of large polar anticyclones, although the surface pressure in some localities has gone above 1,035 millibars. Some of the cold anticyclones have provided sufficient cold air, both from west Antarctica and from east Antarctica, to reach other southern hemisphere continents, although much modified by overwater trajectories of several thousand miles.

The jet stream, the core of winds of maximum velocity, found usually just below the tropopause and in regions of maximum horizontal temperature gradient, tends to broaden its latitudinal extent and strength in winter and tends to narrow and weaken in summer. Surface winds frequently attain speeds of 100 m.p.h. or more during the passage of storms along the coast of east Antarctica. The steep slope of the continent accentuates the geostrophic component of the wind in these cases; along low-lying coast lines, the maximum force of the wind is usually less.

The extension of the "effective" continent as much as six degrees of latitude farther north of its summer coast line comes about through the freezing of the surface layers of the ocean in winter. This inhibits the vertical exchange of heat between ocean and atmosphere and also provides a longer continental trajectory for the air of oceanic origin that reaches the continent. This is one reason for lower average cloudiness in winter as compared with summer.

In the spring and early summer great changes take place in the stratosphere. The circulation that was strongly cyclonic, with westerly winds averaging as much as 100 m.p.h., changes abruptly. In the free atmosphere at altitudes of about 12 mi. and higher, warming of as much as 70° F. takes place between late October and early November, and easterly winds prevail. Much of this warming appears to be due to the transport of warm air from lower latitudes and to adiabatic heating—that is, an increase in air temperature as a consequence of internal processes of contraction caused by sinking motions over the continent; it is only partly caused by absorption of solar radiation in the atmosphere. During this period there is a sharp rise in surface pressure from the late wintertime minima that are noted almost everywhere over Antarctica to the summertime maxima. Great masses of air are transported and as much as 150,000,000 tons of air are lost or gained over Antarctica from one month to another. Water-vapour condensation not only adds to the snow cover but also contributes about 14% of the net heat energy transported by the atmosphere. It is estimated that between five and eight inches of water equivalent is deposited in the form of snow over Antarctica in one year, on the average. The coastal regions have up to ten or more times the two inches snowfall deposited on the interior. If there were no outflow of this snow, or no loss in any other way, it would have taken from 9,000 to 15,000 years to deposit the 5,750,000 cubic miles of ice that is currently thought to cover the continent.

(M. J. Ru.)

**2. Geology.**—The geology of Antarctica is imperfectly known, as would be expected in a continent not fully explored and whose exposed bedrock amounts to less than 1% of the continent's surface. However, in a general way Antarctica can be divided into east Antarctica, which lies south of Australia and Africa, and west Antarctica, which lies south of South America. The dividing line between these two areas lies along the west side of the Ross sea and Ross ice shelf and extends north of the Horlick mountains to the Weddell sea.

East Antarctica is considered a shield area of igneous and metamorphic basement rocks of Pre-Cambrian (?) Age partly overlain by sedimentary rocks of Paleozoic to Mesozoic Age. This shield is bounded on the west side of the Ross sea and Ross ice shelf by the Antarctic horst. In the interior ice about 9,000 ft. thick rises to altitudes of 7,000 to 12,000 ft. and caps the bedrock. The bedrock is below sea level in many places.

Basement rocks in Victoria Land consist of granitic gneiss, mica schist, granulite and crystalline limestone which is intruded by granite containing veins of aplite and pegmatite. Overlying these rocks and extending at least to the Horlick mountains are flat-lying sedimentary rocks that consist of limestone of Cambrian (?) Age, and the Beacon group, consisting of quartz sandstone, arkose, conglomerate, shale, limestone and coal of Devonian (?) to Triassic (?) Age. These sedimentary rocks are intruded by diabase sills and dikes and cut by faults. Volcanic rocks at Mt. Discovery and at Mt. Erebus on Ross Island (the only continuously active volcano in Antarctica) are the youngest rocks in the area. Volcanic rocks also are found on offshore islands and in the northern part of Victoria Land in the vicinity of Cape Adare, where occur

slates and graywackes of the Robertson bay group, of possible Early Paleozoic Age. Basement rocks similar to those in Victoria Land are exposed in some places along the coast of Wilkes Land.

From Wilkes Land to Enderby Land the basement is composed of quartzite, hornfels, gneiss, aplite, pegmatite, gabbro, norite, pyroxenite and hypersthene of Pre-Cambrian (?) Age. Large bodies of hypersthene granite, and diabase and basalt intrude part of these rocks. Southeast of Mawson, flat-lying arkosic sandstones and grits with pebble beds and coal of Permian (?) Age are tentatively correlated with the Beacon group of Victoria Land. Slates, graywackes and volcanic rocks are exposed along the coast farther west.

West Antarctica has mountains jutting through an icecap that is thicker in places (over 14,000 ft.) but also generally lower in elevation than the plateau of east Antarctica.

Andean folding can be traced southward from Cape Horn to the Scotia arc and Graham-Palmer peninsula, where plutonic rocks are flanked on the west and north by a volcanic belt along the Scotia arc and on the east by sedimentary rocks. Conglomerates, sandstones and slates containing fossils of Jurassic Age occur on the east side of the Graham-Palmer peninsula, and similar rocks and limestone are along the east side of Alexander I Island. Volcanic rocks have invaded the sedimentary sequence. Islands at the northeastern end of the Graham-Palmer peninsula contain conglomerates and sandstones of the Snow Hill group of Cretaceous Age, which are overlain unconformably by conglomerates and sandstones of the Seymour Island group of Eocene to Miocene Age.

In Marie Byrd Land quartzites and slates about 15,000 ft. thick in the Edsel Ford ranges and the Rockefeller mountains are intruded by granite, granodiorite, quartz monzonite and recent volcanic rocks. Samples collected in the Executive Committee range and south of the Kohler range indicate that those mountains are of volcanic origin, whereas low-grade metamorphic rocks have been found in the foothills of the Sentinel mountains. Diorite is exposed in a part of the Thurston peninsula but most of the peninsula was unexplored in the early 1960s.

Geologists have thought that a broad ice-filled channel exists between the Ross and Weddell seas. However, new data indicate that a ridge of bedrock from the Sentinel mountains to the Antarctic horst crosses the supposed channel, and, instead, a deep trough may exist between the Bellingshausen and the Ross seas.

No minerals have been found in economic concentrations, but those of potential value include atacamite, azurite, beryl, bornite, cassiterite, chalcopryrite, chromite, fluorite, galena, gold, graphite, hematite, magnetite, malachite, manganese minerals, molybdenite, monazite, sphalerite, stibnite and uranium minerals.

Coal has been found near Mawson and in many places in the Beacon group from Coats Land, the Horlick mountains, Queen Maud range, Beardmore glacier region and northward into Victoria Land. The coal ranges from lignite to anthracite in grade and is generally in seams only a few inches thick, but one seam eight-feet thick was found near the top of Beardmore glacier by Shackleton's party in 1908. No petroleum has been discovered but it is conceivable that some may be in sedimentary rocks. (A. R. TA.)

**3. Antarctic Ocean.**—The Antarctic, or Southern, ocean forms the principal connecting link between the other major subdivisions of the world ocean (*see OCEAN AND OCEANOGRAPHY*). Although its northern limit has to be set quite arbitrarily and therefore has been characterized in various ways, it is convenient to follow the practice of the British admiralty and to define the Antarctic ocean as all the waters south of latitude 55° S. It thus has a total area, up to ice shelf edges, of 12,451,000 sq.mi., with an average depth of 12,240 ft. Of this total area 5,643,000 sq.mi. is south of the Pacific ocean, 3,180,000 sq.mi. is south of the Atlantic ocean and 3,628,000 sq.mi. is south of the Indian ocean.

An appreciable additional portion of the Antarctic ocean is overlain by floating ice shelves and hence is commonly included in the area assigned to antarctic land. The Ross ice shelf covers about 160,000 sq.mi. of ocean, and the Filchner ice shelf and the extensive ice shelves off Marie Byrd Land, Queen Maud Land and elsewhere bring the total to about 360,000 sq.mi. Even inland from the ice shelves, Antarctica cannot be considered wholly as



dry land, since measurements made during the International Geophysical year of 1957-58 showed that a large portion of the interior (possibly as much as a quarter) consists of ice of a thickness greater than its height above sea level. Thus, much of the "continent" is an island archipelago with glacier ice extending to the bottom of a former shallow ocean area.

The great circle routes between Cape Town and Melbourne, and from Australia or New Zealand to the North Atlantic via Cape Horn, penetrate deep into the Antarctic ocean. The use of the Suez and Panama canals, however, has greatly reduced the shipping in southern waters, and many parts of the Antarctic are regularly visited now only by whalers.

*Seas and Islands.*—The narrowest part of the Antarctic ocean, the strait between South America and the Graham-Palmer peninsula, is known as Drake strait or Drake passage. The sea to the east, bounded by South Georgia and the Falkland, South Sandwich, South Orkney and South Shetland islands, is the Scotia sea. The Weddell sea is the area south of the Scotia sea from the Graham-Palmer peninsula eastward to Cape Norvegia in 12° W. Cape Adare in 170° 15' E. and Cape Colbeck in 158° 10' W. mark the extremities of the Ross sea. The Amundsen sea is the bight between Cape Dart in 123° W. and Cape Flying Fish in 101° W. The Bellingshausen sea extends from Cape Flying Fish to the Graham-Palmer peninsula.

There are few oceanic islands in the Antarctic. The Scotia ridge trends east from Tierra del Fuego and then loops south and west to join the Graham-Palmer peninsula. Its elevated portions form South Georgia (which lies just north of 55° S.), the Clerke rocks (about 40 mi. to the southeast), the South Sandwich Islands (a chain of volcanoes, some still active) and the South Orkneys. Bishop and Clark islands are a group of rocks in 158° E., outliers of Macquarie Island in 54° 45' S. The Balleny Islands are an ice-covered volcanic chain in 67° S., 164° E. Scott Island, in 67° 24' S., 179° 55' E., is less than 100 mi. from the intersection of the Antarctic circle with the international date line. Peter I Island is a glacier-covered extinct volcano rising nearly 4,000 ft. above sea level in 68° 50' S., 90° 35' W.

The principal islands of the continental shelf areas of the Antarctic ocean are Cape Horn and the neighbouring islands off Tierra del Fuego, and the South Shetlands and numerous other islands off the Graham-Palmer peninsula. Alexander I Island (16,700 sq.mi.), in the eastern Bellingshausen sea, is the largest island south of 55° S. discovered by 1960. It is joined to the mainland by an ice shelf. Several islands have been identified beneath the Ross sea ice shelf.

*Ocean Floor.*—The continental shelves surrounding Antarctica are to a large extent covered with ice shelves. Seaward of the ice shelf edges the continental shelves are mostly at a depth of 1,200 to 1,800 ft. They are widest in the western portion of the Weddell sea and in the southern Ross, Amundsen and Bellingshausen seas, with a maximum width of more than 300 mi. Elsewhere, as off Queen Maud Land, the continental shelf is virtually lacking. The sediments of the continental shelves are a random mixture of fine to coarse fragments of the continental rocks.

The deeper waters of the Antarctic ocean are characterized by four deep basins with soundings mainly from 15,000 to 18,000 ft., separated by ridges with depths of less than 12,000 ft. The largest of these basins lies between the Scotia ridge and a ridge running north and south through the middle of the Indian ocean (the mid-Atlantic ridge ends at the northern limit of the Antarctic ocean). It includes the Meteor Deep, a trench with a maximum sounding of 27,108 ft., just east of the South Sandwich chain; elsewhere its greatest depth does not exceed 19,500 ft. Between the mid-Indian ridge and a ridge running south from Tasmania is a smaller basin with a greatest depth of about 16,000 ft.; farther east a basin having a greatest depth of about 19,000 ft. about midway between New Zealand and Victoria Land is separated from the fourth basin by a ridge that runs northeast across the Pacific from Victoria Land. North of the Amundsen and Bellingshausen seas, this basin has a maximum depth of about 18,000 ft.

The pelagic sediments of the Antarctic ocean are composed chiefly of diatomaceous oozes, with an admixture of glacial clays,

particularly north of the Weddell sea. These grade into the globigerina ooze of the central Pacific and into red clay closer to South America.

*Tides and Currents.*—There is a fairly uniform progression of the tidal wave from east to west around Antarctica. The tides are mainly diurnal, but mixed tides exist south of the Indian ocean along the western part of Wilkes Land and on the other side of the continent on the northern part of the Graham-Palmer peninsula and the off-lying islands. Tidal ranges are moderate, mostly less than five feet, except at the northeastern tip of the Graham-Palmer peninsula, where they may reach eight feet.

The principal surface circulation of the Antarctic is part of the west wind drift, with a current of generally less than a knot setting easterly around the continent. South of the Antarctic divergence, which, except in the Weddell and Ross seas, is about 250 mi. from the continent, there is a surface flow to the west. This current is best developed in the Weddell sea where it sweeps clockwise against the Graham-Palmer peninsula.

*Water Masses and Deep Circulation.*—The Antarctic divergence, which exists around most of Antarctica, marks roughly the boundary between the prevailing westerly winds and the easterly and northeasterly winds that blow off the continent. About 600 mi. northward is the Antarctic convergence, the position of which varies greatly with longitude, depending on the configuration of the coastal boundaries and the bottom topography. The surface waters south of the Antarctic convergence are colder than 35° F. in winter, except where the convergence reaches its farthest northerly limits. North of the Antarctic divergence there is a summer increase of about 5° F. in water surface temperature, but farther south most of the summer heat is used to melt pack ice, and water of 30° F. or colder still surrounds the continent. This belt of cold water undergoes an increase in salinity and hence in density during the winter as the pack ice freezes, and it sinks to great depths all around the continent, especially off the Weddell sea. Deep water is forced to the surface by this process. At the Antarctic convergence cold surface water sinks beneath the subantarctic waters to the north. This Antarctic intermediate water can be traced as far north in the Atlantic as 20° N. The surface salinities in the Antarctic are close to 34<sup>0</sup>/<sub>00</sub>, except in the vicinity of melting ice, where they may be as low as 32<sup>0</sup>/<sub>00</sub>. The deep convection of the Antarctic ocean is the main mechanism preventing stagnation in the deeper waters of the oceans to the north.

*The Barrier.*—A unique phenomenon of Antarctica is the floating shelf ice, which is a derivative of the inland ice sheet. When Capt. J. Clark Ross in 1841 first penetrated the pack ice into the Ross sea, he sailed due south until he was brought up in about 77° S. by the ice front of the greatest of these shelves, from 50 to 200 ft. high, barring his way to the south. The Ross ice shelf, as it is called, is the largest of these floating ice shelves but is typical of many others in the Antarctic. It is roughly the size of France and consists of a sheet of ice varying from 500 to 1,000 ft. or more in thickness, the outer end being open to the ocean and the inner end held fast to the continent by the glaciers, which act as feeders, and by being anchored on shoals close to the actual coast. Its surface is smooth, and it forms the easiest approach to the pole itself, since it reaches to within 300 mi. of that spot. The tabular icebergs typical of the southern hemisphere, with their flat tops, stratified appearance and immense size (up to 90 mi. in length of side), are derived from this and similar shelf ice.

*The Sea Ice.*—The sea ice itself is comparatively temporary. It begins to form in sheltered bays as early as the end of January and by the beginning of March any ship is liable to be frozen in unless its harbour is a windy one. There are large variations from year to year in the area of sea solidly frozen over, since strong winds, and such are very frequent, will prevent sea ice from forming or will blow out any that is not of considerable thickness. In sheltered bays the ice will continue to increase in thickness until October or November, by which time it will be any thickness up to seven feet. This will begin to break up and float northward from the beginning of December onward, but the innermost bays may not lose their ice until late in February, or occasionally not at all for two years or more in succession. The belt of pack ice which

rings the continent is made up of the ice from this summer breakup. (J. L.)

**4. Animal Life.—Birds.**—Bird life of Antarctica is essentially marine, and, in keeping with general characteristics of the plant and animal life of cold oceans, it is poor in number of species but relatively rich in number of individuals. The birds of the region may be generally divided into those species inhabiting the islands within the subantarctic, some of which are within the Antarctic convergence, and those found on islands within the Antarctic circle and along the continent.

Within the Antarctic circle the emperor penguin (*Aptenodytes forsteri*), the Adélie penguin (*Pygoscelis adeliae*), the snow petrel (*Pagodroma nivea*) and the south polar skua (*Catharacta macrormicki*) are circumpolar in distribution and might be considered truly indigenous to the area. The emperor penguin, following the end of its winter breeding season, spends the summer no farther north than the edge of the pack ice. Conversely, the Adélie penguin nests on the islands and on the mainland of the continent during the summer and spends the winter within the pack ice. The south polar skua has the distinction of being the world's most southerly bird in its distribution. It has been observed within 80 mi. of the geographic south pole.

The emperor penguin is the most truly antarctic of all birds and is distinctive from other polar species in that it begins nesting in the winter. Unlike the Adélie penguin which has a fixed nest site that it returns to annually, the emperor penguin has no nest and merely carries the egg on top of its feet. It has no territorialism, and most of the rookeries are located on sea ice adjacent to the continent.

Prior to the IGY six emperor penguin rookeries had been located in Antarctica. These known rookeries included Cape Crozier in the McMurdo sound area at longitude 169° E., the first ever discovered; the Dion Islet rookery off the west coast of the Graham-Palmer peninsula, south of Adelaide Island, where the British conducted the first detailed studies of the species; a rookery near Gaussberg in Kaiser Wilhelm II Land at longitude 89° E., reported by the Germans; the Point Géologie rookery in Adélie Land at longitude 140° E., which was studied by the French; the Haswell Islet rookery at longitude 92° E., discovered by Mawson in 1915; and a rookery at Taylor glacier on Mac-Robertson Coast at longitude 61° E., reported by the Australians in 1955. Known population figures for all these rookeries totaled less than 40,000 birds.

The Cape Crozier rookery, found in 1902 by members of the British National Antarctic expedition, was revisited by New Zealand scientists in Sept. 1957. It had shifted position somewhat from its original location on the sea ice and had about 1,000 adult birds, approximately five times the estimated population 50 years earlier.

During the IGY five new emperor penguin rookeries were discovered by the Australians, bringing to six the known number between longitudes 55° E. and 80° E. Two other rookeries were found in the Weddell sea area at Halley bay and Gould bay, numbering 21,000 and 8,000 birds respectively. These discoveries confirmed earlier reports of the presence of breeding birds.

Another large emperor penguin nesting area was discovered from a helicopter by United States personnel in Dec. 1958. Located approximately 250 mi. N. of McMurdo sound at latitude 73° S., longitude 169° E., between Coulman Island and Lady Newnes ice shelf, the rookery contained an estimated 33,000 breeding pairs. By 1960 known emperor penguin rookeries numbered 14 with an estimated population of more than 150,000. (See also PENGUIN.)

Additional bird species either nest on the islands and coasts of Antarctica or spend much of their time within this zone, and can be considered circumpolar in distribution. These include the giant petrel (*Macronectes giganteus*); silver-gray fulmar (*Priocella antarctica*), which except for the snow petrel is the commonest bird in the pack ice throughout the whole circumpolar belt; Cape pigeon (*Daption capensis*); antarctic petrel (*Thalassoica antarctica*); Wilson's petrel (*Oceanites oceanicus*); antarctic whalebird (*Pachyptila desolata*); antarctic tern (*Sterna vittata*); antarctic blue-eyed shag (*Phalacrocorax atriceps bransfieldensis*); and the

kelp gull (*Larus dominicanus*). Other species will come within the zone at times but only about 32 species of birds penetrate beyond latitude 60° S. and most of these are subantarctic rather than polar wanderers. One of these, the arctic tern (*Sterna paradisaea*), migrates from its nesting grounds in the arctic to the antarctic.

**Mammals.**—Although the antarctic seas are rich in marine mammals, particularly seals and whales, whaling constitutes the only industry in the whole antarctic region. This industry is controlled, in part, through action of the International Whaling commission, organized in 1946. About 70% of the annual world catch of whales is taken in the antarctic. The species of most importance belong to two suborders, the Odontoceti (toothed whales) and the Mysticeti (whalebone whales). The whalebone, or baleen, whales, instead of having teeth, have a straining mechanism which enables them to feed on small marine organisms. The antarctic baleen whales of greatest industrial importance include the fin, sei, humpback and blue—the last mentioned being the largest of all whales. The sperm whale is the most important of the toothed whales. Fin whales, which form about 50% of the world catch, constitute about 70% of the total antarctic catch of all species. The more common smaller whales in antarctic waters, which are not usually taken commercially, include the killer whales. (See also WHALE; WHALE FISHERIES.)

Whereas mammal life in the arctic is closely related to forms found within the adjacent temperate belt, much of the similar life in the antarctic is largely endemic. This distinctive character is exemplified in the four well-marked genera of truly antarctic seals, which are unusual in that they show remarkably diverse structure correlated with no less distinct habits.

The crabeater seal (*Lobodon carcinophagus*) lives in the pack ice during winter and summer and is circumpolar in the antarctic but occasionally reaches subantarctic latitudes. It appears to be semimigratory, is gregarious and is the commonest seal in those waters. It lives almost exclusively on the pelagic shrimp *Euphausia superba*.

The Weddell seal (*Leptonychotes weddelli*) is more southern in distribution than the crabeater seal, and its range is confined more to the fast ice along the coasts throughout the year. It is gregarious, occurs in considerable numbers in parts of its range, is circumpolar, and occasionally reaches subantarctic latitudes. It feeds on fish and cephalopods (squids, octopuses, etc.).

The circumpolar Ross seal (*Ommatophoca rossi*) is the rarest of the four polar species. It inhabits the pack-ice belt, is solitary in its habits and appears to feed on fish and cephalopods.

The leopard seal (*Hydrurga leptonyx*) has a rather broad latitudinal range and is found from the shores of the antarctic continent northward to parts of the temperate zone. It is semimigratory, solitary in its habits and relatively widespread, but scarce. This aggressive seal preys on other seals and penguins as well as on fish and cephalopods.

The elephant seal (*Mirounga leonina*) normally breeds on the subantarctic islands but is occasionally found in antarctic waters. Two rookeries have been found on the edge of the continent in the Indian ocean waters. These largest of all seals were formerly hunted for their oil. Although once nearly extinct, their numbers are increasing. Fur seals, for nearly a century reported extinct, have been reported in small colonies on several subantarctic islands. (See also SEAL.)

**Marine Zoology.**—As a result of upwelling of replacement water, bringing up plant nutrients such as phosphates and nitrates, antarctic waters are perhaps the most productive in the world for marine animals. The enriched waters produce heavy plant plankton growths, which in turn result in rich growths of animal plankton. These are fed upon by various vertebrates and invertebrates, which results in an extremely rich population of marine fauna. Representatives of most invertebrate groups are found there, one of the more important being the small shrimp *Euphausia superba*, whose food consists of plankton. This shrimp is a most important food for great numbers of vertebrates, particularly whales.

Fishes native to the antarctic are primarily of the order Nototheniiformes, a perchlike group confined to waters of the far south



and somewhat analogous to the cod in the northern hemisphere. The order is remarkable for including several species that lack pigment in their blood. It is believed that the high solubility of oxygen at the temperature of the cold antarctic waters and the low metabolic rates required at these same near-freezing temperatures make it possible for these fishes to transfer sufficient oxygen to their tissues from their gills by simple physical solution in the blood plasma, without the necessity for the chemical linkage with hemoglobin that is required in nearly all other vertebrates. Other fishes include eelpouts (Zoarcidae), many species of which are circumpolar. Of the antarctic fish about 90% are of endemic species and 65% of endemic genera.

**Terrestrial and Fresh-Water Animal Life.**—The land and fresh-water animal life within the Antarctic convergence is comprised primarily of primitive forms of arthropods (insects, crustaceans, etc.), which are usually found among mosses, algae and lichens, or in moist soils or fresh-water pools. The more widely distributed species of insects in the antarctic appear to be parasites of birds and seals. About 44 terrestrial species are presently known and include biting and sucking lice, mites, springtails, ticks and wingless flies. Other animal life includes the tardigrades, or water bears, and various species of fresh-water rotifers. (C. R. E.)

**5. Plant Life.**—The plant life of Antarctica consists preponderantly of low-growing sorts, lichens, algae and mosses being the dominant forms. No large showy fungi have been reported on the antarctic. A rust organism has been collected on a grass (*Deschampsia antarctica*). With exception of a few specialized groups of terrestrial algae which use snow as a substratum, the plants, particularly the lichens, have been found wherever mountain peaks have breached the polar icecap, or wherever the ice sheet has receded, exposing the low shore line. Their abundance is relative and their size inconspicuous, but they exhibit a vigour which, in view of the severity of the environment, is frequently described as profuse.

Lichens are the most common plants found in Antarctica and some 300 species have been found to occur there. A maximum of 75 species of mosses and hepatics have been reported from the continent and subantarctic islands. Many of these have a cosmopolitan distribution. Only two species of flowering plants, a grass (*Deschampsia antarctica*) and a pink (*Colobanthus crassifolius*), have been collected within the Antarctic circle.

Approximately 160 species of fresh-water algae have been collected from areas of the Ross sea, Kaiser Wilhelm II Land and the Graham-Palmer peninsula. Those are chiefly of two families, the Myxophyceae and Chlorophyceae. During the summer season the most conspicuous fresh-water algae include *Prasiola* and *Crista* species, *Nostoc commune*, *Phormidium autumnale*, and *Plectonemus Nostocorum*, seen most frequently in pools and ponds. In addition about 60 species of fresh-water diatoms have been reported from the antarctic and nearby islands. (See also ALGAE; DIATOMS; LICHENS; MOSS.) (G. A. LL.)

### III. EXPLORATION AND DISCOVERY

**1. Conjecture About Antarctica.**—The remoteness of the antarctic regions delayed exploration until comparatively modern times, although the existence of climate zones similar to those in the northern hemisphere had been predicted by Greek philosophers; the name of the region is from the Greek *antarktikos*, "opposite the Bear," the northern constellation. The first humans to approach the far southern frozen seas may have been Polynesians. According to Rarotongan legends, Ui-te-Rangiora and his Polynesian companions made such a voyage about A.D. 650 in the canoe Te-Ivi-o-Atea. For western civilization, however, it was not until the 15th century that exploration of the southern hemisphere began, when Prince Henry the Navigator in 1418 encouraged the penetration of the torrid zone in the effort to reach India by circumnavigating Africa, which led to Vasco da Gama's rounding of the Cape of Good Hope in 1497. Successive explorations set a southern limit to the great known continents without approaching the true antarctic regions, but geographers still believed in the existence of a vast southern continent.

The search for it was a leading motive of explorers in the 16th

and early 17th centuries. Men lost the fear of open oceans after the Columbian period, but they were inhibited from going far south by choice after Amerigo Vespucci, Ferdinand Magellan and Sir Francis Drake pioneered the shortest route around the tip of South America. Voyagers rounding Cape Horn frequently met with contrary winds and were driven southward, but no navigator is known to have crossed the Antarctic circle before James Cook. Almost all of those who encountered the southern ice before 1750 did so by being driven off their course and not of set purpose. An exception is the French naval officer J. B. C. Bouvet de Lozier, who during Jan. 1739 traveled through ice-encumbered sea for 48° of longitude in 55° S., a voyage that resulted in the discovery of Bouvet Island in 54° 10' S. On Feb. 12, 1772, another Frenchman, Y. J. Kerguelen-Trémarec, discovered land in 50° S. which he believed to be part of the southern continent. Sent out again to complete the exploration of the new land, he found it to be only the inhospitable archipelago now called Kerguelen Islands. Meanwhile, between Jan. 13–24, 1772, yet another French navigator, Marion Dufresne, had discovered the Crozet and Prince Edward islands.

**2. Crossing the Antarctic Circle.**—On his voyage of 1772–75 Capt. James Cook, one of the most famous British seamen of his day, boldly approached the antarctic pack ice with the sailing ships "Resolution" and "Adventure," circumnavigating Antarctica without sighting land. In the course of his voyage he crossed the Antarctic circle several times, reaching 71° 10' S. at 106° 54' W. on Jan. 30, 1774, a record not to be surpassed in the 18th century. He disproved connection of islands, such as New Zealand, to any southern continent, and reduced the conjectured size of Antarctica to lie within the 60th parallel. After he discovered the South Sandwich Islands in the South Atlantic he concluded that if land lay farther south it was inaccessible and valueless; and his voyage suggested that there might be no antarctic land mass at all.

**Sealers.**—Cook's voyage ushered in a new era of antarctic history. Mariners now dared to enter the cold seas up to the forbidding ice pack, and soon sealers began to visit southern waters, in the exploration of which they played an important part. Between 1790 and 1820 there entered antarctic waters about 19 voyages, one Australian and the rest half U.S. and half British. In 1790–92 Capt. Daniel F. Greene from New Haven, Conn., visited South Georgia and took the first fur sealskins to China. This U.S. sealing expedition was the first American approach to the antarctic and culminated in a circumnavigation of the globe. In 1810 Frederick Hasselborough, an Australian, discovered Macquarie Island.

Then suddenly the antarctic experienced an economic boom. In the period between 1819 and 1822 about 110 U.S. and British voyages were made by sealers into the area south of South America, but, because there was considerable rivalry and secrecy, discoveries became confused and lost. In Feb. 1819 William Smith of the British brig "Williams" saw land in 62° 42' S.; repeating the voyage in October, he landed on the South Shetland Islands. Within a year these islands were the haunts of many U.S. and British sealing ships.

**3. Discovery of the Mainland (1820–99).**—The "Williams" with Smith aboard was chartered by the British naval commander Edward Bransfield, who on Jan. 30, 1820, surveyed the South Shetlands and went as far as 64° 30' S. Bransfield and Smith may have been the first to discover and chart a portion of the antarctic mainland, which they named Trinity Land. Later in the same year, on Nov. 16, the young U.S. sealer Nathaniel B. Palmer discovered an archipelago and more of the mainland coast. In early 1821 Capt. John Davis, another U.S. sealer, made what appears to be the first landing on the mainland. Thus began the complex history of the discovery of the Palmer peninsula. A party of British sealers made the first antarctic wintering on King George Island in the South Shetlands in 1821. In 1821–22 George Powell, accompanied by Palmer, discovered and surveyed the South Orkney Islands.

**Bellingshausen.**—In 1819 a Russian expedition was sent out under the command of Fabian von Bellingshausen in the "Vostok,"

with M. P. Lazarev in the "Mirny" in company, each sloop of about 500 tons. The object was to circumnavigate the antarctic area, keeping as far south as possible in those longitudes where Cook had made his northward detours. On Jan. 22, 1821, as he was completing his journey, Bellingshausen sighted the first land ever seen within the circle, the little island named for Peter I. A week later another and larger island, named for Alexander I, was seen. Bellingshausen then made for the South Shetlands and thence returned to Russia.

*Exploring Whalers.*—The furious slaughter of seals in the South Shetlands and South Orkneys during two seasons from 1820 through 1822 depleted the supply and came suddenly to an end. In the next 15 years an average of less than two ships per year approached the antarctic, and in some years there were none. During this period, however, as the commercial emphasis turned toward whaling, ships ranged more widely and began to push their way into the ice pack. The Enderby whaling firm of London in particular encouraged their whaling captains to explore. In 1823 James Weddell in command of the "Jane," a brig of 160 tons, with the cutter "Beaufoy" (65 tons), sailed into the sea which now bears his name and on Feb. 20 reached a new southing record of  $74^{\circ} 15' S.$ ,  $34^{\circ} 17' W.$  In 1830 John Biscoe, in command of another Enderby brig, sailed eastward from the South Sandwich Islands and crossed the circle in  $1^{\circ} E.$  He saw Enderby Land in  $49^{\circ} 18' E.$  but was unable to reach it. Biscoe later crossed the whole of the southern Pacific in a high latitude in Feb. 1832 and discovered the Biscoe Islands and Graham Land (now Graham Coast), a southward extension of Bransfield's Trinity Land and the Palmer peninsula; the coast was named for Sir James R. G. Graham, first lord of the admiralty at that time.

In 1833 another Enderby captain, Peter Kemp, discovered Heard Island and Kemp Coast, about  $10^{\circ} E.$  of Enderby Land. Heard Island was named after the U.S. whaling captain John J. Heard, the third of the many independent discoverers of this small, out-of-the-way island in the far south Indian ocean. In 1839 John Balleny, sailing from New Zealand, crossed the circle in  $178^{\circ} E.$  and discovered the Balleny Islands.

*Dumont d'Urville.*—About 1835 the importance of obtaining magnetic observations in the far south, and scientific interest in the antarctic, led to plans for expeditions being put forward in the U.S., France and Great Britain. The French were first in the field; J. S. C. Dumont d'Urville with the frigates "Astrolabe" and "Zélée" was instructed to surpass Weddell's latitude in the South Atlantic. This attempt failed but on Jan. 21, 1840, he discovered the area now called Adélie Coast for Mme d'Urville. Ten days later in  $64^{\circ} 30' S.$  he cruised westward along a high shelf of ice from longitude  $131^{\circ} E.$  and then returned northward.

*Wilkes.*—Charles Wilkes was appointed to command the first U.S. exploring expedition of six vessels in Aug. 1838. His instructions required him to follow Weddell's route as far as possible, to visit the most southerly point reached by Cook and to try to penetrate the southern ocean "as far west as longitude  $45^{\circ} E.$ , or to Enderby Land." In following Weddell's route Wilkes in March 1839 fared no better than d'Urville in the previous year, but the "Flying Fish" (96 tons), under W. M. Walker, reached  $70^{\circ} S.$ ,  $105^{\circ} W.$  and reported having seen land about 100 mi. offshore from Thurston peninsula, discovered by Richard E. Byrd a century later. Wilkes sailed from Sydney in the "Vincennes" on Dec. 26, 1839, accompanied by the "Peacock," the "Porpoise" and the "Flying Fish." The expedition went south to the west of the Balleny Islands and cruised west toward Enderby Land. The weather was bad, and although land was reported by each vessel at several points, it was rarely seen distinctly. Some doubt was cast upon Wilkes' discoveries and his positions were occasionally inaccurate, but explorations in the 20th century revealed the coast of Wilkes Land essentially as he described it. He was first to see a major segment of Antarctica and the first to recognize the probability of a continental land mass. His locating of the south magnetic pole was also creditable.

*Ross.*—The British government outfitted its 1839 expedition more adequately for antarctic exploration and magnetic surveys. There were two ships, both strengthened for navigation in sea ice—

the "Erebus" (370 tons), commanded by James Clark Ross, and the "Terror" (340 tons), commanded by F. R. M. Crozier. Ross had intended to make straight for the meridian of the magnetic pole but, finding that d'Urville and Wilkes had already made similar plans, determined to try to make a high latitude farther east. Leaving Hobart on Nov. 12, 1840, he crossed the circle on Jan. 1, 1841, and entered the pack ice on Jan. 5 in  $174^{\circ} E.$  Five days later both vessels reached open water of the Ross sea, which in later years proved the gateway to the continent for Scott, Shackleton, Amundsen and Byrd. A chain of mountains was sighted rising from a coast which ran due south in  $71^{\circ} S.$  This land was claimed and named for Queen Victoria. The ships continued southward in sight of land until twin volcanoes, named Erebus and Terror, were sighted in  $78^{\circ} S.$  on Jan. 28. From Cape Crozier, at the base of the mountains, a lofty ice front ran eastward, rising perpendicularly from the water to the height of 200 or 300 ft. After attaining  $78^{\circ} 4' S.$ ,  $167^{\circ} W.$ , Ross returned to Hobart.

In Nov. 1841 Ross returned to the same area but did not greatly extend his discoveries. However, he did break his own southing record by six miles in the neighbourhood of the Bay of Whales region along the Ross ice shelf. This record of  $78^{\circ} 10' S.$  at  $161^{\circ} 27' W.$ , set on Feb. 22, 1842, was to stand for another 58 years, until men grew bold enough to tramp inland across the surface of Antarctica.

*Return of U.S. Whalers and Sealers.*—Following the briefly awakened interest in Antarctica by the French, American and British government expeditions, antarctic waters became the almost exclusive haunt of U.S. whalers and sealers from 1839 until the mid-1880s, when mineral oils began to supplant the high demand for animal oils. U.S. activities centred around Kerguelen, Crozet and Heard islands. In spite of the fact that the American Civil War brought great losses to the whaling fleets, some 200 American voyages were made to antarctic waters from the period of d'Urville, Wilkes and Ross until the end of the 19th century. During the same interval there were only about 18 British voyages, some of which were merchant vessels taking great circle routes to shorten the course around Africa to Australia and New Zealand; ships of other nations approaching the continent did not exceed a total of about 25. Aside from occupation and rediscovery of some of the off-lying islands, the U.S. sealing and whaling fleets did not add appreciably to the knowledge of the region.

During the transit of Venus in 1874, which was best observable at Kerguelen Island, American, British, German and French expeditions converged on that isolated outpost.

The first steamer to cross the circle, on Feb. 16, 1874, was the "Challenger" commanded by Capt. George S. Nares of the Royal Navy. Although the "Challenger" penetrated only to  $66^{\circ} 40' S.$ ,  $78^{\circ} 30' E.$ , its dredgings and soundings showed a general shoaling of the ocean toward the antarctic ice and indicated the approach to a continent. (See also "CHALLENGER" EXPEDITION.)

Between 1872 and 1888 there was a revival of the sealing industry, especially at the South Shetland Islands. In 1873 Eduard Dallmann in the German sealer "Grönland" made several discoveries on the northwest coast of the Graham-Palmer peninsula. In 1882–83 three German vessels wintered at Royal bay, South Georgia Island, making scientific observations as their contribution to the first International Polar year.

*Further 19th-Century Developments.*—In 1894 the Norwegian whaler Svend Foyn sent the "Antarctic," under Capt. Leonard Kristensen, to visit the coast of Victoria Land, having on board C. E. Borchgrevink, who was to return to Antarctica four years later. A small party landed on the mainland on Jan. 23, 1895.

From time to time efforts had been made by Georg von Neumayer in Germany and by Sir John Murray and others in Great Britain to inaugurate a new era of antarctic research. In 1895 Sir Clements Markham, as president of the Royal Geographical society and of the International Geographical congress, also took the matter up, and interest in the antarctic regions became general. In 1897 Adrien de Gerlache organized and led a Belgian expedition in the "Belgica," which crossed to the west of the Graham-Palmer peninsula and made surveys of the archipelago there. The ship finally penetrated the pack as far south as  $71^{\circ} 30'$ , where it was

beset for more than a year, making scientific collections of unique value. This was the first truly international antarctic expedition, with scientists and crew from many nations; Roald Amundsen, a Norwegian, was first mate and Frederick Cook, an American, was the medical officer.

The attention given to the arctic in the last half of the 19th century, especially stimulated by the search for the lost expedition of Sir John Franklin (*q.v.*), had deflected interest from the antarctic. As the century ended, however, man had lost his fear of the ice pack and was ready to begin the first serious exploration of the continent of Antarctica—a task undertaken largely by the nations of northwestern Europe.

**4. Quest for the South Pole.**—*Borchgrevink.*—The first expedition to winter on the continent was that of C. E. Borchgrevink, which left England in 1898 and landed at Cape Adare, the northeast point of Victoria Land. No sledge journeys to the south were possible, but valuable scientific work was done. Before returning, Borchgrevink sailed south to the Ross ice shelf and discovered that the ice front was considerably farther south than it had been in 1842. His short journey inland on skis at the Bay of Whales on Feb. 16, 1900, gave a new southing record of approximately  $78^{\circ} 50' \text{ S.}$ ,  $165^{\circ} \text{ W.}$  It was from there that Amundsen 12 years later was to journey onward to the south pole; about 30 years later Byrd chose the site for the Little America bases.

*Scott.*—The British national antarctic expedition of 1901–04 was organized by a joint committee of the Royal society and the Royal Geographical society and was equipped under the superintendence of Sir Clements Markham. The “Discovery,” a ship of 700 tons register, was specially built for the work. The expedition sailed under the command of Comdr. R. F. Scott of the Royal Navy. McMurdo sound at the southwest corner of the Ross sea was selected as the expedition’s headquarters. This area was to become not only a major centre of Scott’s and Shackleton’s expeditions but a half century later the major port for U.S. and New Zealand scientific activities. Before laying up for the winter, Scott cruised eastward of the farthest point reached by Ross and discovered land of continental character which he named King Edward VII Land (later known as Edward VII peninsula). Like that of Borchgrevink, this expedition initiated a new phase of exploration by working from a settled base. The main journey was that of Scott, Ernest Shackleton and E. A. Wilson, who sledged southward to a new southing record of  $82^{\circ} 17' \text{ S.}$ , which they reached on Dec. 30, 1902. The second year’s work was distinguished by Scott’s man-hauling sledge journey to a point 300 mi. W. of the ship and more than 250 mi. inland.

*Drygalski.*—Simultaneously with Scott’s British expedition and in full scientific co-operation with it, the German government equipped an expedition in the “Gauss,” led by Erich von Drygalski. A supplementary expedition set up a station in the Kerguelen Islands. The “Gauss” crossed the parallel of  $60^{\circ} \text{ S.}$ ,  $92^{\circ} \text{ E.}$  early in Feb. 1902, but was beset soon afterward and spent the winter in the ice. Land of considerable extent was seen to the south and was named Kaiser Wilhelm II Land (later called Wilhelm II Coast); the most conspicuous feature on it was a volcanic hill called Gaussberg (Mt. Gauss), in  $67^{\circ} \text{ S.}$ ,  $90^{\circ} \text{ E.}$

*Nordenskjöld and Bruce.*—Two private expeditions were in the antarctic simultaneously with the British and German national expeditions, making synchronous meteorological and magnetic observations. Otto Nordenskjöld led a Swedish party in the “Antarctic,” with C. A. Larsen in command of the ship, and penetrated the Weddell sea almost to the circle in  $50^{\circ} \text{ W.}$  Two winters were spent at the base on Snow Hill Island. The “Antarctic” was crushed in the ice on her way to take the shore party off, but they were rescued by the Argentine gunboat “Uruguay,” under Capt. Julian Irizar.

Meanwhile W. S. Bruce equipped a Scottish expedition in the “Scotia,” which made valuable oceanographical investigations in the Weddell sea in 1903 and, returning again the next summer, sighted Coats Land, named for supporters of the expedition. A meteorological station, Orcadas, established by the expedition on Laurie Island in the South Orkneys, was handed over to the Argentine government and has been occupied ever since.

*Charcot.*—Jean B. Charcot, a scientist and yachtsman, reached the antarctic in Jan. 1904 in the “*Français*,” cruising along the western side of the Graham-Palmer peninsula to  $67^{\circ} \text{ S.}$ , and again in 1908 in the “*Pourquoi Pas?*,” wintering in 1909 on Petermann Island,  $65^{\circ} \text{ S.}$  In the next summer he pushed farther south and west after discovering a coast later identified as Charcot Island.

*Shackleton.*—In 1908 Ernest Shackleton established an expedition at Cape Royd on Ross Island, his ship the “*Nimrod*” returning to New Zealand for the winter. A new departure in antarctic sledging was initiated by the use of Manchurian ponies. Before the winter set in, a party under T. W. E. David reached the summit of Mt. Erebus. In the succeeding summer David, accompanied by the geologist Douglas Mawson, sledged to the magnetic pole, situated in latitude  $72^{\circ} 25' \text{ S.}$ ,  $155^{\circ} 16' \text{ E.}$  at an altitude of more than 7,000 ft.

The greatest achievement of the expedition, however, was the journey made by Shackleton, J. B. Adams, E. Marshall and F. Wild to the latitude of  $88^{\circ} 23' \text{ S.}$ , in the course of which they discovered a route on to the plateau by way of the Beardmore glacier and pioneered the way to the pole itself. As a member of this group and as a former member of Scott’s southern party in 1903, Shackleton thus took part in the most extensive southward advance since Cook, and fell short of reaching the very pole itself by a mere 97 mi. Alarm over the change in appearance of the Bay of Whales deterred him from basing at this closer point, from which Amundsen met success three years later.

*Scott and Amundsen.*—Captain Scott again left England in 1910 with an expedition in the “*Terra Nova*,” his objectives being a journey to the south pole and scientific investigation of the Ross sea area. The main party established itself on the west side of Ross Island. The “*Fram*,” with a Norwegian party under Roald Amundsen, was encountered shortly afterward by the “*Terra Nova*” in the Bay of Whales on the Ross ice shelf. With the news of Peary and Cook’s discovery of the north pole this expedition, intended for the north polar regions, had changed its plans and decided to attempt to reach the south pole instead.

After some very successful depot-laying journeys Amundsen set out on Oct. 20, 1911, for the pole, accompanied by four companions on ski with 52 dogs. They reached the polar plateau by way of the Axel Heiberg glacier in  $85^{\circ} \text{ S.}$  and arrived at the pole on Dec. 14. The return journey took 38 days, and they returned to their winter quarters with 12 dogs and ample food—a model of technical performance. Another sledge party visited Edward VII peninsula to the east.

Meanwhile Scott sent a subsidiary party to Cape Adare, where they wintered in Borchgrevink’s hut. This party later made a hazardous land journey of 300 mi. back to Cape Evans along the coast of Victoria Land, wintering on the way with improvised equipment. A winter journey to the emperor penguin rookery at Cape Crozier was made by E. A. Wilson, H. R. Bowers and A. Cherry-Garrard in severe conditions. The pole party started from Cape Evans on Oct. 24, 1911, with motor sledges, ponies and dogs. The motors soon broke down, the ponies were shot before reaching  $83^{\circ} 30' \text{ S.}$ , and from there also the dog teams were sent back to the base.

On Dec. 10 Scott with 11 others began the ascent of the Beardmore glacier with three man-hauled sledges. On Dec. 21 four men with one sledge were sent back from  $85^{\circ} 7' \text{ S.}$ , and on Dec. 31 the last supporting party of three under Lieut. E. R. G. R. Evans returned from  $86^{\circ} 56' \text{ S.}$

The polar party—Scott, Wilson, Bowers, L. E. G. Oates and Edgar Evans—reached the pole on Jan. 17, 1912. All were tired out from their 69 days’ march and bitterly disappointed to find that they had been forestalled by Amundsen. The weather on the return journey was exceptionally bad. Evans died on the Beardmore glacier on Feb. 17. Oates, at the end of his strength, sacrificed himself on March 17 in  $79^{\circ} 50' \text{ S.}$  by crawling out into the blizzard. The supply of fuel oil at the last depot had been deficient and 20 mi. remained before they reached the next. The three survivors struggled on for 10 mi. but they were bound to their camp by a blizzard that lasted for nine days, and they awaited death with quiet fortitude. The tent with the frozen bodies was found by



search parties on Nov. 12, 1912.

*Mawson.*—The Australian antarctic expedition which set out in the "Aurora" in Dec. 1911 was organized by Douglas Mawson. The main base was established at Cape Denison at Commonwealth bay on George V Coast, where Mawson wintered with 17 companions. The ship, under the command of J. K. Davis, proceeded 1,500 mi. to the west where Queen Mary Coast was discovered, and Frank Wild landed with a party of seven men and a hut to form the western base. Sledge parties started from the main base in Nov. 1912, diverging to explore inland toward the magnetic pole and eastward and westward near the coast. Mawson's two companions, B. B. S. Ninnis and X. Mertz, perished, leaving him with scant stores 100 mi. from Commonwealth bay. He reached the hut on Feb. 10, 1913, by an effort of almost superhuman endurance and found that the "Aurora" had just sailed to relieve Wild, leaving a volunteer rescue party with whom he awaited the return of the ship in Dec. 1913.

*Filchner and Shirase.*—A German expedition led by Wilhelm Filchner in the "Deutschland," under Capt. R. Vahsel, penetrated the Weddell sea to 77° 50' S. early in 1912 and delimited part of its southern boundary. The Luitpold Coast between 29° and 37° W., named for the prince regent of Bavaria, was discovered and charted. The vessel was beset in March 1912 and drifted for nearly nine months with the pack ice, finally escaping on Nov. 26 in 63° 37' S., 36° 34' W.

Choku Shirase led a Japanese party in the "Kainan Maru," which cruised in the Ross sea during the summers of 1910–12. A short sledge journey was made on the Ross ice shelf, followed by a landing on Edward VII peninsula.

*Shackleton.*—Sir Ernest Shackleton planned the Imperial Trans-Antarctic expedition in 1914, intending to cross the continent from the Weddell sea to the Ross sea by way of the south pole. The "Endurance" entered the Weddell sea early in Dec. 1914 and worked southward between 15° and 20° W. Caird Coast was discovered between Coats Land and Luitpold Coast on Jan. 11, 1915, but no landing place was found. The ship, beset in the ice on Jan. 18, drifted northward and was crushed and abandoned on Oct. 27 in 69° 5' S. The 28 men camped on an ice floe, which continued to move northward until April 9, 1916, when it broke up in 62° S., 54° W. after a drift of 457 days. The party took to their three small boats and landed six days later on Elephant Island. Shackleton with five men reached South Georgia, 750 mi. distant, in a 22-ft. boat and finally succeeded with the Chilean trawler "Yelcho" in rescuing the others on Aug. 30, 1916. The expedition had a companion group in the McMurdo area led by A. E. Mackintosh for the purpose of laying depots for the transcontinental party. Their ship "Aurora" was also beset in the pack ice and drifted for 315 days. The leader and two others perished.

Among a series of minor activities during the pre-World War I period was the fourth cruise of the U.S. scientific ship "Carnegie" under W. J. Peters in 1915–16, which made magnetic observations on a subantarctic circumnavigation of the continent. During 1918 and 1919 Antarctica was abandoned.

**5. Exploration, 1920–40.**—The first party to winter in Antarctica after World War I was the smallest expedition in Antarctic history. In 1920–22 T. W. Bagshaw and M. C. Lester, two young British explorers, landed from a whaling ship and lived for a year at Waterboat point on the west coast of Graham-Palmer peninsula. Despite their primitive shelter made of an upturned lifeboat and packing boxes, they carried out creditable observations of meteorology, tides and zoology.

Shackleton sailed in the "Quest" in Sept. 1921 to explore the Enderby Land area (0° to 90° E.). He died at South Georgia on Jan. 5, 1922. Frank Wild, second in command, carried on the voyage to 69° 17' S., 17° E.

During the period from 1922 to 1928 no wintering bases were established in Antarctica and activities were confined to minor scientific investigations of off-lying islands. Whaling activities in the southern Atlantic and Pacific were largely carried on by the Norwegians and in the southern Indian ocean by the French.

*"Discovery" Investigations.*—The Discovery committee was appointed by the British government in 1923 to undertake compre-

hensive oceanographical research in antarctic waters, with a view to regulating and perpetuating the whaling industry there. The first southern cruise was made by the old "Discovery" in 1925–27. In 1926 the research vessel "William Scoresby" (324 gross tons) was commissioned and during the following 12 years made eight cruises in the waters of the southern ocean. In 1929 a new research vessel, the "Discovery II" (1,036 gross tons), replaced the "Discovery" and up to the outbreak of World War II in 1939 had undertaken five southern commissions.

*Christensen.*—Between 1927 and 1937 a series of eight exploratory voyages in the southern ocean were promoted by the Norwegian whaling magnate Lars Christensen. During these years a large number of important geographical discoveries were made along the coasts of the antarctic mainland by expeditions led by H. Mosby, Ola Olstad, Hjalmar Riiser-Larsen, Klarius Mikkelsen and others. In the four summer seasons between 1927 and 1931 the "Norvegia" cruised in antarctic waters. Bouvet Island and Peter I Island were claimed for Norway at this time. The former island was photographed from the air during the season of 1929–30, and an air reconnaissance was made of western Enderby Land and parts of the coast of Queen Maud Land between 40° and 50° E. and 0° and 10° W. Further flights were made in 1930–31 and the coast of Queen Maud Land between 20° and 30° E. was discovered and roughly charted. In the summer of 1933–34 a number of flights were made from the "Thorshavn," during which parts of Princess Elizabeth Land were discovered. During the following season the "Thorshavn" landed a party on the Ingrid Christensen Coast, part of Princess Elizabeth Land, in about 80° E., and topographical surveys were made in that area. During one of these cruises four women guests aboard the whaler were the first of their sex to visit Antarctica. In 1936–37 part of Queen Maud Land between 30° and 40° E. was photographed from the air. Queen Maud Land was claimed for Norway in 1939.

*Wilkins.*—In 1928–29 Australian-born Sir George Hubert Wilkins led an American-financed expedition to the Graham-Palmer peninsula region and made an air reconnaissance of the east coast. Local flights were made again the following year. These appeared to confirm the erroneous impression, gained in 1928–29, that the Graham-Palmer peninsula was an archipelago rather than part of the continent. Wilkins discovered the insularity of Charcot Island.

*Byrd.*—After his successful flight over the north pole (1926) and across the Atlantic (1927), U.S. naval aviation commander Richard E. Byrd turned his energies toward antarctic exploration, believing that airplanes and aerial cameras were the answers to exploring Antarctica. He organized a private expedition in 1928 and constructed a 42-man station, Little America, on shelf ice about four miles north of the site of Amundsen's Framheim on the east side of the Bay of Whales. On fall flights to the east he discovered the Rockefeller mountains, named for John D. Rockefeller, Jr., a patron of the expedition, and the peninsular structure of Scott's Edward VII peninsula. Farther to the east, beyond 150° W., he discovered Marie Byrd Land, named in honour of his wife, and the Edsel Ford ranges, named for another of the sponsors. During the winter night a meteorological, magnetic and auroral program was carried out. The following summer (1929) Lawrence M. Gould and a party of five sledged by dog team to the Queen Maud mountains due southward for geological reconnaissance. On Nov. 29, 1929, Byrd as navigator, accompanied by Bernt Balchen and Harold June as pilots and Ashley McKinley as aerial photographer, flew successfully to the vicinity of the geographic south pole in a tri-motored Ford airplane "Floyd Bennett." Several new glaciers were aerially mapped and the escarpment to the east of the Queen Maud mountains could be seen for another 100 to 200 mi.

Byrd returned to Little America II in Jan. 1934 after making seaplane flights from the ice-laden seas north of Marie Byrd Land. Additional buildings were erected at Little America to house the 56 members of the expedition. Cows were taken along for fresh milk. Using a Curtis Condor biplane for his major exploratory work, Byrd discovered the trend of Ruppert Coast, the Horlick mountains extending eastward of the Queen Maud mountains to at least 115° W. and peaks as far eastward as longitude 130° W. in

Marie Byrd Land. (The names are for Jacob Ruppert and William Horlick, who helped support the expedition.) Byrd alone occupied Bolling Advanced Weather station about 123 mi. S. of Little America on the Ross ice shelf, the first inland station in Antarctica. During his five months' winter isolation there Byrd recorded temperatures to nearly  $-80^{\circ}$  F.

The following summer four major field parties operated out of Little America. A tractor party under E. J. Demas began sounding ice thickness by seismic methods; deflected eastward on a southern journey by crevasses near  $81^{\circ}$  S., the party returned over the high plateau of western Marie Byrd Land east of the 150th meridian. This expedition made the first successful use of tractors for freighting and exploring in the antarctic. Quinn Blackburn with two companions and three dog teams retraced Amundsen's and Gould's route to the Queen Maud range and made a geological cross section up Robert Scott glacier to Mt. Weaver on the plateau 230 mi. from the south pole. Coal and fossil specimens were collected. Meanwhile, a four man dog-sledging party led by Paul A. Siple traveled eastward from Little America II to make the first mapping, geological and biological surveys of the newly discovered Marie Byrd Land. They visited the Rockefeller mountains and traveled through the central Edsel Ford ranges to the Fosdick mountains,  $77^{\circ} 30'$  S.,  $144^{\circ}$  W., named for Raymond B. Fosdick, president of the Rockefeller foundation. They collected 89 new species of mosses and lichens. The fourth important field party, led by Thomas C. Poulter, second in command of the expedition, made seismic soundings of the Ross ice shelf from the Bay of Whales to Discovery inlet, charting ice thicknesses and ocean depths below the shelf. An extensive scientific program was carried on at Little America II, including meteorology, cosmic radiation and magnetic studies, vertebrate and invertebrate zoology, bacteriology, auroral and meteor studies, glaciology and oceanography.

*Mawson.*—The British-Australian-New Zealand Antarctic Research expedition led by Sir Douglas Mawson made two extensive cruises in the "Discovery" in 1929–30 and again in 1930–31. Important work was done between  $45^{\circ}$  and  $75^{\circ}$  E. and between  $120^{\circ}$  and  $130^{\circ}$  E., the coast line of these parts of Antarctica being roughly charted. A number of landings on the continent were made and Princess Elizabeth Land, Mac-Robertson Coast and the Banzare coast were discovered. The sector known as the Australian Antarctic territory was formally annexed by Australia at this time.

*Ellsworth.*—In 1933–34 the U.S. explorer Lincoln Ellsworth visited the Bay of Whales in the "Wyatt Earp," but his aircraft was damaged beyond use for that season. In the following summer he visited the east coast of the Graham-Palmer peninsula with the intention of making the 2,200-mi. transantarctic flight to the Ross sea. This did not prove possible until his third trip at the end of 1935. With H. Hollick-Kenyon as pilot, Ellsworth set out on Nov. 23, 1935, from Dundee Island off Louis Philippe peninsula, for the Bay of Whales. He discovered the Sentinel mountains between  $77^{\circ}$  and  $79^{\circ}$  S. and  $86^{\circ}$  and  $89^{\circ}$  W., so named because of their prominent position as a landmark; the corridor over which he flew is now called the Ellsworth Highland. Three landings were made during the crossing of the continent and the aircraft finally arrived near the Bay of Whales on Dec. 5. These landings on unprepared terrains, made in bad weather, were a new departure in polar aviation. The two fliers were rescued by the "Discovery II" in mid-Jan. 1936. Ellsworth made one more antarctic voyage in the "Wyatt Earp" in the summer of 1938–39. A flight was made inland to  $72^{\circ}$  S.,  $79^{\circ}$  E. in Princess Elizabeth Land. He named the plateau he discovered there the American Highland and claimed it for the United States.

*Rymill.*—The British Graham Land expedition of 1934–37, led by John Rymill, went south in the "Penola" and in successive seasons wintered at the Argentine Islands and the Debenham Islands, off the west coast of the Graham-Palmer peninsula. In addition to comprehensive scientific investigations, flights and sledge journeys were made and the coast and off-lying islands of the western Graham-Palmer peninsula were surveyed from the Palmer archipelago to Alexander I Island. Two major discoveries were made: first, that the Graham-Palmer peninsula is part of the antarctic mainland and not an archipelago; second, that Alexander I Island

is separated from the peninsula by George VI sound.

*Ritscher.*—A German expedition in the "Schwabenland," commanded by Alfred Ritscher, spent three weeks off the coast of Queen Maud Land during the summer of 1938–39. Two aircraft made extensive flights between  $14^{\circ}$  W. and  $20^{\circ}$  E., penetrating inland to about  $74^{\circ} 25'$  S. and photographing about 135,000 sq. mi. The area was renamed New Schwabenland and claimed for Germany.

*U.S. Antarctic Service.*—In 1939 the U.S. government inaugurated the U.S. Antarctic service to commence permanent occupation and scientific exploration of sections of Antarctica but the advent of World War II brought an untimely end to field operations in 1941. Admiral Byrd was assigned command, logistics were assigned to P. A. Siple and the science program to F. Alton Wade. Two major bases were established: West base, 33 men, at Little America III at the Bay of Whales, led by Siple; and East base, 29 men, at Marguerite bay, Stonington Island on the Graham-Palmer peninsula coast, led by Richard B. Black. The U.S.S. "Bear" and the U.S.S. "North Star" serviced the bases. Using a Barkley Grow seaplane from the "Bear," Byrd discovered the Thurston peninsula region along the icebound coast facing the Pacific ocean near  $72^{\circ}$  S.,  $100^{\circ}$  W. Byrd did not winter in Antarctica; instead he initiated the system of absentee management of the affairs of an expedition from the home country used in most subsequent expeditions. Wade was in charge of a specially built overland snow cruiser designed by T. C. Poulter for inland exploration. The 35-ton machine was underpowered and remained at Little America III as a scientific laboratory. At West base major exploratory flights included gross observation of the Ross ice shelf, aerial photography of the region between Beardmore and Robert Scott glaciers of the Queen Maud mountains, delineation of the eastern limits of the Ross ice shelf and extension of Ruppert Coast  $76^{\circ}$  S.,  $146^{\circ}$  W. to Mt. Siple,  $73^{\circ} 15'$  S.,  $123^{\circ}$  W. Inland, the Hal Flood and Executive Committee ranges were more completely investigated. Aerial photography of the Edsel Ford ranges taken in February and March 1940 were reduced to maps for several dog sledge field teams working in the area the following December. The geology party of four men to the central Edsel Ford ranges was led by Lawrence A. Warner; the biological party of three to the Fosdick mountains was led by Jack E. Perkins; the Pacific coast survey party of three to the Hal Flood range was led by Leonard M. Berlin. Two additional field parties explored Edward VII peninsula, one led by Wade for geological investigations, the other for surveys by Roy G. Fitzsimmons. Extensive science programs at the main base featured the first antarctic upper air meteorological soundings, obtaining minimum temperatures of  $-130^{\circ}$  F.; glaciology of the Ross ice shelf, found to move a third of a mile per year; magnetism; aurora; biology; and radio wave propagation studies. A similar scientific program was carried on at East base. Geographic discoveries included an extension of the Graham-Palmer peninsula southward to  $77^{\circ}$  S. and reconnaissance of the peninsula northward and of Alexander I Island. A Weddell coast dog team party led by Paul Knowles did geology and surveys to  $72^{\circ}$  S.,  $61^{\circ}$  W., and a second major sledge journey was made by Finn Ronne and Carl Eklund along the eastern and southern sides of Alexander I to within sight of open water along Robert English Coast. Important biological, geological and meteorological observations were made on shorter excursions near the base. East base was evacuated by air because the ice in Marguerite bay did not break up in 1941 to permit the relief ships to enter. While awaiting relief operations, scientists of the already relieved West base made surveys and collections of botanical and geological specimens at the Melchior archipelago.

*World War II Antarctic Activity.*—During World War II antarctic waters became involved in military activities. Kerguelen became the "Alstertor" resupply point for German raiders Hilfskreuger 33, 16 and 45, "Pinguin," "Atlantis" and "Komet" raiding the South Pacific. The German raider "Pinguin" captured an entire Norwegian whaling fleet, including the whale factory ships "Ole Wegger" and "Pelagos," the supply ship "Solglimt" and 11 catchers. British and Australian naval vessels searched for the enemy. H.M.S. "Cornwall" sank the "Pinguin" in May 1941 after



she had captured 136,550 tons of Allied shipping. After 1941 pelagic whaling ceased for the duration of the war.

In 1941 the British established a meteorological forecasting station in the Falkland Islands and destroyed fuel stocks at Deception Island. On a 1943 visit to the same island they obliterated signs of sovereignty claims left there the year before by Argentina. H.M.S. "Carnarvon Castle" also visited Signy bay and Laurie Island in the South Orkneys. The Argentine vessel "Primera de Mayo" made voyages to Antarctica in 1942 and 1943 to take formal possession of the sector between 25° and 68° 34' W. south of 60° S. and to remove British emblems of sovereignty. On the latter voyage the ship visited Stonington Island in Marguerite bay and removed some instruments and materials from the U.S. East base, which were later returned to the U.S.

The winter of 1943 was the last time Antarctica was without at least a transient population.

Partly for reasons of sovereignty and partly for wartime surveillance, the British naval Operation "Tabarin I" in 1943 began permanent occupation of meteorological stations along the west Graham-Palmer peninsula. Base A was established at Port Lockroy under the leadership of J. W. S. Marr, commander of the shore staffs, and Base B at Deception Island under the leadership of W. R. Flett. Scientific programs including geology, biology and surveys were carried on during the winter. The following year, 1944-45, the bases were relieved, and a new one, Base D, was established at Hope bay. After the war the administration of British bases became the Falkland Island Dependencies surveys.

See also biographies of the explorers.

#### IV. NATIONAL EFFORTS AT OCCUPATION (1943-55)

**1. Conflicting Claims.**—During the decade following World War II, attitudes toward Antarctica became singularly nationalistic. Claims of territory had been announced by seven countries—the United Kingdom, Australia, New Zealand, Norway, France, Argentina and Chile. The only remaining segments of the continent not specifically claimed lay between 90° and 150° W. in west Antarctica and between 45° E. and 20° W. in east Antarctica, southward toward the pole from the explored coast claimed by Norway. The basis of claims varied with individual countries, although, with the exception of Norway, the claimants adhered to the "sector" principle, propounded by Paschal Poririer in the Canadian senate on Feb. 20, 1907. His concept would recognize the extended claims of any nation bordering the polar regions by extending the meridians of its extreme boundaries to the north or south pole. The concept has never been tested in a world court, and the United States has been notably among those nations which have never accepted the principle in either the arctic or antarctic. The majority of claimants in Antarctica have used this sort of convenient pie-shaped wedge claim system, but their reasons for the chosen boundaries have been devious and varied. The French claim of Terre Adélie, for example, extends d'Urville's coastal discovery of 1840 to the pole, although he did not set foot on the land and the first French return to the area was not until Dec. 1949; but the more intensive and extensive explorations of Charcot in 1903-05 were not used as a basis of claim. Norway made no attempt to exploit the discoveries of Amundsen but claimed the Russian-discovered (1821) Peter I Island and the French-discovered (1739) Bouvet Island; the coast claimed by Norway was largely explored by Norwegian whalers, although it lies in the sector which South Africa might conceivably claim if it extended its boundaries according to Poririer's principle, as Argentina, Chile and Australia have done.

The vigorous British claim to the Falkland Island dependencies is based upon some priority rights of discovery, but the region includes land and islands first explored and, in some cases, occupied by the U.S., the U.S.S.R., France, Sweden, Germany, Norway, Belgium, Argentina and Chile. Although other nations might assert justifiable formal claims in this region, only Argentina and Chile, who previously had explored it less than some of the others, have formally made such assertion. Argentina, in addition, voices claim to the Falkland Islands and South Georgia. Argentina's nearly 60 years' occupation of the Laurie Island weather station

gives it the longest record of possession of any single spot in Antarctica south of 60° S.

U.S. policy as stated by Charles E. Hughes, secretary of state in 1924, that occupation was the strongest basis for claims of a territory, had an impact on antarctic exploration. The U.S. Antarctic service, 1939-41, was intended as the first step toward occupying Antarctica on a permanent basis, but the effort had to be temporarily abandoned because of World War II. Even before the war had ended British naval forces established three bases in the Falkland Island dependencies and announced them as permanent meteorological stations. These stations opened post offices, issued postage stamps and had appointed barristers. Britain added progressively to the number of permanent stations during the next decade, as did Argentina and Chile, sometimes at the same sites and manned by military personnel. High officials, governors of provinces, and even the president of Chile and Prince Philip of Great Britain visited their countries' respective stations. The competition for possession grew serious enough that whenever foreign stores, national emblems or unoccupied refuge huts were discovered, they were destroyed. Arrests and deportations occurred and there was one instance of armed resistance without casualties by Argentina against a British landing party at Hope bay in 1952. British naval war vessels put in an annual appearance in the Falkland Island dependencies and during 1948 Argentina had about 15 naval vessels in the area on maneuvers, in addition to a 13-vessel flotilla to establish bases. Tension caused by this show of naval force was eased somewhat after 1949 by annual declarations between Argentina, Chile and Britain aimed at restricting the use of warships.

By the outset of IGY in the 1956-57 season the British were occupying 11 permanent stations, Argentina 8 and Chile 6. Although these stations were primarily political, valuable work resulted during the nationalistic decade. The Chileans did some hydrographic and survey work. The Argentines did comparatively more scientific work and produced superior hydrographic charts of the regions surrounding the South Shetlands, South Orkneys and the Graham-Palmer peninsula. The British were still better equipped for biological, geological and electromagnetic reconnaissance and in addition did superior ground surveys and mapping of the land. Vertical aerial-strip surveys of the entire northern half of the Graham-Palmer peninsula have been accomplished, resulting in the most detailed maps of any portion of Antarctica.

At the close of the nationalistic period, the continent's periphery was mapped for the first time and U.S. personnel, with the aid of aircraft, had seen more of Antarctica than all other explorers combined. However, the U.S. continued its policy of making no official territorial claims, recognizing no one else's claims but reserving its rights to make claims at a future time. In 1950 the U.S.S.R. announced a similar policy, and although it had done no active exploration since 1822, it had been carrying on whaling since 1946 and was preparing to take a highly active part in IGY antarctic activity. Germany and Japan were forced to surrender their rights to antarctic claims at the close of World War II.

The accompanying station location table will help to clarify the sequence of activities from 1943 to 1955, which were especially complicated in the British, Argentine and Chilean area around the South Shetland and South Orkney islands and the Graham-Palmer peninsula. The station list includes, for the most part, only bases that were occupied through one or more winter seasons. It does not include temporary summer stations or many refuge huts built by these nations.

#### 2. Operation "Highjump" and Other U.S. Expeditions.

—In 1946-47 the U.S. naval task force 68 undertook Operation "Highjump," the largest expedition attempted in the antarctic up to that time. The enterprise was under the general direction of Rear Admiral Byrd and the 13 ships taking part were commanded by Rear Admiral Richard H. Cruzen. The objectives were to test equipment, to give polar experience to 4,000 men, to extend the basis for United States claims and to photograph as much of Antarctica as possible from the air. The task force was divided into three groups and worked around most of the periphery of the continent during the summer. More than 100 men were based at Lit-

the America IV from January to March. Operation "Highjump" utilized six R4D aircraft, the largest planes to take off successfully from a carrier and subsequently from the improvised snow surface airstrip. In the first of these, Admiral Byrd flew to the base from the aircraft carrier "Philippine Sea" near Scott Island. Twenty-nine photographic flights extending into previously unexplored territory radiated into Marie Byrd Land, the Horlick mountains,

the polar plateau and Victoria Land. Byrd made his second flight over the geographic south pole on Feb. 15, 1947. Some meteorology, glaciology and geophysical work was accomplished. P. A. Siple led an attached war department, army and air force observation team. The eastern group under command of Capt. George J. Dufek explored and photographed by seaplane the Pacific coast area of west Antarctica between Mt. Siple and Charcot and Alex-

*Stations in Antarctica Established by Various Countries*

Country	Station*	Place	Founding leader†	Latitude	Longitude	Year established	‡Years occupied
WEDDELL SEA REGION (sector 0° to 45° W.)							
Argentina	General Belgrano; P-I	Filchner ice shelf	Pujato (Ogara)	77° 56' S.	38° 29' E.	1955	6
Norway (U.K. and Sweden)	Maudheim	Queen Maud Land	Gjaever	71° 03' S.	10° 53' W.	1950	2
Norway	Norway base; I	Queen Maud Land	Helle	70° 30' S.	02° 32' W.	1957	3
Norway-USA	Norway base; I	Queen Maud Land	La Grange	70° 30' S.	02° 52' W.	1960	1
United Kingdom	Halley Bay; P-I	Halley bay, Coats Land	Dalglish (Smart)§	75° 31' S.	26° 36' W.	1956	5
United Kingdom	Shackleton	Filchner ice shelf	Fuchs	77° 57' S.	37° 16' W.	1956	2
United Kingdom	South Ice	inland	Lester (Fuchs)	81° 56' S.	29° 30' W.	1957	1
United States	Ellsworth; P-I	Filchner ice shelf	Ronne	77° 43' S.	41° 07' W.	1957	2
(U.S.)-Argentina	Ellsworth	Filchner ice shelf	Swarcz-Johnson	77° 43' S.	41° 07' W.	1959	2
SOUTH SHETLAND and SOUTH ORKNEY ISLANDS							
Argentina	Orcadas; P-I	Laurie Island	Bruce (Galindez)	60° 45' S.	44° 43' W.	1903	58
	Primero de Mayo; P-I	Deception Island	Cabrera (Hemelo)	62° 59' S.	60° 43' W.	1948	13
	Teniente Camara; P-I	Half Moon Island	?(Panzarini)	62° 36' S.	59° 57' W.	1952	8
Chile	Arturo Prat; P-I	Greenwich Island	O'Neil (Toro)	62° 29' S.	59° 38' W.	1947	14
	Pedro Aguirre Cerda; P-I	Deception Island	del Rio (Bofil)	62° 56' S.	60° 36' W.	1955	6
United Kingdom	First Antarctic wintering Base B; P-I	King George Island	(Clark)	62° 00' S.	58° 15' W.	1821	1
	Base C	Deception Island	Flett (Marr)	62° 59' S.	60° 34' W.	1944	17
	Base H; P-I	Cape Geddes, Laurie Island	Choyce (Bingham)	60° 42' S.	44° 34' W.	1946	1
	Base G; P-I	Signy Island	Robin (Butler)	60° 43' S.	45° 36' W.	1947	14
		Admiralty bay	Platt (Fuchs)	62° 05' S.	58° 25' W.	1948	13
GRAHAM-PALMER PENINSULA (sector 45° W. to 90° W.)							
Argentina	Melchior; P-I	Gamma Island, Melchior archipelago	Nadau (Garcia)	64° 20' S.	62° 59' W.	1947	14
	San Martin; P-I	Barry Island	?(Panzarini)	68° 08' S.	67° 07' W.	1951	10
	Admirante Brown; P-I	Paradise harbour	?(Panzarini)	64° 53' S.	62° 53' W.	1951	10
	Camp Esperanza; P-I	Hope bay	Casanova (Diaz)	63° 16' S.	56° 49' W.	1952	9
Chile	Bernardo O'Higgins; P-I	Cape Legoupil, Trinity peninsula	Prado (Navarrete)	63° 19' S.	57° 54' W.	1948	13
	Gonzalez Videla; P-I	Waterboat point, Paradise harbour	Tapia	64° 49' S.	62° 52' W.	1951	10
Norway	Shipwrecked Antarctic crew	Paulet Island	Larsen	63° 35' S.	55° 47' W.	1903	1
Sweden	Snow Hill Island (3 men)	Snow Hill Island	Nordenskjöld	64° 28' S.	57° 12' W.	1902	2
		Hope bay	Andersson	63° 24' S.	57° 00' W.	1903	1
United Kingdom	British Graham land expedition	Argentine Island	Rymill	65° 15' S.	64° 15' W.	1935	1
		Debenham Island	Rymill	68° 08' S.	67° 07' W.	1936	1
	Base A; P-I	Port Lockroy	Marr	64° 50' S.	63° 30' W.	1944	14
	Base D; P-I	Hope bay	Taylor	63° 24' S.	56° 59' W.	1945	13
	Base F; P-I	Argentine Island	Burd (Butler)	65° 15' S.	64° 16' W.	1947	14
	Base J; I	Prospect point, Ferin Head	Miller (Rice)	66° 00' S.	65° 24' W.	1957	4
	Base V; P-I	Horseshoe Island	Gaul (Anderson)	67° 49' S.	67° 17' W.	1955	6
	Base O	Danco Is.	Foster (Worswick)	64° 44' S.	62° 37' W.	1956	
	Base N	Arthur harbour, Anvers Island	Hooper (Anderson)	64° 46' S.	64° 04' W.	1955	
	Base W; I (Shackleton)	Detaille Island, Loubert Coast	Murphy (Anderson)	66° 52' S.	66° 48' W.	1956	
	Base E	Stonington Island	Bingham	67° 11' S.	67° 00' W.	1946	4
	Waterboat point	Paradise harbour	Bagshawe-Lester	64° 49' S.	62° 52' W.	1921	1
United States	East base (USA)	Stonington Island	Black (Byrd)	68° 11' S.	67° 00' W.	1940	1
	East base	Stonington Island	Ronne	68° 11' S.	67° 00' W.	1948	1
France	Pour Quoi Pas	Booth Island	Charcot	65° 05' S.	64° 00' W.	1904	1
ROSS SEA (sector 90° W. to 180° to 160° E.)							
New Zealand	Scott; P-I	Ross Island, McMurdo sound	Hatherton-Hillary	70° 50' S.	166° 44' E.	1957	4
New Zealand-U.S.	Hallett; P-I	Cape Hallett	Shear-Tur	72° 18' S.	170° 18' E.	1957	4
Norway	Framheim	Bay of Whales, Ross ice shelf	Amundsen	78° 38' S.	163° 37' W.	1911	1
United Kingdom	Cape Adare	Cape Adare, Victoria Land	Borchgrevink	71° 18' S.	170° 09' W.	1889	1
	Hut Point	Ross Island, McMurdo sound	Scott	77° 51' S.	166° 45' W.	1902	2
	Cape Royds	Ross Island, McMurdo sound	Shackleton	77° 34' S.	166° 09' W.	1908	1
	Cape Evans	Ross Island, McMurdo sound	Scott	77° 38' S.	166° 24' W.	1911	2
United States	Little America I	Bay of Whales, Ross ice shelf	Byrd	78° 34' S.	163° 56' W.	1929	1
	Little America II	Bay of Whales, Ross ice shelf	Byrd	78° 34' S.	163° 56' W.	1934	1
	Bolling Advanced weather station	Ross ice shelf	Byrd	80° 10' S.	164° 00' W.	1934	½
	Little America III, West base	Bay of Whales, Ross ice shelf	Siple (Byrd)	78° 29' S.	163° 50' W.	1940	1
	Little America IV, Operation "Highjump," USN	Bay of Whales, Ross ice shelf	(Byrd-Cruzen)	78° 29' S.	163° 50' W.	1947	0.2
	Little America V; I	Kainan bay, Ross ice shelf	Graham-Crary	78° 11' S.	162° 10' W.	1956	3
	Williams naval air facility; P-I	Ross Island, McMurdo sound	Canaham	77° 51' S.	166° 37' E.	1956	5
	Amundsen-Scott; P-I	south pole	Siple-Tuck	90° 00' S.		1956	4
	Byrd; P-I	Marie Byrd Land	Toney-Dalton	80° 00' S.	120° 00' W.	1957	4
EAST ANTARCTICA (sector 0° to 160° E.)							
Australia	Main base, Cape Denison	George V Coast	Mawson	67° 00' S.	142° 40' E.	1912	2
	West base	Shackleton ice shelf	Wild (Mawson)	66° 18' S.	95° 05' E.	1912	1
	Mawson; P-I	Mac-Robertson Land	Dovers (Law)	67° 36' S.	62° 53' E.	1954	7
	Davis; P-I	Princess Elizabeth Land	Dingle (Law)	68° 34' S.	77° 58' E.	1957	4
Belgium	King Baudoin	Princess Ragnhild Coast	Gerlache de Gomery	70° 26' S.	24° 19' E.	1958	3
France	Port Martin	Terre Adélie	Liotard (Victor)	66° 49' S.	141° 24' E.	1950	2
	Ile de Petrels	Point Géologie	Marret (Victor)	66° 40' S.	140° 00' E.	1952	1
	D'Urville; P-I	Point Géologie	Imbert (Victor)	66° 40' S.	140° 01' E.	1956	5
	Charcot; I	south magnetic pole	Guillard (Imbert)	69° 22' S.	139° 02' E.	1956	2
Japan	Showa; I	Prince Harald Coast	Nishibori (Nagata)	69° 00' S.	39° 35' E.	1957	3
United States	Wilkes; P-I	Budd Coast; Wilkes Land	Eklund-Burnett	66° 15' S.	110° 31' E.	1957	2
	Wilkes (satellite); I	inland	Cameçon (Eklund)	66° 28' S.	112° 17' E.	1957	17
(U.S.)-Australia	Wilkes; P	Wilkes Land	Dingle-Hansen	66° 15' S.	110° 31' E.	1959	2
U.S.S.R.	Mirny; P-I	Queen Mary Coast	Sornov	66° 33' S.	93° 00' E.	1956	5
	Oazis; I	Wilkes Land	Tselishchev	66° 16' S.	100° 44' E.	1956	3
	Pionerskaya; I	inland	Gusev	69° 44' S.	95° 30' E.	1956	2
	Komsomolskaya; I	inland	Pelevin	75° 00' S.	93° 00' E.	1957	1
	Vostok I; I	geomagnetic pole	Aver'yanov	78° 27' S.	106° 52' E.	1958	3
	Sovietskaya; I	inland	Babarykin	78° 24' S.	87° 35' E.	1958	1
	Lazarev	Astrid Coast	Kruchinin	69° 56' S.	12° 58' E.	1959	2

\*"P" after station names indicates permanency; "I" after station names indicates that it carried on an IGY program. †Names in parentheses denote responsible senior leader not in residence at the station. ‡Years occupied prior to 1961. §Leader first year of IGY. ¶Intermediate station.

ander I islands. One aircraft crashed on Thurston peninsula with loss of part of its crew. This group later circumnavigated the Graham-Palmer peninsula and Weddell sea to explore part of Princess Martha Coast. The Western group under Capt. Charles A. Bond explored and photographed by seaplane the coasts of east Antarctica from Oates Coast to the Princess Astrid Coast. Near longitude 100° E. this group discovered Bunger Hills, an extensive area of ice-free land, misleadingly called an oasis.

During this nationalistic period the superior technical capability of the United States to explore the entire surface of Antarctica from the air was thwarted when the more ambitious "Highjump II" expedition was canceled on the eve of departure because of the Korean war.

A smaller naval expedition, designated Operation "Windmill," consisting of two icebreakers under Comdr. G. L. Ketchum, visited Antarctica during the following season. The object was to fix geographical points so that the air surveys of the previous expedition could be properly located.

A private antarctic research expedition, heavily supported by government sources, was undertaken by Finn Ronne in 1946-48. The expedition reoccupied East base of the U.S. Antarctic service (1939-41) at Stonington Island in southwest Graham-Palmer peninsula. Noteworthy scientific and topographical survey work was accomplished, some of which was in co-operation with the staff of the Falkland Island Dependencies survey's southernmost station, also at Stonington Island. An important summer journey of 1,180 mi. was made, using British sledging equipment and U.S. air support. The combined party reached 74° 45' on the east coast of the Graham-Palmer peninsula and returned after 105 days in the field. Mrs. Ronne and Mrs. Harry Darlington, who accompanied their husbands, were the first women to winter on the antarctic mainland.

**3. A.N.A.R.E.**—The Australian National Antarctic Research expedition (A.N.A.R.E.) was established by the Australian government in 1947 under the direction of Stuart Campbell and later of P. G. Law. Scientific stations were set up on Heard Island in Dec. 1947 and on Macquarie Island in March 1948. The Heard Island station was closed in 1955; the Macquarie Island station has been operated continuously, annual relief parties being sent to the island each summer. In Feb. 1954 Mawson station, led the first year by R. G. Dovers, was established on the antarctic mainland and has been maintained permanently. Subsequent explorations along the coast and inland have added much to the knowledge of this region. The Prince Charles mountains were found to extend inland to about 74° 30' S.

**4. Other Events.**—In Dec. 1947 the South African government annexed the Prince Edward Islands, which lie halfway between South Africa and Antarctica, and in Feb. 1948 a weather station was erected on Marion Island. This station has been manned by successive relief parties since that time.

An antarctic expedition organized by the private body known as Expéditions Polaires Françaises, under the direction of Paul-Émile Victor, established a station at Port Martin in Jan. 1950. A. F. Liotard was in command during the first year. He was succeeded by M. Barré early in 1951. During 1950 and 1951 a number of important journeys were made in mechanical tracked vehicles along the Adélie coast line and inland toward the magnetic pole. The station at Port Martin was destroyed by fire in Jan. 1952, but a small party led by M. Marret wintered at Pointe Géologie, about 40 mi. E. of Port Martin.

In Dec. 1949 the French government established a large scientific station at Port-aux-Français on the Kerguelen Islands. The station was manned continuously after Jan. 1951 by members of an official organization known as Missions, aux Terres Australes et Antarctiques Françaises, under the direction of Pierre Sicaud. An airfield was established on the islands, which lie midway between South Africa and Australia.

An international expedition, sponsored by the Norwegian, British and Swedish governments—the first of its kind—worked in Queen Maud Land in 1949-52. The primary objective was to try to determine whether the antarctic icecap is waning, as is true of most northern glaciers, in response to a warming climate trend which

has been in progress since 1900. The expedition, which was led by the Norwegian John Gjaever and comprised members of all three nationalities, established a station called Maudheim on a floating ice shelf. During the field seasons of 1950-51 and 1951-52 a number of journeys were made, using mechanical tracked vehicles and dog sledges, and an advanced base was established in 72° 17' S., 3° 48' W. An important seismic sounding journey was made inland to a point 370 mi. from Maudheim on the inland ice plateau. A number of flights were made over Queen Maud Land and air photographs were taken.

## V. INTERNATIONAL CO-OPERATION

**1. International Geophysical Year.**—When the committee in charge began organizing the International Geophysical year, to extend from July 1, 1957, to Dec. 31, 1958, it became apparent that nearly a fifth of the world-wide data to be collected would be missing if Antarctica was not included in the effort. Of the 66 nations that eventually joined the IGY effort, 12 volunteered to use existing stations in the antarctic regions or to establish new ones. The south pole was to become the tie point of north-south lines of stations extending through the other continents. It became further obvious that inland stations would be required as well as ones on the coast. These would be both costly to build and difficult to achieve. Only the United States and the U.S.S.R. volunteered to use their resources to attain far inland goals, although France and the United Kingdom later placed small stations short distances inland.

The seven claimant nations all played an active role but restricted their station efforts to localities within their claimed areas. The nonclaimant nations taking part, in addition to the U.S. and U.S.S.R., were Japan, Belgium and the Union of South Africa. Correlation was achieved by means of an International Antarctic committee organized in Paris in 1955. The nonclaimant nations established their stations in gap areas to improve spacing. In some cases, however, there were more stations than were essential to the program; for example, the United Kingdom, Chile and Argentina had stations at Deception Island and Hope bay and the U.S., the United Kingdom and Argentina established new stations not far apart on the Filchner ice shelf. On the other hand, areas such as the Pacific-facing coast of west Antarctica were neglected because of the difficulty in approaching them; its protecting pack ice was first breached in 1960, well after IGY.

Along the coast of Norwegian-claimed Queen Maud Land, nearly 2,000 mi. long, Norway's single station on the Princess Martha Coast was joined by a Japanese station, Showa at Prince Harald Coast on Lützow-Holm bay, and by a Belgian station, King Baudoin station on Princess Ragnhild Coast. Australia added Davis station at Princess Elizabeth Land on Ingrid Christensen Coast to its existing Mawson station. To help fill in gaps along this coast the U.S. located Wilkes station on Budd Coast and the U.S.S.R. located two stations, Mirny on Queen Mary Coast and Oazis at Bunger Hills in Wilkes Land. The French station Dumont d'Urville at Point Géologie on the Adélie Coast further filled in the observing points in this region. The French also established a small, temporary inland station, Charcot, near the south magnetic pole. In its claimed Ross dependency sector New Zealand established Scott station on Ross Island, McMurdo sound, close to the Williams naval air facility, a U.S. installation. The U.S. and New Zealand jointly established Hallett station at Cape Hallett near Cape Adare of Victoria Land. The U.S. main IGY station, Little America V, was established in this same sector at Kainan bay, about 20 mi. N.E. of the former Little America sites.

In the Weddell sea sector claimed in part by both Britain and Argentina the latter built a politically motivated station, General Belgrano, just prior to IGY. Later, and nearby on the Filchner ice shelf, the U.S. built its Ellsworth station and Vivian E. Fuchs his Shackleton station for the British Trans-Antarctic expedition, only coincidentally a part of IGY. This group also built a support station, South Ice, inland. The only strictly new British IGY station, Halley Bay, was established about 250 mi. to the northwest on Coats Land. In the area of the Graham-Palmer peninsula and the South Shetland and South Orkney islands claimed by the