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THE 1961 GEOLOGICAL RECONNAISSANCE IN THE SOUTHERN PRINCE CHARLES MOUNTAINS, ANTARCTICA.

by

D.S. Trail

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CONTENTS

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APPENDIX 1

Petrographic descriptions of samples,
by W.R. McCarthy.
(Australian Mineral Development Laboratories)

ILLUSTRATIONS

THE 1961 GEOLOGICAL RECONNAISSANCE IN THE SOUTHERN PRINCE CHARLES MOUNTAINS, ANTARCTICA.

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SUMMARY

The Prince Charles Mountains are located in Australian Antarctic Territory, in Mac-Robertson Land between 150 and 500 miles south of Mawson. The mountains are grouped around a 500-mile-long meridional depression in the continental ice cap formed by the Lambert Glacier and the Amery Ice Shelf.

In 1961 an Australian National Antarctic Research Expeditions party from Mawson extended the reconnaissance geological survey of these mountains to Mount Menzies and Mount Bayliss, south of the Fisher Glacier.

Inland ice in Mac-Robertson Land mostly drains into the great trough containing the Lambert Glacier. In the southern Prince Charles Mountains ice-flow north of the Fisher Glacier is complex. The Fisher Glacier and the Geysen Glacier are well defined. The south side of Mount Menzies maintains active mountain glaciers.

Most high nunataks have flat or gently rounded summit plateaux; some nunataks are fringed by moraine-covered benches or rock benches.

Large cirques originally formed by mountain glaciers on Mount Menzies are now abandoned or have been flooded by the ice cap.

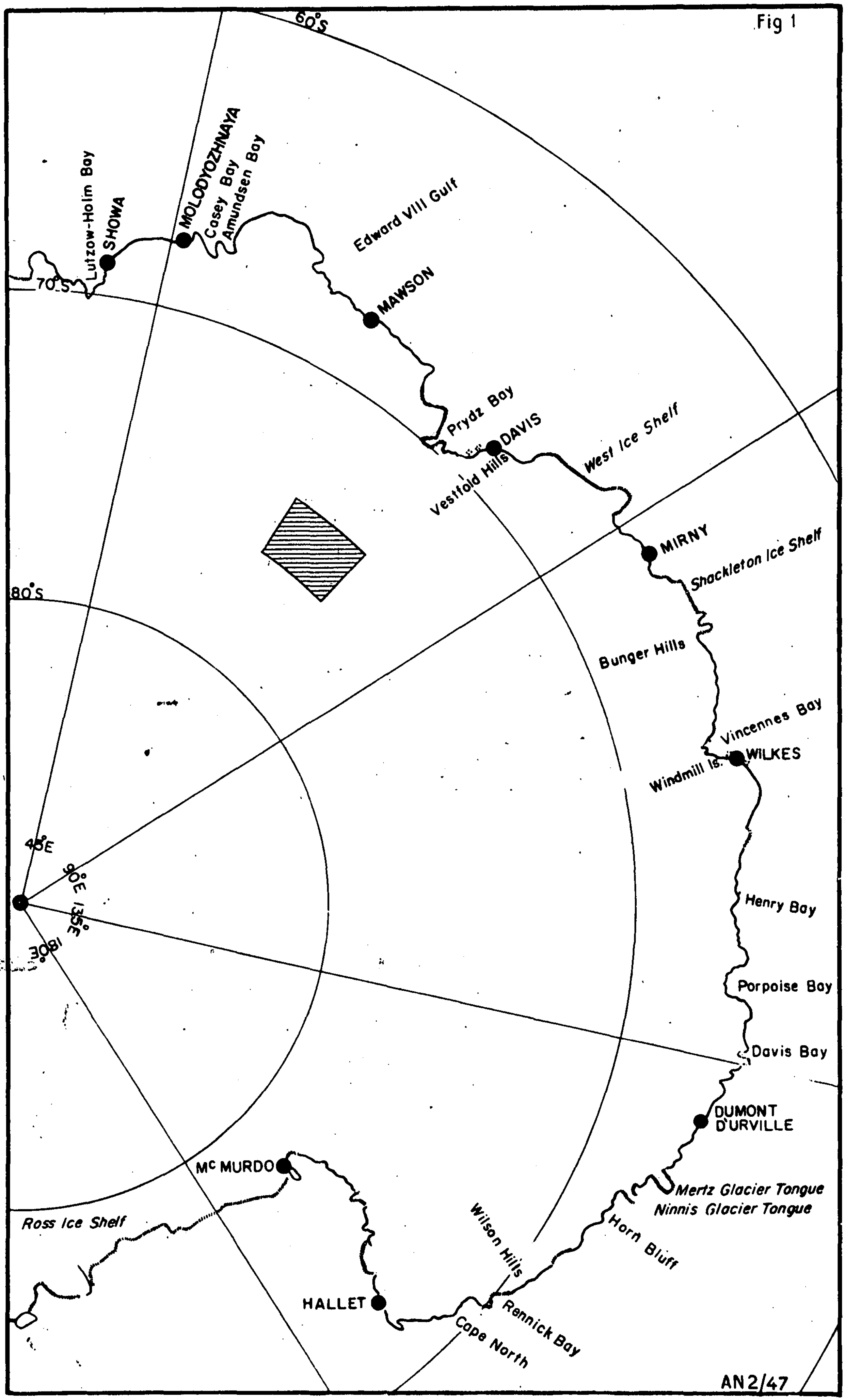
Unpatterned moraine appears to be younger than the widespread patterned moraine, which may have formed by the ablation of masses of moraine-charged ice.

The cirques of Mount Menzies may have been formed before the formation of the continental ice cap. The height of the ice cap has fluctuated greatly; it once stood between 2,000 feet and 4,000 feet higher than its present level. Mountain glaciers have also formed and have wasted away at various times on Mount Menzies.

The glacial features are controlled primarily by precipitation, and this in turn may be controlled by the position of the ice coast.

Mount Menzies is composed of quartzite containing bands of quartz-rich schist and amphibolite; all rocks are in the green schist facies of metamorphism.

Mount Bayliss is composed of sub-horizontal layers of quartzite, sheared granite, and amphibolite. At a nearby small nunatak, quartz reefs are developed in a contact between granite and marble. Thermal metamorphism is prominent, probably as a result of the emplacement of the granite. Later shearing has affected all rocks at Mount Bayliss.



LOCATION OF SOUTHERN PRINCE CHARLES MOUNTAINS ANTARCTICA

Among the amphibolites there is no structural distinction between metamorphosed impure limestones and metamorphosed basic igneous rocks.

The quartzites were probably derived from a land mass composed mainly of Precambrian gneisses. The low-grade may have been metamorphosed in Lower Palaeozoic times.

Mac-Robertson Land has probably persisted as a land-mass since the Lower Palaeozoic. Permian sediments have been found by Crohn (1959) and Ruker (1963)

Boxworks in quartz reefs at Mount Bayliss and fluorite in granite intruding the low-grade metamorphic rocks suggest that metallic minerals may be associated with these granites.

Further exploration in these mountains should be carried out between November and February by ground parties with air support or by parties using air transport.

INTRODUCTION

General

The Prince Charles Mountains (Fig.1) are located in Mac-Robertson Land in Australian Antarctic Territory between latitudes 69°30'S. and 74°30'S., and longitudes 60°E. and 70°E. between 150 miles and 500 miles south of Mawson. They are grouped around a 500-mile-long meridional depression in the continental ice cap formed by the Lambert Glacier and the Amery Ice Shelf.(Fig. 2). The mountains are nunataks (rock masses surrounded by ice,up to 50 square miles in area. The higher nunataks rise between 4000 and 8500 feet above sea level. Mount Menzies is exceptional and exceeds 11,000 feet.

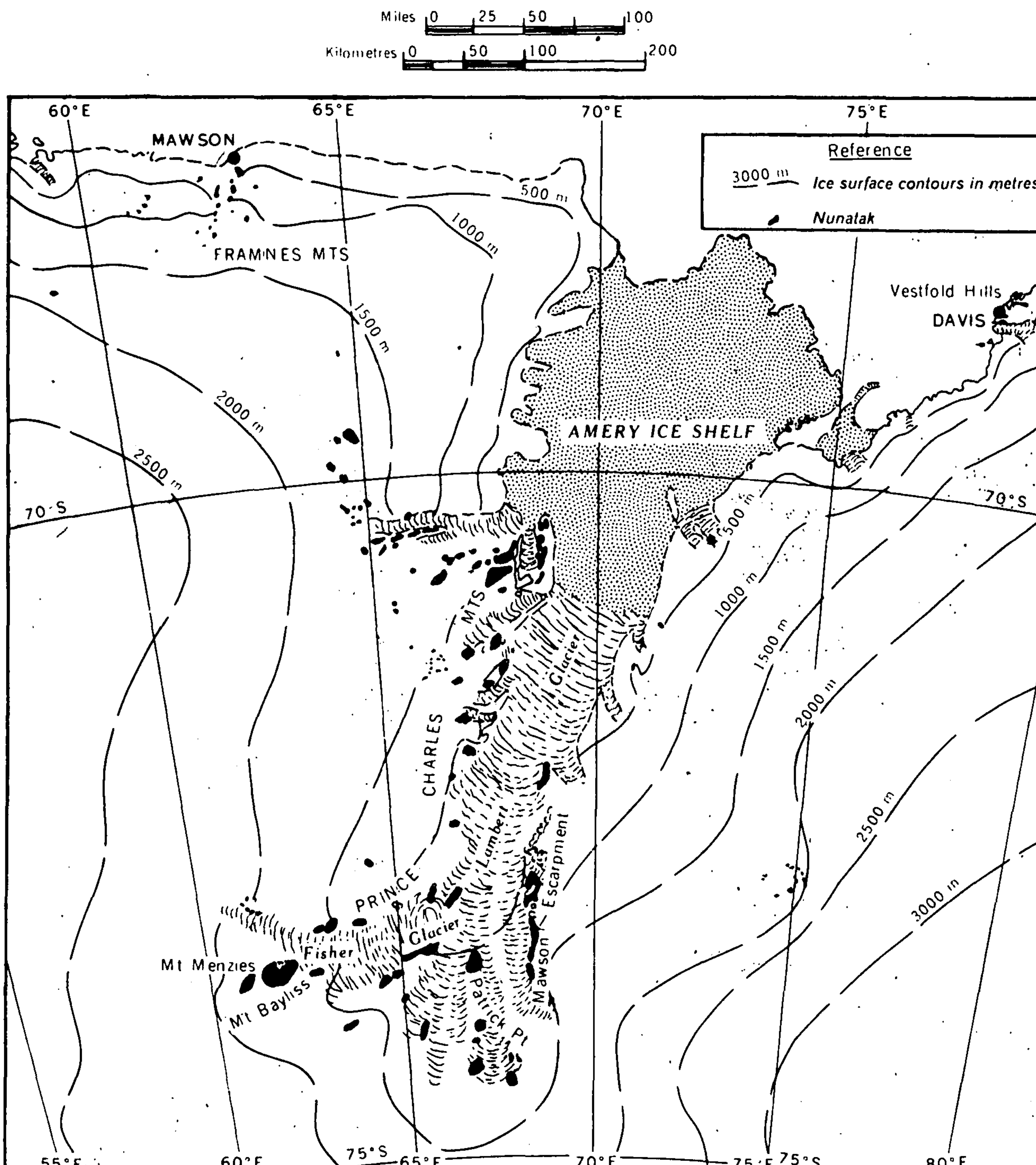
The Prince Charles Mountains were discovered in December, 1954, by R.G. Dovers, B.H. Stinear, and R.O. Summers, of the Australian National Antarctic Research Expeditions (ANARE) who travelled 150 miles south from Mawson to the northern outliers named the Stinear Nunataks. Since then ANARE exploration of the Prince Charles Mountains has progressed steadily by direct examination and by aerial photography.

The long meridional depression reaching from the sea to the southern Prince Charles Mountains, produces an inland extension of climatic effects normally found adjacent to the Antarctic coast. In December and January cumulus cloud and falls of snow are frequent in the southern ranges 400 miles from the sea; at 8,000 feet on the Mac-Robertson Land ice cap 200 miles nearer the coast, the precipitation of ice crystals from cirrus clouds was seen on several days. Temperature is also more a function of altitude than latitude in summer. In the southern ranges in December, temperatures between 5°F and -5°F were normal at altitudes between 4000 feet and 6000 feet. At 7000 feet on the Mac-Robertson Land ice cap, temperatures between 0°F and -20°F were common in December and January.

As observed by Mather (1962) there is a progressive change in the direction of the katabatic wind between Mawson and the southern ranges of the Prince Charles Mountains. The wind direction is south-south-east at Mawson, south on the ice cap about 120 miles south of Mawson, and south-west in the southern mountains. Wind velocity appears to decrease southwards from Mawson, and north of the Fisher Glacier light winds probably prevail. On the Fisher Glacier and among the mountains south of it a strong south-westerly katabatic wind blew on most

Fig. 2.

PRINCE CHARLES MOUNTAINS
ANTARCTICA



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days between 16th and 29th December, 1961. This wind sprang up suddenly at 2100 GMT (0100 Zone Time), and blew at speeds between 15 and 30 knots until 0700 GMT after which the wind steadily decreased.

Poor visibility frequently prevents oversnow travel in the Prince Charles Mountains. It is caused by overcast sky producing a "whiteout", in which snow surface features cannot be distinguished, or by large quantities of snow drifting in a strong wind and producing a dense drift haze. A geologist may well be able to work on a rock surface under such conditions.

De Havilland "Beaver" aircraft operating from Mawson or Davis have landed at several points in the Prince Charles Mountains on flat areas of snow or ice. Proved landing grounds are located at Jetty Peninsula, Beaver Lake, Grove Nunataks, Clemence Massif, Fisher Massif, Mawson Escarpment in latitude 73°33', Mount Stinear, and Wilson Bluff. Beaver and DC-3 aircraft have landed at Binders Nunataks on a snow airstrip prepared by a bulldozer.

In 1954, 1955, and 1956, light tracked vehicles (weasels) reached the northern outliers of the Prince Charles Mountains along a route running south-south-east from Mawson via Depot Peak and the Stinear Nunataks. Crohn (1959) records that the terrain within the northern ranges is too dangerous for vehicles; in 1956 exploration there was carried out entirely by dog sledge.

Tractor trains, composed of D-4 Caterpillar tractors pulling several heavy sledges, reached the southern ranges of the Prince Charles Mountains in 1957 and 1960. Both parties travelled south from Mawson along the 62nd meridian, and both experienced great difficulty with crevasses within 20 miles of the mountains. In 1960 Ruker (1963) made a geological traverse along the north side of the Fisher Glacier. He used a weasel, with a dog team for emergency transport. The weasel broke through a crevasse at Mount Scherger and was recovered with great difficulty. Ruker suggests that tractor trains may be able to reach Mount Seddon, on the north side of the Fisher Glacier, and that light vehicles or dog sledges may be able to cross the Fisher Glacier to Mount Rubin from Mount Seddon. Following a reconnaissance map prepared by Ruker a dog sledge route was found across the Fisher Glacier from Binders Nunataks to Mount Menzies in 1961. This route may be suitable for light tracked vehicles.

A caravan with a depot containing small quantities of man food and petrol was located in 1961 at a small rock outcrop about one mile north-west of the west end of the largest of Binders Nunataks. The depot was on the small outcrop, the caravan is 30 yards north-east of it. The caravan was buried in snow but provided excellent shelter. It was poorly ventilated and THE DANGER OF CARBON MONOXIDE POISONING WAS VERY GREAT, when a stove or heater was burning.

A small depot of dog food and man food was left in 1961 on the ice cap along the route from Mawson to the southern ranges of the Prince Charles Mountains, in latitude 70°33.3'S., longitude 62°29.8'E., about sixty miles west of the west end of the Porthos Range. About five miles south of this depot were two snow cairns spaced about a mile apart, each containing a small quantity of dog food.

A large fuel dump containing kerosene and petrol was left in 1961 on the ice cap in latitude 68°48'S., longitude 62°07'E. On the north side of this fuel dump a snow cairn contained a small amount of dog food and a very small amount of man food.

Between Mawson and the depot in latitude 70°33.3'S. the track of the 1961 tractor party was marked by drums, snow cairns, and flags spaced at intervals ranging from ½ mile to 5 miles. Between this depot and Binders Nunataks the track of the 1961 dog party was marked by snow cairns and flags at intervals ranging from 1 mile to 4 miles. Of these markers, only some drums and some bamboo flagstaffs will remain for any length of time.

Field Work.

Personnel of the Australian National Antarctic Research Expedition manning Mawson base in 1961 were directed to travel by tractor train to the southern ranges of the Prince Charles Mountains in October of that year, and to use light tracked vehicles to explore the mountains south of the Fisher Glacier.

In April, 1961, during a fuel-dumping operation in connection with this program, the two D-4 tractors at Mawson were immobilised 50 miles south of the base, and were abandoned for the winter. The plan for the journey to the Prince Charles Mountains was shelved.

On the recovery of these tractors in October, 1961, the Officer-in-Charge at Mawson was directed to use them to recover a third D-4 tractor abandoned for lack of fuel, 200 miles south of Mawson, by the 1960 party on returning from the Prince Charles Mountains.

D. Keyser, radio operator, suggested that the tractor party might support a dog-sledge party which could then reach the 1960 depot at Binders Nunataks, on the northern fringe of the southern Prince Charles Mountains.

D. Trail, geologist, D. Keyser, and J. Seavers, assistant cook, with two five-dog teams, reached this depot on 12th December, 1961, and using a route map prepared by Ruker (1963) crossed the Fisher Glacier and mapped the geology of Mount Bayliss and Mount Menzies. They spent five days in attempts to reach Keyser Ridge 40 miles south-east of Mount Menzies, and Mount Ruker and Mount Rubin, 60 miles east of Mount Menzies. Both attempts were stopped by a continuous zone of large crevasses occupying the south-eastern side of the Geysen Glacier.

The party turned on 26th December and retraced their outward route, arriving at Mawson on 27th January, 1962.

In crossing the ice cap and in route-finding among the mountains the party used 1:500,000 scale maps compiled by the Division of National Mapping. These maps are based on Royal Australian Air Force trimetrogon photography tied to astronomical observations by ANARE surveyors. One run of trimetrogon photographs was available to the field party. Information obtained in the field was plotted, on return to Australia, on large scale sketch maps drawn from further RAAF trimetrogon photography made in 1960.

While travelling on the ice cap, the dog sledge party steered by the sun. In poor visibility the party steered by the sastrugi - wind-cut snow ridges - which are locally constant in direction. The course was checked hourly by a careful magnetic compass reading. The lack of a distance recorder on the dog sledge caused great inconvenience. Observations of the sun were made each suitable day with a bubble sextant, for latitude by meridian passage, and for longitude by position line. Neither the magnetic compass nor the bubble sextant was dependable. An astrocompass and a light theodolite would probably be more suitable for navigation.

A geologist intending to work in Antarctica should learn to use a light theodolite for celestial and distant terrestrial observations.

On gentle slopes in the Prince Charles Mountains, bedrock is commonly concealed under a thick blanket of moraine. Steep slopes provide excellent exposures, but these may be inaccessible because of disturbed ice lying against them.

In any wind, note-taking is difficult, and through the day the geologist normally makes very brief notes, which are expanded in the shelter and warmth of the tent in the evening. The examination of specimens by hand lens in the field is very difficult, since the lens almost always becomes coated with ice.

PREVIOUS WORK

The geological reconnaissance of the northern ranges of the Prince Charles Mountains is reviewed by Crohn (1959).

In 1957, M. Fisher, surveyor at Mawson, was landed at Mount Stinear in the southern Prince Charles Mountains (Fig. 4). From the moraine along the eastern side of the mountain he collected samples of massive biotite granite, amphibole gneiss, mica schist, and slate.

At the southern limit of an oversnow seismic traverse from Mawson in January 1958, M. Mellor, glaciologist, collected samples of massive granite, metamorphosed sandstone, and hornfels, from moraine at the Goodspeed Nunataks, the north-western outliers of the southern Prince Charles Mountains. The samples are described by McLeod (1959).

Later in 1958, McLeod (1959) landed at Wilson Bluff, near the southern termination of the Prince Charles Mountains. He found outcrops of mica schist, quartzite, and amphibole-bearing rocks, quite unlike the gneisses which form the northern ranges of the Prince Charles Mountains.

In 1960 a field party from Mawson travelled by tractor to the southern Prince Charles Mountains. From their depot at Binders Nunataks, Ruker (1963) reconnoitred the mountains north of the Fisher Glacier.

Ruker found that Binders Nunataks and Mount Creswell are composed of high-grade metamorphic rocks, typically biotite gneisses. Mount Bloomfield is sheared granite. The large mountains fringing the Fisher Glacier are dominantly composed of quartzites and mica schists, low-grade metamorphic rocks in the greenschist facies of metamorphism (Fyfe, Turner, & Verhoogen, 1958). They are intruded by large bodies of massive granite and by amphibolite dykes. In moraine fringing Mount Rymill, Ruker discovered fragments of red sandstones and shales, with Glossopteris and other plant fossils determined as Permian by Mary White (1962).

Ruker (1963) was flown to the Mawson Escarpment in 73°33'S., where he found high-grade metamorphics, including staurolite schist.

PHYSIOGRAPHY

General

The form of the inland ice in Mac-Robertson Land is dominated by the huge meridional trough, over 300 miles long and 20 to 60 miles broad, which contains the Lambert Glacier and the southern part of the Amery Ice Shelf (Fig.2).

This trough so greatly facilitates the drainage of the inland ice to the sea that the surface of the continental ice cap is considerably depressed throughout Mac-Robertson Land. 300 miles inland, the surface of the Lambert Glacier lies only 500 feet above sea level. The normal height of the continental ice cap at this distance from the coast is about 8,000 feet. Between 100 and 200 miles east and west of the Lambert Glacier the ice cap surface slopes gently towards it, and the overall depression in the ice cap runs southwards for at least 500 miles from the coast.

The form of the ice cap surface in Mac-Robertson Land suggests that the inland ice flows directly into the sea north of the 70th parallel only. South of this parallel the accumulated ice in Mac-Robertson Land, together with ice from western Princess Elizabeth Land and ice from south-eastern Kemp Land, flows radially inwards towards the Lambert Glacier and the Amery Ice Shelf. Broad, east and north-east trending rock valleys, occupied by the Fisher Glacier and other huge ice streams, supply ice to the Lambert Glacier along its western side. The west-trending rock ridge mapped by Goodspeed and Jesson (1959) under the ice west of Stinear Nunataks, about latitude 69°40'S., may dam the northward flow of the ice west of the Prince Charles Mountains and divert it towards the Lambert Glacier. The ice cap east of the Lambert Glacier is to some extent cut off from it by the north-trending range of mountains whose western face is exposed in the Mawson Escarpment.

The high rock walls of many glacier valleys are partly exposed above the ice cap as nunataks. Near the junction of the Lambert Glacier with the Amery Ice Shelf, the lowest part of the depression in the ice cap, many large nunataks form the northern ranges of the Prince Charles Mountains. The southern ranges of the Prince Charles Mountains are formed by the exposed tops of the rock walls containing the upper Lambert Glacier, the Fisher Glacier, and other large tributaries of the Lambert Glacier (Fig.3).

Ice Cap

The 1961 geological party crossed the inland ice between Mawson and the southern Prince Charles Mountains along the 62nd meridian, following the route taken by geophysical parties in 1957 and 1958 and by the geological party in 1960.

The surface of the ice cap along this route has been described by Mather and Goodspeed (1959) and by Mather (1962).

From the sea at Mawson the blue ice surface of the ice cap rises for 20 to 30 miles through the marginal ablation zone to an altitude between 2,000 and 3,000 feet. At this height and distance from the sea the ice surface passes under the cover of wind-compacted snow (névé) which forms the greater part of the ice cap surface in the accumulation zone.

The neve surface is almost everywhere cut by the wind into sastrugi, low closely packed ridges parallel to the prevailing wind-direction, which range from a few inches to 2 or 3 feet in height, Where the wind has eroded a mound or dune of compacted snow, steep-sided ridges may rise 5 feet or more.

In 1961, between latitudes 69°S, and 72°S. patches, several miles wide, of sastrugi up to 2 feet high appeared to be separated by equally wide patches of relatively smooth névé carrying sastrugi less than 1 foot high. The broad patches of high sastrugi probably correspond to the snow "waves" from 2 to 6 kilometres wide described by Dolgushin (1960) between Mirnyy and Pionerskaya.

As described by Mather (1962) the sastrugi direction changes from south-south-east near Mawson through south to south-west in the region of the southern Prince Charles Mountains. Mather attributes this systematic change to the diversion of the katabatic wind - the seaward-flowing current of dense cold air - into the deep trough of the Lambert Glacier.

From an altitude of 4,000 feet at the southernmost nunataks of the Framnes Mountains, 45 miles south of Mawson, the névé surface of the inland ice along the 62nd meridian rises gently with an overall gradient between 1 in 150 and 1 in 300 to reach an altitude of 7,000 feet at 69°38'S. 155 miles south of Mawson. For the greater part of this distance, the névé surface is a succession of ill-defined and very gentle undulations. Crest to crest, the undulations are several miles apart and they rarely exceed 50 feet in amplitude. About 68°30'S., between 70 miles and 80 miles from Mawson, a group of steep, north-facing, neve ridges and domes forms a step about 100 feet high in the surface of the ice cap. The face of the step has a gradient of about 1 in 100. The crests of the domes and ridges carry large crevasses up to 20 feet broad. This zone of disturbed ice is located on the northern edge of a depression in the rock surface, 3,000 feet deep and 30 miles wide, mapped by Goodspeed and Jesson (1959). The southern edge of the depression is marked at the surface by a six-mile-wide zone of low névé domes.

At 69°38'S. the north face of a steep névé dome rises abruptly between 100 and 200 feet; the crest of the dome is broken by hugh crevasses over 50 feet wide. For 35 miles south of this dome the névé surface is disturbed by steep domes and ridges with irregular hummocky surfaces and with large snow-filled crevasses on their crests. The névé surface is little disturbed in the broad valleys between the domes, but valley floor gradients are locally steeper than 1 in 100.

These domes and ridges overlie a high, steep-sided, west-trending rock ridge mapped by Goodspeed and Jesson (1959), which rises 3,000 feet to approach within 1,000 feet of the ice cap surface.

South of this disturbed zone the névé surface of the ice cap rises in gentle undulations from 7,700 feet to reach 8,000 feet at 70°15'S. where it levels out as a gently undulating surface extending to 70°30'S.

From 70°30'S. to 71°S. the ice cap surface falls gently for 500 feet, but the undulations in the surface are more clearly defined over this distance. They form a succession of broad hills and closed valleys. The crests of the hills are spaced between 3 and 5 miles apart; the hills rise between 50 and 100 feet. The valleys are commonly elliptical; their long axes trend eastwards.

At 70°54'S. a small névé dome marks the southern edge of a 1500 foot rise in the rock surface, mapped by Goodspeed and Jesson (1959).

South of 71°S. the snow-surface undulations increase in amplitude, exceeding 100 feet, and their south-facing slopes steepen. Locally, gradients may exceed 1 in 100. Between latitude 71°27' and latitude 71°40' there are at least three distinct south-facing steps in the ice cap surface. They are spaced between 5 and 10 miles from each other; the highest falls about 200 feet; gradients on the steps approach 1 in 50. In this area the undulations in ice cap surface, as Mather and Goodspeed (1959) observed, develop a distinct easterly slope, and the valleys between the swells visibly broaden and deepen eastwards towards the Lambert Glacier.

This markedly undulating, east-sloping surface continu continues to descend gently to 72°S. where there is a sharp change. Here a steep, south-east-facing snow slope drops about 150 feet into a narrow snow valley, closed at its north-east end, which descends and widens south-westwards. From the slope above this valley, Mount Menzies, Mount McCauley, and Mount Scherger are clearly seen in good weather.

The low south-east wall of the valley is a névé ridge with cracks and small crevasses on its crest. Southwards this ridge rises and broadens into a line of large neve domes, over 100 feet high and more than 3 miles broad, carrying large crevasses; the line extends at least 13 miles south, towards the Goodspeed Nunataks.

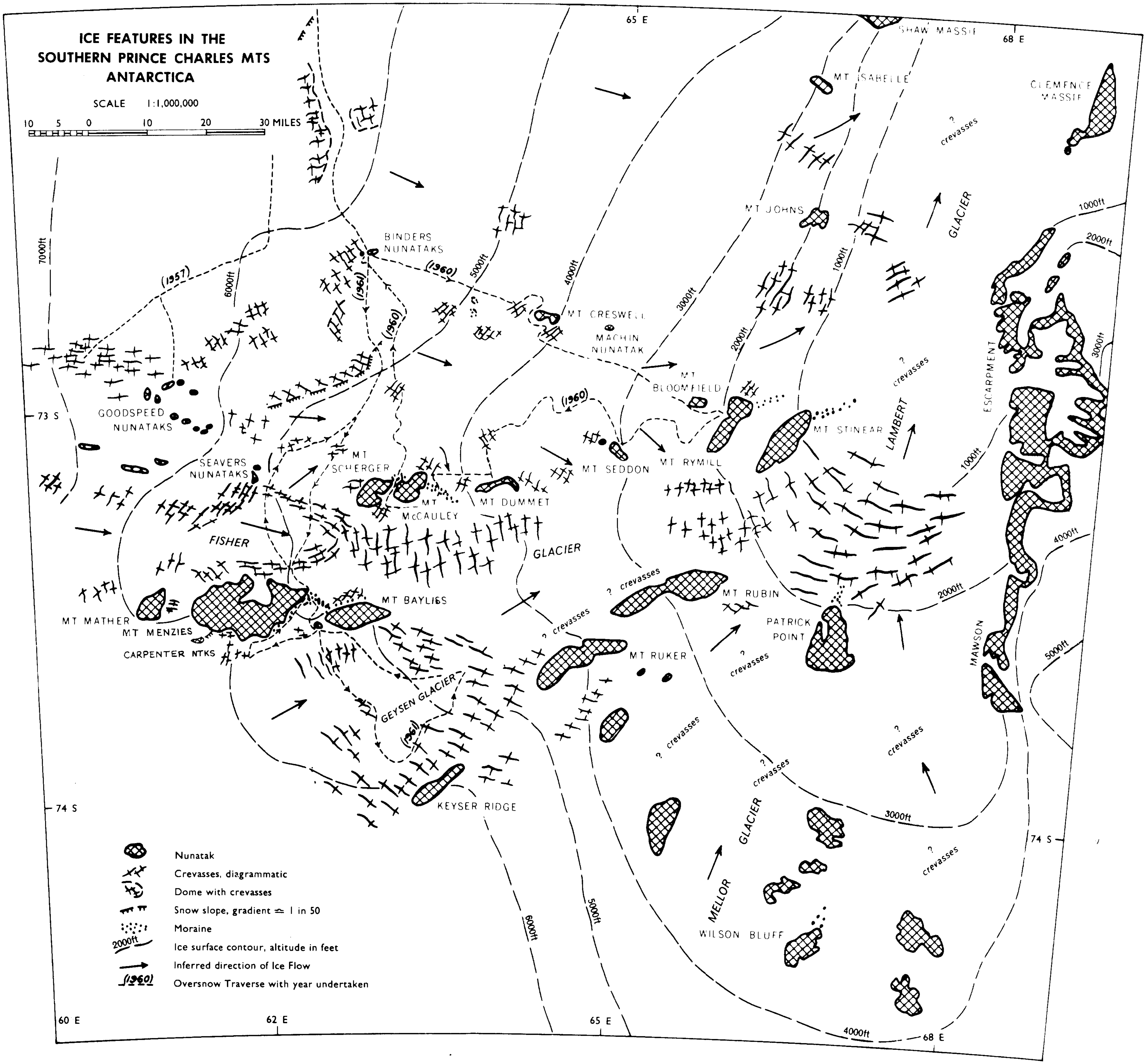
This disturbed region overlies the north-west trending extension, mapped by Goodspeed and Jesson (1959), of the rock ridge which breaks the surface at Binders Nunataks and Mount Creswell, the northern outliers of the southern ranges of the Prince Charles Mountains.

Glaciers

Ground observations in the southern Prince Charles Mountains are augmented by information collected by Ruker (1963) and by airphoto interpretation. Figure 3 shows the ice features of the southern Prince Charles Mountains.

From the western side of Binders Nunataks a succession of high and steep névé domes with large crevasses runs southwards for 15 miles to merge with an elongated névé ridge which runs 25 miles south-westwards to the Goodspeed Nunataks. The south side of this ridge is about 200 feet high, the north side is considerably lower. On its crest and on its south side the ridge has large crevasses. South of the ridge a broad basin of smooth névé, with a few small domes and patches of concealed crevasses, stretches 20 miles to the north side of the Fisher Glacier.

Fig. 3



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Between Binders Nunataks and the Fisher Glacier, and along the north side of that glacier to its confluence with the Lambert Glacier, ice flow is complex.

A small glacier flows eastwards from the Goodspeed Nunataks to merge with the disturbed ice flowing south-eastwards between Binders Nunataks and the Goodspeed Nunataks and passing north of Mount Scherger and Mount McCauley. The Fisher Glacier is constricted between Mount Menzies and Mount Scherger, and the distribution of crevasses around Mount Scherger, together with flow lines west of Mount Scherger, suggests that some ice from the constricted Fisher Glacier is diverted northwards around Mount Scherger.

The constriction in the Fisher Glacier is relieved east of Mount McCauley and Mount Bayliss, and ice from the 30-mile-broad area between Mount McCauley and Mount Creswell flows into the Fisher Glacier between Mount McCauley and Mount Dummet, between Mount Dummet and Mount Seddon, and between Mount Seddon and Mount Rymill. The Fisher Glacier, greatly augmented by these northern tributaries and by its large south-eastern tributary the Geysen Glacier, is again constricted between Mount Stinear and Mount Rubin. The ice occupying the valley between Mount Rymill and Mount Stinear appears to be stagnant.

North of Mount Stinear the surface of the ice cap dips sharply down to the Lambert Glacier, and an enormous quantity of ice must here flow into the glacier along its western side from the ice cap north of Mount Creswell.

The Fisher Glacier, the most prominent and most clearly defined tributary of the Lambert Glacier, has its source in the ice cap west of 60°E., over 7,000 feet above sea level. The glacier falls 5,000 feet in 120 miles to its confluence with the Lambert Glacier. Over most of its length the Fisher Glacier is about 25 miles broad; its breadth is reduced to 16 miles between Mount Menzies and Mount Scherger.

West of Mount Menzies, the upper part of the Fisher Glacier carries large areas of disturbed ice, domes, and ice falls with hugh crevasses and seracs. The eastern limit of this disturbed area is marked by the large ice fall which runs for several miles south-westwards from Seavers Nunataks.

Within about 4 miles of the northern sides of Mount Menzies and Mount Bayliss, and probably of Mount Mather, the névé surface of the glacier has been stripped off by wind or by radiation to expose blue ice. North of Mount Menzies this blue ice zone is broken by large and small longitudinal crevasses (parallel to the direction of ice flow) and by potholes filled with soft snow. Ruker (1963) records that blue ice forms the surface of the north side of the Fisher Glacier east of Mount Scherger.

The proved dog-sledge route across the Fisher Glacier runs in a straight line from a point about 1½ miles east of Seavers Nunataks to the north-east corner of Mount Menzies (Fig.3). This route crosses small and well-bridged longitudinal crevasses within a few miles of Seavers Nunataks, and runs over several miles of smooth névé to the edge of the blue ice zone north of Mount Menzies. In this zone the route runs for 3 or 4 miles over narrow longitudinal crevasses and rough, potholed blue ice, to south-sloping smooth blue ice within 1 mile of the mountain.

A few miles east of this route steep longitudinal névé ridges develop along the north side and the centre of the glacier, as the ice is constricted between Mount Menzies and Mount Scherger. Large longitudinal crevasses in these ridges increase eastwards in size and number. Some are 60 feet wide, others have their lips contorted upwards as steep névé hummocks up to 8 feet high.

Between Mount Bayliss and Mount Scherger the longitudinal ridges unite in a mass of intensely deformed ice several miles broad; rising several hundred feet above the margin of the glacier. The surface of the glacier is broken by lateral and diagonal crevasses over 100 feet wide, and by high séracs. The uplifted area of disturbed ice ranges from 5 to 10 miles in breadth and occupies the centre of the glacier for at least 30 miles, from Mount Scherger to Mount Dummet.

The surface of the Fisher Glacier appears to be relatively little disturbed between Mount Rubin on the south and Mount Dummet and Mount Seddon on the north, and Ruker (1963) has suggested that the glacier may be crossed here. However, a zone of crevasses may exist along the north side of Mount Rubin.

Between Mount Rubin and Mount Rymill the Fisher Glacier, augmented by its south-eastern tributary, the Geysen Glacier, is again constricted and its surface is raised up in two broad areas of crevasses and seracs which converge eastwards into the area of intensely deformed ice which occupies the confluence of the Fisher, Lambert, and Mellor Glaciers.

The Geysen Glacier is the north-east flowing stream of ice located south-east of Mount Menzies and north-west of Keyser Ridge, which joins the Fisher Glacier at Mount Ruker. This glacier has its source in the ice cap south of Mount Mather at an altitude of over 7,000 feet. The surface of the glacier south of Mount Menzies is about one thousand feet higher than the surface of the Fisher Glacier north of Mount Menzies. As a result of its relatively steep gradient, the Geysen Glacier carries many extensive areas of disturbed ice.

West of Keyser Ridge a succession of neve domes with large crevasses extends northwards towards Mount Mather. A continuous 8-mile-broad zone of large lateral crevasses extends along the north-west side of Keyser Ridge to the north-west side of Mount Ruker where it broadens to merge with an area of large crevasses extending from the east end of Mount Bayliss. A broad névé dome with large crevasses is located about 3 miles south of the west end of Mount Bayliss.

Between Mount Menzies and Mount Bayliss a steep slope of undisturbed blue ice, about 1,000 feet high, provides a safe route from the Fisher Glacier to the south side of Mount Menzies. There are a few small crevasses and potholes in the blue ice at the top of the slope.

Debris from the southern cliffs of Mount Menzies accumulates as lateral moraine on this slope and moves very slowly downhill to augment a broad area of moraine overlying almost stagnant ice at the north-east corner of the Mount Menzies massif. This area of moraine lies in an ice depression about 100 feet lower than the southern margin of the Fisher Glacier. Some of the moraine has been caught up by the Fisher Glacier and has been drawn out across the foot of the slope as far as the broad area of stagnant moraine on the north side of Mount Bayliss.

Although this blue ice slope is steep, it appears to be composed of very slow-moving ice, probably cut off from the abundant supply of ice south of Mount Menzies by a submerged rock bar running between Mount Menzies and Mount Bayliss.

The stagnant ice occupying the outer part of the floor of the large abandoned cirque on the north side of Mount Menzies, is depressed about 100 feet below the south margin of the Fisher Glacier.

A snowfield about 4 miles long, east to west, by 1 mile broad lies high on the south side of Mount Menzies close below the summit. This snowfield feeds two glaciers. One is a 4-mile-wide, steep mountain glacier which flows more than 3,000 vertical feet down the southern cliffs of Mount Menzies in a series of ice falls. It continues southwards from the foot of the mountain as a distinct upraised ice stream with large crevasses for at least two miles before it loses its identity in the great mass of ice flowing north-eastwards towards the Fisher Glacier. The other glacier fed by the snowfield flows gently eastwards for 4 miles along the broad east ridge of the mountain and terminates among the patterned ground at the south end of the east platform.

The present accumulation of snow on the south side of Mount Menzies is evidently great enough to feed these glaciers though one large and several small mountain glaciers previously occupying cirques on the north side of the mountain have been starved out of existence.

Nunataks

With the exception of Mount Menzies, the large nunataks in the southern ranges of the Prince Charles Mountains have flat or gently rounded platform summits.

Crohn (1959) records that platform summits are common in the northern ranges of the Prince Charles Mountains. Many nunataks around the inner edge of the Amery Ice Shelf have very flat tops.

The platform summits lie at various levels up to 8,500 feet above sea level. The platforms are not simply concordant and they cannot be directly related to a simple, pre-glacial peneplain. Crohn (1959) suggests that faulting has produced the discordance of the levels.

The Fisher Massif and the Clemence Massif, nunataks at the edge of the Lambert Glacier, have broad flat benches developed well below their gently rounded summits.

Mount Menzies has broad moraine-covered benches on its east and west flanks. These are linked by a narrow, rock-floored bench cut along the north side of the mountain. These benches are roughly concordant with the broad, flat summit of Mount Bayliss, 5 miles east of Mount Menzies.

The east bench of Mount Menzies is composed of glacial debris, exposed to a depth of 150 feet in one dry valley, banked between the main mass of the mountain and the low rock peaks along the north side of the platform. The platform has been built by the accumulation of glacial debris.

The west platform was not visited; it appears to be similar from air photographs.

The flat summit of Mount Bayliss has large striae, seen on air photographs, running parallel to the present ice-flow direction. The upstream face of the mountain is rounded and the downstream face is abrupt and craggy, thus the mountain has the form of a roche moutonnée, a rock rounded by flowing ice.

The benches may be remnants of old valley floors. Since the floor of the Fisher Glacier probably lies well over 2,000 feet below the prominent bench on the north side of Mount Menzies, this interpretation involves the removal of an enormous mass of rock. However, the glaciers of the Prince Charles Mountains are among the largest glaciers in the world, and they may well be capable of eroding and transporting such quantities of rock.

In the European Alps similar benches have been attributed to erosion by tributary glaciers confined to the side of the parent mountain by the lateral pressure of the great glaciers (Charlesworth, 1957). The benches of the Prince Charles Mountains may have a similar origin.

Mount Menzies is essentially an east-west trending rock ridge between 15 miles and 20 miles long. On its north side subsidiary ridges separated by cirques drop gently to the Fisher Glacier.

Along the south side of Mount Menzies the surface of the ice cap is at least 1,000 feet higher than the surface of the Fisher Glacier. Subsidiary ridges on the south side of the mountain drop steeply between 3,000 feet and 5,000 feet to the ice cap surface. A small nunatak 4 miles south-west of the mountain is connected to it by a low ice ridge.

The most prominent feature on Mount Menzies is the great northern cirque which almost bisects the mountain. This cirque is about 5 miles long by 1½ miles broad, and its walls reach 4,000 feet in height. The cirque has been eroded by a large north-flowing mountain glacier originally located high on Mount Menzies. At present there is no significant accumulation of permanent snow in the cirque. It is floored mainly by patterned moraine with a small strip of unpatterned moraine along the inner edge of a depressed area of stagnant ice bordering the Fisher Glacier.

On the north-east side of Mount Menzies several small cirques are located at the heads of small glaciated valleys cut for the most part in the patterned moraine of the eastern platform; one valley cuts moraine at least 150 feet thick. Most of these valleys contain large patches of neve. Moraine on their floors is unpatterned. The valleys commonly contain one or more heaps of moraine which stretch across their floors as steps or mounds up to 15 feet high.

On the south side of Mount Menzies the pattern of the rock ridges reveals at least two large cirques, comparable in size to the great cirque on the north side, which are partly concealed by the present high level of the ice cap. The upper part of one, located below the summit of the mountain, contains the steep, active mountain glacier referred to above. The upper part of the other is empty.

The radiation of solar heat from the great area of dark rock exposed on the northern side of the mountain probably prevents the persistent accumulation of snow in all but the most sheltered situations, and the present prevailing wind direction also affects adversely the accumulation of snow on the north side of the mountain'. On the south side, though previously eroded cirques are now occupied by the continental ice cap, the accumulation of snow is sufficient to maintain active mountain glaciers high on the mountain.

GLACIAL GEOLOGY

The glacial debris has been divided into unpatterned moraine and patterned moraine. Much of the unpatterned moraine has been moulded by glacial action into distinct forms - steep straight mounds, or long sinuous mounds - which nevertheless do not constitute patterned ground as defined by Washburn (1956).

Unpatterned Moraine

Unpatterned moraine forms the lateral moraines of the active glaciers and is commonly found overlying bedrock up to about 100 feet above and near the present ice surface. Unpatterned moraine is also found up to 1000 metres above the ice surface on some nunataks, on the floors of dry valleys previously occupied by mountain glaciers.

The unpatterned moraine overlying or adjacent to the active ice streams commonly forms long, low sinuous ridges, up to about 10 feet high, roughly parallel to the direction of ice flow. In the dry valleys on some nunataks, straight steep-sided mounds of unpatterned moraine, up to 15 or 20 feet high, are elongated across the valleys. These are terminal moraines, and mark pauses in the recession of the mountain glaciers. In one shallow dry valley on Mount Menzies there are at least seven terminal moraines.

The unpatterned moraine is an unsorted accumulation of pebbles, cobbles, and boulders. Fine-grained material is notably rare. The fragments are mainly sub-angular; the largest are angular. They range up to 10 feet in diameter; the majority are between one inch and 2 feet in diameter.

Patterned Moraine

Moraine lying on the broad summit plateaux of many nunataks, and on the broad benches which flank many nunataks, and some moraine extending from these benches down gentle slopes to the present ice level, is commonly arranged in regularly spaced and similar sub-conical mounds approximating to the type of patterned ground defined by Washburn (1956) as unsorted nets.

Extensive areas of patterned moraine were superficially examined on Mount Bayliss and Mount Menzies. The patterned moraine was nowhere excavated and consequently cannot be fully described. The fragments forming the patterned moraine are not sorted, but clay-grade and silt-grade material is rarely present on the surface. Most of the fragments range from 1 inch to 2 feet in diameter; a few range up to 12 feet in diameter. Fragments are dominantly sub-angular, a few are sub-round, and the largest fragments are angular.

In the patterned moraine accumulations of these fragments form low cones, typically between 8 feet and 20 feet in diameter and between 2 feet and 4 feet high. The centres of the cones are roughly equidistant and each core is in contact with the surrounding cones. In a small area - a few hundred square yards - on the broad moraine-covered platform on the east side of Mount Menzies, relatively steep cones range up to 8 feet in height; they are between 20 feet and 30 feet in diameter. The boundaries between neighbouring cones are almost everywhere obscured by the soft snow which accumulates in the intervening hollows. The material at the few boundaries seen did not appear to be markedly different from the material forming the cones.

Some cones are arranged in linear groups, some parallel, some at right angles to the slope of the moraine surface. These linear patterns may be picked out in one preferred direction by the accumulation of snow in wind-controlled stripes among the cones; this direction may be thus apparent rather than real.

The bottom of the long dry valley which forms the western limit of the moraine-covered platform at the east end of Mount Menzies, is covered by unpatterned moraine, partly concealed by snow, Where this valley debouches on to stagnant ice adjacent to the Fisher Glacier, about 1 square mile of moraine derived from the valley has a roughly patterned surface. This area was observed at a distance of about one mile and it was not examined in detail. It appears to be made up of irregularly spaced cones of moraine ranging between 2 feet and 30 feet in height. The depressions between some cones are occupied by "ponds" of flat ice up to 50 yards across. This roughly patterned moraine may be transitional between unpatterned and regularly patterned moraine. It suggests that patterned moraine may be produced by the ablation of stagnant, moraine-charged ice.

The patterned moraine in the Prince Charles Mountains may be further investigated by the study of aerial photographs, by excavation, and by the close examination of natural sections. Some of the areas of patterned moraine may lie on cores of very old stagnant ice.

Glacial History

The blanket of patterned moraine which covers most of Mount Menzies and Mount Bayliss appears to have been deposited by the receding ice-caps, since the distribution of the moraine is not evidently related to cirques or to valleys cut by mountain glaciers. The spread of the moraine blanket over benches and cirque floors demonstrates that the benches and cirques were formed before the deposition of the moraine blanket.

Mountain glaciers probably existed in Mac-Robertson Land long before the coalescence of the independent glacier systems formed the continental ice cap. The more prominent features formed by mountain glaciers, such as the very large cirques on Mount Menzies, may have been at least initiated during the long period of mountain glacier activity which preceded the formation of the ice cap.

As the cirques are cut into the summit plateaux and into at least one bench, the plateaux and benches may well be remnants of a pre-glacial landscape of rolling hills, whose tops are preserved as summit plateaux, and broad valleys, partly preserved as benches.

Following the formation of the continental ice cap, it rose, in the Prince Charles Mountains, to a height between 2,000 and 4,000 feet higher than its present level. It may have attained this height several times, and the height of the ice cap has probably fluctuated considerably. It has at least once dropped below its present level since patterned moraine extends beneath the ice in places.

The greatest vertical and lateral extent of the Antarctic ice cap probably coincided, as Hollin (1962) claims, with the world-wide drop in sea level during the Pleistocene. The recession of the sea and the lateral expansion of the ice cap reduced precipitation drastically in inland Antarctica, and the vertical recession of the ice cap inevitably followed.

This recession revealed many mountains which had been buried by the ice cap. Large masses of moraine-charged ice which had been stranded on the mountains ablated slowly to deposit thick blankets of moraine with patterned surfaces. Other large accumulations of moraine had been built up, during the flow of the ice, in the shelter of large rock features, duplicating on a large scale the crag-and-tail features of northern Europe (Charlesworth, 1957).

Vertical recession was probably accompanied by lateral recession at the coast, and the overall shrinkage in the ice cap was accompanied by an increase in height of sea level. The encroachment of the sea probably increased precipitation in the southern Prince Charles Mountains sufficiently to form mountain glaciers on Mount Menzies, the highest and largest nunatak, and eventually to bring the height of the ice cap some way above the lowest limit of the moraine deposited at the earlier recession.

The mountain glaciers of Mount Menzies completed the excavation of the great cirques on the north and south sides of the mountain, probably before the ice cap rose sufficiently to inundate the lower parts of the southern cirques. Then the ice cap margin responded, after an interval of several thousand years, to the increased precipitation in the interior, and the lateral expansion again reduced precipitation. The mountain glaciers on the north side of Mount Menzies receded step by step, leaving mounds of unpatterned moraine. Some masses of stranded moraine-charged ice, particularly on the floor of the great northern cirque, may have formed patterned moraine.

The large surface of rock and moraine now exposed on the north side of the mountain absorbs and re-radiates so much solar heat in summer that considerable quantities of snow cannot accumulate there permanently.

Only the snowfield located high on the southern side of the mountain continues to nourish mountain glaciers, since this field receives little solar heat and appears to be favourably located for the accumulation of snow in the prevailing south-west wind.

GEOLOGY

The petrographic descriptions and the metamorphic histories of rocks from Mount Menzies and Mount Bayliss have been taken directly from descriptions of thin sections of these rocks by W.R. McCarthy of Australian Mineral Development Laboratories (Appendix I). Figure 4 is a reconnaissance geological map of the southern Prince Charles Mountains.

Mount Menzies

The rocks described were collected from the eastern part of Mount Menzies. This part is mainly covered by moraine at low levels and by nivation debris at higher levels. Good exposures are accessible at the north end of the eastern moraine platform, in the high cliffs of the south-east and south sides of the mountain and on its topmost 3,000 feet.

Mount Menzies is composed of quartzite containing minor bands of quartz-rich schist and of amphibolite. Colour bands up to 1,000 feet thick are evident in the cliffs of the mountain. They are almost all composed of quartzite; the colour depends on the accessory minerals. Black quartzite is coloured by iron-staining, greenish-grey quartzite contains chloritoid and white quartzite contains sericite. Pink quartzite is also prominent, but this rock was not sampled.

In hand-specimen the quartzites are fine-grained, massive and tough; one sample has a pronounced lineation. Crystals of chloritoid, chlorite, sericite, and rarely garnet and biotite, may be visible.

Lenses and thin bands of green-grey quartz-rich schist are locally common in the quartzite. On the north-east ridge of Mount Menzies, within a mile of the summit, the quartzites alternate with bands of quartz-rich schists; the boundaries of the bands are gradational. Veins of milky quartz up to 6 inches broad are locally abundant in the quartz schists. Iron-staining is common.

Microscopic examination shows that the quartzites are composed of 90 percent to 97 percent recrystallised quartz. Chloritoid is the second most abundant mineral; chlorite is common and appears to have formed by the retrogressive alteration of chloritoid. Muscovite and sericite are common accessory minerals; in a few quartzites they are more abundant than chloritoid. Zircon and opaque minerals are present in small quantities.

One specimen (R11362), from the summit area, is a garnet-muscovite quartzite. Muscovite and chlorite form about 10 percent of the rock and poikiloblastic porphyroblasts of garnet, probably spessartite, form about 1 percent. Corroded crystals associated with muscovite may be chloritoid. A few porphyroblasts of biotite are present; they have no preferred orientation. The biotite appears to have formed by replacement of muscovite.

The bands and lenses of schist in the quartzite are mainly chloritoid-quartz schist. In one specimen (R11358) chloritoid forms 60 percent of the rock; the remainder is mainly quartz; sericite, muscovite, and chlorite have apparently formed by the retrogressive alteration of the chloritoid.

Near the summit of the mountain a black, fine-grained hard, tough rock, commonly with a strong slaty cleavage, is interbanded with the quartzite. This rock was named slate in the field; it is a cordierite-chloritoid-muscovite-quartz schist (R11581). Fine-grained quartz is the most abundant mineral, chloritoid and muscovite each form about 15 percent. Under the microscope, the fine-grained muscovite reveals an excellent schistosity which is plicated. The axial areas of these plications contain porphyroblasts of cordierite. Lenses of quartz parallel the schistosity of the rock and other lenses possibly of goethite and of a golden-brown transparent mineral (?monazite) are present.

Near the summit of Mount Menzies bands of actinolite amphibolite are interbanded with the quartzite. The amphibolite is a black, fine-grained, hard and massive rock; its boundaries with the quartzite are concealed. McCarthy describes one specimen (R11363) as an epidote-quartz-actinolite amphibolite, composed of 85 percent actinolite, 12 percent quartz, 2 percent epidote, and 1 percent feldspar. Opaques are common accessory minerals; zircon and apatite are rare. Some of the grains of actinolite have a preferred orientation, and augen-like lenses of quartz lie parallel to these.

Mount Bayliss

The broad summit plateau of Mount Bayliss is mantled by patterned moraine. The uniform composition of the moraine suggests that most of it is locally derived. Good exposures may be found in cliffs along all sides of Mount Bayliss. At the south-east corner a cliff section up to 500 feet high and several miles long is exposed; this was not examined.

Figure 5 is a diagrammatic section of the west end of Mount Bayliss.

In the low, irregular cliffs at the western end of Mount Bayliss, foliation is horizontal or dips gently northwards. The lowest rock is quartzite over 200 feet thick. In hand-specimen this is a light-green rock with large black spots of dark mineral; it is massive or poorly banded. The weathered rock resembles flaggy sandstone. It is composed of 85 percent quartz, and 5 percent muscovite, sericite, and biotite, Epidote, sphene, and apatite are accessory minerals. Shearing is prominent in thin section.

A well-banded gneissic rock less than 50 feet thick lies on the quartzite. This (R11365) is an epidote-biotite-hornblende-quartz-calcite-microcline amphibolite. Bands of quartz or bands of calcite, alternate with bands of ferromagnesian minerals and microcline. The microcline crystals contain inclusions of biotite, of large and crypto-crystalline opaque minerals, and of quartz. Green hornblende, which may be uralitic, and green biotite are not confined to particular bands. Sphene is a minor constituent of the dark bands. Opaque minerals are common accessories and apatite is rare.

Foliated granite and augen gneiss, at least 500 feet thick, overlie the amphibolite. The granite is a pink, medium-grained rock with foliation formed by stringers of biotite and stringers of quartz. Parts of the granite have large rounded augen of feldspar in a dark matrix of fine-grained quartz. McCarthy describes the thin section of this rock (R11371) as a cataclasite or cataclastic gneiss formed by the brecciation of a granitic rock. Microcline forms 50 percent of the rock and quartz 45 percent. Biotite and muscovite are scattered or concentrated in lenses with quartz and feldspar. The rock is composed of sub-parallel lens-like bodies containing one or more major minerals. One specimen contains orthoclase and plagioclase in addition to microcline. Some of the plagioclase crystals are deformed and some others are recrystallised. Epidote and probable orthite are rare; some mica has altered to chlorite. Sphene may be a common accessory, zircon is rare. In one specimen (R11371) irregular crystals of fluorite are contained in feldspar and quartz crystals, fine veins of fluorite cut a large orthite crystal, and large aggregates of fluorite lie adjacent to the veins. Towards the west end of Mount Bayliss the foliated granite is overlain by patterned moraine composed almost exclusively of amphibolite. Air photos of Mount Bayliss suggest that this moraine is locally derived, and overlies outcrops of amphibolite. The fragments in the moraine are all black rocks, fine-grained to coarse-grained, massive to well-foliated, many with visible fibrous amphibole, some with biotite.

Two specimens are andesine-quartz-hornblende amphibolites (R11368, R11369); another is quartz-hornblende amphibolite (R11367). In these, hornblende forms between 60 percent and 75 percent of the rock and quartz between 20 percent and 37 percent. Andesine makes up 3 percent where present. Biotite and chlorite have formed by the retrogressive alteration of hornblende. Hornblende and quartz occur in alternating bands, and sheared minerals lie along the boundaries of the bands. In one hornblende amphibolite (R11370) tourmaline forms 1 percent of the rock as large or medium-sized crystals associated with hornblende.

One specimen from the summit platform of Mount Bayliss is described by McCarthy as a biotite-quartz-actinolite amphibolite (R11366) in which no preferred orient is evident. The actinolite occurs as large non-oriented crystals up to 7 mm. long, and forms 70 percent of the rock. Proportions of the other constituents are chlorite 20 percent, quartz 10 percent, and biotite 3 percent. Quartz appears to have segregated in large and small bodies during the metamorphic growth of actinolite and biotite. Chlorite and calcite have probably formed by the retrogressive alteration of actinolite.

A small nunatak, about 1 square mile in area, lies less than one mile west of the west end of Mount Bayliss. At the north side of the nunatak a contact between marble and granite is exposed.

The marble in hand specimen is a yellow-brown to red, fine-grained to medium-grained rock which strongly resembles a bedded sandstone both in exposure and hand specimen. The rock (R11352) is 90percent calcite, 5 percent quartz, and the remainder muscovite, epidote, green biotite, and opaques concentrated in thin lenses.

The rock (R11353) in contact with this marble is a foliated granite similar to the foliated granite at the west end of Mount Bayliss.

The marble and the foliated granite are separated by less than 100 feet of dark, flaggy, coarse-grained biotite-bearing rock (R11354). This contact rock is scapolite-biotite-calcite-epidote-hornblende-quartz hornfels. The assemblage biotite, scapolite, hornblende, quartz, and calcite, has been retrogressively altered to produce uralitic hornblende, epidote and chlorite some of which is antigorite.

The marble and the contact rock contain many quartz veins and small reefs a few feet wide. The quartz is translucent, or greenish-white, or dark brown. Some coarse, weathered ferruginous boxwork occurs among the quartz reefs and veins.

Goodspeed Nunataks

These nunataks were not visited by the 1961 geological party. M. Mellor collected samples from rubble on one of the nunataks in January, 1958. Some of these samples, recrystallised sandstone and hornfels, and a sample of granite from moraine on the ice adjacent to the nunatak, have been described by McLeod (1959).

Two undescribed samples collected by Mellor were submitted in 1962 to Australian Mineral Development Laboratories for microscopic examination.

One of the samples (R11600) is a partly brecciated marble composed of large calcite crystals with quartz in the interfragmental spaces of the brecciated parts. Silica has replaced some calcite along cleavage planes and thin vein-like bodies of silica cut the calcite crystals.

The other sample (R11599) is described by McCarthy as a calcite-pistacite-quartz hornfels. Quartz forms 70 percent of the rock; green biotite, muscovite, sericite, and chlorite are relatively abundant; biotite crystals range up to 1.2 mm. Pistacite (epidote), is present as euhedral to subhedral crystals. Calcite is common, generally intergranular, with a few larger poikiloblastic crystals. Opaque minerals, associated with the ferromagnesian minerals, are very abundant accessories. Zircon, apatite, tourmaline, and sphene are less common.

Other Nunataks

Previously unvisited features approached but not visited by the party are Seavers Nunataks, Keyser Ridge, and Mount Ruker.

All these features have extensive cliffs of dark-coloured rocks in which neither banding nor differential erosion could be discerned at distances from 2 miles to 10 miles. The lower slopes of Keyser Ridge are covered by reddish patterned moraine.

Erratic

One dark, fine-grained rock collected on the summit of Mount Bayliss is quite unlike any rocks seen in outcrop in 1961.

McCarthy describes the frock (R11370) as 60 percent orthoclase, 15 percent brown hornblende, 10 percent biotite, 5 percent riebeckite, 5 percent opaques, 3 percent calcite, and 2 percent quartz. McCarthy infers that 8-sided bodies of orthoclase are in fact altered leucite crystals, and he names the rock leucitophyre. At present no source is known for this rock. The nearest outcrop is Gaussberg in Wilhelm II Land about 700 miles east of Mawson. However, basic dykes have been observed by Crohn (1959) in the northern ranges of Prince Charles Mountains, and this rock may be derived from a basic dyke.

METAMORPHISM

McCarthy has assigned the rocks of Mount Menzies to the greenschist facies of metamorphism, as defined by Fyfe, Turner, and Verhoogen (1958).

According to Fyfe, Turner, and Verhoogen (1958), chloritoid is a mineral typical of the quartz-albite-epidote-biotite subfacies or of the quartz-albite-epidote-almandine subfacies of the greenschist facies, though it may occur in the quartz-albite-muscovite-chlorite subfacies in rocks low in K_2O and high in Al_2O_3 and FeO.

As actinolite is the common amphibole in the amphibolite interbanded with these rocks, they are assigned to the quartz-albite-epidote-biotite subfacies. The only garnet found is, according to McCarthy, probably spessartite, which may occur in any subfacies of the greenschist facies.

The cordierite in one sample is anomalous for regionally metamorphosed rocks. However, the assemblage is correct for a member of the albite-epidote hornfels facies, and McCarthy suggests that the cordierite in this rock together with the common large, non-orientated flakes of biotite in other schists and quartzites, indicates that the rocks of Mount Menzies continued to undergo thermal metamorphism at a relatively high temperature after the relief of the stress accompanying regional metamorphism.

The rocks of Mount Menzies are metamorphosed sandstones and quartzites which originally contained a few beds of sandy or silty clay. The significance of the amphibolite among these rocks is uncertain. Ruker (1963) records intrusive amphibolite from Mount McCauley. The actinolite amphibolite sampled on Mount Menzies is composed of 85 percent actinolite, 12 percent quartz, and only 1 percent feldspar.

Possibly the actinolite amphibolite has been produced by the metamorphism of an impure, sandy limestone, with the copious effusion of carbon dioxide. It may be a basic intrusive. Another possibility is that the rock may be a water-laid crystal tuff contaminated by sand.

The metamorphic history of the rocks from Mount Bayliss is complex. Shearing is evident in most of these specimens; in some the shearing antedates the growth of minerals produced by thermal metamorphism, in others the metamorphic minerals are deformed by the shearing.

The main episode of thermal metamorphism is tentatively correlated with the emplacement of the granite which is now a cataclastic gneiss.

The sequence of events recorded in the Mount Bayliss rocks is possibly this:

1. A group of impure sandstones and limestones were metamorphosed in the greenschist facies in the same orogeny which metamorphosed the rocks of Mount Menzies.

2. Granite was emplaced in these rocks and they were thermally metamorphosed, some to the albite-epidote hornfels facies and some to the hornblende hornfels facies.

3. All these rocks including the granite were strongly sheared; in many the shearing produced foliation. The brittle style of the deformation is attributed to a relatively small depth of burial.

4. Thermal metamorphism persisted after the shearing and resulted in the growth of minerals typical of the albite-epidote hornfels facies in all rocks. Thus the low-grade rocks show a continuation of metamorphism throughout the shearing, while rocks in the hornblende hornfels facies have undergone retrograde metamorphism in which biotite and uralite have grown from green hornblende.

The samples described by McCarthy from the Goodspeed Nunataks are thermally metamorphosed limestone and impure limestone. These are probably related to thermally metamorphosed rocks from the locality described by McLeod (1959).

STRUCTURE

Exposures examined on Mount Menzies mainly display steeply dipping or vertical schistosity which strikes broadly east, and is expressed by aligned mica flakes or by partings in the quartzites. In many places this schistosity is sharply discordant to gently dipping or folded lithological boundaries seen in distant observations or in aerial photographs of the mountain.

The steeply dipping schistosity in quartzite exposed on the north-east ridge of Mount Menzies between the summit and a level 2,000 feet below it, is developed parallel to the axial plane of a fold which can be made out in aerial photographs of the northern cirque. The amplitude of the fold is about 5,000 feet and its wave length is also about 5,000 feet. The axis of the fold appears to plunge gently south-eastwards. A fold of similar trend and style with an amplitude and wave-length between 1,000 and 2,000 feet is exposed in the south-eastern cliffs of Mount Menzies. The common schistosity on Mount Menzies is parallel to axial planes of these folds.

In the long west wall of the great northern cirque, below the west peak of Mount Menzies, bands of black rock several hundred feet thick are abruptly and irregularly truncated. The northern end of this wall provides a sectional view of some truncated bands, which appear to be attenuated and disrupted by intense plastic folding. This folding has a style and trend different from the folding described above, in the quartzites in the south wall of the cirque.

The deformation of the black bands may antedate the isoclinal folding, or the difference in fold style may reflect the difference in resistance to deformation between quartzite and the dark rocks. McLeod (1959) illustrates a cliff at Patrick Point where a band of black rock several hundred feet thick is deformed by plastic recumbent folding, although the band is surrounded by regularly banded and apparently more competent, light-coloured rocks.

Ruker (1963) describes discordant and intrusive amphibolites among low-grade metamorphic rocks at Mount McCauley and among high-grade metamorphic rocks at Mawson Escarpment at 73°30'S. Some of these are evidently deformed minor intrusives but others have unusual mineralogical compositions; they contain relatively large quantities of quartz, or they are ultramafic or lamprophyric rocks.

Deformed intrusive amphibolites may be difficult to distinguish from originally concordant amphibolites which have been more intensely deformed than more competent quartz-rich rocks containing them.

The structure of Mount Bayliss is dominated by semibrittle shearing on sub-horizontal planes which is probably later than the fold structures preserved at Mount Menzies, though folding and shearing could be contemporaneous.

The marked foliation evident in many rocks on Mount Bayliss originated in the shearing, and all the rock boundaries on Mount Bayliss appear to have been aligned with the shear planes in a simple sub-horizontal structure, though their inter-relationship before shearing may have been more complex. The intensity of the shearing suggests that a major thrust plane may be located at or near Mount Bayliss.

In Antarctica, mountains, the sides of mountains, and groups of mountains commonly form straight-line features. In the southern Prince Charles Mountains straight-line features may be seen in the alignment of the western sides of Keyser Ridge, Mount Ruker, and Mount Rubin, in the southern sides of Mount Bayliss and Mount Menzies, and in the straight sides of many large nunataks.

These straight lines resemble the surface traces of fault planes and block-faulting is commonly thought to be the principal control of outcrop distribution in Antarctica. However, the straight-line features in the southern Prince Charles Mountains are aligned on the margins of very active and powerful ice streams. The ice streams may have originally been channelled along fault lines, but the present-day escarpments which form the sides of the mountains have probably receded a considerable distance since the onset of glaciation and their present form and alignment are probably the results of directional ice erosion. Most glaciers run straight, whether following faults or not.

Faults traced in the air photos of Mount Menzies run broadly east-west across the north side of the mountain and dip steeply northwards. These faults appear to displace dark banded rocks several hundred feet vertically. The trend of these faults is parallel to the valley of the Fisher Glacier, and sub-parallel to the observed schistosity.

GEOLOGICAL HISTORY

The quartzites of Mount Menzies were deposited as relatively pure sandstones containing a few beds of silty clay. The marbles and some amphibolites represent limestones formed when the deposition of sand was relatively slow. The great thickness of quartzite may have been derived from quartz-rich gneisses. Some amphibolites may be metamorphosed pyroclastic rocks.

These shelf sediments were presumably buried below a thick pile of similar or other sediments before they were metamorphosed in an orogeny. Fyfe, Turner, and Verhoogen (1958) suggest a minimum depth of burial of 10 kilometres for the formation of greenschist facies rocks.

In the early stages of the orogeny, the quartzites were thrown into huge, relatively regular folds.

At Mount Bayliss, the folding was followed by the emplacement of granite, and high temperatures prevailed after the relief of the stress associated with the folding.

Subsequent to the emplacement of the granite, while the temperature remained high, strong lateral pressure resulted in shearing at Mount Bayliss and in the formation of a foliation in many rocks there. This deformation may have been accompanied by the horizontal transport of large bodies of rock.

From determinations of both high-grade and low-grade metamorphic rocks in East Antarctica, Starik et al. (1960), and Deutsch et al. (1961) have obtained an age between 400 million and 500 million years for the latest metamorphism. The low-grade metamorphic rocks of the southern Prince Charles Mountains have probably been metamorphosed only in the latest, Lower Palaeozoic orogeny. The high-grade metamorphic rocks typical of the East Antarctic Shield have been repeatedly metamorphosed in successive orogenies dating from at least 1500 million years ago, according to Starik et al. (1960).

Subsequent to the orogeny, much of the thick cover lying on the greenschist facies rocks was no doubt rapidly removed by erosion, but the area covered by the southern Prince Charles Mountains has probably existed as a land for most of the time from the Lower Palaeozoic to the present day.

Sediments found by Ruker (1963) and the Amery Formation described by Crohn (1959) indicate that one or more depositional basins existed in Mac-Robertson Land in Permian times. The erratic of volcanic rock found on Mount Bayliss may be a product of the Jurassic or Tertiary igneous episodes recorded elsewhere in Antarctica. Little is known of the past metamorphic geological history of the southern Prince Charles Mountains before the onset of glaciation.

ECONOMIC GEOLOGY

The presence of ferruginous boxworks in quartz reefs and veins at the contact between granite and marble on the small nunatak at the west end of Mount Bayliss, suggests that metallic minerals are associated with the contact. Fluorite at another locality at Mount Bayliss, in foliated granite also suggests that metallic minerals may be present. Fluorite occurs in granite associated with hornfels of the Goodspeed Nunataks (McLeod, 1959). The granites emplaced in the low-grade metamorphic rocks of the Prince Charles Mountains should be examined and sampled for metallic minerals in future.

A quartzite sample containing visible crystals of a metallic mineral was collected from patterned moraine on the east platform of Mount Menzies. The sample was described by G.J.G. Greaves of the Bureau of Mineral Resources Laboratory, as iron-stained quartz containing 5 percent magnetite.

FUTURE WORK

The variety of rocks found in the Prince Charles Mountains suggests that the geological reconnaissance should be extended to cover the mountains between Mount Menzies and Wilson Bluff and the numerous unvisited mountains in the northern and central ranges.

The first requisite in planning this work is an aerial reconnaissance of the ice cap surface among the mountains selected for mapping. If crevasse-free routes are found, air-supported dog-sledge transport is strongly recommended for the mapping party. A dog-sledge party may travel in these mountains on many days when flying will be impossible.

Should the ice surface prohibit ground travel and require air transport, camps comprehensively equipped and stocked with sledging rations for two weeks should be established at the mountains visited. The geologists should then spend, ideally, between three and five days on each mountain, changing camp when the weather is suitable for flying. Skis, a manhauling sledge, and sufficient sledging rations should be cached at a conspicuous central feature in the mapping area to enable the party to walk to Mawson or Davis if the supporting aircraft are disabled. Air support from other expeditions should only be requested for the evacuation of an injured man, and it may only be available after an interval of many days.

The field party must maintain radio contact with base at least daily and possibly twice each day, to plan flying schedules and to transmit local weather information. A radio operator skilled in morse should accompany the geologist, and a third unskilled but enthusiastic assistant should complete the party. If a glaciologist or other scientist is included, the party must contain at least four men, since each field scientist must have at least one working companion.

Temperatures(between $-20^{\circ}F$ and $+15^{\circ}F$) suitable for camping will be found below 6,000 feet altitude in the Prince Charles Mountains from November to February, In November and February, parties travelling on the ice cap between Mawson and the southern ranges should expect temperatures down to $-40^{\circ}F$ at altitudes over 7,000 feet.

ACKNOWLEDGEMENTS

I very gratefully acknowledge the endurance, patience, and unlimited enthusiasm of my sledging companions, D.O. Keyser and J. Seavers, during three months living and travelling under difficult conditions. Without their determination to succeed we could not have started our journey.

I gratefully record the labour and patience of G.D.P. Smith and Dr. R. Pardoe who trained and maintained two excellent dog teams and who surrendered the teams to us for the summer season. I acknowledge a great debt to the dogs, Nils, Phil, Peter, Slob, Ian, Blizzard, Flash, Igy, and particularly to Nellie, who lost a litter of pups in the mountains, and Pancho, lost on the return journey less than two days from Mawson.

I acknowledge the assistance and patience of the tractor party, G. Maslen, G. Wilkinson, W. Young, R. Wyers, and I. Tod, who carried us 200 miles south of Mawson and established our depot there, and the assistance of B. Ryder in preparing for the journey and personnel at Mawson, D. Harvey in particular, who helped the dogs up the steep seaward slope of the ice cap.

I.R. McLeod has discussed with me the problems associated with this report and R. Ruker has provided much information. The officers of the Antarctic Mapping Branch of National Mapping have provided maps and advice, and G. MacKinnon of the Antarctic Division, Department of External Affairs, supplied the latest air photographs of Mount Menzies and Mount Bayliss. McLeod and R.R. Harding read and criticised the manuscript of this Record.

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APPENDIX 1

Petrographic descriptions of samples.

by

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Mount Bayliss, West Nunatak

R11352

The rock is a medium-grained marble, Several thin lenses of silicate minerals and opaques cut the rock. These lenses were laminae of sedimentary impurities which have recrystallised during metamorphism of the specimen. The calcite crystals give the sample a granoblastic texture.

Calcite forms about 90 per cent of the specimen, and occurs as anhedral to euhedral crystals. Quartz is present as scattered, intergranular crystals which form about 5 per cent of the specimen. Muscovite, epidote, green biotite, and opaques are scattered through the rock, but the largest quantities are present in the lenses.

The present rock has formed by lowgrade metamorphism of an impure limestone.

R11353

The rock is a cataclasite or cataclastic gneiss. The specimen has formed by brecciation of an earlier granitic rock. Large scale movements such as block or thrust faulting are generally associated with the genesis of this type of rock.

Microcline (50 per cent) and quartz (45 per cent) are the major constituents of the rock. Both are present as lens-like bodies which show a rude parallelism. Lenses are often of a single mineral (i.e., either microcline or quartz) but the quartz ones generally have inclusions of microcline. Quartz is generally medium to coarse-grained and has a lenticular shape. Microcline is fine to coarse-grained and many crystals show strained extinction.

Both biotite and muscovite are present as scattered crystals and in lenticular concentrations with feldspar and quartz. Epidote and probable orthite are rare and associated with mica. A few very strained, bent, fractured plagioclase crystals of the precataclastic granitic rock occur with the microcline. Some of the biotite and muscovite have retrograded to chlorite. Apatite is present in accessory amounts and associated with fine-grained aggregates of epidote minerals.

R11354

The rock is a scapolite-biotite-calcite-epidote-hornblende-quartz hornfels. The metamorphic assemblage does not appear to be representative of a single metamorphic facies. Two hornfels facies assemblages appear to comprise the rock. An earlier and higher grade of thermal metamorphism produced an assemblage of biotite, scapolite with some hornblende, quartz and calcite. The later and retrogressive metamorphism formed a second green, uralitic, hornblende and the abundant epidote of the rock. The uralitic hornblende has formed from the earlier hornblende and biotite. Epidote has formed by alteration of biotite and hornblende. Chlorite and antigorite are also present as retrogressive minerals formed by the alteration of ferromagnesians.

The original sedimentary rock was probably an impure limestone (laminae of siliceous and argillaceous material). Final interpretation of the retrogressive metamorphism will of course depend on the regional metamorphic history of the area. However, due to the close proximity of the cataclastic gneiss (11353), the retrogressive alteration of this rock may be a product of the large scale deformation which formed the cataclasite.

Mount Bayliss

R11364

The rock has formed by metamorphism of an impure quartz arenite. It shows an incipient shear structure; shearing has been active and fine shears most frequently pass around quartz grains but often they combine into larger composite shears. Sericite forms an augen-shaped envelope around quartz grains and has crystallized around the composite shears. Scattered, large (some reach a diameter of 3 mm.), poikiloblastic, porphyroblasts of biotite have grown post-deformation; they show no preferred orientation and often are normal to the shear orientation of sericite-muscovite. The biotite porphyroblasts have grown by incorporation and recrystallization of sericite-muscovite. The structure of the rock and the growth of biotite porphyroblasts indicate that the rock has been subjected to an earlier synkinematic lowgrade (greenschist facies) metamorphism and a later thermal metamorphism (albite-epidote hornfels). Whether thermal metamorphism followed immediately the synkinematic metamorphism or occurred much later is not determinable from this sample. The rock is a sheared, biotite-sericite-muscovite quartzite.

Mica forms 10-16 per cent of the rock and quartz the remainder. Epidote is present as scattered crystals in accessory amounts, as is sphene and apatite. Several tentative identifications are noted. Altered porphyroblasts (two in number) of feldspar occur and another epidote mineral, zoisite, is present as microcrystalline grains generally included in sericite.

Some of the mica has altered to chlorite.

R11365

This is a gneissic, epidote-biotite-hornblende quartz-calcite-microcline amphibolite. The mineral assemblage has an unstable gross aspect. The instability and varied mineral assemblage indicate a polymetamorphic history. The gneissic structure of the rock is formed by laminae which are dominantly composed of quartz or calcite and alternate with ferromagnesian-microcline laminae. This structure may be interpreted as resulting from original sedimentary bedding or differentiation under stress conditions.

The general metamorphic history of the specimen must be determined from a survey of nearby samples and regional metamorphic and field interpretation, as there is not sufficient conclusive information in this sample. A few features in the rock give some definite information about the metamorphic history. These are green uralitic-appearing hornblende and green biotite, which are not confined to particular laminae and indicate that thermal metamorphism was the last phase of the petrogenesis, and quartz laminae that have shouldered aside other laminae suggesting they are differentiation laminae. Microcline also appears to have crystallized during the thermal metamorphism and has inclusions of other minerals (biotite, opaques - large and cryptocrystalline, and quartz). Sphene is a minor constituent and occurs in the darker laminations. Accessories are apatite (rare) and opaques (common).

R11366

The rock is a biotite-quartz-actinolite amphibolite and is assigned to the hornblende hornfels facies. No structure is apparent; actinolite occurs as large (up to 7.0 mm. in length) non-oriented, crystals.

Estimated proportions of mineral constituents are biotite (3 per cent), quartz (10 per cent), chlorite (20 per cent) and actinolite (70 per cent).

During the metamorphic crystallization of actinolite and biotite, excess silica was concentrated between these crystals and now occurs as quartz. The quartz inclusion in the rock appears to have formed by the same process. Actinolite crystals terminate as fibrous crystals which penetrate the quartz, of the inclusion and the matrix. Calcite is present as a segregated body at one extremity of the quartz inclusion, but this is more likely a product of the retrogressive alteration of actinolite to chlorite; generally it is associated with the chlorite and is not found with unaltered actinolite. Chlorite is not a primary meta-mineral, but has formed during retrogressive alteration of actinolite and biotite. Opaques are frequent accessories and occur as inclusions in actinolite or as intergranular bodies.

R11367

This is a quartz-hornblende amphibolite and is assigned to the hornblende hornfels facies. Hornblende is generally very coarse-grained (some crystals reach a length of 8.0 mm) and many crystals are poikiloblastic with quartz inclusions. Quartz occurs as elongated segregations between hornblende crystals or as inclusions in hornblende. Segregation quartz reached a maximum grain diameter of 0.65 mm. and inclusion quartz is fine-grained. Chlorite and biotite comprise 5 per cent of the specimen and have formed by retrogressive alteration of hornblende. Hornblende forms about 75 per cent of the specimen and quartz about 20 per cent. Opaques are a common accessory and occur as fine to medium-grained, xenoblastic to subhedral inclusions in hornblende.

R11368

This is an andesine-quartz-hornblende amphibolite and is assigned to the almandine-amphibolite facies. In thin-section, the structure of the rock is seen to be produced by alternating laminae of hornblende and quartz. Sheared minerals along the boundaries of the laminae and still thinner lenses of actinolite in quartz laminae, make it quite evident that shearing, producing differential movement, has been an important process in forming the structure of the rock. Whether the laminae are inherited sedimentary bedding features or have formed by metamorphic differentiation accompanied by shearing is uncertain. It appears most likely that the rock has undergone regional synkinematic metamorphism and is thus assigned to the almandine-amphibolite facies. Thin stringers or bands of opaques parallel the structure and are generally included within the hornblende laminae.

Estimated proportions of mineral constituents are andesine (3 per cent), quartz (37 per cent), and hornblende (60 percent). Opaques are common accessories.

R11369

This specimen compares in general mineralogy and fabric to rock 11368.

Several mineralogical differences are noted. Rock R11369 contains tourmaline which forms about 1 per cent of the sample and is present as large or medium-sized crystals associated with hornblende. Hornblende forms about 75 per cent of the rock. A part of the amphibole of the sample is probably cummingtonite. Biotite is a rare accessory.

Chlorite, formed by retrogressive alteration of amphibole, comprises about 2 per cent of the sample.

R11370

This is an extrusive rock. The rock has a pseudo-vesicular structure given by numerous orthoclase bodies which appear to be vesicular fillings. The orthoclase bodies sometimes have all or combinations of the following minerals as inclusions: calcite, sphene, quartz, and rare ferromagnesians. When closely examined most of these bodies are seen to have many straight sides and some have eight sided sections. It is then inferred by their shape and present composition that these orthoclase bodies were originally crystals of leucite which have altered to orthoclase. Alteration of leucite may have occurred either during the cooling of the lava or by subsequent processes.

Estimated proportions of mineral constituents are quartz (2 per cent), calcite (3 per cent), opaques (5 per cent), reibeckite (5 per cent), biotite (10 per cent), brown hornblende (15 per cent), and orthoclase (60 per cent). Orthoclase has been identified by oils in the vesicle-like bodies and the matrix feldspar gives a positive staining test for potash feldspar and is thought to be orthoclase.

Before alteration, the rock was a leucitophyre.

R11371

This is a cataclasite (cataclastic gneiss) which compares in structure and general mineralogy to rock 11353. Again largo scale movements seem to be necessary for the intense deformation and recrystallization of the specimen.

The detailed mineralogy of this rock (11371) has some differences which are noted. Orthoclase is an important constituent of the feldspar and both deformed and recrystallised plagioclase are rare. Probable orthite is present as a large crystal and as scattered finer crystals. Fluorite is a common accessory mineral; its location is not confined, nor is it only associated with one mineral. It occurs as irregular, fine, crystals included in feldspar and quartz; a few fine vein-like bodies cut the large orthite (?) crystal and several larger aggregates of fluorite are adjacent to it. Sphene is a very common accessory mineral and associated with green biotite. Zircon is a rare accessory.

Mount Menzies

R11355

This is a sericite-chloritoid quartzite. No positive sedimentary features are present in the metasediment. Considerable recrystallization has occurred as is evident by the habit of the quartz (anhedral to euhedral) and by the crystallization of chloritoid. Quartz forms about 95 per cent of the rock and ranges in crystal diameter from 0.23 mm. to 0.56 mm. Chloritoid is found primarily in thin laminae; the genesis of these laminae is not certain (i.e. sedimentary or metamorphic). Sericite is present in the laminae and intergranular areas. Chloritoid is fine to medium-grained and is subhedral to anhedral. Sericite occurs as very fine, crystals or in medium-sized crystal aggregates.

While metamorphic structure is not certain in this rock, other chloritoid quartzites of this locality are assigned to the greenschist facies on the basis of structure and it seems likely then that this rock has been formed by the same type of metamorphism.

R11356

The rock is a chloritoid-chlorite quartzite. It resembles rock R11355 in all regards except for the following differences.

This rock originally contained a greater percentage of micas (about 10 per cent). Chloritoid is still present but portions of it have now altered to chlorite (a green variety and penninite). No sericite is present. This specimen contains several crystals of accessory zircon. Alteration of the chloritoid has left iron stains which coat crystals; staining apparently gives the rock its dark colour.

R11357

This is an epidote-actinolite-quartz amphibolite and is assigned to the greenschist facies. Structure of the rock is formed by lineated actinolite present in thin laminae and by alternating actinolite and quartz laminae. The rock has been formed by sykinematic metamorphism of a sediment. Lineation of the actinolite is fair; the majority of crystals show a preferred orientation.

Estimated proportions of constituents are epidote (3 per cent), actinolite (47 per cent), and quartz (50 per cent). Quartz ranges in grain diameter from 0.13 mm. to less than 0.0625 mm. Epidote occurs as cryptocrystalline to fine-grained crystals which are intergranular to quartz.

R11358

This is a chloritoid-quartz schist and is assigned to the highest portion of the greenschist facies. The rock has poor to fair structure which is shown by lineated chloritoid. The lineation of the specimen shows minor plications. The rock has formed by the low-grade synkinematic metamorphism of a sediment deficient in K and Mg and rich in Al, Fe, and Si (an argillaceous quartz rock).

Estimated proportions of constituents are sericite, muscovite and chlorite (about 5 per cent), quartz (35 per cent), and chloritoid (60 per cent). Quartz is fine to medium-grained, anhedral to subhedral, and is noteable in that it has inclusions of opaques and probable micro-crystalline sericite. Chloritoid is fine-grained, shows blue pleochroism, and is subhedral to euhedral. Accessories are zircon (rare), sphene (rare), tourmaline (rare), and opaques (common).

Sericite, muscovite, and chlorite occur as retrogressive minerals formed by retrograde of chloritoid. Chlorite is penninite and occurs as large radiating porphyroblasts.

R11359

The rock is a sheared, fine to medium-grained quartz-feldspar-actinolite amphibolite. The structure of the specimen is formed by shear planes; these planes are marked by fine lines of dust-like opaques and by parallel bodies of actinolite in which the dust-like opaques occur. The petrogenesis of the rock is not clear; it is complicated by several probable periods of metamorphism whose mutual relationships are uncertain. A tentative metamorphic history is presented below. It seems to be comparable with the petrogenesis of other rocks from this locality whose history is clearer. Crystallization of actinolite with accompanying shearing, occurred during what is presumably the earliest metamorphism. Growth of poikiloblastic feldspar porphyroblasts, which partially destroy the elements of shearing, indicate that a period of thermal metamorphism followed synkinematic metamorphism (the porphyroblast and shearing relations are not certain). Texture of the specimen between planar actinolite is hornfelsic and thought to have formed contemporaneous with porphyroblast growth.

Estimated proportions of constituents are quartz (4 per cent), andesine (15 per cent), and amphibole (80 per cent). Opaques, as anhedral to subhedral crystals, are common accessories. Amphibole is actinolite and probable cummingtonite. Cummingtonite (??) appears to have formed during thermal metamorphism.

R11360

This is a chloritoid-quartzite. The rock compares very closely to specimens R11355,6 in mineralogy and texture. All three rocks have been subjected to low grade metamorphism.

Quartz forms about 97 per cent of the rock, chloritoid about 2 per cent and the remainder is composed of opaques and chlorite. Chlorite appears to have formed retrogressively from chloritoid.

R11361

The specimen is a chloritoid-sericite-muscovite quartzite. The rock is another of the Mount Menzies chloritoid quartzites but it has been subjected to more intense deformation than other quartzites of the locality the writer has described.

The quartz grains show a slight to fair parallel elongation. Muscovite often occurs in lens-like bodies which parallel the quartz elongation. Thicker, less abundant lenses of muscovite with some chloritoid transect the general quartz elongation. Sericite is a common intergranular mineral and present in the muscovite lens-like bodies also. Due to the complex nature of the structure and because sericite and chloritoid show preferred and non-preferred orientations, the metamorphic history of the rock is not clearly defined. It can be stated with certainty that the rock has undergone a low grade metamorphism. Zircon and opaques are present as accessories. Sericite and muscovite form about 7 per cent of the rock, chloritoid about 3 per cent and quartz about 90 per cent.

R11362

This is a schistose, garnet-muscovite quartzite and is assigned to the higher portion of the greenschist facies; the petrogenesis of this specimen is discussed further below. The unmetamorphosed sediment was an impure quartz arenite. Foliated mica minerals give the rock its foliation. The specimen also shows a poor crystallisation foliation; quartz crystals are elongated.

Muscovite and chlorite form about 10 per cent of the specimen and are present in about equal quantities; quartz forms about 90 per cent of the rock. Chlorite is penninite and has probably formed by retrograde alteration of muscovite. Garnet is present as poikiloblastic porphyroblasts, forms about 1 per cent of the rock, and is probably spessartite. Several corroded, embayed crystals present with muscovite are tentatively identified as chloritoid. This may indicate that chloritoid was more abundant at a lower metamorphic grade and has progressively altered during metamorphism. Opaques are present as rare accessory minerals. Random porphyroblasts of biotite showing no preferred orientation have crystallised and formed by replacing some of the muscovite.

The unoriented aggregates of biotite complicate the petrogenesis of this rock. It is evident that the initial metamorphism has been a sykinematic one principally, but that biotite growth has occurred during a time when differential stress has been lacking or only weakly present.

Biotite replaces earlier synkinematic mica and thus crystallized under thermal conditions either during the "dying" stages of synkinematic metamorphism or during a later thermal metamorphism.

R11363

This is a fine to medium-grained, epidote-quartz-actinolite amphibolite. The rock has a low-grade metamorphic mineral assemblage. It has a rather vague structure, but the structural element does suggest that the rock has been metamorphosed under sykinematic conditions. The poor structure is formed by linear elements within the general aggregate of actinolite. These elements are parallel crystals of actinolite, aggregates of opaques and augen-like lenses of quartz.

Estimated proportions of mineral constituents are epidote (2 per cent), feldspar (1 per cent), quartz (12 per cent), actinolite (85 per cent). Accessories are apatite (rare), zircon (rare), and opaques (common). Opaques occur in lens-like to xenoblastic aggregates. Epidote is present as cryptocrystalline to fine-grained crystals which are intergranular to quartz. Quartz occurs as aggregates of fine-to medium-grained crystals which generally have actinolite crystals extending into or as inclusions within the aggregates.

R11580

This rock is a sericite-quartzite and is assigned to the greenschist facies. The rock has formed by low grade metamorphism of a slightly argillaceous quartz arenite or siltstone. The specimen has a poorly developed structure imparted by foliated sericite resulting from shearing stress. In some places the quartz shows crystallization foliation.

Estimated proportions of mineral constituents are sericite (10 per cent), and quartz (90 per cent). The quartz has recrystallized into anhedral to subhedral crystals. The specimen has an equigranular texture; quartz has an average diameter of about 0.19 mm. Sericite shows a range of crystal length from cryptocrystalline to 0.2 mm. Several lens-like aggregates of sericite cut the rock and opaques, present in accessory amounts, are associated with the sericite bodies. A few large crystals of chlorite are scattered through the rock. Rounded accessory minerals (tourmaline, zircon and apatite) attest to sedimentary origin of the rock.

From field relations, can this specimen be correlative with the chloritoid quartzites of Mount Menzies?

Mineralogically, the rock could be a lower grade equivalent of the chloritoid quartzites.

R11581

This rock is a corderite-chloritoid-muscovite-quartz schist. The rock has an excellent schistosity formed by foliated, fine-grained muscovite. The muscovite is puckered and occasionally a secondary S-plane is developed by muscovite parallel to the axial plane of the plications. The original sediment was probably an argillaceous siltstone.

Fine-grained quartz is the major constituent; chloritoid and muscovite form about 30 per cent of the rock and are present in about equal quantities. Cordierite occurs as fine to medium-grained porphyroblasts often with dust-like, opaque inclusions. The porphyroblasts generally have a structural location in the axial areas of the plications Several lenses of quartz, probably segregation veinlets, parallel the schistosity of the rock. Several similarly shaped bodies formed by aggregates of goethite (?) and golden-brown, transparent minerals (monazite?) also are present.

Metamorphism of the sediment has been complex and its petrogenesis is perhaps not determinable from this single sample. However, several features of the history can be stated with certainty:-

1. Initially the rock has undergone a synkinematic, low grade (greenschist facies), regional metamorphism,

2. As cordierite occurs only in regional metamorphism in higher grades, the specimen has undergone a later period of thermal metamorphism. While time relations of these two periods of metamorphism cannot be stated emphatically, the relationships of chloritoid and cordierite with structure indicate that thermal metamorphism occurred during the waning stages of synkinematic metamorphism. About half of the chloritoid shows no preferred orientation; this appears to indicate that chloritoid began crystallization during synkinematic metamorphism and completed its

crystallization during thermal metamorphism. The favoured structural location of cordierite, in the axial areas of the plications, indicates that stress was still active during the initial stages of cordierite crystallization.

Goodspeed Nunataks

R11599

This is a calcite-pistacite-quartz hornfels. The rock has a very poor structure -- some linear concentrations of opaques and pistacite are present. These concentrations are thought to be inherited sedimentary bedding features rather than structure formed by metamorphism with accompanying differential stress. The rock has a typical hornfelsic texture with poikiloblastic, directionless mica and non-oriented minerals present in a matrix of relatively equigranular quartz. The rock is thus assigned to the albite-epidote hornfels facies and is thought to have formed by thermal metamorphism of a fine-grained, impure quartzose arenite.

Quartz, as a mosaic of interlocking crystals, forms about 70 per cent of the specimen; mica is the next most important constituent. Mica is green biotite (most abundant), muscovite, sericite and chlorite (probably a retrogressive alteration product of biotite). Biotite forms the coarsest crystals of the rock (some reach a length of 1.2 mm). Pistacite showing typical yellow pleochroism is present as euhedral to subhedral crystals. Calcite is common and generally is intergranular although occasional larger, poikiloblastic crystals are seen. Opaques, showing varied shape and size and association with the ferromagnesians are a very abundant accessory mineral. Present as more rare accessory minerals are zircon, apatite, tourmaline and sphene.

R11600

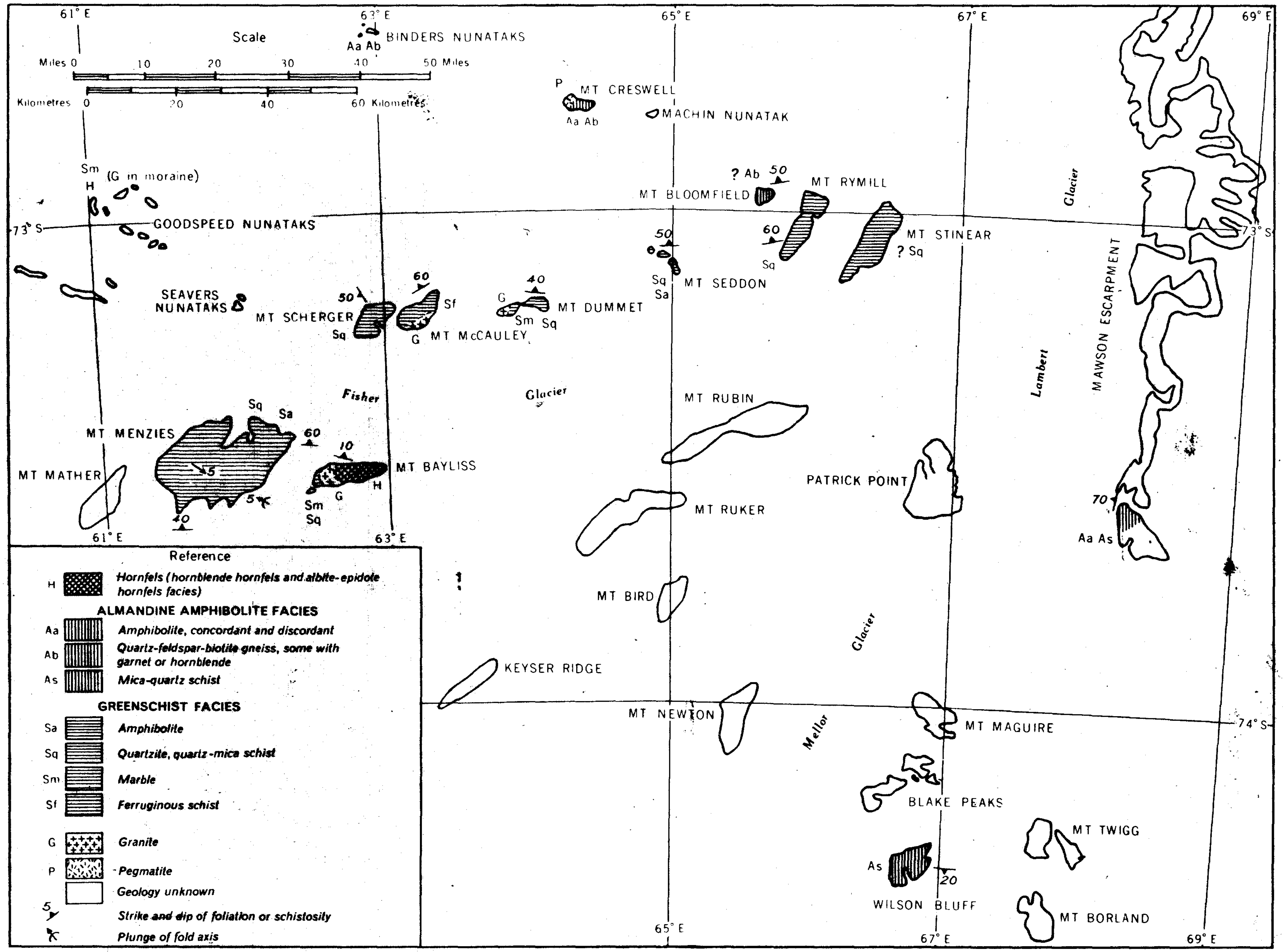
This is a calcite marble which has been brecciated in places. Large calcite crystals (reaching a diameter of 10.0 mm.) wholly comprised the rock before brecciation.

Fragments of the brecciated portions are extremely angular and little or no attrition has occurred. Intrafragmental spaces are filled with quartz which generally has a very elongated habit. Silica has also replaced part of the carbonate along cleavages and fills or replaces it along thin vein-like, cross-cutting bodies. The source of the silica for the silicification is an interesting problem - perhaps it is hydrothermal and the rock is a fault breccia.

Calcite is the fluorescent mineral.

Fig. 4.

RECONNAISSANCE GEOLOGICAL MAP OF THE SOUTHERN PRINCE CHARLES MOUNTAINS ANTARCTICA



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To accompany Record No 1963/155

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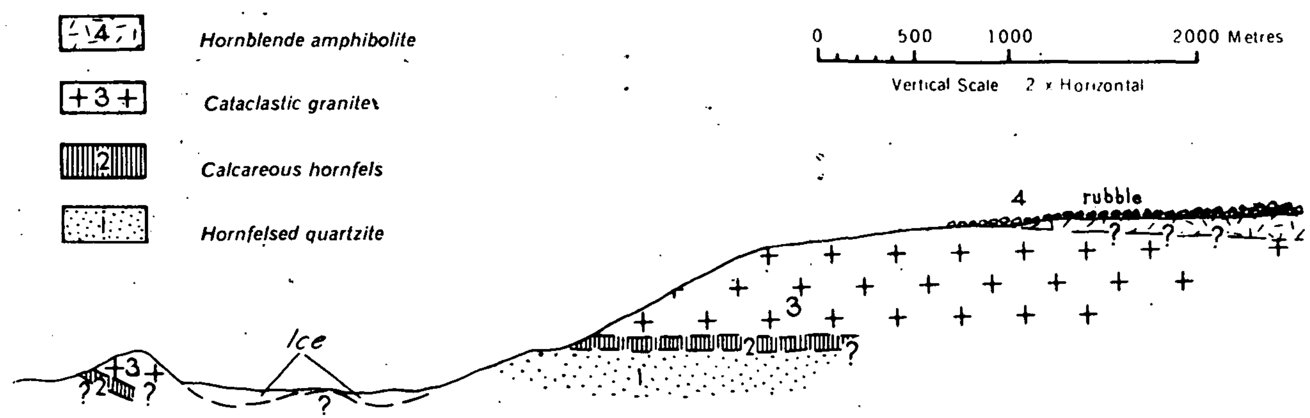
FIG. 5



DIAGRAMMATIC SECTION OF MOUNT BAYLISS, WEST END

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SEPTEMBER 1963