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Coastal-Change and Glaciological Map of the Ross Island Area, Antarctica: 1962–2005

By Jane G. Ferrigno, Kevin M. Foley, Charles Swithinbank,
and Richard S. Williams, Jr.

Pamphlet to accompany
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Conversion Factors

Multiply	By	To obtain
	Length	
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
	Area	
square kilometer (km^2)	0.3861	square mile (mi^2)
	Volume	
cubic kilometer (km^3)	0.2399	cubic mile (mi^3)

Coastal-Change and Glaciological Map of the Ross Island Area, Antarctica: 1962–2005

By Jane G. Ferrigno,[1] Kevin M. Foley,[1] Charles Swithinbank,[2] and Richard S. Williams, Jr.[3]

Introduction

Background

Reduction in the area and volume of the two polar ice sheets is intricately linked to changes in global climate, and the resulting rise in sea level could severely impact the densely populated coastal regions on Earth. Antarctica is Earth's largest reservoir of glacial ice. Melting of the West Antarctic part alone of the Antarctic ice sheet would cause a sea-level rise of approximately 6 meters (m), and the potential sea-level rise after melting of the entire Antarctic ice sheet is estimated to be 65 m (Lythe and others, 2001) to 73 m (Williams and Hall, 1993). Shepherd and Wingham (2007) discussed change in the Antarctic ice sheet as part of the global picture, and Jenkins and Holland (2007) discussed the real potential of sea-level rise from the melting of floating ice such as ice shelves and icebergs. The mass balance (the net volumetric gain or loss) of the Antarctic ice sheet is highly complex, responding differently to different climatic and other conditions in each region (Vaughan, 2005). In a review paper, Rignot and Thomas (2002) concluded that the West Antarctic ice sheet is probably becoming thinner overall; although it is known to be thickening in the west, it is thinning in the north. Thomas and others (2004), on the basis of aircraft and satellite laser altimetry surveys, believe that the thinning may be accelerating. Joughin and Tulaczyk (2002), on the basis of ice-flow velocities derived from analysis of synthetic-aperture radar data, concluded that most of the Ross ice streams (ice streams flowing into the east side of the Ross Ice Shelf) have a positive mass balance, whereas Rignot and others (2004) infer a larger negative mass balance for glaciers flowing northward into the Amundsen Sea, a trend indicated by Swithinbank and others (2003a, b, 2004). The mass balance of the East Antarctic ice sheet is thought by Davis and others (2005) to be positive on the basis of the change in satellite-altimetry measurements made between 1992 and 2003. On the basis of Gravity, Recovery, and Climate Experiment (GRACE) satellite measurements of Earth's gravity from 2002 to 2005, Velicogna and Wahr (2006) concluded that the mass of the Antarctic ice sheet decreased during the period of measurement, and that the West Antarctic ice sheet accounted for most of the loss of ice. Rignot and others (2008) studied loss of ice from the Antarctic ice sheet on the basis of regional climate modeling and satellite interferometric synthetic-aperture radar measurements acquired during the period between 1992 and 2006. They concluded that ice in East Antarctica is at near-equilibrium or has a slightly negative mass balance; ice in West Antarctica, including the Antarctic Peninsula, has a negative mass balance.

Measurement of changes in area and mass balance of the Antarctic ice sheet was given a very high priority in recommendations by the Polar Research Board of the National Research Council (1986), in subsequent recommendations by the Scientific Committee on Antarctic Research (SCAR) (1989, 1993), and by the National Science Foundation's (1990) Division of Polar Programs. On the basis of these recommendations, the U.S. Geological Survey (USGS) decided that the archive of early 1970s Landsat 1, 2, and 3 Multispectral Scanner (MSS) images of Antarctica and the subsequent repeat coverage made possible with Landsat and other satellite images provided an excellent means of documenting changes in the cryospheric coastline of Antarctica (Ferrigno and Gould, 1987). Although changes in the areal extent of the Antarctic ice sheet are not directly related to changes in mass balance, the two are related, and the analysis of the changing coastline can yield important information. The availability of this information provided the impetus for carrying out a comprehensive analysis of the glaciological features of the coastal regions and changes in ice fronts of Antarctica (Swithinbank, 1988; Williams and Ferrigno, 1988). The project was later modified to include Landsat 4 and 5 MSS and Thematic Mapper (TM) images, RADARSAT images, and in some areas, aerial photography, NOAA AVHRR (National Oceanic and Atmospheric Administration, Advanced Very High Resolution Radiometer), MODIS (Moderate Resolution Imaging Spectroradiometer),

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and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) data to compare changes that occurred during a 20- to 25- or 30-year time interval (or longer where data were available, as in the Antarctic Peninsula). The results of the analysis are being used to produce a digital database and a series of USGS Geologic Investigations Series Maps (I–2600) (Williams and others, 1995; Ferrigno and others, 2002, 2005, 2006, 2007, 2008, and 2009; Swithinbank and others, 2003a,b, 2004; and Williams and Ferrigno, 2005) (available online at http://www.glaciers.er.usgs.gov). Table 1 lists the USGS Geologic Investigations Series coastal-change and glaciological maps of Antarctica that have been published to date.

Objectives

The coastal-change and glaciological mapping project has five primary objectives:

1. to determine coastline changes that have occurred during the past three decades, or longer where additional information exists;
2. to establish an accurate baseline series of 1:1,000,000-scale maps (fig. 1) that defines, from the analysis of Landsat and other satellite images, the glaciological characteristics (for example, floating ice, grounded ice, and so forth) of the coastline of Antarctica during three main time intervals: (1) early 1970s (Landsat 1, 2, or 3), (2) middle 1980s to early 1990s (Landsat 4 or 5), and (3) late 1990s to early 2000s (RADARSAT or Landsat 7 ETM+);
3. to determine velocities of outlet glaciers, ice streams, and ice shelves, and the position of the grounding line, from analysis of Landsat images and other sources;

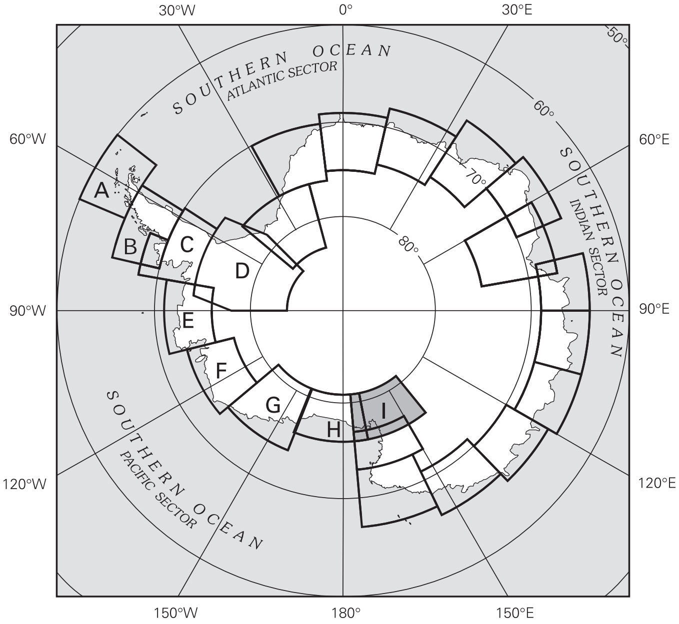

Figure 1. Index map of the planned and published 1:1,000,000-scale coastal-change and glaciological maps of Antarctica. Ross Island area map is shaded. Maps published to date are indicated by letter and described in table 1. They are available printed and online; see table 1 for more information.

4. to compile a comprehensive inventory of named (from published maps) and unnamed (from analysis of Landsat images) outlet glaciers and ice streams in Antarctica that are mappable from Landsat and other satellite images or from ancillary sources (for example, maps, gazetteers, digital databases, and so forth) (Swithinbank, 1980, 1985; Alberts, 1981, 1995; National Science Foundation, 1989; British Antarctic Survey and others, 1993);

Table 1. Coastal-change and glaciological maps of Antarctica at 1:1,000,000 scale, published to date.

[Information on ordering published maps can be obtained by calling the U.S. Geological Survey at 1-888-ASK-USGS or by visiting the USGS online at http://www.usgs.gov/pubprod]

As shown on index map	Map number	Map name	References (see References Cited)	URL for online access
A	I–2600–A	Trinity Peninsula and South Shetland Islands	Ferrigno and others (2006)	http://pubs.usgs.gov/imap/2600/A
B	I–2600–B	Larsen Ice Shelf	Ferrigno and others (2008)	http://pubs.usgs.gov/imap/2600/B
C	I–2600–C	Palmer Land	Ferrigno and others (2009)	http://pubs.usgs.gov/imap/2600/C
D	I–2600–D	Ronne Ice Shelf	Ferrigno and others (2005)	http://pubs.usgs.gov/imap/2600/D
E	I–2600–E	Eights Coast	Swithinbank and others (2004)	http://pubs.usgs.gov/imap/2600/E
F	I–2600–F (2d ed.)	Bakutis Coast	Swithinbank and others (2003b)	http://pubs.usgs.gov/imap/2600/F
G	I–2600–G	Saunders Coast	Swithinbank and others (2003a)	http://pubs.usgs.gov/imap/2600/G
H	I–2600–H	Northern Ross Ice Shelf	Ferrigno and others (2007)	http://pubs.usgs.gov/imap/i-2600-h
I	I–2600–I	Ross Island	This report	http://pubs.usgs.gov/imap/2600/I

5. to compile a 1:5,000,000-scale map of Antarctica derived from the 1:1,000,000-scale maps. Each 1:1,000,000-scale map, apart from the three sheets covering the Antarctic Peninsula, extends to the southernmost nunatak within each map area or to the southernmost extent of Landsat images (about lat 81.5º S.). The coverage area of some maps (for example, those covering the Ronne and Filchner Ice Shelves) was extended farther south to encompass the entire ice shelf.

Sources

Most of the earlier maps in the Coastal-Change and Glaciological Maps of Antarctica series relied almost exclusively on Landsat and other satellite data as the source of information. The coverage areas of the Landsat 1, 2, and 3 MSS images, Landsat 4 and 5 MSS and TM images, and Landsat 7 ETM+ images used in the compilation of these maps are shown on the index maps contained on the margin of each map. Below the index maps, information about each image is listed.

On this map, the early Landsat 1 MSS scenes were acquired from 1973 to 1974. The Landsat 4 TM images date from 1988 to 1990. The Landsat 7 ETM+ images used in the analysis of coastline change were digital and date from 2001. Other satellite images used were AVHRR data from 2000 and 2001 and MODIS images from 2002, 2004, and 2005. The base for the map was the 1997 RADARSAT image mosaic. The 125-meter picture-element (pixel)-resolution 1997 RADARSAT image mosaic of Antarctica, compiled by The Ohio State University's Byrd Polar Research Center (BPRC), was used both as a base for correct geographic position and geometric rectification of digitized Landsat imagery and as an additional source of coastal-change data.

In addition to incorporating Landsat and other satellite imagery, the three Antarctic Peninsula maps (Trinity Peninsula area and South Shetland Islands (map I–2600–A), Larsen Ice Shelf area (map I–2600–B), and Palmer Land area (map I–2600–C)) were compiled utilizing the abundance of current and historical vertical and (or) oblique aerial photographs and other source material archived by the British Antarctic Survey (BAS).

The source material for this map also included the large number of topographic and thematic maps produced for the Ross Island map area by the USGS and cooperators (see table 2 and map margin). The maps used for the compilation of this publication date from 1962 to 2003.

Although not completed in time to be used in this map compilation, the Landsat Image Mosaic of Antarctica (LIMA), using about 1,000 Landsat 7 ETM+ images acquired between 1999 and 2006 (USGS, 2007), was produced in a recent cooperative project between the USGS, the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and BAS. The mosaic is seamless, virtually cloud-free, and has been corrected for sun angle and elevation. It is the most geometrically accurate and highest resolution satellite mosaic of Antarctica produced to date and is a superb tool for glaciological studies. It is located online at http://lima.usgs.gov.

Methodology

The primary steps in the compilation of the Ross Island area map are listed and discussed below:

1. Identification of optimum Landsat MSS, TM, or ETM+ images for three time intervals (early 1970s, middle 1980s to early 1990s, and early 2000s);

2. Manual annotation of glaciological features by SCAR Code (Scientific Committee on Antarctic Research, 1980) or Antarctic Digital Database (ADD) Geocode (British Antarctic Survey and others, 1993; ADD Consortium, 2007) on 1:500,000-scale transparent overlays of Landsat images for both earlier time intervals and directly on the computer workstation monitor for the 1997 RADARSAT image mosaic and Landsat ETM+ images;

3. Positional control of mapped features. Because our goal is to produce the most accurate, high-resolution printed maps and digital databases of the coastal regions of Antarctica, we expended considerable thought and research on choosing the optimum method of geolocating mapped features. The decision was made to georegister the imagery and annotations to the 1997 RADARSAT image mosaic of Antarctica, in order to give the most geometrically accurate base then available. An added benefit was that the RADARSAT mosaic was compiled in polar stereographic projection, having a standard parallel at lat 71º S.— the same projection selected for the map series, making georegistration simpler—with due consideration given to scale distortion on map coverage north and south of lat 71º S. (Sievers and Bennat, 1989). The primary benefit of the polar stereographic projection is cartographic continuity between adjacent maps in the coverage provided of the coastal regions of Antarctica;

4. Scanning hard-copy photographic images to produce 400 dots-per-inch (dpi), 256-shade, gray-scale digitized satellite images. The digitized satellite images, and those already in digital format, were coregistered and geometrically corrected to the RADARSAT image mosaic using ERDAS Imagine software. Pass points were used for coregistration to geometrically fit the scenes to the RADARSAT base;

5. Addition of velocity vectors and geographic place-names; and addition of topographic contours at

selected intervals, generated from the BPRC Digital Elevation Model data and modified where necessary to be congruent with surface features;

6. Description of glaciological features (including the position of the grounding line) and analysis of ice-surface velocities of selected outlet glaciers and ice shelves.

RADARSAT Image Mosaic of Antarctica and its Geodetic Accuracy[4]

The 125-meter picture-element (pixel)-resolution RADARSAT image mosaic of Antarctica was used both as a base for correct geographic position and geometric rectification of digitized Landsat imagery and as an additional source of coastal-change data. The RADARSAT image mosaic is composed of data recorded from 9 September to 20 October 1997 and was selected as the most accurate base available at the time for geolocating the Landsat imagery; therefore, it was considered essential to confirm the published geodetic accuracy of the mosaic (±150 m; Noltimier and others, 1999). For a description of BPRC procedure for constructing the RADARSAT image mosaic, see Jezek, 1998; Norikane and others, 1998; and Liu, 1999. The USGS analysis is described more fully in earlier coastal-change maps (see USGS Maps I–2600–D through H).

Geographic Description

The Ross Island area map is bounded by long 141º E. and 175° E. and by lat 76° S. and 81º S. Ross Island is named for the British explorer James Clark Ross. Ross entered the Navy at the age of 11 and spent much of his career exploring first the Arctic and then the Antarctic. Between 1839 and 1843, he sailed to the Antarctic in his ships, HMS *Erebus* and HMS *Terror*, sailing farther south than any other known European and discovering the sea and the "ice barrier" (ice shelf) that are named for him.

The Ross Island area map covers the part of southern Victoria Land that includes a small part of the northwestern Ross Ice Shelf (fig. 2) (the northern Ross Ice Shelf is described on USGS Map I–2600–H), the McMurdo Ice Shelf, part of the polar plateau, the Transantarctic Mountains from Byrd Glacier to Mawson Glacier, the McMurdo Dry Valleys, northernmost Shackleton Coast, Hillary Coast, the southern part of Scott Coast, and Ross Island. In the western part of the map area, the polar plateau of East Antarctica, once thought to be a featureless region, has subtle wavelike surface forms and flow traces of glaciers that originate far inland and extend to the coast or into the Ross Ice Shelf. There are numerous outlet glaciers. In the northern part of the map area, many glaciers drain into the McMurdo Dry Valleys; the rest drain through the Transantarctic Mountains into the Ross Sea or are tributaries of glaciers that do. In the southern part of the map area, many of the glaciers drain into the Ross Ice Shelf, and Byrd Glacier is the largest. West of the Transantarctic Mountains are areas of blue ice, where drainage of the ice through the mountains has been impeded. These blue ice areas, readily identifiable on Landsat images, have been determined to be prime areas for finding meteorites (Williams and others, 1983; Schutt, 2007). In addition, three subglacial lakes have been identified in the map area (Siegert, 2002). Because McMurdo Station, the main U.S. scientific research station, is located on Ross Island in the map area, many of these and other features in the area have been studied extensively. In addition, the USGS has produced a large number of reconnaissance, topographic, satellite image, and orthophoto maps of McMurdo Sound, McMurdo Station, Ross Island, Ross Sea, the McMurdo Dry Valleys, and northern Victoria Land at a variety of scales to represent the area cartographically and support scientific research (see table 2).

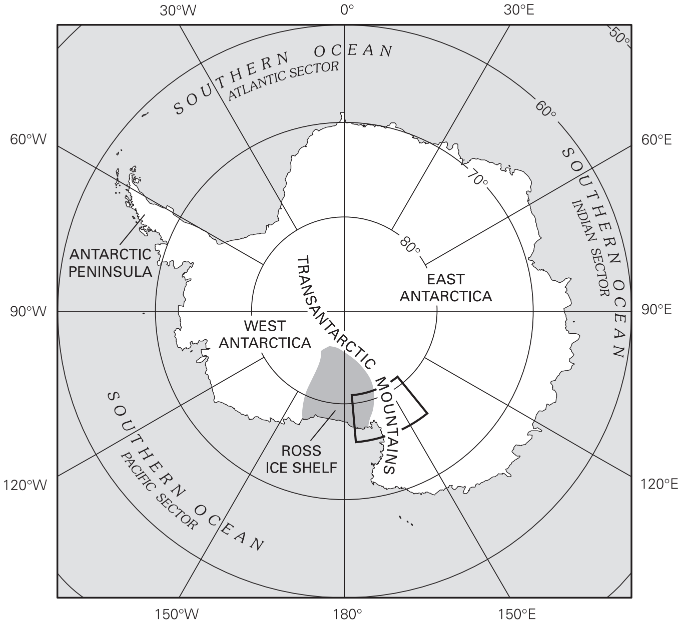

Figure 2. Location map of Antarctica showing West and East Antarctica, the Transantarctic Mountains, the Ross Ice Shelf, and the Antarctic Peninsula. The map area of this report is outlined.

Glacier Inventory and Glaciological Features

Producing a sophisticated glacier inventory of the entire continent of Antarctica according to the requirements of the World Glacier Monitoring Service (Müller and others, 1977,

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[4] Geodetic accuracy determined by J. William Schoonmaker, research geodesist, U.S. Geological Survey (retired).

1978), as part of its ongoing "World Glacier Inventory" program, has been impossible with the present state of glaciological knowledge about Antarctica (Swithinbank, 1980). As recently as 2009, the World Glacier Inventory Web site hosted by the National Snow and Ice Data Center (NSIDC) did not include Antarctic data. However, as more remotely sensed data become available, and as more scientific interest is focused on Antarctica, more glacier inventories will be developed, especially for localized areas. The first glacier inventory carried out in Antarctica using the methodology of the World Glacier Inventory was done on the northern end of the Antarctic Peninsula on James Ross Island by Rabassa and others (1982). Braun and others (2001) proposed a geographic information system (GIS)-based glacier inventory for the Antarctic Peninsula as part of the Global Land Ice Measurements from Space (GLIMS) Project (Kieffer and others, 2000), and Rau and others (2004) carried out a comprehensive GIS inventory of 900 individual glaciers and glaciological features in the northern part of the Antarctic Peninsula.

Because of the glaciological complexity and the large number of unnamed and unidentified glaciers in the map area, we have not attempted to compile a comprehensive glacier inventory of the unnamed glaciers. Instead, we have compiled a list of named glaciers and related glaciological features within the Ross Island map area, gathered from published maps, the USGS Geographic Names Information System (GNIS) database (http://geonames.usgs.gov/antarctic/index.html), and the SCAR Composite Gazetteer of Antarctica (http://data.aad.gov.au/aadc/gaz/scar/). This list is presented in table 3.

The map area has an amazing variety of glaciological features. There are 323 named glaciers and related glaciological features on the map as defined in various scientific glossaries (Armstrong and others, 1973, 1977; Neuendorf and others, 2005). The named features include outlet, valley, and cirque glaciers, and ice shelves, ice piedmonts, snowfields, ice fields, icefalls, and glacier tongues (table 3).

Coastal-Change Analysis—Discussion of Selected Glaciological Features

As would be expected, floating ice fronts, iceberg tongues, and glacier tongues are the most dynamic and changeable features in the coastal regions of Antarctica. On this map, unlike most of the previous maps in this series, the ice fronts do not show much change. The positions of the ice fronts as observed on the three sets of Landsat imagery and on other satellite imagery were mapped and annotated with the date for each position. This made it possible to date and analyze changes that have occurred. The only noticeable change, however, is along the front of the McMurdo Ice Shelf, where recession of a few kilometers to as much as 5 km occurred between January 1974 and October 1997. As a result, the following discussion focuses on the glaciological features of the area.

Glaciers that Drain from or through the Transantarctic Mountains

Byrd Glacier

Byrd Glacier is one of the largest valley glaciers in the world and possibly the most active glacier draining the polar plateau of East Antarctica. It has surface velocities of more than 800 m a^{-1}, as fast as some surging glaciers. Byrd Glacier is more than 180 km long and is 22 km wide at its narrowest point (Swithinbank, 1988). It drains an area greater than 1 x 10^6 km^2 and is the largest single source of ice (more than 18 km^3 a^{-1}) flowing into the western margin of the Ross Ice Shelf. Its flow pattern can be followed across the Ross Ice Shelf to the Ross Sea. In spite of its size and importance, it was not well known or named before 1960 (Swithinbank, 1963). The entire length of Byrd Glacier was not successfully imaged by moderate-resolution satellite imagery until 1982, when Landsat 4 with its more southerly orbit was able to view the upper region of the glacier (Swithinbank, 1988).

Because of the fact that Byrd Glacier provides the primary outflow for a major part of East Antarctica, studies have been made of its current and past behavior to help predict its future and to understand its role in influencing the mass balance of the entire East Antarctic ice sheet. Work was first done on Byrd Glacier as part of the International Geophysical Year (IGY). Swithinbank's measurements, made between 1960 and 1962, of seven glaciers flowing into the Ross Ice Shelf discovered the overwhelming contribution of the outflow of Byrd Glacier (Swithinbank, 1963). In 1978 and 1979, extensive field studies were carried out on the glacier as part of the Byrd-Darwin Glacier project. The studies included aerial photography, radio echo sounding, ground-survey ice sampling, and ablation measurements (Hughes, 1979; Hughes and Fastook, 1981). Brecher (1982) used stereographic vertical aerial photographs to photogrammetrically determine surface velocities and elevations. He calculated a maximum surface velocity of 875 m a^{-1} well upstream of the glacier mouth. All velocities compared well with Swithinbank's 1960–62 measurements and with the 1978–79 field measurements. Brecher (1962) also compared the 1978–79 aerial photographs with aerial photographs acquired in 1960 and 1963; he determined that there was no appreciable change in the surface elevation during the time interval. Further surface-velocity measurements were made by Lucchitta and Ferguson (1986) using Landsat MSS data from January 1974 and November 1983. Their average velocities were between 750 and 800 m a^{-1}, about the same as the earlier measurements. In contrast, recent ice-velocity measurements acquired using 2000–2001 Advanced Spaceborne Thermal Emission and Reflectance

(ASTER) imagery by Stearns and Hamilton (2005) showed substantial deceleration of Byrd Glacier. Parts of the glacier that had been flowing at 850 m a^{-1} in 1978–79 were flowing at 650 m a^{-1} in the ASTER data, indicating the flow of this glacier is very dynamic and changeable over time.

Models to describe the dynamics of Byrd Glacier were made using the 1978–79 field data and radio-echo sounding data. Reusch and Hughes (2003) suggest that Byrd Glacier may be undergoing rapid changes based on evidence of ice flux, information on basal melting (Rignot and Thomas, 2002), and a position for the grounding line (Rignot and Thomas, 2002) that is 20 km farther inland than where it was located by Hughes and Fastook (1981). Kenneally and Hughes (2004) suggest that if the grounding line is retreating upglacier, this eventually could lead to the drawdown of ice from the interior of East Antarctica.

Darwin Glacier

Darwin Glacier, more than 90 km long and 3 km wide, is a large glacier that flows from the Darwin Mountains into the Ross Ice Shelf. The lower part of the glacier was first mapped in the early 1900s by the British National Antarctic Expedition. The glacier was visited by the Commonwealth Trans-Antarctic Expedition in 1956–58. In 1978–79, the Byrd-Darwin Glacier field project visited Darwin Glacier. Although most of the focus of the project was on Byrd Glacier, ice-surface-velocity measurements were made on Darwin Glacier and indicated a maximum surface velocity of 100 m a^{-1} (Hughes, 1979; Hughes and Fastook, 1981).

Hatherton Glacier

Hatherton Glacier is a large glacier, approximately 3 km wide and more than 60 km long. It is a tributary to Darwin Glacier, which it joins after flowing through the Transantarctic Mountains. Both Darwin and Hatherton Glaciers are ice starved, with little to no flow from the polar plateau and little contribution to the Ross Ice Shelf. A modeling study of the response of Hatherton Glacier to Ross Ice Sheet grounding-line retreat in the Holocene was carried out by Anderson and others (2004) to contribute to the understanding of present and future grounding-line retreat of the West Antarctic ice sheet.

Mulock Glacier

Mulock Glacier is a large glacier, more than 80 km long and about 12 km wide, that drains the polar plateau. Less than half as wide as Byrd Glacier, it is still considered an important outlet glacier. Its surface elevation is 1,400 m at the plateau and decreases to 100 m where it joins the Ross Ice Shelf (Swithinbank, 1988). Swithinbank (1963) made surface-velocity measurements during 1960–62 to assess the overall contribution of several outlet glaciers to the total regime of the Ross Ice Shelf. The surface velocity of Mulock Glacier was measured at about 390 m a^{-1} near its mouth, contributing 5.6 km^3 a^{-1} of ice to the shelf. Scambos and others (http://nsidc.org/data/velmap/ross_shelf/ross_nw/ross_nw_vel.html) used Landsat imagery from 1989 to calculate ice-surface velocity. Their results were similar to the earlier measurements, with velocities at the grounding line about 350 to 400 m a^{-1}, increasing to more than 700 m a^{-1} as the glacier moved into the Ross Ice Shelf.

Skelton Glacier

Skelton Glacier is a large glacier flowing from Skelton Névé, from which it gets most, if not all, of its nourishment, into the Ross Ice Shelf. It is about 130 km long, and its maximum thickness is 1,450 m. Its surface drops from 2,200 m on the plateau to 100 m at the grounding line. The glacier was the route for traveling from the Ross Ice Shelf to the polar plateau by the Commonwealth Trans-Antarctic Expedition in 1956–58 and the Victoria Land Traverse in 1958– 59. During the latter ascent, seismic, gravity, magnetic, and glaciological studies were made. The glaciological studies included ice-thickness and ice-movement measurements. At the mouth of the glacier, the ice thickness ranged from 490 to 600 m, the ice-surface velocity averaged about 89 m a^{-1}, and the discharge to the shelf was only 0.8 km^3 a^{-1} of ice (Wilson and Crary, 1961). As a result, Skelton Glacier has very little effect on the flow of the ice shelf. During the 1960–61 geophysical traverse from McMurdo Station to the South Pole, Skelton Glacier was also the route chosen to access the polar plateau.

Koettlitz Glacier

Koettlitz Glacier drains from Koettlitz Névé in the Transantarctic Mountains and flows between Brown Peninsula and the mainland, entering McMurdo Sound near Cape Chocolate. Koettlitz Glacier is more than 75 km long, and its tongue is afloat for at least 25 km. It has received scientific attention since the days of Scott’s expeditions (1910–13) because of the fish and marine invertebrates found on its surface. The hypothesis that the surface distribution of marine fauna was explained by freezing of marine organisms to the base of the ice shelf (basal freezing) and gradual migration upward to the surface (surface ablation) was confirmed by Gow and Epstein (1972). Gow and Govoni (1994) used map data, field observations, and remotely sensed data to observe the retreat of the ice front from 1910–13 to 1992; they estimated that more than 300 km^2 of ice had calved off the glacier tongue during that 80-year period.

Erebus Glacier Tongue

A small but distinctive feature on the map, due to its serrated edges, is the Erebus Glacier Tongue, the extension of Erebus Glacier into Erebus Bay. Erebus Glacier Tongue is unusually long (14 km) and unusually narrow, averaging only about 1.5 km in width (Delisle and others, 1989). The tongue was originally mapped by the British National Antarctic Expedition under Scott (1901–04) and has been intensively studied with radio-echo sounding and other techniques since 1967. It is floating for about 13.5 km of its length (Delisle and others, 1989). According to Holdsworth (1974, 1982), it is 350 m thick at the grounding line and thins to 120 m at its seaward end. Holdsworth (1974) measured an ice-surface velocity at the seaward end of 165 m a^{-1}, but Delisle and others (1989) cited an average velocity of 140 m a^{-1}. Holdsworth (1974) determined that the glacier tongue has a calving recurrence interval of 30 years, but according to Delisle and others (1989), the last calving event occurred about 1944 and was long overdue. The delay in calving may have been due, in part, to buffering by the sea ice that surrounds the glacier tongue.

McMurdo Dry Valleys

The McMurdo Dry Valleys region on this map, extending roughly from lat 76.5º S. to 78.5º S. and from long 160º E. to 164.5º E., is an area of about 16,000 km^2, of which approximately 2,000 km^2 is essentially snow free (Chinn, 1988). The three major, mostly ice-free valleys are Taylor, Wright, and Victoria Valleys. There are three main types of glaciers in the region. Outlet glaciers from the East Antarctic ice sheet enter the valleys from the west. The mountain ranges between the valleys support alpine glaciers, and piedmont glaciers are located along the coast (Chinn, 1988). Chinn (1988) thought and Fountain and others (2006) showed that the alpine glaciers were approximately in equilibrium. Glacier velocities in the area are typically very slow, generally 1 m a^{-1} or less, with the maximum of 3 m a^{-1} measured on Meserve Glacier (Chinn, 1988; Fountain and others, 2006). But Chinn (1998) stated that if it is taken into consideration that the flow and ablation regimes of the McMurdo Dry Valleys' glaciers are two orders of magnitude slower than those of temperate glaciers, then the glaciers actually are fluctuating as dynamically as temperate glaciers. Because the McMurdo Dry Valleys are so close to McMurdo Station, many studies have been carried out on the glaciers there. Some of the more comprehensive include Chinn (1980, 1985, 1998), Fountain and others (1998, 2004, 2006), and Fountain and Lyons (2003). Interesting work was done by MacClune and others (2003), who considered that the conditions of high sublimation, low melting, and dust accumulation made the glaciers in the McMurdo Dry Valleys terrestrial analogs for Martian ice caps.

Icebergs

Large icebergs have not calved in the map area recently, but icebergs that have calved and drifted westward from the eastern part of the Ross Ice Shelf have impacted the wildlife on Ross Island and impeded access to McMurdo Station. In the last decade, several very large icebergs calved from the front of the eastern part of the Ross Ice Shelf (Ferrigno and others, 2007). On 17 March 2000, one of the largest tabular icebergs ever recorded was seen; it was named B-15. It calved from west of Roosevelt Island along rifts that had been observed on satellite imagery for several years (Lazzara and others, 1999). It was 295 km long, 37 km wide, and had an area of about 10,000 km^2. Soon afterward, several new icebergs were formed by the breaking of B-15 into smaller pieces (B-15A, B, C, and D) and by the collision of B-15 with the ice shelf (B-16, -17, -18, and -19, and C-16). B-15A, the largest remnant of the original B-15, and C-16 drifted west until they collided with Ross Island in December 2001 and December 2000, respectively, where they remained until at least October 2003. The icebergs disrupted ocean circulation, shipping, and marine life. MacAyeal and others (2003) placed automatic weather stations, ice-sounding radar, seismometers, and tracking devices on B-15A and C-16 for detailed monitoring and to model the effects of future climate change on the ice shelves of Antarctica. See Ferrigno and others (2007) for additional discussion of the calving of these and other icebergs from the Ross Ice Shelf.

Ice Cores

Antarctic ice cores are a unique and powerful resource for studying climate change (Wolff, 2005). Both shallow and deep cores have yielded important information in many parts of the continent. The International Trans-Antarctic Scientific Expedition (ITASE), planned for the continent-wide collection and interpretation of environmental data, has included ice-core drilling in its program to reconstruct the last approximately 200 years of climate change, or longer where data are available (http://www2.umaine.edu/itase/). Since 1968, deep ice cores have been drilled in Antarctica that have yielded information on previous climate for several hundreds of thousands of years. In 1968, the first core to extend through the ice sheet and reach bedrock was drilled at Byrd Station (lat 80° S., long 119.5° W.). It was 2,191 m long and was dated at more than 50,000 years (Hammer and others, 1994). The 3,623-m Vostok core (drilled in different intervals from 1970 to 1998) gave information from the last four glacial-interglacial cycles, extending back about 420,000 years (Petit and others, 1999). The first Dome Fuji (lat 77°19′ S., long 39°42′ E.) deep ice core, drilled in 1995 and 1996, was 2,500 m long and extended back 340,000 years (Watanabe and others, 1999; Kawamura and others, 2007). Another deep core from Dome Fuji, drilled from 2003 to 2007 and 3,035 m long, may cover as many as 720,000 years (Motoyama, 2007). The Dome Charlie (C) ice core (lat 75°06′ S., long 123°24′ E.) has reached the oldest ice to date. Drilled from 1999 to 2004, it was 3,270 m long and reached ice extending back more than 800,000 years and covering at least eight glacial cycles (EPICA, 2004).

On this map sheet, Taylor Dome (lat 77°40′ S., long 157°40′ E.), which receives ice from Dome Charlie and drains to the Ross Sea through Scott Coast (Frezzotti and others, 2000), is the location of an ice-drilling project that successfully reached bedrock at a depth of 554 m. The project was started in 1990–91, and drilling, which was begun in 1991–92, was completed in the 1993–94 season. The Taylor Dome ice core, containing a paleoclimatic record longer than 130,000 years, was only the second (after Vostok) to provide a stratigraphically undisturbed record through the entire last glacial cycle. Because the core is relatively shallow, it has provided excellent CO_2 and $\delta\,^{13}C$ (proxy temperature) measurements (http://depts.washington.edu/isolab/taylor). Reviews of the project and results are in Morse and others (1999) and Steig and others (2000).

Blue-Ice Areas and Meteorites

Areas of bare glacier ice, turquoise-blue in color, contrasting sharply with the more extensive white snow cover, occur in many parts of Antarctica and are called “blue ice,” a term first used by the Swedish glaciologist Valter Schytt (1961) during the 1944–52 Norwegian-British-Swedish Expedition to Queen Maud Land. Blue ice is found primarily near coastal mountains and nunataks but can appear in the interior within the main flow of the ice sheet. Blue-ice areas became linked with the search for meteorites in 1970. From earliest exploration until 1969, only four meteorites had been found in Antarctica, all during overland traverses, and it was thought that there were extremely limited opportunities for finding meteorites in Antarctica. During the 1969–70 Antarctic field season, Japanese scientists found nine meteorites in a blue-ice area of the Queen Fabiola (Yamato) Mountains (Yoshida and others, 1971) and many more in succeeding years. This unexpected discovery suggested that blue-ice areas might be a rich source of meteorites. In 1975, the United States inaugurated a search program (Antarctic Search for Meteorites, ANSMET) that first focused in the blue-ice areas around the Allan Hills in cooperation with Japanese scientists; eleven meteorites were found (Cassidy, 1977). The successful search soon expanded to other areas and found increasing numbers of specimens. Since then, international search teams have located about 35,000 specimens in Antarctica (Schutt, 2007).

Blue ice occurs in areas of low accumulation (less snowfall), high ablation, high wind speed (removes snow and increases ablation), and slow horizontal motion (Annexstad, 1982), where the ice movement is completely or partly blocked by subglacier or subaerial mountain ranges. A meteorite fall is a rare occurrence, and slow ice flow against a blockage concentrates meteorites on an ablating surface. Low temperatures also slow the deterioration of meteorites that are not in chemical equilibrium at the Earth’s surface (Cassidy and others, 1992). The co-location of meteorites and blue ice has yielded information for both the meteorite and glaciological scientific communities. Blue-ice areas have also been investigated for use as aircraft landing sites for wheeled aircraft (Mellor and Swithinbank, 1989; Swithinbank, 1989, 1991). The idea has proved valid and has been used and developed by private and government entities of several countries.

It was recognized early in the search for meteorites that identification of blue-ice areas, using aerial reconnaissance or inspection of satellite imagery, could greatly aid the search, and a suggestion was made to compile a thematic map of the continent using satellite imagery (Williams and others, 1982, 1983). The Japanese produced early maps of the meteorite locations in the Yamato Mountains and the Allan Hills (Yanai, 1983, 1984). A concerted effort to map meteorite locations grew out of the need to document, present, and maintain ANSMET location data (Antarctic Meteorite Location and Mapping Project, AMLAMP) (Schutt and others, 1989, 1993). Thematic maps were produced until 1994, but currently mapping is being done in the ESRI ArcGIS environment (Schutt, 2007).

Meteorites have been found in East Antarctica in the Yamato and Sør Rondane Mountains and along the Transantarctic Mountains. The greatest number have been found in the Yamato and Sør Rondane Mountains and the nearby area (more than 16,500 meteorites as of 2008, according to Japan’s National Institute of Polar Research, Antarctic Meteorite Research Center Web site (http://www.nipr.ac.jp/english/r_centers/t04_amrc.html)), but the greatest extent is along the Transantarctic Mountains, where the flow of the East Antarctic ice sheet has been obstructed. Several of the sites are located on this map sheet. The Allan Hills-David Glacier region (David Glacier is about 75 km north of the map area) includes numerous meteorites from the Allan Hills, Elephant Moraine, and Reckling Moraine areas and has yielded approximately 3,400 meteorite specimens. The McMurdo Dry Valleys region has yielded a few meteorites, and the Darwin-Byrd Glacier region has yielded more than 1,100 specimens, mostly from the Meteorite Hills (Schutt 2007). Harvey (2003) gave a comprehensive discussion of the origin and significance of Antarctic meteorites.

Subglacial Lakes

Subglacial lakes were first recognized in Antarctica in airborne radio-echo sounding records in the late 1960s by Robin and others (1970). Oswald and Robin (1973) counted 17 of these lakes at the base of the ice sheet beneath several thousand meters of ice. Since then, new data and re-evaluation of older data have increased the number of recognized lakes to 77 (Siegert and others, 1996), and 145 (Siegert and others, 2005). It is worth noting that although the data do not cover the whole continent, subglacial lakes have been found in much of the data, suggesting they exist continent-wide. The lakes range in size from about 500 m in length to the largest known lake, Vostok Subglacial Lake. Vostok, first described by Kapitsa and others (1996), has been studied intensively and is now recognized to have maximum dimensions of 250 km by 80 km and a total area of 14,000 km^2 (Siegert and others, 2005). Most subglacial lakes are located in the interior of the ice sheet where surface slopes, ice velocity, and surface accumulation are low (Siegert, 2002). Dowdeswell and Siegert (2002) divided subglacial lakes into three types based on location: (1) lakes in subglacial basins in the ice-sheet interior, (2) lakes on the flanks of subglacial mountains, and (3) lakes near the onset region of enhanced glacier flow. Sixteen lakes fall into the last category and of these, three occur near the onset of fast flow into Byrd Glacier (Siegert, 2002), the glacier that is a major glaciological feature on this map. Subglacial lakes, especially Vostok Subglacial Lake, are of interest because of the possible inclusion of unique life forms that may indicate if life can exist in harsh conditions in other parts of the solar system and help explain the processes that triggered the evolutionary explosion on Earth. Also their presence may help decipher the geologic history of Antarctica, including the location and dynamics of paleo-ice sheets (Bell and Karl, 1998).

Summary

The analysis of Landsat 1 MSS images (1973 to 1974), Landsat 4 TM images (1988 to 1990), Landsat 7 ETM+ images (2001), and other satellite imagery and historical data of the Ross Island area made it possible to identify and describe glaciological features. Little noticeable change has occurred in the ice fronts on the map, with the exception of overall recession in the McMurdo Ice Shelf area of up to 5 km between 1974 and 1997. Therefore the discussion is focused on a review of selected glaciers that flow from or through the Transantarctic Mountains including Byrd, Darwin, Mulock, Skelton, and Koettlitz Glaciers. The following glaciological topics are also reviewed: the Erebus Glacier Tongue, investigations in the McMurdo Dry Valleys, and iceberg calving, ice cores, subglacial lakes, and the relation of blue ice to accumulation of meteorites.

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Appendix—Tables 2 and 3

Table 2. Topographic, satellite image, and photo maps in the Ross Island map area, produced by the USGS and cooperators.

Name	Publication Date
1:250,000-Scale Topographic Reconnaissance Series	
Cape Selborne	1966
Carlyon Glacier	1966
Convoy Range	1965, revised 1988
Franklin Island	1965
Mount Discovery	1965, revised 1988
Mount Harmsworth	1965, revised 1988
Mount Olympus	1966
Ross Island	1960, revised 1970
Taylor Glacier	1965, revised 1988
Turnstile Ridge	1966, revised 1988
1:250,000-Scale Satellite Image Maps	
Churchill Mountains	2003
Convoy Range	1974 (printed 1989)
Darwin Mountains	2002
Mount Harmsworth	1974 (printed 1989)
Mount Joyce	1974 (printed 1989)
Ross Island	1975 (printed 1989)
South Ross Sea Region	1999
1:100,000-Scale Satellite Image Maps	
Byrd Névé	2003
Convoy Range	2000
Darwin Glacier	2001
McMurdo Dry Valleys	1995
Mount Discovery	1999
Nicholson Peninsula	2003
Ross Island and McMurdo Sound	2000
Skelton Névé	2000
Turnstile Ridge	2001
1:50,000-Scale Topographic Series	
Alatna Valley (co-op with New Zealand)	In preparation
Beacon Valley (co-op with New Zealand)	1993
Cambridge Glacier (co-op with New Zealand)	In preparation
Cape Chocolate (co-op with New Zealand)	1993
Cape Roberts (co-op with New Zealand)	In preparation
Cathedral Rocks (co-op with New Zealand)	1993
Debenham Glacier (co-op with New Zealand)	In preparation
Flagship Mountain (co-op with New Zealand)	In preparation
Granite Knolls (co-op with New Zealand)	1993
Joyce Glacier (co-op with New Zealand)	1997

Table 2. Topographic, satellite image, and photo maps in the Ross Island map area, produced by the USGS and cooperators.—Continued

Name	Publication Date
1:50,000-Scale Topographic Series—Continued	
Knobhead (co-op with New Zealand)	1993
Labyrinth	1977
Lake Bonney	1977
Lake Brownworth	1977
Lake Fryxell	1977
Lake Vanda	1977
Marble Point	1977
Marshall Valley (co-op with New Zealand)	1997
Mount Endeavour (co-op with New Zealand)	In preparation
Mount Huggins (co-op with New Zealand)	1997
Mount Lister (co-op with New Zealand)	1997
Mount Mahony (co-op with New Zealand)	In preparation
Mount Whitcombe (co-op with New Zealand)	In preparation
Skew Peak (co-op with New Zealand)	In preparation
The Pyramid (co-op with New Zealand)	1997
The Spire (co-op with New Zealand)	1997
Twin Rocks (co-op with New Zealand)	1997
Victoria Upper Lake	1977
Webb Lake	1977
Wyandot Ridge (co-op with New Zealand)	In preparation
1:25,000-Scale Satellite Image Maps	
Airdevronsix Icefalls	n.d. [2005]
Beacon Heights	In preparation
Cape Crozier	2002
Cavendish Rocks	In preparation
Dais	n.d. [2005]
Denton Glacier	1999
Hut Point Peninsula	2002
Lake Fryxell	2001
Marble Point	2001
Matterhorn	2001
Miers Valley	In preparation
Mount Bastion	In preparation
Mount Bird	2002
Mount Erebus	2002
Mount Kowalczyk	In preparation
Victoria Valley	In preparation
Miscellaneous Scale Satellite Image Maps	
I-2284 Antarctica, 1:5,000,000	1991
I-2560 Antarctica, 1:5,000,000	1996, 2d ed. 2000

Table 2. Topographic, satellite image, and photo maps in the Ross Island map area, produced by the USGS and cooperators.—Continued

Name	Publication Date
Miscellaneous Scale Satellite Image Maps—Continued	
RADARSAT Image Map of Antarctica, 1:5,000,000	2003
Victoria Land Coast, 1972–73, 1:1,000,000	1976
McMurdo Sound, 1972–74, 1:1,000,000	1976
McMurdo Sound Region, 1:500,000	1973 (printed 1975)
McMurdo Sound Region, 1:250,000	1973
Miscellaneous Scale Photomaps	
Hut Point Peninsula, 1:13,500	1983 (printed 1985)
McMurdo Station, 1:2,500	1983 (printed 1985)
McMurdo Station, 1:1,800	1996
McMurdo Station, 1:1,560	2001
McMurdo Station, USA – Scott Base, NZ, 1:8,000	2000
Miscellaneous Other Maps	
Ross Ice Shelf, 1:2,188,000 (sketch map)	1980 (compiled 1972)
Ross Ice Shelf, 1:1,000,000 (sketch map)	1972
McMurdo Sound, 1:1,000,000 International Map of the World series	1974
Ross Island and vicinity, 1:250,000 Topographic	1986
Ice-Free Valleys, Victoria Land, 2 sheets, 1:100,000 Topographic, USGS Open-File Report 84–303	1984 (compiled 1962)
Skelton Glacier, 1:100,000 Topographic, USGS Open-File Report 84–304	1984 (compiled 1962)
Wright Valley Labyrinth Area, 1:20,000 Topographic, USGS Open-File Report 84–302	1984 (compiled 1965)
Cape Crozier, Ross Island, 1:4,800 Topographic, USGS Open-File Report 84–301	1984 (compiled 1963)

Table 3. Inventory of named glaciers and glaciological features on the coastal-change and glaciological map of the Ross Island area.

Feature Name	Location (latitude, longitude)	
Adams Glacier	780700S	1633800E
Adélie Glacier	771300S	1663000E
Aiken Glacier	773800S	1632400E
Airdevronsix Icefalls	773100S	1602200E
Albatross Glacier	771700S	1663100E
Alberich Glacier	773600S	1613600E
Albrecht Penck Glacier	764000S	1622000E
Alley Glacier	795800S	1580500E
Allison Glacier	781600S	1615500E
Amos Glacier	774900S	1633900E
Amphitheatre Glacier	781700S	1630400E
Ant Hill Glacier	784900S	1613000E
Anu Whakatoro Glacier	771725S	1614200E
Atka Glacier	764100S	1613300E
Aurora Glacier	773700S	1673800E
Bachtold Glacier	770730S	1620000E
Ball Glacier	780300S	1625000E
Barne Glacier	773600S	1662600E
Baronick Glacier	783600S	1615000E
Bartley Glacier	773200S	1621300E
Bartrum Glacier	794400S	1584400E
Baxter Glacier	764000S	1615100E
Benson Glacier	764900S	1621200E
Beowulf Glacier	773800S	1614900E
Bertoglio Glacier	791800S	1602000E
Biker Glacier	771200S	1600700E
Bindschadler Glacier	775800S	1620900E
Blackwelder Glacier	775600S	1641200E
Blankenship Glacier	775900S	1614500E
Blue Glacier	775000S	1641000E
Bol Glacier	775200S	1623400E
Bonne Glacier	775300S	1634900E
Borns Glacier	774700S	1620100E
Bowden Glacier	780800S	1630700E
Bowers Piedmont Glacier	774300S	1641800E
Brecher Glacier	804200S	1572800E
Brier Icefalls	801500S	1553600E
Bryan Glacier	772415S	1605545E
Burrows Glacier	780200S	1635600E
Byrd Glacier	802000S	1590000E
Byrd Névé	810000S	1540000E
Calkin Glacier	774600S	1621700E
Cambridge Glacier	765700S	1603100E
Canada Glacier	773700S	1625900E
Carleton Glacier	780100S	1623000E
Carlyon Glacier	793400S	1595000E
Cassidy Glacier	774600S	1600900E
Cassini Glacier	775300S	1634800E
Catspaw Glacier	774300S	1614200E
Cavendish Icefalls	774900S	1612000E
Cerberus Glacier	772700S	1615400E
Chattahoochee Glacier	763400S	1604200E
Chinn Glacier	772800S	1621500E
Circle Icefall	793800S	1563000E
Clark Glacier	772500S	1622500E
Cleveland Glacier	765500S	1620100E
Clio Glacier	772600S	1620000E
Cocks Glacier	784100S	1620000E
Comberiate Glacier	782100S	1621400E
Commanda Glacier	773000S	1625600E
Commonwealth Glacier	773500S	1631900E
Condit Glacier	775200S	1624800E
Conrow Glacier	773400S	1620700E
Cooper Snowfield	805600S	1584000E
Cotton Glacier	770700S	1614000E
Covert Glacier	775400S	1630400E
Cranfield Icefalls	795600S	1584000E
Creagh Glacier	780100S	1611000E
Creagh Icefall	780200S	1610800E
Crescent Glacier	774000S	1631400E
Crisp Glacier	771200S	1621200E
Cycle Glacier	771200S	1601000E
Dahe Glacier	771500S	1620200E
Dale Glacier	781700S	1620200E
Darkowski Glacier	775200S	1622500E
Darwin Glacier	795300S	1590000E

Table 3. Inventory of named glaciers and glaciological features on the coastal-change and glaciological map of the Ross Island area.—Continued

Feature Name	Location (latitude, longitude)	
Darwin Névé	793000S	1550000E
Debenham Glacier	771000S	1623800E
Deception Glacier	783300S	1583300E
Decker Glacier	772800S	1624700E
Delinski Glacier	772900S	1602600E
Delta Glacier	784200S	1612000E
Denton Glacier	772900S	1623600E
Descent Glacier	775100S	1625200E
DeVries Glacier	802000S	1573000E
Dewdrop Glacier	770100S	1622200E
Diamond Glacier	795100S	1590000E
Dilemma Glacier	784500S	1612500E
Discovery Glacier	782000S	1643000E
Doran Glacier	774300S	1624000E
Double Curtain Glacier	773900S	1633100E
Dromedary Glacier	781800S	1631000E
Dun Glacier	774800S	1621400E
Eady Ice Piedmont	783100S	1652000E
Eastwind Glacier	773700S	1681600E
Emmanuel Glacier	775400S	1620500E
Endeavour Piedmont Glacier	772300S	1664000E
Entrikin Glacier	804900S	1600000E
Enyo Glacier	772900S	1620000E
Eos Glacier	772800S	1621000E
Erebus Glacier	774100S	1670000E
Erebus Glacier Tongue	774200S	1664000E
Evans Piedmont Glacier	764400S	1624000E
Evteev Glacier	785700S	1611200E
Exodus Glacier	795000S	1562200E
Fang Glacier	772900S	1670600E
Fastook Glacier	790200S	1564500E
Fenwick Glacier	771633S	1614135E
Ferguson Glacier	773100S	1625600E
Ferrar Glacier	774600S	1630000E
Ferrigno Glacier	780800S	1615900E
Fireman Glacier	774700S	1601600E
Flight Deck Névé	764700S	1613000E
Foggydog Glacier	794700S	1584000E

Table 3. Inventory of named glaciers and glaciological features on the coastal-change and glaciological map of the Ross Island area.—Continued

Feature Name	Location (latitude, longitude)	
Foster Glacier	782400S	1625000E
Fountain Glacier	774100S	1613800E
Frazier Glacier	770500S	1612500E
Fritter Glacier	770800S	1623500E
Fry Glacier	763800S	1621800E
Gabites Glacier	772054S	1603230E
Garwood Glacier	780100S	1635700E
Gauss Glacier	775800S	1634500E
Gaussiran Glacier	800000S	1591000E
Gawn Ice Piedmont	795800S	1601200E
Gentle Glacier	764600S	1611500E
Geodetic Glacier	774500S	1634800E
Geoid Glacier	774800S	1634700E
Glee Glacier	781600S	1630000E
Glezen Glacier	763200S	1621800E
Glimpse Glacier	781600S	1624600E
Godwit Glacier	773600S	1621200E
Goldman Glacier	774200S	1625100E
Goodspeed Glacier	772900S	1622700E
Gran Glacier	765600S	1611400E
Green Glacier	794300S	1561000E
Griffiths Glacier	771000S	1622000E
Harbour Glacier	770200S	1625400E
Harbour Glacier Tongue	770100S	1625500E
Harp Glacier	773200S	1631400E
Hart Glacier	773000S	1622300E
Haselton Glacier	772115S	1604500E
Haselton Icefall	772100S	1604600E
Hatherton Glacier	795500S	1573500E
Heap Glacier	790300S	1592000E
Hedblom Glacier	763400S	1622400E
Hedley Glacier	774900S	1620700E
Heimdall Glacier	773500S	1615000E
Herbertson Glacier	774200S	1634800E
Hinton Glacier	800300S	1571000E
Hobbs Glacier	775400S	1642400E
Hooker Glacier	780400S	1630600E
Hourihan Glacier	800800S	1584500E

Table 3. Inventory of named glaciers and glaciological features on the coastal-change and glaciological map of the Ross Island area.—Continued

Table 3. Inventory of named glaciers and glaciological features on the coastal-change and glaciological map of the Ross Island area.—Continued

Feature Name	Location (latitude, longitude)	
Howard Glacier	774000S	1630500E
Howchin Glacier	781200S	1632200E
Hughes Glacier	774400S	1622700E
Huka Kapo Glacier	772412S	1604300E
Hunt Glacier	765200S	1622500E
Irving Glacier	761300S	1601600E
Jezek Glacier	775900S	1621300E
Joyce Glacier	780100S	1634200E
Judith Glacier	802900S	1584900E
Kamb Glacier	775500S	1623900E
Kehle Glacier	785600S	1601800E
Kempe Glacier	781800S	1625400E
Kennedy Glacier	773900S	1621200E
Kitticarrara Glacier	774300S	1630200E
Koettlitz Glacier	781500S	1641500E
Koettlitz Névé	782700S	1630000E
Kreutz Snowfield	771730S	1611530E
Lacroix Glacier	774000S	1623300E
Landing, The	782200S	1612500E
Lashly Glacier	775700S	1595000E
Lieske Glacier	800500S	1565000E
Lister Glacier	775900S	1630500E
Lobeck Glacier	771315S	1614600E
Loftus Glacier	773300S	1624600E
Lofty Promenade	773100S	1685200E
Lower Jaw Glacier	782200S	1625700E
Lower Staircase	782500S	1614500E
Lugger Glacier	765800S	1605000E
Mackay Glacier	765800S	1620000E
Mackay Glacier Tongue	765800S	1622000E
Marchant Glacier	780600S	1620300E
Marchetti Glacier	771100S	1613300E
Marin Glacier	760400S	1622200E
Marr Glacier	774300S	1624400E
Marston Glacier	765400S	1623000E
Mason Glacier	785300S	1614100E
Matterhorn Glacier	774100S	1622700E
Mawson Glacier	761300S	1620500E
McCleary Glacier	793300S	1565000E
McCraw Glacier	800700S	1563500E
McDermott Glacier	782000S	1620400E
McMurdo Ice Shelf	780000S	1663000E
Mercury Glacier	793400S	1571700E
Merrick Glacier	801300S	1585200E
Meserve Glacier	773100S	1621700E
Midship Glacier	765200S	1613000E
Miers Glacier	780500S	1634000E
Miller Glacier	771200S	1620000E
Mime Glacier	773700S	1614500E
Minerva Glacier	793412S	1571500E
Minnehaha Icefalls	770200S	1622400E
Mitchell Glacier	775700S	1630300E
Moa Glacier	774200S	1624600E
Mollweide Glacier	775700S	1634500E
Morning Glacier	782700S	1634800E
Mulock Glacier	790000S	1600000E
Nakai Snowfield	772900S	1613100E
Newall Glacier	773000S	1625000E
New Glacier	770200S	1622400E
Nordenskjöld Ice Tongue	761100S	1624500E
Norris Glacier	774000S	1621200E
Northwind Glacier	764000S	1611800E
Nylen Glacier	774100S	1612900E
Oates Piedmont Glacier	762500S	1623500E
Odell Glacier	764400S	1595500E
Odin Glacier	773500S	1613600E
Orestes Glacier	772700S	1615300E
Overflow Glacier	774700S	1631100E
Overturn Glacier	795400S	1571500E
Packard Glacier	772100S	1621000E
Pakaru Icefalls	773800S	1663900E
Palais Glacier	780200S	1611900E
Pascoe Glacier	764600S	1610100E
Peckham Glacier	802100S	1572500E
Pedalling Ice Field	771500S	1595500E
Petrel Glacier	771400S	1662800E

Table 3. Inventory of named glaciers and glaciological features on the coastal-change and glaciological map of the Ross Island area.—Continued

Feature Name	Location (latitude, longitude)	
Pipecleaner Glacier	781400S	1625100E
Plane Table Glacier	773400S	1612900E
Plummet Glacier	774700S	1615400E
Potter Glacier	782300S	1621200E
Prebble Icefalls	795400S	1555500E
Priddy Glacier	775600S	1640100E
Prion Glacier	772000S	1663500E
Pyne Glacier	770400S	1621800E
Pūanu Glacier	772330S	1605840E
Quaternary Icefall	771800S	1663000E
Radian Glacier	781300S	1630000E
Ragotzkie Glacier	800200S	1574500E
Ragotzkie Icefall	800300S	1580000E
Ramseier Glacier	803000S	1561800E
Renegar Glacier	782200S	1630800E
Repeater Glacier	772800S	1625100E
Rhone Glacier	774200S	1621400E
Rim Glacier	771300S	1602500E
Ringer Glacier	771500S	1615100E
Rivard Glacier	780400S	1635500E
Robson Glacier	770500S	1621100E
Ross Ice Shelf	813000S	1750000W
Rotunda Glacier	780000S	1613800E
Ruecroft Glacier	781300S	1614000E
Rutgers Glacier	781400S	1615500E
Salient Glacier	780600S	1630500E
Salmon Glacier	775800S	1640500E
Sandy Glacier	772900S	1615700E
Schlatter Glacier	774100S	1612700E
Schultz Glacier	771900S	1622000E
Schutt Glacier	781600S	1613100E
Scrivener Glacier	765700S	1613700E
Scudding Glacier	765400S	1604500E
Scuppers Icefalls	764800S	1613600E
Sefton Glacier	804500S	1565200E
Sennet Glacier	801200S	1584200E
Shark Fin Glacier	782300S	1625500E
Sharpend Glacier	765200S	1605600E

Table 3. Inventory of named glaciers and glaciological features on the coastal-change and glaciological map of the Ross Island area.—Continued

Feature Name	Location (latitude, longitude)	
Shearwater Glacier	771900S	1663100E
Sheathbill Glacier	7718.70S	1663600E
Shell Glacier	771600S	1662500E
Shimmering Icefield	763900S	1594400E
Skelton Glacier	783500S	1613000E
Skelton Icefalls	781400S	1581900E
Skelton Névé	782000S	1600000E
Sollas Glacier	774300S	1623600E
Solomon Glacier	782300S	1623000E
South America Glacier	774900S	1614700E
Spring Glacier	775500S	1630600E
Sprocket Glacier	771200S	1603400E
Stocking Glacier	774200S	1615000E
Stuckless Glacier	781600S	1661200E
Suess Glacier	773800S	1624000E
Sykes Glacier	773500S	1613200E
Taylor Glacier	774400S	1621000E
Tedrow Glacier	775800S	1615000E
Telemeter Glacier	774800S	1601200E
Tern Glacier	771700S	1663200E
Terra Nova Glacier	772700S	1674200E
Terror Glacier	773700S	1680300E
Topside Glacier	764200S	1605700E
Touchdown Glacier	794800S	1581000E
Towle Glacier	763800S	1610500E
Trepidation Glacier	784600S	1622100E
Tripp Ice Tongue	763400S	1624500E
Turnabout Glacier	774600S	1604300E
Twombley Glacier	803500S	1574500E
Upper Jaw Glacier	782100S	1625700E
Upper Staircase	781500S	1610000E
Valhalla Glacier	773400S	1615800E
Vereyken Glacier	782500S	1635700E
Victoria Lower Glacier	771800S	1624000E
Victoria Upper Glacier	771600S	1612500E
Victoria Upper Névé	771600S	1610500E
Von Guerard Glacier	773900S	1632000E
Waddington Glacier	780300S	1612700E

Table 3. Inventory of named glaciers and glaciological features on the coastal-change and glaciological map of the Ross Island area.—Continued

Feature Name	Location (latitude, longitude)	
Walcott Glacier	781400S	1631500E
Wales Glacier	773700S	1633100E
Walker Glacier	772000S	1603715E
Ward Glacier	781000S	1632700E
Warren Icefall	773300S	1602500E
Weatherwax Glacier	773800S	1633600E
Webb Glacier	771900S	1604500E
Webb Icefall	771600S	1602900E
Wildwind Glacier	765200S	1611000E
Williams Glacier	780600S	1621800E
Willis Glacier	771600S	1620500E
Wilson Piedmont Glacier	771500S	1631000E
Wirdnam Glacier	782500S	1620200E
Wright Lower Glacier	772500S	1630000E
Wright Upper Glacier	773200S	1603500E
Yancey Glacier	801400S	1583000E
Zeller Glacier	805500S	1563000E
Zetland Glacier	780100S	1634900E
Zoller Glacier	775300S	1621800E