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REPORT ON GEOLOGICAL AND GLACIOLOGICAL WORK BY THE 1958 AUSTRALIAN NATIONAL ANTARCTIC RESEARCH EXPEDITION

by

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RECORDS 1959/131

CONTENTS

SUMMARY

The work described in this report is a continuation of that carried out in previous years. The rocks generally are similar to those described in earlier reports, viz. granite gneisses and migmatites, quartz-feldspar-garnet gneisses and quartz-feldspar and pyroxene gneiss; with extreme metamorphism these last two grade into charnockitic gneiss; dolerite and metamorphosed basic dykes cut these gneisses. Quartz-mica schists occurring in the southern Prince Charles Mountains have a notably lower metamorphic grade than the other rocks of the sector. The Permian sediments at Beaver Lake were also examined. Evidence of block faulting was found throughout the area.

Raised beaches were found at Amundsen Bay. Highly saline lakes in the Vestfold Hills are due to concentration of seawater in basins isolated by a fall in the sea level.

Analyses are given of water samples collected at intervals from these lakes, and of water from Beaver Lake, which is shown to be part of the Amery Ice Shelf.

Measurements of snow and ice accumulation and ablation were continued, and a detailed account kept of seaice conditions. Using measurements of the rate of flow of ice, along a line of known thickness, calculations are made of the mass economy of the plateau.

INTRODUCTION

This report embodies the results of geological and glaciological work by the writer while based at Mawson as a Member of the 1958 Australian National Antarctic Research Expedition. The work was a continuation of that carried out since 1954, and consequently this report is, to some extent, supplementary to those by Stinear (1956) and Crohn (1959).

During the year, the writer made field trips to the following places, involving 126 days in the field, and 80 hours flying time: a traverse north of the Framnes Mountains to measure ice thickness; the east end of the Robinson Islands, and the Auster Emperor penguin rookery; Mt. Hordern; Beaver Lake, and several points in the Prince Charles Mountains; Grove Nunataks; Amundsen Bay, Nye Mountains and Perov Nunataks; and a sledging journey of 410 miles from Amundsen Bay to Mawson. Geological observations were also made from the aircraft during various flights.

The routes of these journeys are shown on map 1.

In addition to these journeys, a number of one-day trips were made to Mt. Henderson and the islands within a few miles of the camp.

During the voyage to Mawson, landings at Lewis Island and at several points in the Larsemann Hills allowed examination of the geology at these places.

A brief description is also given of specimens collected from the Wilson Hills area of Oates Land by J. Hollin early in 1959.

Unless otherwise specified, all laboratory work was carried out by the writer, and the conclusions are his own responsibility.

PREVIOUS WORK

With the exception of Beaver Lake, none of the inland areas had previously been visited. Reports of earlier geological work by A.N.A.R.E. personnel are those by Stinear (1956), and Crohn (1959)* (who also lists earlier work). Segnit (1957) has described a sapphirine bearing rock from Mawson. Brief accounts of work by Soviet Antarctic Expeditions are given by Ravich (1958) and Ravich and Varonov (1958)

Earlier glaciological work is described by Loewe (1956a, b) and Mellor 1958, 1959 a, b, and 1960).

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* When this report is referred to in the text which follows, only the appropriate page number will be quoted.

GEOMORPHOLOGY

TOPOGRAPHIC FEATURES

In their general form, the rock exposures of the area can be divided into three groups: (1) The coastal outcrops, most of which are islands or bluffs, or low hummocky hills projecting from the edge of the ice sheet, with deeply indented coastlines and many lakes. (2) Inland exposures of the Alpine type, with jagged ridges and sharp peaks. (3) Large steep-sided flat topped exposures.

The first of these groups has been described by Crohn (p.15); the saline lakes of the Vestfold Hills are described in a later section.

The second group is exemplified by the mountains of Enderby and Kemp Lands, and by the Grove Nunataks. The topography of these features is largely the result of sculpture by ice movement and nivation. The details have commonly been controlled by the foliation of the gneisses or by lines of weakness such as shears (Plate I, fig. 1). Abandoned cirques can be recognised on many of these Peaks (Plate I, fig. 3). It is probable that the original relief was the result of block faulting, but although many of the ridges rise to approximately the same altitude, it is difficult to recognise old land surfaces, so deeply have they been dissected. An exception is Mt. King, where several small flat summits occur between 3000 and 4000 feet above sea level.

The flat-topped outcrops of the third group are best developed in the Prince Charles Mountains and along the eastern edge of the Amery Ice Shelf. The exposures consist of blocky massifs, whose steep sides, with few or no projecting spurs, rise abruptly from the ice to level summit surfaces several square miles in area (Plate 2, fig. 2).

These long straight rock faces are notched by cirques. Many of these still contain active ice, but others are quite free of ice, and have been left "hanging" above the present surface of the ice cap.

These flat topped summits evidently represent an old erosion surface, now greatly disrupted by block faulting. In the southern Prince Charles Mountains, the surface is several thousand feet above sea level, e.g. Patrick Point rises 6800 feet above sea level, and over 3000 feet above the Lambert Glacier. On the other hand, around Beaver Lake, and along the eastern side of the Amery Ice Shelf, extensive plateau surfaces occur only a few hundred feet above sea level (Plate 2, fig. 3). On the eastern and north-western sides of Clemence Massif, broad terraces a few hundred feet above the ice are the southernmost low level representatives of the old surface.

The latest movement along these fault lines was in comparatively recent times, and many scarps are still prominent, even in the sandstones of the Amery Formation. Others have been partially concealed by moraine banked up against the scarp. Evidence of retreat of the scarps, due to back-cutting by cirques, can be seen in places; at the southern end of the Mawson escarpment, retreat amounts to a couple of miles.

Although the extremely level nature of the summit plateaux of the various mountains owes its perfection to partial submergence of the bedrock topography by moraine, inspection of the massifs from the air, and examination of aerial photographs leaves little doubt that the ridges of bedrock all rise to much the same height; the moraine merely fills the intervening valleys. Along the north-western side of Radok Lake, the lip of a fault scarp (the Amery Fault) has been notched by a series of gullys. Although in this case the whole area has been buried by moraine, the original top of the scarp is revealed as a series of projecting buttresses high above the lake (Plate 3, fig. 2).

It is rather remarkable that the ridges of the Vestfold and Larsemann Hills, the exposures down the eastern side of the Amery Ice Shelf, the area around Beaver Lake, and the terraces on Clemence Massif, all rise to roughly the same height above sea level (between 300 and 700 feet). Crohn (p.16) has also recognised an old surface along the coast between Mawson and King Edward VIII Gulf, from 100 to 400 feet above sea level. Around the coast at Amundsen Bay, too, there is evidence of an old surface a few hundred feet above sea level.

One is tempted to speculate that the tops of these exposures represent parts of the original surface level, which underwent little or no vertical movement during the block faulting which elevated the present ranges. Much more work will be required, however, to show whether or not this is the case. The rocks throughout the region have been free of ice for a long time. Honeycomb weathering is well advanced in the quartz-feldspar gneisses at Amundsen Bay, (Plate 4, fig. 1) and in the sandstones at Beaver Lake. Water worn gulleys were seen at several places, notably Beaver Lake and Amphitheatre Lake. The deep (200 feet) gully between Radok Lake and Beaver Lake would require prolonged stream activity, even in the relatively soft sandstone (Plate 5, fig. 3). Rock stacks around Beaver Lake point to a considerable period of subaerial erosion. The wave cut terraces in the Vestfold Hills have not been glaciated, because incoherent shell beds on them are quite undisturbed. This last feature would indicate the Vestfold Hills to have been ice free for at least 5000 years, i.e. since the time of the climatic optimum. The actual retreat of the ice was probably even earlier than this. Shumskii (1957) considers that the Bunger Hills, (which are comparable in area to the Vestfold Hills) have been in existence for at least 10,000 years.

MORAINE

Crohn (p.20) has divided the moraine deposits into an older high level group and younger low level group. The greatest development of the former is in the Prince Charles Mountains, where extensive deposits high above the present ice surface reveal prolonged burial by ice in the past.

In addition to these deposits, extensive terraces of high level moraine were found at the Leckie Range, Mt. Riiser-Larsen, and Amphitheatre Lake in the Nye Mountains. At the first of these places, the moraine partly fills valleys in the range (Plate 3, fig. 3); at the other two, the deposits are along the sides of mountainous exposures, as accumulations several hundred feet thick (Plate 3, fig. 1), where terraces at several levels indicate pauses in the lowering of the ice surface. The largest developments of younger moraine are along the "downstream" faces of extensive rock exposures; here the deposits may be many tens of feet thick, with very uneven and hummocky upper surfaces. This moraine usually passes into a medial moraine, which varies in appearance from a line of scattered boulders to a long trail of debris (Plate 4, fig. 3). In places, young terminal moraine at the snout of a cirque glacier, may actually overlie a deposit of old high level moraine, e.g. Amphitheatre Lake (Plate 3, fig. 1).

RAISED BEACHES

At the north-east corner of Amundsen Bay, a number of small shingle beaches occur around the base of Mts. Oldfield and Rüser Larsen. These consist of smooth well-rounded pebbles, with fairly good sorting, ranging from one to three inches in diameter; large rounded boulders are partly buried in this shingle. At a height of about 25 feet above sea level there is a sharp line of demarcation between this well-rounded debris and similar sized but quite angular fragments which show no signs of wave action.

As these shingle beaches occur even in sheltered inlets, it is unlikely that wave action, even during storms, could bring about rounding of pebbles at a height of 25 feet above the present sea level. It seems then, that they represent raised beaches, formed during a period of higher sea level; such beaches have been found in several other places around the Antarctic coastline, e.g. Stillwell (1918, p.20), Michols (1947), and Adie (1953).

In the Vestfold Hills, about a mile north-east of Davis, is a broad quite flat expanse of moraine several square miles in extent, and only a few tens of feet above sea level. Although it was not examined closely by the writer, it gives the impression of modification by wave action; in particular, the very flat surface is not at all typical of extensive areas of moraine.

East of Davis, several large lakes occur along an east-west trending valley; all have a surface level below present sea level (Lake Dingle - 32 feet, Lake Stinear - 54 feet, Deep Lake - 182 feet, Club Lake - 107 feet, unnamed Lake - 88 feet).

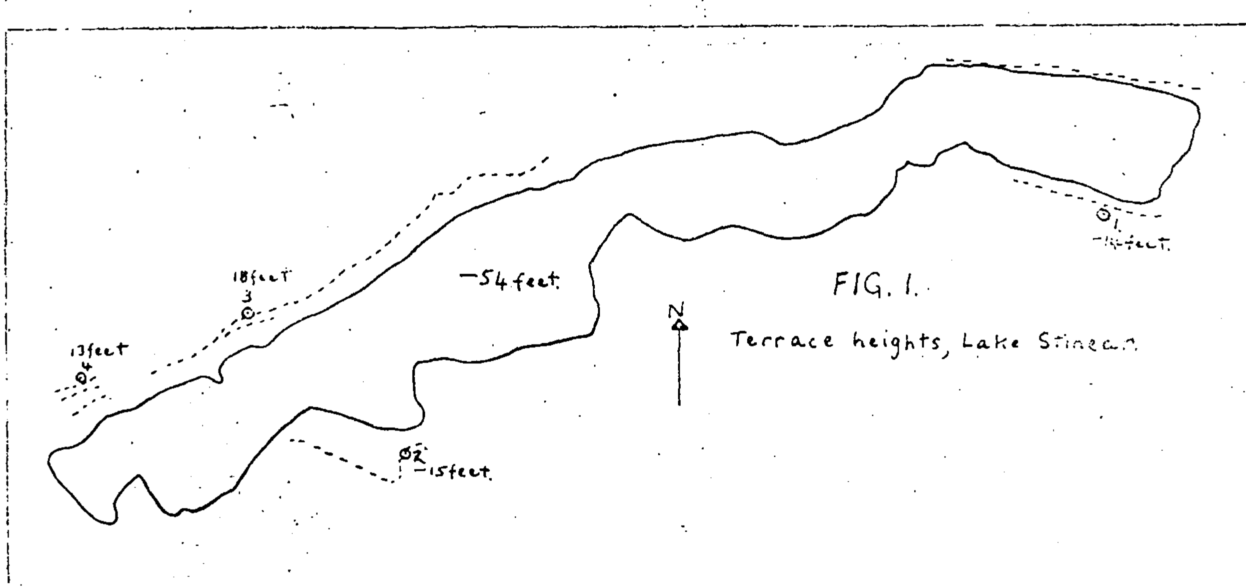


FIG. 1.

Terrace heights, Lake Stinear

With the exception of Lake Dingle, the sides of these lakes are generally steep to precipitous, the slopes rising sharply from the water or narrow steeply inclined boulder beaches. Breaking the line of these cliffs is a well defined terrace, varying from a couple of feet to several yards in width. The barriers between the lakes do not rise much above the level of the terraces, which is approximately at sea level. Mr. W. Simm of the Australian Forestry School kindly measured by photogrammetric methods, the height above water level of several points on the terrace around Lake Stinear. These heights relative to sea level, are shown in Fig. 1. These terraces were formed by wave action during a period of higher sea level, when the present lakes and the sea were joined. This matter is discussed in the next section.

Collections of fossils were made by B.H. Stinear and the writer from the shores of Deep Lake and Lake Dingle. The macrofossils were determined by Dr. McMichael of the Australian Museum as:

Pelecypoda

Laternula elliptica	King and Broderip
Lima hodgsoni	Smith
Malletia pellucida	Thiele
Pecten colbecki	Smith
Thracia meridionalis	Smith

Gastropoda

Nacella depressa	Hedley

Also worm tubes bearing a small vermetid gastropod, possibly Stoa. All the gastropods are rather worn, so that identification is very doubtful.

L. elliptica and worm tubes are particularly common on the terrace around the southern side of Lake Stinear.

All these forms are still in existance around the Antarctic coastline. The remains are obviously not very old; most show their original colouring, and many still retain parts of the nacreous interior surface. Three of the forms (P. colbecki, T. meridionalis and L. hodgsoni) were recorded by Hedley (1916) from raised beaches at McMurdo Sound.

In sand samples collected by B.H. Stinear from the 120 feet level at the north west corner of Deep Lake and from the terrace south of Lake Dingle, Miss I. Crespin of the Bureau of Mineral Resources identified the following foraminifera (Crespin 1960):

Quinqueloculina serra Crespin
Pyrgo patagonica (d'Orb.)
Pyrgo peruviana (d'Orb.)
Cornuspira tasmanica Parr
Trochammina malovensis Heron-Allen and Earland
Lagena ? protea Chaster
Lagena gracillima (Sequenza)
Fissurina reversens (Heron-Allen and Earland)
Parafissurina subovata Parr

Parafissurina lateralis (Cushman)
Parafissurina fusuliformis Loeblich and Tappan
Parafissurina tricarinata Parr
Oolina caudigera (Wiesner)
Oolina globosa (Mintagu)
Glandulina laevigata Reuss

Lingulina translucida Heron-Allen and Earland
Esosyrinx curta (Cushman and Ozawa)
Laryngosigma antarctica Crespin
Laryngosigma [illegible] Crespin
Laryngosigma hyalascidia Loeblich and Tappan
Globigerina bulloides d'Orb.
Discorbis [illegible] Earland
Discorbis vilardeboana (d'Orb.)
Cibicides refulgens (Montf.)
Cibicides lobatulus (W. and J.)
Cibicidella variabilis (d'Orb.)
[illegible] patagonica (d'Orb.)
Patellina antarctica Parr
[illegible] chapmani Heron-Allen and Earland
Astrononion antarcticum Parr
Nonionella iridea Heron-Allen and Earland
Bolivina pseudopunctata Höglund
Stainforthia antarctica Crespin
Stainforthia vestfoldensis Crespin
Cassidulina bicorna Crespin
Cassidulina crassa d'Orb.
Cassidulina sp.

SALINE LAKES

Lakes Dingle and Stinear, and Deep Lake and Club Lake, are all highly saline. Mirabilite is common around them as encrustations, and as layers in the few sandy beaches. In December 1958, Mr. P.W. Elliott collected a number of crystals of halite from a dried rock pool near the edge of Lake Stinear. The deposition of halite here rather than mirabilite was undoubtedly due to the relatively high temperature of precipitation. At intervals through the year, the water temperatures at the surface of Lakes Dingle and Stinear were measured by the men at Davis. At Lake Dingle, temperatures were taken at three places around the southern edge, and at Lake Stinear, near the south-west and north-west corners. The results are shown in Table 1. These temperatures had necessarily to be taken close to the shore, where the water may be slightly warmer than in the centre of the lake, due to solar heating of the dark rocks around the water's edge. (This effect will not, of course, be important during the winter period.

On the 23rd December, temperature measurements were made in the usual way, and in addition, samples of surface water were collected from about five yards offshore, and their temperature quickly measured. The results are shown in Table 2.

It will be seen that the most accurate values of those previously obtained were the ones from the north west corner of Lake Stinear, which was to some extent sheltered by the high cliffs, from direct solar radiation.

A number of water samples were collected through the year by the men at Davis. The report on the analyses of these samples, and of those collected the previous year by B.H. Stinear, is quoted as Appendix III of this report.

TABLE I

Lake temperatures, Vestfold Hills, 1958.

Date	L. Dingle °C	L. Stinear °C	Air Temp. (Davis) °C	Remarks
14th Feb.	4	4.5	-4	⅞ Cloud
28th Feb.	1	1	-4	Overcast
13th March	-1.5	-1.5	-5.5	Overcast
31st March	-3	-4	-4.5	Sunny
10th April	-6	-7	-6.5	Sunny
24th April	-9	-10	-10	Intermittent weak sun
7th May	-12	-13.5	-15.5	Overcast
21st May	-11.5	-11	-2	Overcast
5th June	-14.5	-15.5	-13	Overcast - sun below horizon
19th June	-17	-18	-22	Sun below horizon. L. Dingle frozen except for patch on south side; northern 1/3 of L. Stinear frozen.
16th July	-10.5	-10	-11	Overcast
31st July	2	-	-11.5	Intermittent sun. L. Dingle free of ice.
13th Nov.	-3	-1	-1.5	Intermittent sun; most of L. Dingle covered by soft ice and snow cover 4 inches thick.
27th Nov.	-0.5	1.5	2	Overcast. 90% of L. Dingle covered by 3 inches of soft ice and snow.

Winds were light in all cases.

TABLE 2

Water temperatures, Lake Stinear 23/12/58

	Site	Shore	5 yards out
Lake Dingle	1	6.7°C	4.4°C
	2	5.6	4.4
	3	8.2	6.7 (shallow water)
Lake Stinear	1	6.6	5.6
	2	6.7	6.6
Deep Lake		4.7	4.4

The day was overcast, with little wind; the air temperature at Davis was - 1°C.

There are four possible causes for the salinity of these lakes: Windblown sea spray; percolation of seawater from the ocean through moraine; chemicals derived from rock weathering; concentration of seawater in basins isolated by a eustatic fall of sea level.

The first two of these can be easily dismissed. Even over an extended period of time, it is unlikely that enough spray could be added to produce the present brines; besides, lakes closer to the ocean, and smaller, which should therefore be even more saline than those under consideration, are fresh, or at the most, slightly brackish.

The second case is even more improbable. As much of the ground is permanently frozen, groundwater circulation will be extremely limited; and Deep Lake, at least, is almost completely surrounded by rock.

In the third case, the rocks of the area are not such as would give very saline solutions, and again, freshwater lakes occur on rocks similar to those around the saline lakes.

Most important, none of these three causes can explain the abundant marine fossils found around the shores of the lakes, which show conclusively that the lakes were once part of the sea. The chemical composition of the lake waters, too, suggest that the lakes were once part of the sea. Haldane (Appendix III) concludes that "the present brines have arisen by the evaporation of water from seawater with sodium sulphate alone or with sodium chloride being deposited in the process."

The greater concentrations of Club and Deep Lakes is probably due to their smaller drainage basins, as a consequence of which they receive less run-off than the other two lakes during the summer melt period.

It is hoped that a radiocarbon age determination on the molluscan remains will give an indication of when these lakes were isolated. This event must have occurred in fairly recent times; the writer believes that it was the result of the lowering of sealevel with the waning of the climatic Optimum about 3500 years ago.

HYDROLOGICAL AND OTHER OBSERVATIONS, BEAVER LAKE.

Beaver Lake is an expanse of relatively smooth ice, about 30 square miles in area, at the southern end of the area enclosed by the horseshoe shaped rock outcrops of Jetty Peninsula, Flagstone Bench and the Aramis Range. A long narrow extension of the lake runs along the eastern edge of the Aramis Range.

The lake consists of clear ice, containing numerous streams and efflorescences of trapped air bubbles. The surface is cusped and rather uneven, with long swells a couple of inches high and two or three feet wide running across it in a north-westerly direction. Low mounds on the surface, consisting of a mixture of opaque white, and clear ice, represent melted and recrystallised snow drifts. An analysis of the ice of one of these mounds, and of the lake ice, is given in Table 3. (See also Appendix III.)

TABLE 3

Analyses of water and ice, Beaver Lake.

	Ice from surface		Water from rafted zone	
	Normal	Melted Snowdrift	24/10/58	2/11/58
Ca, Sr	less than 0.1 ppm	less than 0.1 ppm	0.012	0.016
Mg			0.032	0.044
Na	0.003	0.002	0.343	0.470
K	0.002	0.001	0.010	0.010
HCO_3	nil	nil	0.006	0.008
SO_4	0.004	0.004	0.086	0.130
Cl, Br	0.004	0.002	0.626	0.850
Total	-	-	1.115	1.528

Observations by the party which camped at Beaver Lake in November 1957, led them to believe that the ice surface of the lake was afloat. There is ample evidence to support this conclusion. Around the edges of the lake is a zone of rafting, up to 20 yards wide and 15 to 20 feet high in places (Plate 6, fig. 1); at intervals, water wells up through this zone, spreads over the nearby ice, freezes, and is in turn buckled and rafted. Over a period of a fortnight, the amount of rafting increased noticeably. From our camp on the ice, continual sounds of movement could be heard, together with the gurgling of running water. Analyses of the water welling up in the rafted zone are listed in Table 3. Most of the area between Jetty Peninsula and the Aramis Range appears from the air as a series of N.N.E. trending ridges, with long straight valleys intervening, and transverse notches at intervals. These ridges are actually lines of icebergs, some of which, in the southern part at least, are 50 feet high. Further north the height appears to decrease, and the valleys are not so wide. These bergs originate from the Nemesis and Charybdis Glaciers; at the north-west corner of the horseshoe, east-trending flow lines swing south and can be followed into the horseshoe area for several miles.

These icebergs are evidently afloat. Water is welling up around the edges of some; others have toppled, breaking up the lake ice around them; this movement was in cases, quite recent, as snow drifts had been truncated and rafted, and the cracks were not filled with new snow. Many of the bergs are composed partly of black ice, at least 50 feet thick; the colour becomes less intense down from the top, and some distance down, small irregular areas of almost clear bubbly ice occur. The upper surface of the black ice is quite sharp and straight; it is overlain by clear ice with a very high proportion of air bubbles (about 30%) giving it a white opaque appearance. The air content of the black ice, on the other hand, is very low.

The black ice also contains a moderate amount of fine sand, and in cases melt water running down the sides of bergs was building up small piles of sand at the base of the berg. Thin parallel laminae of coarse sand, with sporadic blocks of sandstone several inches in extent, occur near the top of the black ice. From berg to berg, these correspond in number and distance from the top of the black ice, and so must originally have been quite extensive. These laminae probably represent basal shear layers in the ice. (cf. Rausch 1959, p.13).

The black colour of the ice appears to be due to the low proportion of enclosed air bubbles, aided by the fine included debris.

Blocks of sandstone, some weighing a hundredweight or more, occur on the surfaces of tilted bergs, and less commonly, on the lake ice. Most of the fragments are angular, but a few rounded ones occur. Some fragments of black carbonaceous shale were also found but no metamorphic rocks were seen. This means that the rock debris must have been incorporated into the ice east of Mt. Loewe, because no sediments are known west of the Amery Fault.

Areas of ice between the bergs are quite clear, except for streams of air bubbles; the proportion of these is much smaller than in the ice of Beaver Lake. This ice probably derives from pools of water running from the sides of the bergs. In a few places small piles of sand and mud occur on the ice.

Despite the amount of rock debris on the surface and the prevailing high ablation rate, there is a surprising absence of cryconite holes; some of the larger fragments lay in shallow depressions, but most showed no signs at all of melting into the ice.

As opportunity offered, the surveyor read a series of vertical angles between a theodolite set up on the ice, and a point of rock on the nearby cliff; the distance between the instrument and the point was found by triangulation. By this means, the heights shown in Table 4 were obtained. Fig. 2 shows that these movements fit quite well into the pattern of a semi-diurnal tide.

TABLE 4

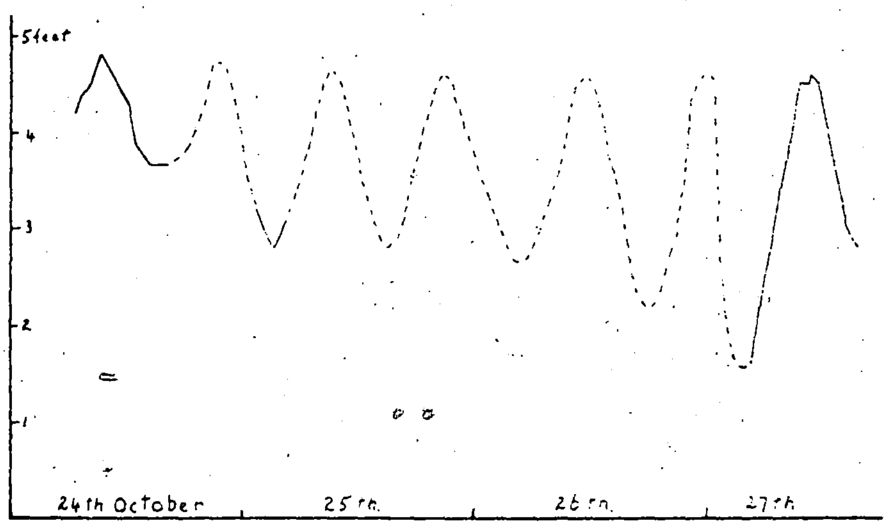
Height of ice surface, Beaver Lake
(in feet above an arbitrary datum)

Date	Time (GMT)	Height
24/10/58	0650	4.2
	0725	4.4
	0815	4.5
	0935	4.8
	1115	4.5
	1210	4.3
	1305	3.9
	1410	3.7
	1515	3.7
25/10/58	0130	3.2
	0210	3.0
	0310	2.8
	0405	3.1

Date	Time (GMT)	Height
27/10/58	0425	1.6
	0535	2.2
	0635	2.7
	0735	3.4
	0835	3.9
	0945	4.5
	1020	4.5
	1050	4.6
	1130	4.5
	1300	3.7
	1400	3.2
	1430	3.0
	1530	2.8

FIG 2.

Tidal movement, Beaver Lake.



The increase in the amplitude may be only apparent, due to movement of the theodolite station as the ice was rafted up towards the cliffs. On the other hand Crohn (personal communication) has pointed out that tidal measurements at Mawson show a great range of amplitudes, and the Beaver Lake measurements could represent the same variation. Thus, although the water oozing through the rafted zone is only brackish, and the ice of the lake surface is almost fresh, it is evident that the Beaver Lake area is actually an arm of the sea. The brackish composition of the water can be explained by dilution of the seawater by partial melting of the enormous volumes of freshwater ice added by the Nemesis and Lambert Glaciers. Mixing of the salt and freshwater by oceanic currents will be severely restricted by the great length of the embayment relative to its width. The ice of Beaver Lake itself, on the other hand, is probably formed largely from meltwater runoff from the nearby ranges. The length of some of the streams of trapped air bubbles (allowing for amounts lost by ablation) indicates that at some period water must have been a couple of feet deep on the lake. The extent of the present summer melting is not known, as the main lake has never been visited during the summer.

REGIONAL GEOLOGY

In this section, a separate account is given of each of the areas visited. The origin of the various rock types is discussed in the section on petrology. A generalised geological map is presented as Map 2 of this report.

LEWIS ISLAND

Lewis Island is a small dome shaped island thirty yards from the edge of the continental ice sheet on the eastern side of Davis Bay, in position 66°06'S, 134°22E. It is about 300 yards long, 200 yards wide and 90 feet high (Plate 7, fig. 1) and is connected by a partly submerged rock shelf to rock exposures in the ice cliffs.

The magnetic declination was found to vary between 70°W and 100°W within 24 hours. At the time of the geological work, it averaged 90°W.

The rocks forming the island are migmatites, consisting of a grey fine to medium-grained gneissic biotite granodiorite, and biotite hornfels. The granodiorite is predominant, but bands of hornfels are fairly common, especially on the northern side of the island, where they are up to 5 feet wide, and mostly sharply demarcated from the granodiorite. Elsewhere the bands are thinner and tend to be discontinuous. Small well defined inclusions of hornfels occur in parts of the granodiorite.

The hornfels is a fine grained granular rock, composed mainly of feldspar and biotite. Variation in the ratio of these two minerals produces a marked banding. The proportion of biotite varies from less than 10 to 50 or 60 percent of the rock.

Small nests of epidote, and scattered grains of pyrite, also occur in the hornfels. The granodiorite consists (4556)* of andesine, quartz, biotite and perthite, with accessory pyrite, magnetite, spinel, sphene, calcite, clinozoisite and muscovite; the last three and some of the magnetite may have been produced by alteration during crushing of the rock as they are concentrated along lines of granulation. Perthite is generally present in only small amount, but in places is common as pink crystals, up to an inch across; the granodiorite containing these is richer than usual in biotite. Along the lines of cataclasis in the rock, the grain fragments (mainly quartz) have been partly recrystallised, so that their boundaries are highly sutured. Narrow pegmatite veins occur, composed of white plagioclase and pink potash feldspar as crystals up to one inch across, with some quartz, brown garnet, small biotite flakes, magnetite and pyrite. Some contain thumbnail sized hornblende grains instead of biotite.

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* Numbers are those of thin sections in the Bureau of Mineral Resources collection.

A few of the wider ones (up to six inches across) have a zonal arrangement of the feldspar and quartz. The pegmatite veins are straight and sharp-edged and run both across and parallel to the foliation of the country rock.

In a few places narrow zones contain a network of thin epidote veins. Veinlets and knots of white quartz with small brown garnets, and of clear quartz with sporadic pyrite, also occur. The strike of gneisses is a constant 070°, and they dip to the south at 50° to 70°.

Only one obvious erratic was noted, a boulder right at the summit of the island, consisting of granite gneiss much more ferric than any seen on the island, and cut by several feldspar veins.

Ice polished surfaces were seen at several places on the island.

MIRNYY

A brief visit was made to the Russian station Mirnyy in the Haswell Islands, (McLeod 1958). These islands were first visited by members of the western party of the Australasian Antarctic Expedition (1911-14); a detailed account of the geology is given by Ravich and Voronov, (1958).

The rocks of the station area are charnockitic granular gneiss (4557), unusual in that they carry small amounts of biotite and hornblende, and the hypersthene displays broad lamellae of clinopyroxene; the dominant feldspar is oligoclase. Dark inclusions are common, and lenses of quartz occur in a number of places.

The rock, except for its high content of plagioclase, appears to be comparable to a vein rock in coarse charnockite, described by Nockolds (1940) from the same area.

LARSEMANN HILLS

These are a group of ice-free ridges projecting from the edge of the ice sheet at about 69°25'S, 76°20'E. Including the numerous outlying islands, an area of about 30 square miles of rock is exposed. The outcrops present a rather ridgy topography, rising to about 400 feet above sealevel. Numerous small lakes occur in the valleys; some of these taste very slightly brackish.

Moraine is not common on the hills, but some of the debris in the valleys could well be ice transported material. Polished surfaces were seen in several places.

The magnetic declination (8th February 1958) was 72°W.

Stinear examined the eastern part of the area in 1957, finding rocks similar to those described below. Lichen Island, 12 miles to the west, was visited by Crohn in 1955. In February 1958, landings were made at three places in the central and western parts of the hills. (Fig. 3)

The rocks are migmatitic, consisting of quartz-feldspar-garnet gneisses and hornfelses with bands of coarse massive granite up to 10 feet thick.

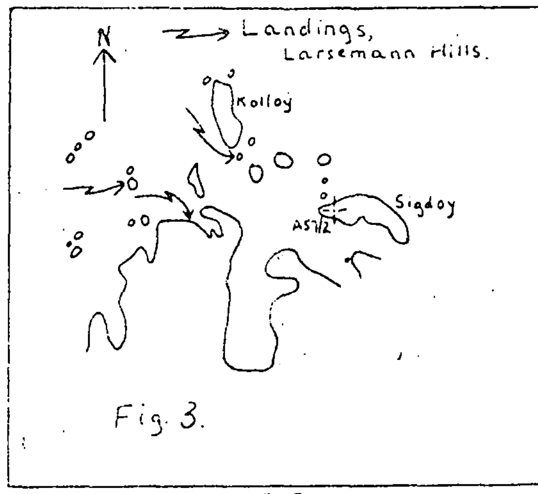

Fig. 3.

The typical gneiss (4559) is a fine to medium grained light coloured rock, containing very finely perthitic potash feldspar, quartz (occurring both as shapeless grains and as small circular blebs included in the feldspar) andesine, faintly pink garnet, red brown biotite and accessory zircon, epidote, apatite and magnetite; some of the plagioclase grains have myrmekitic fringes. In places, the garnets form thin, whispy streaks through the rock; in others, garnet and biotite become quite common, and the garnet then forms sugary textured nodules up to half an inch across. Some bands, a foot or two wide, are almost entirely garnet. In the central part of the hills, the quartz-feldspar-garnet gneiss contains numerous nodules, 3 inches across, of coarse red-brown garnets; veins and grains of magnetite are common in parts of this rock, and also in some of the granites (characterised by a creamy colour). On the mainland in the western part of the hills occur a number of layers up to 30 feet thick, of fine to medium grained feldspar-biotite-pyroxene hornfels, with a banding due to variation in the concentration of the dark minerals. On a nearby island bands of schistose biotite-feldspar-quartz hornfels contain lenses, several feet long, of almost pure biotite. On this same island is a body, several feet across, of a dark, massive fine to medium grained magnetite rich rock, containing (4558) hypersthene, magnetite (with pleonaste closely associated) biotite, pale brown hornblende, partly serpentinised olivine, pyrrhotite and apatite. The texture of this rock is typically igneous, and the mineral composition also suggests an igneous origin, but no other signs of igneous activity were seen in the area, and this rock may have been produced by metasomatism.

The granite is a coarse grained massive red or creamy coloured rock made up of potash feldspar and quartz (in cases amethystine) with rare biotite and garnet. The granite bands all have a sharp straight margin against the gneisses. Coarser pegmatitic rocks (generally of quartz and feldspar only) form lenses several feet thick.

Most of the rocks in this area, especially those rich in iron, show a slight degree of weathering. Limonite is common along joints and the hornfelses are stained brown; the feldspars of much of the gneiss have a brownish tinge, and the rock is rather friable.

In the central part of the hills, the rocks strike 050° and dip south-east at an average of 50°. Small symmetrical folds are common here, the degree of folding varying from open to fairly tight. On the mainland, the strike is 020° and dip 30° to the east, while on the nearby island, rocks with a similar strike (030°) dip west at 30°, to 50°.

ROBINSON ISLANDS

The western part of this group of islands, 15 miles north-east of Mawson, is described by Crohn (p.28) as being garnetiferous porphyritic charnockitic granite.

Islands at the eastern end of the group were found to consist of medium grained well-foliated charnockitic granular gneiss, with scattered small aggregates of dark red garnet. The rock contains numerous dark inclusions (up to 10 percent of the rock in places) elongated along the foliation, with a similar texture to the gneiss, but a much higher pyroxene content, and not so well foliated.

A few veins of blue quartz also occur. The strike of the foliation varies between 020° and 050°, and dips between 45° and 70° to the west.

Only one undoubted erratic was seen, a small piece of light coloured, medium grained garnet feldspar rock, near the summit of one of the islands.

MASSON RANGE

This is one of the units of the Framnes Mountains, extending south from a point about 10 miles south of Mawson. The main range consists of three separate rock masses (North Masson, Central Masson, and South Masson Ranges), and continues south for another ten miles as scattered nunataks.

The geology of the north Masson Range has been described by Crohn (p.46). In December 1958, E. Burnett and P. Trost visited the central and South Masson Ranges, making a number of geological observations and collecting specimens. The central Masson Range consists of porphyritic charnockitic granite with dark hornfelsic inclusions, and a few pegmatite veins, and is sheared in places.

A few lenses and veins of a rather coarse aplite with rare garnet were seen a couple of miles from the northern end of the range.

Although it was not visited, observations by the writer from a distance of a mile or so, suggest that the isolated hill west of the central Masson Range consists of metasediments like those at the north end of the north Masson Range.

MT. HORDERN

This was only briefly visited, and little can be added to the account given by Crohn (p.49). Stone polygons are well developed on the southern side of the col south of the main peak. Moraine extends above this saddle for a couple of hundred feet, and beyond this, bare slabs of porphyritic charnockitic granite rise steeply to the summit of the mountain.

MT. TWINTOP

Mt. Twintop is a twin peaked mountain near the southern end of the David Range. A ridge and several nunataks (Brown Range) continue southward for a few more miles. In January 1959 a number of specimens were collected and observations made by D.A. Brown.

The rocks are rather different to those occurring further north, being dark fine grained foliated granitic gneiss with moderate amounts of biotite and garnet and only rare pyroxene. Biotite rich inclusions occur, and a specimen of garnetiferous granite is described as occurring as a vein; it contains quartz, potash and plagioclase feldspar, biotite and garnet. The rocks strike north-south and dip east at 65°.

Moraine is common on the flanks of the peaks. It is dominantly boulder and pebble sizes, these two generally occurring in about equal amounts.

BEAVER LAKE

This area was first examined by Crohn, who in January 1957, visited the northern extension of the lake east of Mt. Loewe. Stinear examined the rocks around the south-west corner later the same year.

In October 1958 a camp was established five miles east of Stinear's camp-site in connection with the Prince Charles Mountains exploration programme, and the opportunity was taken to examine the rocks east of those seen by Stinear.

The outcrops around the western and southern margins of the lake are of sediments of the Amery Formation (Crohn p.63) which form cliffs and bluffs up to 100 feet high (Plate 6, fig. 1). Along the southern edge of the lake these sediments are sandstones, with a few bands of reddish-brown sandy siltstone.

The typical sandstone is a creamy or fawn coloured rather porous rock, with moderately rounded grains. The grain size varies rapidly, and the degree of sorting is only fair. The particle size ranges from coarse sand to granules, with pebbles along some horizons.

The dominant mineral is quartz, mostly clear, but with smoky quartz common in places. A small amount of white kaolinised feldspar is generally present, and may form up to 20% of the rock; in many specimens, flecks of white clay probably represent the last vestiges of feldspar grains. Sporadic grains of pale pink garnet occur.

A common feature of this rock is the presence of limonite-rich concretions. These consist of localised concentrations of dark brown limonite cementing the grains of the rock into a hard mass, which stands out in relief on exposed surfaces, or weathers out and lies loose on the surface. The concretions are roughly spherical and range from an eighth to over three inches across. In places they form as much as five percent of the rock.

Current bedding is well developed in the sandstone; the structures indicate currents from a general west to north-westerly direction.

Some horizons show penecontemporaneous folding; the bedding is highly contorted and overturned (Plate 6, fig. 3), with several small faults; the tops of these structures are eroded, and the overlying beds show no sign of slumping. Near, but stratigraphically above this slumping, is a band of fine grained greenish grey laminated sandstone, eighteen inches thick, which contains several sandstone "dykes" (Plate 6, fig. 2) with a texture very similar to that of the normal arenites above and below the laminated sandstone; the bedding of the latter is compacted down around the dykes. The material under an inverted-L shaped "dyke" is apparently identical to the rest of the band. The largest of the dykes is about nine inches wide and a foot high. They appear to be sharply separated from the underlying sandstone (a wedge of greenish sandstone actually extends partly under the base of one "dyke".) The underlying sandstone appears undisturbed, except for one case, where there is some minor contorting in the top six inches.

Time did not allow a more thorough examination in the occurrence, and no idea could be gained of the mode of origin of the "dykes". Near the south east corner of the lake on the crest of a ridge 150 feet above the lake, the sandstone has been silicified, and parts are mottled with patches of red limonite. The silicified zone is at least ten feet thick. It is cut by numerous veins, up to half an inch wide, which are straight, more or less uniform in width, and subparallel in one of two or three directions which probably represent joint lines (although there is some anastomosing in places). The texture in these veins is the same as in the rock on either side but they are white where the rock is creamy or buff coloured, and the degree of silicification along them appears to be higher. Exposed surfaces of the rock produced by fracture along the veins, have a "varnished" look, and some display slickensiding.

Unlike those in the normal sandstones, fractures in this silicified rock run through the grains, and not around them. In thin section (4560), the silicification shows as authigenic outgrowths on the quartz grains, and small intergranular mosaics of very fine silica grains. Feldspar is present in only small amounts. Apatite, magnetite, and rarely, epidote occur in traces.

Although these light coloured feldspathic current bedded sandstones are the most common rocks along the southern edge of Beaver Lake, several other distinctive types are interbedded with them. One of these is a hard brown feldspathic sandstone with clear quartz and minor altered feldspar set in a dark brown limonitic cement.

There are also a number of occurrences of reddish brown massive sandy siltstone containing scattered small grains of feldspar and quartz. This forms bands several feet thick overlain by, and grading rapidly into, a few inches of creamy grey or yellow sandy shale or fine sandstone, which in turn is overlain sharply by coarse grits of the normal arenites. Interbedded in the sandy siltstone are lenses, up to two feet thick, of grey sandy shale, mottled red, and with thin red bands, especially towards the base of the lens.

At its base, the siltstone grades rapidly into a purple or grey massive fine grained arkose, containing up to 50 percent white opaque feldspar, and in some bands, a dominantly limonitic cement. This arkose is several feet thick; in all exposures, its base was obscured by scree.

About 30 feet above one of these sandy siltstone horizons is a bed of arkose, varying from one to two feet in thickness. This is separated sharply above and below from the light coloured feldspathic sandstone and differs from it in having a strong purple colour, the result of the staining of the feldspars and the chalcedonic cement (4561) by iron oxide. The constituent minerals are quartz (generally rather strained) and potash feldspar, with rare biotite.

Along the base of this arkose is a discontinuous bed a couple of inches thick, of grey laminated fine grained micaceous sandstone, consisting (4562) of angular quartz and feldspar, flakes of biotite (partly chloritised) and sericite and magnetite, with interstitial fine silty material. Shreds of limonite elongated along the bedding, are a common feature. No outcrops of coal or carbonaceous shale were seen on the ground by the writer, but a number of coal seams, each several feet thick were seen from the air at the head of the gully between Radok and Beaver Lakes. Stinear found seams at the mouth of this same gully, the largest of which is eight feet thick.

No identifiable macrofossils have yet been found in the Amery Formation. However, after examination of plant microfossils from samples of coal and carbonaceous shale collected by B.H. Stinear and P.W. Crohn, Balme and Playford (1958) place the assemblages in the Upper Artinkskian or Kungurian. The sediments south of the lake dip S.S.E. at angles less than 5°, with a few almost imperceptible dips to the north-west. Seen from a distance, the cliffs along the southern edge show a series of broad very gentle flexures, striking about 60°. Several fault scarps, striking about south-west, can be seen from the air.

Aerial observation show that the sediments extend west to Radok Lake. At the southern corner of this lake, sediments dipping east at 15° adjoin vertically dipping metamorphics with an E.N.E. strike. At the head of the valley joining Radok and Beaver Lakes, sandstones with interbedded shale and coal seams strike 15° and dip east at 30°. Radok Lake has evidently developed along the line of the Amery Fault (Crohn p.61). High cliffs of steeply dipping metamorphics occur along its western side, while along its eastern edge, low cliffs of sandstone rise to the charactistic low plateau surface (Flagstone Bench) of the Amery Formation.

Outcrops of sediments were seen all along the western edge of Beaver Lake, but their westward extension is obscured by moraine. Near the meltwater lake south east of Mt. Loewe, the moraine changes in appearance from a dark colour with numerous large blocks to a light brown colour with very few large blocks. This lake is on the line of the Amery Fault, and the change in the moraine apparently reflects the change from metamorphics to sediments in the underlying rocks.

JETTY PENINSULA

This arm of rock and ice separating Beaver Lake from the Amery Ice Shelf rises steeply about 200 feet above the general level of the lake area to an extensive rock surface on which the only relief is provided by numerous shallow depressions, many occupied by frozen meltwater lakes. A landing was made on one of these lakes near the north end of the peninsula at 70°23'S, 68°43'E.

The most common rock is a coarse grained massive creamy coloured granite, forming bands over 50 feet thick, and containing feldspar, quartz, biotite and red garnets; generally, the biotite and garnet do not occur together. The feldspar (4563) is very finely perthitic, and commonly partly altered to sericite, with some calcite and epidote; most of the biotite is altered to pennine. Many of the feldspar crystals are several inches across, but the other mineral grains only rarely exceed ¼ inch in diameter. The rock has evidently undergone shearing, because the quartz and some of the feldspars show marked undulose extinction, and the garnet is slightly birefringent.

Interbanded with this coarse granite are horizons of fine- to medium grained more or less equigranular rock, varying considerably in composition. At one extreme is a white quartz-feldspar-garnet gneiss (4565), the minerals of which show even greater strain effects than those of the coarse granite; in thin section, too, the rock shows a slight foliation, not apparent in the field.

The other extreme is a dark hornfelsic-looking biotite-rich rock, with a moderately well developed banding of the light and dark minerals.

All gradations of composition occur between the two extremes.

In thin section 4564, from a rock with a moderate amount of biotite, quartz is not common and the feldspar is mainly andesine, some grains showing slight zoning. A few small patches of myrmekite are present. Further differences from the other rocks of the locality are the occurrence of small amounts of magnetite, and the presence of numerous inclusions of quartz, biotite and magnetite in the garnet.

The strike at this locality varies from 065° to 135°, with dips of 70° to 80° to the north. In places the banded biotite rich rock displays small contortions. The rocks are well jointed in a north-south direction, with a less well developed east-west system; both sets dip vertically.

This locality has little, if any, moraine, but further south along the peninsula, the surface, as seen from the air, is chocolate coloured, with a hummocky appearance and scattered stone polygons. This is probably moraine, as it appears very similar to the morainal flats along the western side of Beaver Lake.

JENNINGS PROMONTORY

A number of rock exposures occur along the eastern edge of the Amery Ice Shelf. The largest, Jennings Promontory, is typical of these.

The outcrop is about five miles long and a couple of miles wide. On the western side, cliffs rise vertically 400 feet from a meltwater lake to a very flat plateau surface about 700 feet above sea level (Plate 2, fig. 3). On the eastern side, this surface merges with the ice of the plateau which is at a similar altitude, so that the promontory forms a bluff projecting from the ice, which on either side flows north-west into the ice shelf. The rock here is a porphyritic charnockitic granodiorite, (4566) with phenocrysts of microperthitic potash feldspar in a medium grained matrix of andesine (partly myrmekitic), quartz and potash feldspar, with smaller amounts of hypersthene, hornblende, magnetite and biotite. Apatite is unusually abundant; a few grains of zircon also occur. The ferromagnesian minerals all occur in close association; the hornblende is somewhat ophitic and is commonly replacing the hypersthene.

In some other parts of the granodiorite ophitic grains of hornblende, several inches in diameter are common; similar sized biotite plates are less numerous. A few lenses, (up to three feet wide) of fine to medium grained massive charnockitic granular gneiss occur; these do not show any parallelism of alignment. There are also some veins and small masses, a few feet across, of pink coarse grained pegmatite made up of perthite, greenish plagioclase and quartz, with smaller amounts of biotite, dark red garnet and hornblende.

The granodiorite is generally massive, but in places, alignment of the feldspars produces a foliation striking 010° and dipping east at 80°.

Thin lines of shearing are common. Many strike about north and dip east at about 10°, but others run in different directions. Many are filled by thin veins of feldspar, quartz, red garnet and biotite; small lenses of quartz occur in others.

Moraine is not common along the front of the promontory; it occurs mainly at the north western end, as hummocks on the ice. The size of the fragments is very variable, with a good deal of fine material present. Most show a moderate degree of rounding. The bulk of the deposit consists of porphyritic charnockitic rock like that outcropping nearby, with some quartz feldspar-garnet gneiss which was not seen in situ.

CLEMENCE MASSIF

This is a large ridge of rock rising 3900 feet above the Lambert Glacier, which here is about 300 feet above sea level. A landing was made beside the small nunatak three miles south of the massif.

The rocks are migmatitic, mainly pink medium grained granitic gneisses with scattered large feldspars and a rather irregular small scale banding due to concentration of biotite, the total content of which varies considerably from place to place. The typical rock is made up (4567) of antiperthitic oligoclase, quartz, potash feldspar, biotite, magnetite and apatite; the plagioclase is partly altered to muscovite and calcite.

With an increase in biotite and decrease of quartz and potash feldspar this granitic rock grades into a dark fine-to medium grained well foliated hornfelsic looking rock, forming scattered bands a foot or so wide.

A number of veins and lenses of coarse red graphic pegmatite occur, up to 10 feet wide, containing perthite-quartz intergrowths several inches across, biotite plates, and rarely, garnet. These pegmatites are usually more or less concordant with the gneisses, but near the southern end of the nunatak, a vein occupies a shear, and the adjacent gneiss is highly contorted.

The strike of the rocks ranges from 350° to 010°; dips increase from 10° to the west at the north-eastern end to 40° in the central and southern parts of the nunatak.

From the air, the main Clemence Massif is seen to consist of banded rocks very like those of the nunatak, with a similar strike of 340° and dip of 40° west. Irregular pink pegmatite masses also occur.

A small nunatak a few miles south-east of the massif consists of banded light brown and dark brown rocks striking east-west and dipping north at 60°.

WILSON BLUFF

South of the junction of the Mellor and Lambert Glaciers are a number of flat-topped massifs, each several miles in extent. The south-western most of these, Wilson Bluff, is marked by a long trail of moraine running off to the north-east (Plate 4, fig. 3).

The rocks of the bluff are dominantly medium-grained finely banded quartz-biotite schists, with varying amounts of plagioclase (andesine-labradorite) and muscovite. Fibres of cummingtonite are common in places (4568). A number of lenses, several inches thick, contain dark green amphibole with some feldspar and rare garnet. Small stumpy prisms of tourmaline occur along some layers, especially in the more feldspathic rocks (4569). At the north-east corner of the massif is a horizon, 15 feet thick, of almost pure quartzite.

Cutting these schists are numerous irregular veins and masses of coarse pink graphic pegmatite, up to 10 feet wide. They generally transgress the foliation of the schists, but some thin concordant ones do occur. Most contain scattered plates of biotite, more rarely muscovite, and in some cases, small crystals of red garnet; tourmaline crystals occur along both edges of one.

Near the south eastern corner of the massif, these irregular pegmatite masses are cut by straight veins, a few feet wide, of similar pegmatite, but zoned, with concentrations of quartz and biotite in the centre. These veins strike 020° and dip west at 80°. A few thin concordant veins of white alaskite with rare garnet and biotite also occur, and seams of quartz are common in places; these two generally occur only in plicated portions of the schists.

The general strike of the schists is east-west, with dips of 10° to 20° to the south. Near the south-east corner are a number of recumbent folds, each about 10 feet across with the axial planes dipping south at about 10°.

Small plications occur in places, especially near the lenses of green amphibole. Near the western end, the dip on either side of a valley increases to 30°; this valley may mark a north-west striking fault downthrown on the eastern side.

A notable feature of the moraine along the northern side of the massif, and forming the long trail extending to the north-east, is the small size of the debris. Except at the foot of the massif, boulders more than a foot across are not common, and most of the fragments are less than three inches in diameter. Many have almost a water-worn appearance, with rounded edges to the facets and slightly convex faces. Pegmatitic and quartzitic types are predominant, with a few examples of mica schist and fine grained biotite-rich hornfels.

GROVE NUNATAKS

The Grove Nunataks are a group of isolated peaks extending about 30 miles from north to south and 20 miles from east to west. The altitude of the plateau of the landing area (which is in a depression west of the main group of peaks) is 6000 feet; the highest peaks rise almost 1000 feet above this. Immediately east of the group, the plateau rises steeply in a series of terraces for over a thousand feet.

The nunataks are very rugged, with vertical sides and jagged summits. There do not appear to be any old erosion surfaces comparable to those in the Prince Charles Mountains.

The rocks forming these nunataks are migmatitic gneissic granites, with a few bands of hornfels. In the nunatak north-east of the landing area (i.e. at the north-west end of the main group) hornfels and granite occur in about equal amounts, as alternating bands up to 20 feet thick. The hornfels is variable in composition, ranging from a dark coloured fine- to medium grained biotite rich rock to a light coloured medium grained almost granitic rock with only minor biotite. In places, small feldspathic porphyroblasts occur. The rock is moderately well foliated; a rather irregular banding may also be developed. The most common type is intermediate between the two extremes. It is a light pinkish grey fine to medium grained rock, with a rather whispy banding of the light and dark minerals and made up of (4570) a fine grained mosaic of perthite, quartz and oligoclase, with lesser amounts of hornblende, biotite and magnetite, and accessory apatite and zircon. Perthite porphyroblasts in this mosaic contain small rounded blebs of quartz, many in optical continuity.

The granite is a reddish coloured medium grained rock, containing creamy iron stained feldspar and dark smoky quartz, with smaller amounts of biotite and hornblende and accessory zircon. Potash feldspar phenocrysts may, in cases, form up to 50% of the rock; alignment of these produces a marked foliation. Both microperthite and oligoclase occur in the ground mass (4571). Patches of myrmekite are common, and some of the perthite also contains micrographic quartz. Most of the minerals show marked undulose extinction.

Despite the variation in appearance of the hornfels, the contact between granite and hornfels is quite sharp, and usually more or less parallel to the foliation of both; but in places, the granite cuts across the hornfels, forming veins, or leaving lenses of hornfels in the granite, according to the relative proportions of the two.

At the southern corner of the nunatak, a small mass of dark hornfels has a very irregular foliation, oriented quite differently to that of the rest of the mass.

Cutting both the granite and the hornfels is a series of veins of pink medium grained granite, made up of potash and some plagioclase feldspar, quartz, and a little biotite. A few phenocrysts of feldspar, slightly coarser than the matrix, occur. These veins are straight, sharp edged (in some cases there is an increase of grain size along the edge) and steeply dipping.

The small nunatak south of this one has a similar interbanding of gneissic granite and hornfels, with a similar dip, but the cross cutting granite veins are much less common.

The largest nunatak of the group has some bands of dark biotite rich hornfels; but most of it is porphyritic granite like that just described (Plate 5, fig. 2). Cutting irregularly through this are veins and masses (commonly anastomosing) of a second type of porphyritic granite, distinguishable from the first type by its massive texture flesh coloured feldspar, clear quartz and rarity of ferromagnesian minerals (mostly biotite). The contacts between the two types are sharp.

Near the western corner of this nunatak is a dyke like body of brown aplite with blebs of hornblende. It is almost vertical, widening and curving towards the base, and has smooth sharp edges. It cuts the main mass of granite, but is cut by the granite veins. One rectangular sharp edged inclusion of porphyritic granite was seen. The strike of the rocks in this main group is uniformly 105°, with dips of 30° to 40° to the north.

From the air most of the other nunataks also appear to be granite and biotite hornfels. Strikes are variable, and dips usually at moderate angles in the south east quadrant.

In the long trail of moraine extending west from the main nunatak, the following size distribution (by volume) was estimated:

Large boulders (over 6 feet diam.)	15%
Boulders (6 inches-6 feet)	70%
Pebbles (1 inch-6 inches)	10%
Screenings and sand (less than 1 inch)	5%

Many of the larger boulders consist of tabular blocks, but the smaller ones tend to be equidimensional. The edges generally show a good degree of rounding. Granitic rocks predominate, with some hornfels, a few boulders of white quartz feldspar-garnet gneiss (not seen in situ) and one of medium grained green diopside, (4572) with a small amount of pale brown phlogopite.

GOODSPEED NUNATAKS

These are a group of isolated hills, rising up to 1000 feet above the plateau, near the head of the Fisher Glacier, in about 73°S, 61°E. In January 1958, a number of specimens of moraine were collected by M. Mellor from two localities, one from the hill on which the astrofix was located, the other from the ice north of this hill.

The specimens from the second locality are all coarse grained massive granitic rocks; most contain perthite, plagioclase, quartz and biotite; other minerals include lepidolite, fluorite, beryl, tourmaline, zircon, muscovite, and magnetite.

At the second locality, specimens are of two types; one is a massive fine grained light brown partly recrystallised sandstone (4599, 4600) consisting of a mosaic of quartz grains with flakes of muscovite fairly common, and rare magnetite, zircon, tourmaline and sphene.

The second type is a grey porphyroblastic rock (4609) with elongated highly poikiloblastic biotite flakes in a fine grained mosaic of quartz, sericite, biotite and magnetite, with rare apatite and calcite. The biotite porphyroblasts produce a pronounced lineation. In some specimens, the porphyroblasts are rare or absent.

These quartzites and hornfelses are described as forming 92% of moraine which completely covers the surface of the nunatak. This predominance suggests that the underlying rock is lithologically similar, and that the granite fragments from the ice represent the rock responsible for the alteration.

AERIAL OBSERVATIONS, PRINCE CHARLES MOUNTAINS

During flights in this area, a number of rock exposures were examined from the aircraft. The rocks all appeared to be metamorphic in origin, with transcurrent dykes of pink rock, probably pegmatites. Most are well banded, so that a reasonably accurate estimate of the attitude could be obtained.

Manning Nunataks. (71°S, 71°40'E.) An attempt to land here was abandoned when the aircraft broke through the crust of the melt lake when landing.

The rocks are banded light grey (?Acid gneisses) and brown (probably hornfels) with a few straight light coloured veins (probably pegmatite) running in different directions. The strike is W.N.W. with dips of 60° to the south; but near the south-western corner the rock is highly contorted and faulted.

Patrick Point. (73°20'S, 67°25'E.) consists of light coloured metamorphics, with dark hornfels (?) bands. At the northern end the strike is about W.N.W., changing to N.N.W. further south; the dip is 30 to 40° south. The hornfels bands display very tight folds (Plate 2, fig. 2).

Blake Peaks. (73°55'S, 67°E.) are composed of banded metamorphics with low dips (about 5°) to the south or south-west, except at the south-western end, where there is a north-south strike and westerly dip of 50°.

Mawson Escarpment. This appears to consist of the same rock types along its entire length, viz. white and brown bands, with some large irregular masses of white rock, probably pegmatite. Near the northern end, the strike is N.N.W. and the dip west at 20°. This attitude seems more or less constant along the whole escarpment.

Gielock Island-Spayd Island. (70°13'S, 71°32'E.) These consist of alternating creamy and chocolate coloured metamorphics, dipping south at 50°. Spayd Island has reddish coloured bands interbedded with the others.

McKaskle Hills. (70°S, 72°30'E.) These consist of brown and creamy banded rocks. Strikes are variable and dips about 30° in the south-east quadrant.

Statler Hills (69°50'S, 73°E.) The rocks here appear to be similar to those of the McKaskle Hills.

AMUNDSEN BAY

This area had previously been visited by Crohn, who describes the rocks on Observation Island and the mainland at the south-east corner of the bay. The writer examined the geology of the north-eastern part of the bay.

The rocks are dominantly quartz-feldspar gneiss and pyroxene gneiss, occurring in alternating bands ranging from a few inches to many yards in width. The former is much the more common of the two. It is a brown medium grained rock containing brown or blue translucent quartz and brownish feldspar in greatly varying proportions, with rare pyroxene and garnet. The rocks are generally banded, due to the concentration of quartz in some layers, and mostly have a fairly good foliation. The feldspar shows (4580) a remarkable development of perthite; the potash feldspar and andesine are almost equal in amount (some grains, in fact are better termed antiperthite), one component forming an anastomosing network through the other. A few small grains of homogeneous plagioclase also occur. Quartz has a slight brownish tint, due to myriads of minute inclusions.

In several places, thick bands of a similar (4581) but lighter coloured rock occur, with about 20 percent made up of opaque brown garnets, and containing also small amounts of magnetite and biotite. It may also have small amounts of bluish-green pyroxene. The quartz in these garnetiferous types has a characteristic opalescent bluish colour. In a few places are thin seams of quartz and red-brown garnet, with small amounts of green pyroxene, and sporadic pyrite. At a height of about 2,000 feet on the south-east side of Mt. Riiser-Larsen, a thick horizon of bluish-grey quartz-feldspar gneiss with a moderate amount of chloritised pyroxene is associated with a shear.

The pyroxene gneiss is a medium-grained equigranular, rather massive rock, with little obvious banding or foliation. It consists (4579) of oligoclase, (commonly moderately anti-perthitic, and with bent very fine twin lamellae) and hypersthene (filled with dusty inclusions) with a small amount of magnetite and accessory apatite. The grain size is rather variable from place to place, as is the pyroxene content; some thin layers are almost entirely hypersthene with, in cases, small amounts of bottle green diopside. Near the foot of Mt. Riiser-Larsen, pyroxene is not common, but magnetite is a prominent constituent. In a few places, the pyroxene gneiss contains small amounts of quartz.

The pyroxene gneiss and quartz-feldspar gneiss are very widely distributed in the interior of Enderby Land.

In several places, the quartz-feldspar gneiss contains segregations several feet in extent, of pale brown enstatite consisting of a massive aggregate of coarse crystals. In some, the large crystals have been crushed (4582) and the interstices are occupied by small grains of plagioclase, and flakes of phlogopite are scattered through the whole. A small erratic of grass-green enstatite was found.

Bands of black medium- to coarse grained hypersthenite, up to 10 feet thick, are interbedded in the gneisses. Some are almost pure pyroxene, but other contain small amounts of feldspar.

Basic dykes, with either a basaltic or doleritic texture, are associated with lines of shearing.

The strike of the gneisses in this area is about 100°, and they dip 40° to the south.

Evidence of large scale shearing was seen in several places. The gneisses have been converted to bands of black mylonite, with the nearby rocks contorted. Along the northern edge of Adams Fiord, one such band is 30 feet thick. These mylonite bands all strike east-west and dip vertically.

Small scale faulting has occurred normal to this direction; displacements of only a few inches were seen in one section; there has been little mylonitisation. A few basaltic dykes run in this direction also.

On the north-western side of Mt. Riiser-Larsen is an extensive terrace of moraine, about 150 feet above sea level, with several large meltwater lakes on it (Richardson Lakes). The detritus in this moraine is rather angular, with only slight rounding of the edges. Fragments greater than 18 inches diameter are not common. In places, considerable amounts of sandy mud occur; this was quite wet in mid November and supported a prolific growth of mosses and lichens. A visual estimate of the size distribution (by volume) within the moraine gave:

Large boulders (over 6 feet diameter)	5%
Boulders (6 inches to 6 feet)	35%
Pebbles (1 inch to 6 inches)	30%
Screenings ($\frac{1}{16}$ inch to 1 inch)	20%
Sand and flour (less than $\frac{1}{16}$ inch)	10%

Stone polygons are well developed on this moraine; the coarsest particles are distributed around the periphery of each polygon.

The raised beaches of this area have already been described.

PEROV NUNATAKS

The rocks of this group are mainly quartz-feldspar gneiss and pyroxene gneiss very like those at Amundsen Bay. Some layers of white quartz-feldspar-garnet gneiss also occur, with pale pink garnets and flakes of biotite. In one place the quartz-feldspar gneiss is cut across the foliation by a vein of similar looking but coarser rock. In addition, several horizons of a well-banded rock occur, consisting (4576) of alternating layers, one set containing quartz and andesine (mostly in micrographic intergrowth) with minor perthite, and the other enstatite and andesine, with minor diopside and biotite.

Several bands, a foot or so thick, are composed of hypersthene (4575) with minor biotite and diopside. Magnetite granules rim many of the grains, and most (the clinopyroxene especially) are crowded with small grains of magnetite.

In the second nunatak from the south, green enstatite (4577) forms segregations rimmed by quartz up to four feet across in the quartz feldspar gneiss.

In the same nunatak is a dyke of fine grained dolerite, (4578) consisting of laths of zoned labradorite in a plexus of pyroxene, magnetite and biotite.

The rocks of this group strike 075° and dip north at 80°.

Moraine is rare, occurring mainly as angular blocks resting on the ice. Most are less than one foot across, and sand is common. The moraine is composed almost entirely of local rocks; a small block of coarse graphic pegmatite representing the only type not found in situ.

NYE MOUNTAINS

This group of rugged peaks on the eastern side of the Rayner Glacier is about 70 square miles in extent and rises 2,000 feet above the plateau. A landing was made on a melt lake (Amphitheatre Lake) at the western end of the group. On the peak east of this lake, a considerable variety of rock types occur.

At the base, the rock is dominantly a white medium grained anorthosite, made up (4573) of labradorite (some showing slight zoning) and small amounts of hornblende, quartz, potash feldspar, myrmekite and biotite. The hornblende generally occurs in thin, rather whispy bands, but in places is concentrated into layers of hornblende and biotite, several inches thick; parts of many of the feldspar grains have a reddish colour, possibly due to numerous minute clear inclusions visible in thin section. Some of the anorthosite is finer grained, richer in quartz and has the amphibole distributed in thin well defined layers; the feldspar in this rock does not show any reddish colouration.

Further east, the anorthosite gives way to migmatitic gneisses with a well-defined but discontinuous banding, which is bent around garnet crystals and, in places, around grains of feldspar. The rock is made up (4574) of porphyroblasts of garnet (commonly poikiloblastic, with inclusions of quartz) and potash feldspar in a matrix of potash feldspar, quartz, andesine, sillimanite, biotite, magnetite and remnants of colourless pyroxene; zircon and apatite occur in accessory amounts. The potash feldspar is crowded with small colourless inclusions; the garnet is bordered by kelyphitic rims, probably of a feldspar-quartz intergrowth, and with which the magnetite is closely associated. In some bands of this rock are concentrations of garnet; others are almost entirely biotite. Small masses of epidote occur in places.

Further east again, the proportion of dark minerals decreases, and the gneiss passes into a light coloured medium to coarse grained garnetiferous granite gneiss, with white and pink feldspar, quartz and red garnets; this is cut by veins of aplite and coarse graphic pegmatite. A few thin bands of finer grained quartz-poor, hornblende-rich rock, without garnets, still occur, resembling the amphibole rich bands in the anorthosite.

The structure here is simple; the strike varies between 035° and 045°, and the dip between 45° and 60° to the south east.

Extensive deposits of moraine occur on the northern and eastern sides of Amphitheatre Lake (Plate 3, fig. 1). Several terraces occur in this moraine. The best defined are approximately 20, 100 and 200 feet above the lake. The rocks in the moraine are all of types represented in nearby outcrops, with the exception of a characteristic textured augen gneiss, very common in the moraine, but not found in situ. The rounding of the debris is fair to moderately good. An estimate of the size distribution (by volume) gave:

Large boulders (over 6 feet diam.)	5%
Boulders (6 inches to 6 feet)	50%
Pebbles (1 inch to 6 inches)	30%
Screenings ($\frac{1}{16}$ inch to 1 inch)	10%
Sand and flour (less than $\frac{1}{16}$ inch)	5%

AERIAL OBSERVATIONS, ENDERBY LAND

The Tula, Scott and Raggatt Mountains are made up of a series of peaks and ridges, some many square miles in extent, projecting up to more than 2,000 feet above the intervening ice; the highest point in the Tula Mountains, Pythagoras Peak, has a height of 4180 feet above sea level.

The rocks seen from the aircraft during flights through these ranges, appeared identical with those examined on the ground.

A large scale banding is very apparent in most of the exposures; this generally strikes about east-west, with northerly dips of 40° to 60°. Some northerly strikes were seen in the western section of the Scott Mountains, and near the south-eastern corner of Amundsen Bay strikes are very variable, and large folds are visible. A large anticline and syncline, striking west, can be seen in a long ridge west of the Perov Nunataks.

TULA MOUNTAINS

During the journey through the Tula Mountains, brief observations were made at a number of places. The rocks are the same as those around Adams Fiord, viz. quartz-feldspar gneiss and pyroxene gneiss with a few bands of quartz-feldspar-garnet gneiss.

At the small nunatak of astrofix A58/15, a common rock is a medium grained blue quartzite, made up (4683) of very irregular quartz grains, with the interstices occupied by granophyric intergrowths or by riebeckite rimmed by a colourless pyroxene(?); a few grains of colourless amphibole occur also. Most of the quartz grains contain long, perfectly straight, needle-like inclusions, possibly riebeckite, arranged in three sets at 120° to each other. The granophyric intergrowths have a beautifully delicate texture; some contain aggregates of tiny clear granules, possibly pyroxene. A few bands of this quartzite contain up to 50 percent of clear feldspar laths, and sporadic very pale pink garnets.

Alternating with this blue quartzite are brown iron stained bands of a similar rock, but containing a much higher proportion of pale pink garnet, as well as feldspar; copper staining is fairly common in these bands.

At the eastern end of the nunatak, several bands of garnet-rich white quartzite have up to 30 percent of red garnet. Here also, veins of white massive quartzite cut obliquely across the layering of the rocks.

At the base of the cliffs of this nunatak is a concordant band of massive medium grained bronzitite, at least ten feet thick, with thin offshoots into the adjoining massive blue quartzite. Over a width of six inches along part of its upper margin, it contains up to 40 percent feldspar, except for the topmost half inch, which is again pure bronzite. In this nunatak too, are several sills of metabasalt, now a sugary textured aggregate of feldspar, pyroxene and biotite. These sills are a foot wide; with concentrations of white quartz along their edges, from which small tongues project into the sill.

A dyke of fine to medium grained dolerite, 50 feet wide, strikes 015° and dips vertically. A medium to coarse grained gabbro with up to 15 percent magnetite, was seen as boulders, but not in situ.

The strike of the rocks at this nunatak is 055°, with a dip of 20° to the north-west; the rocks of the large nunatak a few miles to the south-east have a similar strike, but here the dip is 30° to the east. On the north-western part of the Pythagoras Peak massif, a shallow syncline pitches flatly south, with flat lying drag folds on the eastern limb. The rocks of Mts. Harvey and Storer have east-west strikes, with dips of 70° to the south. When seen from some distance to the east, the Pythagoras Peak massif and the peaks south of it appear to form a syncline, striking about east-west; the limbs dip at 45°, and there appears to be a partial closure at the eastern end.

MT. KING

This is a broad flat topped mass several square miles in extent, at the eastern end of the Tula Mountains.

The rocks again are alternating quartz-feldspar gneiss and pyroxene gneiss, but here the grain size is rather more variable in both types, and much of the quartz in the former is brown rather than blue. The pyroxene gneiss in rare cases contains small pink garnets. One band of pyroxene gneiss grades into a thin layer of pure pyroxenite. In one place the quartz-feldspar gneiss contains a segregation of pyroxene, biotite and green amphibole; the different minerals are segregated into groups, and the whole is surrounded by an inch or so of white quartz. A few veins of dark brown massive quartz also occur in the quartz-feldspar gneiss. Bands of green and brown pyroxene (hypersthene and diopside) also occur, identical with the erratic (3955) found by Crohn at Amundsen Bay. The rocks strike 035° and dip west at 50° to 80°. Shearing occurs in several places, striking 055° and dipping 80° west; the strike of the rocks near these shears, is in the same direction as the shear. The rock in the shears is mylonitised, and the nearby rocks chloritised and granulated, in cases to a fine massive aggregate of chlorite and feldspar.

The slopes and upper surface of Mt. King are covered with very angular debris, all of rock identical to that occurring in situ. The absence of any rounding of the edges of this detritus suggests that it is the result of nivation of the underlying rock, and is not moraine. Moraine does occur around the base of the cliffs, and at the mouth of a U-shaped valley on the western side of the mountain.

Stone polygons are well developed in places on the mountain. Near the south-western corner, they are only four feet in diameter; the constituent debris ranges in size from fine sand in the centre to 18 inches in diameter at the margins, with six to twelve inches a common size. Near the summit, polygons are developed to varying degrees of perfection; the best are about 20 feet long; once again, the size of the debris ranges from fine sand and gravel in the centre to 18 inches at the edge.

McLEOD NUNATAKS

These consist of a group of peaks and several outlying nunataks scattered over an area of 30 square miles, and rising up to 500 feet above the ice.

The rocks of the northern part of the group are quartz-feldspar gneiss with a small amount of pyroxene gneiss. The latter is macroscopically similar to the rocks in the Tula Mountains (apart from a rather more variable texture) but in thin section (4584) shows several differences. The feldspar is labradorite rather than antiperthitic oligoclase; over half the pyroxene is diopside, and much of it is rimmed by green hornblende; red-brown biotite is in turn moulded on this, or directly onto the pyroxene. Biotite is moderately common in some bands, and lenses composed of medium to coarse grained greenish pyroxene and bronzite occur.

The quartz-feldspar gneiss is of two types; one (similar to the rocks of the Tula Mountains) is medium grained, poorly foliated, with a moderate amount of quartz, and veins of blue quartz along the foliation. The second type is fine- to medium grained and rather massive, with scattered grains of pyroxene, which, in cases, comprises up to 10 percent of the rock. This latter type has undoubted charnockitic affinities, although it does not possess the dark colour of the typical charnockitic granular gneiss.

These two types of quartz-feldspar-gneiss tend to grade into each other.

Thin lenses of porphyritic charnockitic granite which occur in places, show some tendency to grade into the enclosing quartz-feldspar gneiss. Except for its rather lighter colour, this granite is quite like the granite of the Mawson area. Small patches and veins of massive dirty white quartz occur near these lenses.

Coarse grained hypersthenite forms concordant veins up to 10 feet wide. The coarsest of these has lenses of feldspar in the centre, and small flecks of clinopyroxene in the hypersthene (4585). The veins have a sharp junction with the pyroxene gneiss on either side, although the gneiss contains schlieren of pyroxene and quartz, and, in one case, a scattering of pink garnets three feet from the pyroxenite.

Several bands of pegmatite occur. Some, a foot or so wide, which cut sharply across the foliation of the gneisses, are composed of coarse grained pink feldspar and quartz, and are bordered by six inches of hybridised feldspar-quartz-biotite rock, which grades into the quartz-feldspar gneiss.

This hybridisation is more pronounced on either side of a concordant vein of coarse plagioclase-quartz-potash feldspar-biotite pegmatite, which varies from a couple of inches to several feet in width. On one side biotite hornfels with ptygmatic veins grades rapidly into the pyroxene gneiss and quartz-feldspar gneiss. On the other side is a pink hybrid rock, containing potash and plagioclase feldspar, quartz, biotite streaks, thin bands of red granite and small masses of white quartz, with tourmaline and plates of sphene in places. Over a distance of five feet, this grades into the quartz-feldspar gneiss by disappearance of biotite and change in the nature of the feldspar. The rock midway between the two extremes (4586) contains microcline-microperthite, quartz, oligoclase (with small patches of myrmekite), nests of somewhat poikilitic biotite, and aggregates of riebeckite and magnetite (probably a complete replacement of another mineral); apatite is common.

Several dykes of dolerite occur, all striking 005° and dipping east at 80°. The largest is 50 feet wide, and can be traced right through the main group of nunataks. It is a medium grained rock containing (4581) strongly clouded labradorite (commonly with oscillatory zoning) both clino- and orthopyroxene (in cases as intergrowths and crowded with needles of iron ore), magnetite, small patches of quartz, and accessory pyrite. Green hornblende granules invariably rim the pyroxene grains, or form trails through them. The magnetite, too, is commonly surrounded by hornblende and biotite flakes, and in one case, has a thin rim of pale pink garnet(?).

These mineral changes may have resulted from reactions between crystals and magma during crystallisation of the dolerite on the other hand, they could be the result of metamorphism after emplacement of the dolerite. It is noteworthy that pyroxenes in the country rock also are rimmed by hornblende and biotite, and it seems probable that here is further evidence for at least two metamorphic episodes in the history of the area.

The strike of the gneisses is 115°, with an abrupt change to 125° at the north-east end of the main group; the dip is 80° to the south. A few small shears were found, striking 165°, dipping east at 40°, and with a lineation in this plane pitching south at 10°. At the south-east corner of the nunatak five miles east of the main group, the rocks appear to form a syncline, striking about W.N.W., with dips of 45° on either limb.

The moraine along the northern side of the main group is moderately well rounded. Most of the fragments are between one and three inches across; diameters of more than twelve inches are not common. The moraine forms piles, with some tendency for sandy material to be concentrated in the upper part of the pile. The debris is mostly local rock, but about five percent is composed of white quartz-feldspar-garnet gneiss, with some augen gneiss. The size of these fragments generally is between one and two feet.

Detritus is also scattered across the ice surface for some distance from the nunataks. Some of the smaller of these fragments must have been exposed for a considerable time, as they could readily be crumbled between the fingers.

KNUCKEY PEAKS

These are a group of nunataks, each a few hundred feet high, in an area of about 40 square miles.

The most common rock in the southern part of the group is a typical dark coloured fine- to medium-grained charnockitic granular gneiss. The rock shows moderately good banding due to concentration of the pyroxene into layers, so that pyroxene is almost absent from parts of the rock (4588). Oligoclase is relatively abundant, forming possibly a third of the feldspar of the finer grained parts of the rock; biotite occurs in accessory amounts. Small schlieren of coarse pyroxene grains are common.

Parts of this gneiss are rather coarser and more massive, with normal light coloured feldspars and a higher pyroxene content; these rocks are very like the pyroxene gneiss of the Tula Mountains, except for sporadic aggregates of red garnet.

Small lenses and irregular veins of coarse feldspar, with some pyroxene, have sharp margins against the enclosing gneiss. Several bands of green pyroxenite contain (4589) hypersthene, diopside and zoisite with pale biotite and pleonaste.

A few bands, in which the rock is medium grained and well foliated, with little pyroxene and a high quartz content, are reminiscent of the quartz-feldspar gneiss of the Amundsen Bay area.

A number of dykes of pink graphic pegmatite cut acutely across the banding of the gneisses. One, six feet in width, has a central inch zone of quartz, on either side of which is pink perthite with some quartz and magnetite, and an outer 18 inches of graphic granite; biotite is scattered through all zones. Other pegmatites, although they have sharp margins, have on either side a zone of pink granitised rock, similar to that described from the McLeod Nunataks. This hybrid rock grades into the charnockitic gneiss over a distance of up to 10 feet.

A foot or so on either side of one of these pegmatites, occur bands, each a couple of feet thick, of soft, massive, green or grey highly altered rock. The green type consists (4590) of a decussate aggregate of actinolite, and biotite, with some quartz and rare apatite, while the grey rock consists almost entirely of fibrous tremolite completely pseudomorphing some other mineral. Small irregular masses, a few inches across, of red graphic granite occur in both types, and along one band is a nine inch thick layer of massive fine grained hornblende.

The rocks of these nunataks form a series of folds with their axes striking about east-west. In most cases, only the south dipping limb is exposed, but changes in the dip suggest structural troughs and crests. One syncline about one hundred yards across, is visible. The strike of the rocks is about 100°, with one case of 050°. dips depend on the position in a fold; they may be as steep as 80°.

The moraine around the southern part of the group is quite unsorted, except on a ridge about fifty yards from the base of the eastern face of the highest nunatak. The slope of this ridge facing the cliffs is steep, and about ten feet high. A short distance above the base a marked change occurs from detritus two to four inches across to boulders a foot or so in diameter, which pass upwards into boulders up to three feet across. The debris on this slope is slightly rounded; elsewhere it is angular. The opposite face of this ridge has a more gentle slope, and is quite unsorted.

The rocks forming the moraine are all local types, except for some blocks of mylonite, which was not seen in situ.

MT. CHANNON

Mt. Channon (originally called Nevlingen) is a prominant isolated peak a few miles west of the Dismal Mountains, near the border of Enderby and Kemp Lands.

The lowest rocks exposed are medium grained equigranular pyroxene gneisses, with a moderate foliation and some banding of the pyroxene, and containing numerous bands and lenses of medium to coarse grained rock, similar mineralogically, but with sharp edges against the medium grained type. Small knots and veins of coarse pegmatite, of two types occur; one appears to be merely a coarse variety of the pyroxene gneiss; the second is lighter coloured, has more quartz, and contains biotite instead of pyroxene. The banding of the charnockite is irregular near these pegmatites, as though the rock was plastic when they were emplaced.

Over a distance of a couple of feet, the pyroxene gneiss grades into quartz-feldspar-garnet gneiss with a moderate but variable amount of biotite. The rock is creamy or light brown coloured, fine to medium grained, with a fairly good banding due to variation in the amounts of biotite and garnet. The typical rock consists of (4834) equal amounts of microperthite and oligoclase-andesine, quartz, garnet, biotite and rare magnetite and apatite. On the other hand, some bands are almost pure feldspar. In one place, the rock is cut by discordant ptygmatically folded veins, slightly coarser than the enclosing rock, and with less feldspar and quartz.

Near the base of this quartz-feldspar-garnet gneiss is a band of dark fine grained hypersthene-rich charnockite, in which (4591) the feldspar is dominantly oligoclase-andesine crowded with irregular slivers of exsolved potash feldspar, and with blebs of graphically intergrown quartz; apatite is unusually abundant.

This more or less equigranular gneiss in turn passes into quartz-feldspar-garnet gneiss with a rapidly varying texture, less quartz and almost no biotite, except in biotite rich bands a foot or so thick; pale green sillimanite occurs along some horizons, and ilmenite-feldspar blebs a couple of inches across are scattered through the rock.

Further from the junction with the equigranular type, this rock contains thin streaks of pyroxene, which are cut by narrow quartz-feldspar veins.

The rocks here strike 140° to 150°, and dip north-east at 40°. The biotite-rich bands in the variable textured quartz-feldspar-garnet gneiss display a series of very tight folds, some with attenuated limbs, roughly parallel to the banding of the equigranular gneiss and overturned towards the southwest. Near the junction of the equigranular and variable textured gneisses, a horizon in the latter shows small drag folds and boudin age structure, with coarse grained quartz and feldspar forming the "boudins" and fine to medium grained quartz-feldspar-garnet gneiss outlining them.

The moraine around the peak consists only of scattered boulders, all of local rock except for numerous blocks of a dark medium grained rock made up (4591) of quartz, cordierite, garnet, green sillimenite, and magnetite.

LECKIE RANGE

The Leckie Range consists of a main massif some 10 square miles in area, and rising over 2,000 feet above the ice, with several outlying nunataks.

The rocks are largely quartz-feldspar-garnet gneisses and quartz-feldspar gneisses, with minor pyroxene gneiss and charnockite. Alternation of the various types produces a prominent large-scale banding.

The quartz-feldspar gneiss is a pale brown or pinkish coloured fine- to medium-grained rock with a pronounced lineation due to concentration of the quartz grains into thin discontinuous streaks. With addition of pink garnet, they pass into light brown quartz-feldspar-garnet gneisses, resembling (except for the lineation) those occurring at Mt. Channon. The amount of quartz present is variable; when it is small, the lineation is much less obvious. Garnet may be distributed through the rock, or concentrated into thin discontinuous layers. Biotite occurs in variable amount. In other cases, garnet is absent, but the rock contains (4592) thin streaks of biotite and small amounts of hypersthene; the feldspar of this rock is largely oligoclase-andesine; sphene is unusually common; thin fringes of biotite occur around and along cracks in the hypersthene; pyrite appears sporadically. When the pyroxene is common, the rock resembles the pyroxene gneisses of the Tula Mountains, except in possessing a lineation, which is revealed by streaking out of the dark minerals. Parts of these pyroxene gneisses are cut by sharp-edged anastomosing veins of white feldspar with scattered pyroxene.

In cases, pyroxene and garnet occur together, and at one place, fragments of magnetite several inches across are common on the surface.

A few layers of white quartz-feldspar-garnet gneiss were found, showing concentration of the garnet into bands, but no discernable lineation. Small drag folds are beautifully displayed by many of the bands.

Parts of the quartz-feldspar gneiss contain numerous irregular veins, a foot or so thick, of quartz and feldspar, which are cut by the metabasalt dykes described below. The gneisses are also invaded by small pegmatite veins, generally porphyritic, with plagioclase phenocrysts several inches across in a matrix of potash feldspar, quartz, biotite and rarely, magnetite. A few equigranular veins, with thumbnail sized crystals of potash feldspar, quartz and biotite also occur. These pegmatites all have sharp edges against the enclosing gneisses. Cutting through the gneisses and the metabasalt dykes are thin irregular, sharp edged, veins of medium grained granite; most are concordant, but several cut acutely across the foliation of the gneisses. A few irregular veins of enstatite (4593) have thin seams of phlogopite running through them.

A number of altered basic dykes and sills occur in the gneisses. Most are a foot or so wide with sharp edges against the gneiss. Many of the dykes cut across the foliation for part of their length, then turn parallel to it and appear to pinch out (Plate 7, fig. 3). (This last point could not be checked, as the exposure was high up a cliff face). The original rock has been almost completely recrystallised, (4594) and is now a fine to medium grained aggregate of labradorite, biotite, hypersthene, diopside, hornblende, magnetite and sporadic apatite and calcite. Its texture is massive, except for some parallelism of the biotite flakes. A few remnants of clinopyroxene, almost completely replaced by hornblende, may represent original mineral grains.

Many of the dykes show a faint banding parallel to their edges, due to variation in the amount of biotite. This banding is especially prominant in a dyke ten feet thick, much wider than any others seen.

The strike of the gneisses along the northern side of the range is 060° to 070° with dips of 70° to 80° to the south, and a lineation pitching south-east at 60°. Towards the south, dips decrease, and at the summit (Mt. Cook) the rocks strike 090°, dip south at 60°, and have a lineation pitching south east at 40°.

The gneisses are cut by a number of faults striking N.N.E. and dipping north west at about 20°. The hanging wall has moved to the south and west by a few tens of feet. Dykes of coarse grained graphic feldspar-quartz-biotite pegmatite, a couple of feet thick, occur along all the observed faults.

A large fault cuts through the centre of the range, striking about north east and dipping south east at 50°.

Moraine is common along the northern side of the range, and forms a well defined terrace about 500 feet above the ice, with another less obvious one a couple of hundred feet higher. The surface of these terraces is fairly smooth, in contrast to the hummocky nature of the moraine along the northern foot of the range.

On the ridge leading to the summit, moraine was found almost 2,000-feet above the present ice level. The rounding of the debris at all places is slight to moderate.

For the moraine along the northern foot of the range, a visual estimate gave the following size distribution (by volume):

Large boulders (over 6 feet diam.)	5%
Boulders (6 inches to 6 feet)	10%
Pebbles (1 inch to 6 inches)	50%
Screenings and sand (less than 1 inch)	35%

A notable feature is the large amount of sand present. Much of it has been washed out from the moraine by meltwater, and forms flat areas several yards in extent. Despite an air temperature below - 5°C, and overcast conditions at the time of the visit (late December), water rapidly seeped into holes dug a few inches into this sand.

The moraine of the terraces has a similar size distribution to the low level moraine; a few stone polygons occur, about ten feet in diameter, but with little sorting of the various sizes of debris.

FRAM PEAK

Fram Peak is at the southern end of a group of peaks about a mile long and a quarter of a mile wide. A buried extension of the group is marked by a steep strongly crevassed scarp running several miles eastward from the peaks.

The rocks are migmatites, and represent quite a different suite to those occurring further west. The most common type is a poorly foliated granite, with pearly feldspars up to 1½ inches in length, scattered through a crushed looking matrix of quartz and feldspar. Segregation of the quartz produces a moderately good banding.

In thin section, (4595) the typical granite is a medium-grained mosaic of quartz and feldspar with a tendency to segregation of the quartz into lenses. Both potash feldspar (some of it perthitic) and oligoclase-andesine are present. Clinochlore forms small interstitial aggregates, and rare biotite, magnetite, zircon and apatite occur. Many feldspars contain trails of minute stumpy crystals with a hexagonal cross section. Many of these trails are more or less parallel in different grains, and a few continue from one grain to the next; these features suggest they are relict either from the original sediment or from an earlier recrystallisation; the perfect euhedral form of most would suggest the latter alternative.

Scattered through this medium-grained aggregate are fine-grained aggregates of quartz and sodic oligoclase; mosaics of even finer grains border many of the feldspars; myrmekite which fringes a number of the feldspars appears to be an intermediate stage in this recrystallisation. The irregular distribution of the recrystallisation, its occurrence as fringes to the larger grains, and the small degree of strain shown by the unaffected minerals suggest that this recrystallisation is the result of thermal rather than dynamic processes. The veins of olivine, magnetite and calcite described below also point to an igneous body at depth.

At the southern end of the peak, the host rock of the migmatites is a fine grained, banded hornfelsic rock, made up of feldspar, quartz and markedly reddish coloured biotite; it occurs as inclusions and bands up to a couple of feet wide, commonly showing very tight folding. The inclusions are sharp edged, and in places the edge cuts across the banding (Plate 7, fig. 2). Some are veined by the granite, and the granite is poor in quartz for a distance of three or four inches from most of them.

In places, the rock is intermediate in appearance between the normal granite and the hornfels, and does not have any banding.

Here and there, massive blue quartz forms lenses up to a foot wide. North of the main peak, the migmatite consists of narrow alternating layers of granite and dark pyroxene hornfels. The latter is a fine grained rock containing pyroxene, feldspar and reddish biotite; parts of it, except for the finer grain size and presence of biotite, are not unlike the pyroxene gneisses of the Tula Mountains. Granite veins, a few inches wide, cut sharply across the hornfels from one granite layer to another.

The strike of the layers of the migmatites is 070° to 080°, and the dip 70° to 80° to the north.

North of the southernmost summit of the group is a shear zone, about 60 feet wide, along which the granite has been converted to phyllonite, striking 100°, dipping 60° north, and with a lineation pitching 80° east. A short distance north of this shear, and parallel to it, is a vein, about 15 feet thick, composed of (4595) calcite, olivine (almost completely altered to serpentine minerals and magnetite), magnetite, pyrrhotite and pleonaste, with some apatite. Calcite forms over 50% of the rock. Scattered through it are spherical segregations a couple of inches in diameter, of (4597) olivine, magnetite and pleonaste, enstatite and apatite, with rare calcite, phlogopite and zircon; and also rather larger aggregates of olivine and biotite with only a small amount of magnetite. The two different types occur along different layers, the second being much the more common. The edges of this calcite rich vein are marked by a concentration of biotite and epidote over a width of a couple of inches, and are quite sharp against the granite, the foliation of which is very disturbed.

Another ten yards to the north is a similar calcite-magnetite-olivine band, with the calcite much more varied in texture, and containing fewer segregations, most of which are the biotite-rich type (with some epidote in addition). Along one edge is a layer of dolomite, with some olivine and magnetite, the latter in places forming masses several inches in extent. In the granite on either side of this band occur streaks of garnet, and quartz and quartz-garnet lenses.

Nearby are several masses, up to five feet across, of epidote with minor biotite and feldspar, and segregations of pure biotite.

There is little moraine in the southern part of these peaks, except for a few boulders on the ice on the western side.

MILL PEAK

This isolated steep-sided nunatak is composed of fine- to medium grained charnockitic granular gneiss containing (4598) quartz and andesine (rarely myrmekitic) with small amounts of hypersthene, magnetite and diopside, and accessory apatite. The diopside is moulded on, or closely associated with, the hypersthene. The grain size is rather irregular; quartz grains up to 3 mm. across and with sutured margins, occur as streaks in an irregular mosaic of quartz and andesine grains only a fraction of a millimetre in diameter. All grains display marked undulose extinction. Except for its low pyroxene content, the rock is very like the charnockitic granular gneisses described by Crohn from many places near Mawson.

The rock has an ill-defined banding, due to slight concentration of pyroxenes along some horizons. Scattered grains of red-brown garnet occur in places, and there are a few small concentrations of quartz, commonly associated with garnets.

Included in this charnockite are a number of lenses, a foot or so wide, of dark fine- to medium-grained pyroxene-rich rock, containing also feldspar and biotite. In one place, the pyroxene grains have a thin rim of garnet. The inclusions may be massive, but in many cases possess a lineation due to parallelism of pyroxene grains rather coarser than normal. Some of the lenses are straight for fifty feet or more, but others are sharply arcuate, suggesting folding of the enclosing rock. Several small shears have caused granulation of the quartz and feldspar and chloritisation of the pyroxene, and in places have produced a foliation striking W.N.W. and dipping vertically, with a suggestion of horizontal lineation in this plane.

A number of veins of pegmatite occur, composed of thumbnail sized grains of feldspar and quartz, with sporadic pyroxene and rare magnetite. These veins are either sharp edged and transcurrent, or occur along the edge of the pyroxene rich lenses, when they are finer, and tend to grade into the rock on either side.

The charnockitic gneiss strikes between 090° and 110° with dips of 10° either side of the vertical.

A few blocks on the ice north of the peak was the only moraine seen. Small sized angular debris in the radiation moat at the foot of the cliffs appears to be detritus derived from the cliffs by nivation.

ECONOMIC GEOLOGY

No deposits of economic interest were found. Traces of copper (as encrustations of chrysocolla and malachite) were found at Amundsen Bay, Amphitheatre Lake, Perov Nunataks, parts of the Tula Mountains, Mt. King, the McLeod Nunataks, and in moraine at Wilson Bluff. A few specks of chalcopyrite were found at Mt. King. At A58/15 in the Tula mountains, the staining originated in thin iron-stained riebeckite quartzite bands.

No significant radioactivity counts were obtained with a portable ratemeter. At Grove Nunataks parts of the early phase of the porphyritic granite gave readings up to 1½ times background; this activity is probably due to disseminated thorium minerals. A couple of specimens from thin quartz-feldspar veins at McLeod Nunataks also gave counts of 1½ background, also probably the result of radiation from thorium minerals.

PETROLOGY

Crohn has already given an account of the petrology of many of the rock types of the area. The discussion which follows deals only with those types which he did not encounter, or which differ in some respect from his descriptions.

GNEISSIC GRANITE AND GRANITE

The greatest development of these is in the Grove Nunataks, where a porphyritic gneissic granite is the main rock in the central part of the group. It has a foliation parallel to that of the nearby hornfels; the junction between the two is roughly parallel to this foliation, but in many places the granite cuts across the hornfels. The contact between the two is quite sharp, but from place to place the hornfels shows mineralogical and textural variations ranging from dark biotite-rich rock on the one hand to light coloured granitic-looking rock on the other, and it is likely that the gneissic granite is the result of an advanced stage of migmatisation.

The veins of massive granite which cut sharply across the gneissic granite here may be the result of extreme mobilisation, or may be connected with a later episode of injection. There were two phases of pegmatite injection at Wilson Bluff. The gneissic granodiorite at Lewis Island also is migmatitic in origin; its foliation is the result of post-crystallisation deformation, with slight recrystallisation of the small granulated fragments.

The veins of massive granite in the Larsemann Hills may also be the result of extreme migmatisation of the quartz-feldspar-garnet gneisses there.

QUARTZ-FELDSPAR-GARNET GNEISS

Crohn's (p.72) description of these rocks is generally valid for exposures seen by the present writer. Their greatest development is at Mt. Channon and the Leckie Range, where they grade into bands of similar textured rock without garnet, but containing pyroxene, and reminiscent of the pyroxene gneiss of the Tula Mountains. The grade of metamorphism is high, but the only signs of mobilisation seen were thin feldspathic or quartzo-feldspathic veins.

At a number of places among these brown coloured rocks, and in the quartz-feldspar gneiss, are interbedded bands of characteristic white quartz-feldspar-garnet gneiss, in which the only colour contrast is provided by sporadic pink or red garnets. These rocks, despite their moderate content of feldspar, appear similar to some distinguished by Crohn (P.73) as garnetiferous quartzite. On Jetty Peninsula, all gradations can be found from biotite hornfels with thin quartzo-feldspathic streaks, through biotite-rich quartz-feldspar-garnet gneiss, white quartz-feldspar-garnet gneiss and "porphyritic" garnetiferous granite gneiss to massive coarse grained granite with perthite and biotite grains several inches in extent.

QUARTZ-FELDSPAR GNEISS AND PYROXENE GNEISS

These two types occur over a wide area as alternating bands, with the quartz-feldspar gneiss the more common.

The quartz-feldspar gneiss is identical with one of the types (3951) called banded gneiss by Crohn. In the Amundsen Bay - Tula mountains area the great bulk of this type has a characteristic appearance, and consists almost entirely of quartz and perthite only; in some cases, the quartz content is as much as 80%.

The pyroxene gneiss also does not vary much through the Tula and Scott Mountains, except in the ratio of ortho-pyroxene to clinopyroxene.

The quartz-feldspar gneiss was probably derived from a sequence of arenaceous sediments, and the pyroxene gneiss from intercalations of dolomitic pelites.

Explanations which can be advanced for the extreme degree to which perthite is developed in the quartz-feldspar gneisses are: (1) The rock was originally recrystallised at a very high temperature with little stress. Exsolution of the two components was then brought about by a later regional heating, or by regional stress. (2) The plagioclase has been metasomatically replaced by potash feldspar.

In favour of (1) are: The evidence from other parts of the region, of a second metamorphism; the moderate amount of strain shown by some of the rocks in thin section; the much smaller degree to which perthite occurs in the pyroxene gneiss compared to the quartz-feldspar gneiss; the absence, on a megascopic scale, of any other evidence of metasomatism (this appears to be the case in the Tula mountains, but may not apply in the Observation Island area - Crohn, (P. 40).

Features suggesting metasomatic action are: The lack of signs of recrystallisation of the pyroxene due to heat or stress (except for a moderate dusting of many of the grains);

the crenulate margins of the feldspar grains, and embayments in the quartz grains (it is not impossible, but unlikely that this texture dates from the initial recrystallisation); and the very high temperature of metamorphism required to produce an originally homogeneous feldspar containing equal amounts of the potash feldspar and plagioclase components.

Although the available evidence is inconclusive, the writer favours formation of the perthite by unmixing due to heat or (less likely,) stress; any metasomatism was of only minor importance.

At the McLeod Nunataks, parts of the quartz-feldspar gneiss have undoubted charnockitic affinities; this rock is fine- to medium-grained, with a granulitic texture and a small content of pyroxene; it does not, however, have the characteristic dark colour of the normal charnockite. There are, in addition, several veins of porphyritic charnockitic granite, with brown feldspars, which are very like, if rather lighter coloured than, the granite at Mawson.

Further south, in the Knuckey Peaks, rocks with a typical charnockitic appearance occur, with a few bands of pyroxene gneiss associated.

Thus it appears that these charnockites are the result of extreme metamorphism of rocks similar to those from which the quartz-feldspar and pyroxene gneisses were derived.

QUARTZ-MICA SCHISTS

These were found only at Wilson Bluff, in the southern Prince Charles mountains, although metaquartzites occur in the Masson and David Ranges. It is apparent that the precursors of the quartz-biotite schists were quartz-rich arenites.

Whereas most of the metamorphic rocks of the region come within the bounds of the granulite facies or the sillimanite-almandine subfacies, the mineral assemblage of these schists is that of the cordierite-anthophyllite subfacies, and indicates original rocks rich in silica and deficient in potash (Turner and Verhoogen 1951, P.449).

Despite the rather lower metamorphic grade, it is thought that these rocks belong to the same suite as the other higher grade metamorphic rocks of the region, and not to the chlorite and other schists found in Dronning Maud Land (Roots, 1953) and Queen Mary Land (Ravich and Voronov, 1958). On the other hand, it is at present not known if they have gone through more than one episode of metamorphism (such as in some other parts of the area). It is not impossible that the original sediments were deposited after the period of high grade metamorphism and migmatisation of the other rocks of the region, and then altered by the later metamorphism which has left its imprint on some of the rocks of Enderby and Kemp Lands.

METAMORPHOSED BASIC DYKES AND SILLS

These were found in the Tula Mountains and Leckie Range. Most are only a foot or so thick, but one dyke 10 feet wide was found. The only one examined in thin section has been almost completely reconstituted, little trace of the original minerals remaining.

Tilley (1937) has described erratics from Proclamation Island as metamorphosed quartz dolerites; the rocks of the Tula Mountains and Leckie Range differ from these by showing little evidence of the original igneous texture, and in containing important amounts of biotite and hornblende, in addition to the pyroxenes.

There are two alternatives for the age of these intrusions: They could have been emplaced in the original sediments, and altered with them; or they could have been injected after metamorphism and recrystallised by a subsequent metamorphism. The latter alternative seems the more likely. At the Leckie Range, the edges of the dykes are quite sharp and straight against the enclosing gneisses, and they cut across highly contorted quartz veins in the gneisses; the gneisses possess a good lineation, which the dykes do not show (although the larger ones have a poorly defined foliation parallel to their margins); however, the dykes themselves are cut by thin granite veins.

There is evidence from other sources of two episodes of metamorphism. Ravich and Voronov (1958) consider that the rocks of the King Edward VIII Gulf area show evidence of metamorphism of the amphibolite facies superimposed on a mineral assemblage of the granulite facies. In one of Crohn's specimens from here (3942), the pyroxene has fringes of hornblende.

Tilley (1937) considers that rocks from Proclamation Island have undergone a second metamorphism, and gneisses in the Nye Mountains also show evidence of alteration.

This second metamorphism must have been quite intense in the Leckie Range, because new hypersthene is very common in the altered dykes. This high grade may explain the absence of any obvious signs of recrystallisation in the gneisses.

Ravich and Voronov (1958) also consider that altered basic dykes in the Bunger Oasis were emplaced after the main phase of migmatisation.

PYROXENITES

These fall into three groups: (1) Lenses of light coloured coarse grained enstatite in the quartz-feldspar gneisses; (2) medium grained bands, mainly hypersthene, but with some or all of clinopyroxene, hornblende, biotite and feldspar; (3) Bands of medium to very coarsely crystalline hypersthene, with some quartz and feldspar.

The first of these groups is probably the result of the segregation during metamorphism, of magnesium present in the original rock, promoted by solutions which would produce the coarse grain size. The second and third groups were probably derived from pre-existing igneous rocks; the coarse and irregular grain size of the third group may again be due to the influence of solutions during recrystallisation. This last type is very like a hypersthenite from Proclamation Island described by Tilley (1937).

PEGMATITES

These were found in most of the areas examined, except in the quartz-feldspar and pyroxene gneisses of the Tula and Scott Mountains. They can be divided into two groups:

(a) Discontinuous veins, irregular in width, direction and grain size, mainly composed of quartz and feldspar, with accessory pyroxene, biotite, amphibole or garnet. Most are coarse, (with grains an inch or two across), but some granitic textured veins (e.g. Leckie Range and Grove Nunataks) can probably also be included with this group.

Although the edges of these veins are usually sharp, they give the impression of having been emplaced while the rock was in a plastic condition. (b) Very coarse grain veins mostly straight and parallel-sided, with crystals up to a foot in extent; the wider ones are zoned. They are mainly pink perthite and quartz (commonly graphically intergrown) with biotite plates, and variable amounts of white plagioclase; small amounts of garnet and minerals such as tourmaline and sphene may also be present. The width of various veins ranges from one to 15 feet. Most have had no macroscopically observable effect on the enclosing rock, but at the McLeod Nunataks and Knuckey Peaks, although the edge of the pegmatite is quite sharply defined, the adjoining rock has been granitised over a distance of several feet from the veins.

The widespread occurrence of these veins, even in areas where there has been little or no migmatisation, and their evident occurrence as fracture fillings (particularly in the Leckie Range) suggests a distinct phase of pegmatite injection in the geological history of the region. This phase could be related to the last episode of metamorphism, or be a later, entirely unconnected event.

BASIC DYKES

Dolerite dykes were found in several places in Enderby and Kemp Land. In all examples the dyke is almost vertical, and strikes between north and N.N.E. Although the grain size varies according to the width of the dyke, the texture is generally that of feldspar laths in a plexus of pyroxene granules.

By analogy with the dolerite dykes of Victoria Land, a Jurassic age can be suggested for these dykes. Also the age of a gabbro-dolerite from Mt. Obruchev has been measured as 170×10^6 years (Starik, et. al. 1959). However, the possibility that the dyke at the McLeod Nunataks has suffered slight metamorphism makes this correlation less certain, as no evidence of post-Jurassic earth movements (other than block faulting) has been reported from any part of the East Antarctic continent. The basalt dykes near lines of shearing may be related to the dolerites, but, on the other hand, as Crohn (P.74) has suggested, could be part of the Tertiary volcanic activity which built up Gaussberg and the Kerguelen Islands, and is still manifested in the sporadic activity of Big Ben, on Heard Island.

SEDIMENTS

The writer can add nothing to Crohn's account of the Amery Formation, except to remark that the sediments were derived from land to the west and north-west. The bands of red mudstone and associated grey chloritic sandstone indicate changes in the source and depositional conditions at irregular intervals.

The silicification of the sandstones probably dates from preglacial times. Even during the interglacial periods, it is unlikely that there would be sufficient ground-water activity to bring about any significant chemical changes in the rocks.

The relationships of the thermally altered sandstone at the Goodspeed Nunataks are unknown, and correlation must await further work. Russian workers (Voronov, et. al. 1959) have described little altered Lower Palaeozoic(?) sandstone and conglomerates from Queen Mary Land, to which the Goodspeed Nunataks sandstones may be equivalent.

STRUCTURE

Minor structural features have already been described in the accounts of the various areas visited. This section deals only with the regional structure, and is, to some extent, hypothetical.

Along the coast from Robinson Islands to the Stanton Group and in the Framnes Mountains, the rocks strike roughly north-south. Elsewhere with few exceptions, trends are approximately east west.

It is interesting to note that the area of northerly strikes is also the area where porphyritic charnockitic granites form a large proportion of the rocks. At Mt. Loewe too, where this rock occurs, the strike differs from that of the surrounding non-charnockitic gneisses; again, at Jennings Promontory, the strike is northerly, but here the regional structure is not known accurately. Block faulting is common throughout the area. Physiographically it is best expressed in the Prince Charles Mountains, where numerous fault scarps are evident; but even in the Amundsen Bay area, despite the dissection of the exposures, signs of block movement can be seen. In the Amundsen Bay - Tula Mountains area, zones of mylonite up to thirty feet wide were found. Some have basaltic dykes intruding them or the nearby rock.

The great majority of the faults fall into one or two systems, trending north-south or east-west. In the norther Prince Charles Mountains there is some evidence (mainly physiographic) for a north-east trending system.

In an earlier section, it has been pointed out that considerable movement along these fault lines has taken place in relatively recent times. The fact that most of the dolerite dykes also run north-south or (in the Vestfold Hills) east-west suggests that this latest movement may have been along lines of weakness dating back to at least the Jurassic, and, perhaps even earlier.

The high concentrated ranges of the Prince Charles Mountains on the one hand, and the low, scattered exposures of the Amery Lowland on the other, point to a major line of dislocation between the two zones. This line appears to run roughly along the 69th east meridian, i.e. down the western edge of the Amery Ice Shelf, along the Amery Fault, and east of Clemence Massif and the Mawson Escarpment. Voronov (1959a,b) has postulated a deep graben like depression extending south from Prydz Bay, at least as far as 80°S, and centred roughly along the 72nd. east meridian. He considers that the trench is bounded on either side by horst structures, the whole forming a meridionally trending zone 300 miles wide. Soundings off the front of the Amery Ice Shelf (Law, 1959 p.44) certainly do point to a meridional trench between longitudes 71°E and 75°E, but south of 69°S, the eastern margin of the graben is, very poorly defined. A series of rock exposures, all rising less than 1,000 feet above sea level, extends from Beaver Lake north-east to the Vestfold Hills. These exposures including Pickering Nunatak and Manning Nunataks do not leave much room for a graben, and it is possible that the discontinuity here is more in the nature of a gigantic step. On the other hand it is quite possible that there is a graben structure between the Mawson Escarpment and the Grove Nunataks, and this is the area seen by the Russians on their reconnaissance flights. **

**. It should be noted that positions given by the Russians for features seen by them (Information Bulletin of Russian Antarctic Expedition (5) -wireless flashes from the Antarctic No.8) do not fit in with features delineated by the Australian Authorities, using astronomical control for positions.

The preliminary results of seismic work along 62°E longitude (Goodspeed, 1958) indicate that the area between 70°S and 72½°S is one where the rock basement is not at any great height above sea level. This low lying area is bordered to the south and east by a high, but greatly dislocated zone, represented by the numerous exposures on either side of the Fisher and Lambert glaciers. Its north eastern boundary is the mass of the Athos, Porthos, and Aramis Ranges, and a prominent subglacial ridge through 69°55'S, 62°10'E. The extension of this ridge is not known; the Hansen Mountains are probably part of it, because the rocks there resemble those of the Prince Charles Mountains rather than those of the other mountains in the interior of Enderby and Kemp Lands.

GEOLOGICAL HISTORY.

This section is a summary of the conclusions reached in other parts of this report. It is very tentative, and the sequence of events visualised will probably be greatly modified by further work. Also, it is most unlikely that different parts of such a large area would have had the same history.

The generalised sequence of events is thought to have been:

(1) Metamorphism, with varying degrees of migmatisation and mobilisation, to rocks of the sillimanite - almandine subfacies or granulite facies. The original rocks were dominantly sedimentary with igneous intercalations of volcanic or hypabyssal origin.

(2) Intrusion of basic dykes and sills into these gneisses.

(3) Further high grade metamorphism, the effects of which are best displayed in Enderby and Kemp Lands. This may have been mainly a regional heating with dynamic effects at a minimum.

(4) Widespread injection of pegmatite dykes. This event may belong to the closing stages of (3) above, or be a separate unrelated event.

(5) Deposition of freshwater sediments, possibly in downfaulted basins. The duration of deposition before and after Lower Permian time is not known.

(6) Injection of numerous dolerite dykes, probably during the Jurassic.

(7) Large scale block faulting in late Tertiary times.

(8) Burial by ice, subsequent partial deglacierisation and eustatic sea level movements.

GLACIOLOGY.

MORPHOLOGY AND SURFACE FEATURES OF THE PLATEAU.

General descriptions of the plateau have been given by Crohn (1959) and Mellor (1958). The present writer was able to examine the morphology and surface features of the inland ice cap during a sledging journey between Amundsen Bay and Mawson. Rock exposures occur at intervals along the whole route, ranging from the extensive masses of the Tula Mountains to small isolated nunataks such as Mill Peak. Consequently, this area cannot be regarded as typical of the high plateau.

The floors of the east-west valleys through the Tula Mountains are flat, rising to the east either with a uniform slope or as a series of terraces, with occasional depressions where gaps in the mountains allow the ice to drain south into the Beaver Glacier. Crevassing is common; from the air, great straight crevasses can be seen extending across the valley north of Mts.Harvey and Storer. Elsewhere, (except on the steep slopes where the ice flows around an obstructing rock exposure) crevasses were generally concealed by a covering of soft snow, and their existence was revealed only when a man or dog broke through the hidden bridge.

As would be expected, the whole of the Tula Mountains is in the zone of ablation. An extensive flat area of cusped, bubbly "blue" ice occurs west of Mt.King at an altitude of 3,000 feet; small snow drifts occur in several places on this ice.

At the time of the visit (late November) the ice in the western part of the range, and the seaice in the Adams Fiord area, was covered by soft snow, up to two feet in depth. The surface was smooth, with no saatrugi, the only relief being a series of transverse sinuous dunes, a foot or two high and up to ten feet wide; In places, especially on the seaice, the snow had a hard "piecrust" surface.

This whole area is evidently one of light prevailing winds. Over a nine day period the average wind speed at the camp at the south-east corner of Adams Fiord would probably have been less than five knots. A few days of strong winds would strip most of the snow from the surface.

Within this zone of ablation are local accumulation areas, consisting of hard névé like that of the plateau. More common are zones of "white ice" (a porous, more-or-less friable granular aggregate of snow and ice crystals containing numerous layers and blebs of ice, transitional from névé to ice), occurring usually on westward facing (i.e. lee) slopes in the ice.

Half a mile south of Mt.King, at an altitude of 3,400 feet, névé begins, and the plateau between this point and the Leckie Range is in the accumulation zone, except for small ablation areas adjacent to the rock exposures.

Between Mt.King and the Knuckey Peaks, the surface is gently undulating, rising from 3,400 feet at Mt.King to 6,100 feet at the southern end of the Knuckey Peaks.

About eight miles south of Mt.King, the névé was cut by several long, quite straight cracks, a quarter to half a mile apart, half an inch wide, and running to the north-east and south-west as far as the eye could see. No other signs of crevassing were visible.

Between the Knuckey Peaks and Mt.Channon, the plateau rises to almost 7,000 feet. This appears to be an area of high precipitation and low wind speeds, for the surface was soft, perfectly smooth snow, into which men sank ankle deep at each step; there were no sastrugi whatsoever. The cloudbase commonly descended to ground level in this area. Further east, where the plateau drops towards Mt.Channon, small areas of hard sastrugi show through the soft snow, and these surface conditions extend almost to the Leckie Range, and occur again on the high area west of Fram Peak.

All the localised ablation areas mentioned above have a similar pattern. They occur on the leeward side of the rock exposure (in nearly all cases this is also the "downstream" side of ice movement) and are roughly triangular in shape, with the rock mass forming the base of the triangle. Depending on the size of the rock mass, the ice may be many square miles in area (e.g. the Grove Nunataks, where it is at an altitude of 6,000 feet), and may extend for several miles from the rock. (Bare ice occurs two miles north of Mill Peak, where the rock is only a quarter of a mile wide, and runs for three or four miles north of the Leckie Range). The plateau surface generally falls gently towards the rock, producing a triangular depression, which is emphasised by the steep slopes on either side near the rock exposure, where the ice begins to flow together again downstream of the obstruction.

At the side of most of the rock exposures is a radiation moat, which opens into the ablation area, and in the opposite direction passes into a wind scour, which in turn ends abruptly against the drift banked up on the windward side of the rock. The Perov Nunataks and Fram Peak provide good examples of these features.

The bare ice of these ablation zones passes into the plateau neve through a transition zone of white ice which may be anything from a chain or so (as at Mill Peak) to a mile (as at McLeod Nunataks) in width.

The factors producing these local ablation areas are not fully understood. Schytt (1958) considers evaporation is the dominant influence, but Swithinbank (1959) attributes an important role to wind erosion and turbulence, which keep the area clear of snow. Although turbulence may contribute towards the ablation (it must be the main agent in the production of white ice on the sides of domes on the high plateau) it is difficult to see how it could be effective at distances of several miles from even large rock exposures.

In some of these areas, wind blown sand is common on the surface; solar heating of these grains will assist ablation to some extent.

Few rock exposures occur between the Leckie Range and the Framnes Mountains, but the surface of the plateau shows considerable relief. Domes and valleys are quite marked, and some of the former are heavily crevassed. The ice falls steeply through the Hansen Mountains and Arnel Blugfs, and a prominent scarp runs eastward from Fram Peak. The surface of many of these domes (particularly the crest and eastern slopes) consists of crevassed white ice. Fifteen miles east of the Leckie Range, white ice was exposed at an altitude of 5,200 feet. Seven miles west of Mt.Hordern, blue ice occurs on top of a dome at 3,500 feet, close to the junction of the accumulation and coastal ablation zones, which was crossed about five miles west of Mt.Hordern, at an altitude of 3,400 feet.

PLATEAU DRAINAGE.

The drainage of the area between the 45th and 80th meridians is dominated by the vast Lambert Glacier system. Together with its tributaries, and the glaciers flowing directly into the Amery Ice Shelf, the Lambert Glacier drains a basin about 200,000 square miles in area, extending beyond 75°S. The western margin runs through 68½°S, 68°E, near the Stinear Nunataks, and through 70½°S, 62°E, south-west to the as yet unknown headwaters of the Fisher Glacier. The eastern limits are not known, but are certainly beyond the Grove Nunataks, because the plateau falls steeply to the west through this group.

The other major drainage basin is that of the Robert and Wilma Glaciers, which flow into King Edward VIII Gulf. Ice flowing north into the Enderby Land Peninsula is obstructed by the Napier Mountains and Akers Peaks. To the west, the Tula, Scott and Raggatt Mountains form a barrier, through which the valley of the Beaver Glacier is the main breach; much of the flow, however, is diverted to the north-east. The north-western margin of this basin probably runs near the McLeod Nunataks and Knuckey Peaks; the ice flows through the former group to the north or east of north, and to the north-west through the Knuckey Peaks. The eastern divide runs through a high point of the plateau (6,000 feet) at 68°10'S, 58°10'E. The high area (6,700 feet) around 68°S, 54°E is probably due to damming of the northward ice flow by the chain of rock exposures formed by the Knucky Peaks, Doggers Nunataks and Dismal Mountains.

In the Tula Mountains the ice flow is south or south-west into the Beaver Glacier, except in the vicinity of Adams Fiord, where it is to the west. The flow through the Perov Nunataks is to the west, but there are no defined ice streams. Elsewhere, where it was observed, the drainage was northwards towards the coast.

ABLATION ZONE

Most of the general features of the coastal ablation zone have been described by Crohn (1959).

During the winter, large amounts of snow accumulate in parts of the ablation zone, right down to sea level. These drifts form where the smooth flow of the wind is affected by obstructions or changes of slope of the plateau surface, and may reach considerable dimensions. They consist of hard wind-packed névé, quite similar to the névé of the accumulation zone; the surface is even eroded into sastrugi. Eight miles west of Mt.King, a snow surface was marked by ripples, quite like those formed in sand by moving water.

At the end of August, névé typical of the accumulation zone formed a continuous cover in the corridor between the Masson and David Ranges, south of a line joining Mt.Parsons and Blair Peak. Parts of the surface were hard and very smooth and slippery, with a polished eggshell-like texture. At this time, too, incipient melting was taking place at the very tips of sharp projections of sastrugi; giving a dark appearance to the snow. Between the beginning and end of October, a good deal of snow was stripped from the surface, leaving vehicle tracks made in early October standing in relief, and by late January 1959, except for a large area of snow banked up against Mt.Coates, a few areas of white ice, and some small drifts, the corridor was clear of snow as far south as, and through, Hordern Gap.

In the upper parts of the ablation zone (i.e. above 1,000 feet) behind Mawson, extensive areas of snow persist throughout the year in the lee of steep slopes, where they are protected to some extent from the scouring and evaporating effects of the wind. The higher ones consist of névé with thin ice layers at various depths; at lesser altitudes, the névé becomes granular, and the ice layers more prominent, and the névé finally becomes "white" ice which grades into the "blue" ice of the ablation zone.

During the summer, meltwater from the smaller snowdrifts spreads as a film over the cusped surface of the adjacent ice, filling the hollows, and producing areas, many square yards in extent, of glass-smooth ice; such smooth areas occur on slopes as great as 15°. In cases, these smooth patches on the ice are the only remnant of snow drifts; in other cases, the drift is represented by a low mound, consisting of opaque ice with a very high content of air bubbles, riddled with veins and blebs of clear ice, the result of percolation of melt water into the snowdrift, followed by re-freezing. These "ice drifts" were common at Jennings Lake, Beaver Lake and Clemence Massif.

In exposed areas, the cusping of the ice surface is quite considerable. Several areas were seen where each pyramid was three or four inches high, and several inches wide. In a number of places, the pyramids are elongated, and oriented parallel to the prevailing wind; they have the shape of an assymetric pyramid, with a long sharp ridge running to leeward of the apex, and a steep triangular face on the windward side.

An example of the formation of these cusps was seen on a melt lake near Mawson. In April, the surface of this was glass smooth, but traversed by numerous cracks. By August, elongated shallow depressions an inch or so deep had formed along the northern side of these cracks, with a vertical southern face, and gently sloping side on the north. During August, these lengthened and broadened, until adjacent ones almost met, leaving a sharp dividing ridge. Unfortunately before the typical cusped surface was developed, the area was covered by snow.

In places, especially on broad flat areas of ice, the regularity of the cusped surface is broken by areas in which the projections are lower, and less angular. These parts of the ice were covered by small snow drifts during the winter, and protected to some extent from ablation; the snow was subsequently removed by the wind.

The small isolated areas of ablation adjoining inland rock exposures show features similar to those of the coastal zone. The ice has the characteristic cusped surface; but at Grove Nunataks it was merely irregular, without the sharp edged cusps; cryoconite holes occur in cases close to the rock, but most morainal detritus remains exposed, lying either on the surface, or in a shallow pit. In the latter case, a rudimentary pillar may be developed, and there is generally a sharp-crested ridge of ice on the leeward side of the larger boulders, even when it is the northern side, indicating that the depression in which a boulder lies is mainly the result of wind, rather than radiation due to solar heating of the rock.

Although the surface in most areas was tending to exfoliate, columnar disintegration such as occurs near the coast, was not seen.

During the summer, considerable amounts of water are produced by melting of the snow on the larger inland rock exposures. Extensive meltwater areas occur along the northern fronts of the Leckie Range and McLeod Nunataks, and small pools form in depressions in the moraine. At the north-west corner of the McLeod Nunataks, there was a pool of water in the ice, despite an air temperature of -8°C. The water was probably derived from an area of morainal rubble on the nearby ice.

Near the rock exposures, isolated boulders of moraine generally were surrounded by a small pool of water, which on overcast days acquired a thin surface layer of ice.

TABLE 6.

ABLATION, MAWSON AREA (IN INCHES OF ICE)

Period Ending	140 feet (beginning 20th March).		250 ft. (beginging 9th March)		330 ft. (beginning 11th March.		590 ft. (beginning 26th February		650 ft. (beginning 26th Feb.	
11th March, 1958							½		1	
22nd "		.027 ins/day.						.043 in. day	¼	.043 in. day
8th April, 1958	1			.045		.049 in. day				
26th "	0				2¼		2		1¼	
2nd May, 1958			2							
5th "	¾									
19th "	0	.022	½							
5th June "	½		¾	.036		.027		.029		.029
5th July "	¼									
21st " "	¼		1¾		2¼					
28th " "	¼		½							
29th "					¼		2¾		2¾	
18th August "	0		½							
25th " "	¼		0							
9th Sept. "	0		½							
15th " "	¼	.010	0	.022		.016		.025		.034
29th " "	0		¼		1					
7th Oct. "	¼		¼							
15th " "	0		¼							
17th "					¼		2		2¾	
20th " "	0		½							
27th " "	⅝		½							
3rd November	⅜	.052	½	.073		.068		.057		.057
10th " "	¼		½		1½		1¼		1¼	
17th " "	⅝		¾							
24th " "	⅜	.071	½	.118						
1st December "	¾		¾							
8th " "	½		1							
15th " "	¼		1⅛							
22nd " "	¼		⅞							
30th " "	1½	.121	1							
5th January 1959	¾		¾	.132						
12th " "	¾		½							
19th " "	1¼		1½							
27th " "	½		½							
2nd February "	¾	107	½	.083						
9th " "	¾		½							

Measurements of ablation in the Mawson area were continued during the year. The results are shown in Table 6.

The total ablation at the various points, derived from these figures, is given in Table 7.

TABLE 7.

TOTAL ABLATION, MAWSON AREA.

(a) 11th March, 1958* to 10th November (244 days).

Altitude (feet)	Inches of Ice		Equivalent inches of water+		cm. of water.
	Total	Per day.	Total	Per day.	
140	5	.025	4.4	.018	11.1
250	8¾	.036	7.6	.031	19.3
330	8	.033	7.0	.029	17.7
590	8	.033	7.0	.029	17.7
650	8¼	.034	7.2	.030	18.2

(b) 10th November, 1958 to 9th February, 1958 (91 days).

Altitude (feet)	Inches of Ice Total	Inches of Ice Per day.	Equivalent inches of water Total	Equivalent inches of water Per day.	cm. of water.
140	9¼	.102	8.0	.088	20.4
250	10½	.115	9.1	.100	23.2

* From 20th March for 140 foot level.

\+ Using a specific gravity of 0.87, the average of values from three different points behind Mawson.

A notable feature is the considerable difference in ablation rates between the 140 and 250 feet levels. The poles at the 140 foot level are on the side of a steep north-facing slope, and so are sheltered to some extent from the prevailing S.S.E winds. The poles at the 250 foot level are exposed to these winds; the poles at the other levels were also exposed to the winds, and have an ablation rate comparable to that at the 250 foot level. The effect of the wind on the ablation rate is also shown by the ablation for the winter period; from 19th May to 28th July, the ablation at 140 feet was 1¼ inches of ice, at 250 feet, 2½ inches; total sunshine in this period of 70 days was 30.1 hours.

The total ablation during the year is less than the amounts measured in previous years. For the period 16th March 1955 to 7th February 1956, Crohn (p.86) records a loss of 32¼ inches of ice, and 23½ inches for the period 7th February, 1956, to 1st January, 1957 (which does not include the period of greatest ablation). Mellor (1958) gives the ablation between February 1957 and February 1958 as 535 mm. of water, equal to about 24 inches of ice, also rather lower than the values for the previous two years.

Detailed figures are not available for 1957, but when those for 1955 and 1956 are compared with those of Table 6, it is found that the rates in all three years are comparable until the beginning of December; thereafter, the rates for 1955 and 1956 show a sharp increase, while the rate for 1958 remains constant (fig.4). When the weather is compared over the same period for each of the three years, it is found that while wind-speeds and average

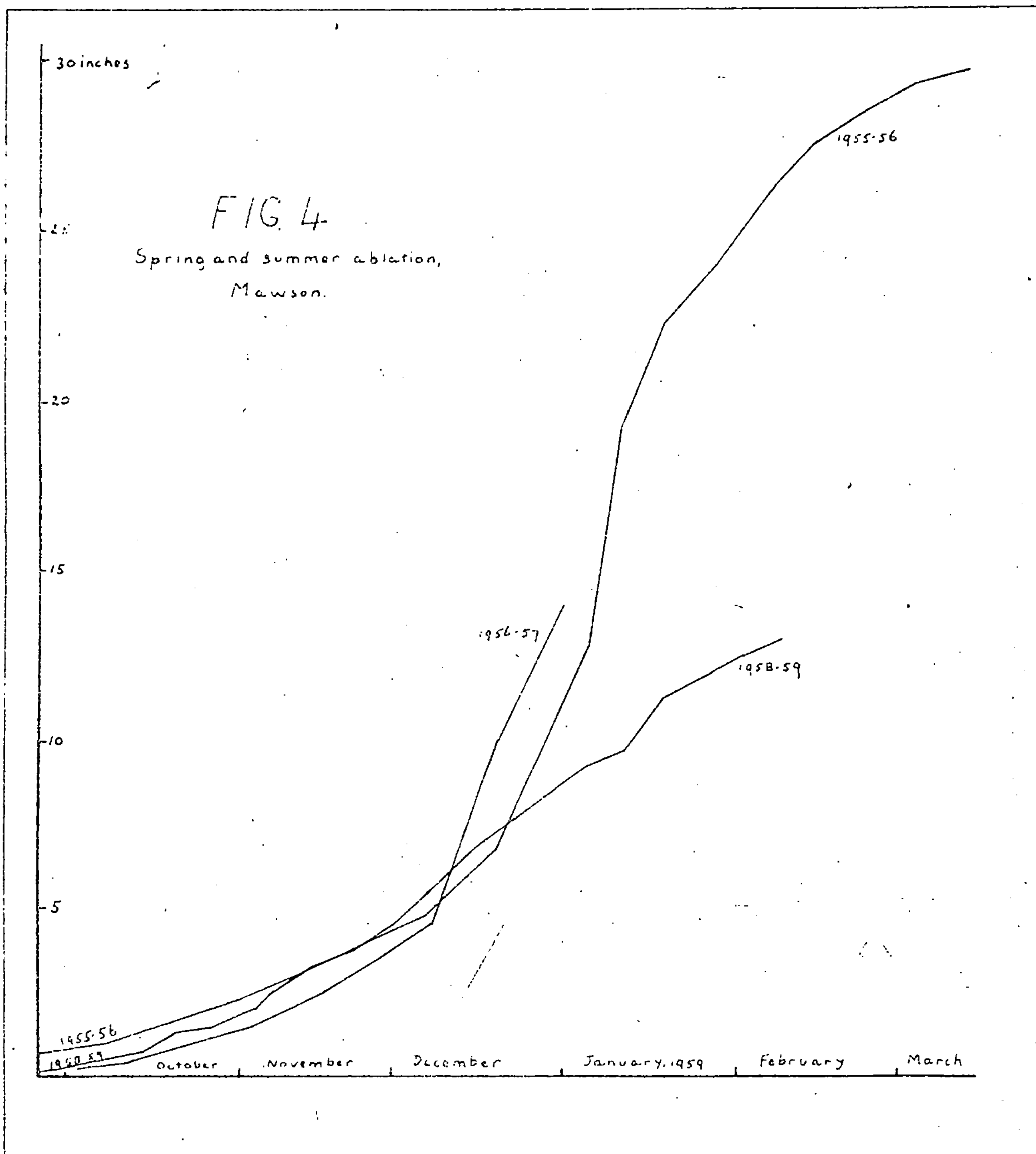

FIG. 4

Spring and summer ablation, Mawson.

temperatures are similar, there was much less sunshine in December, 1958 and January 1959, than for the same two months in 1955-56 and 1956-57 (425.9 hours as against 716.5 and 637.9 hours, i.e. daily averages of 6.9, 11.7 and 10.3 hours respectively). It seems likely that this greatly reduced amount of sunshine, with the corresponding decrease in incoming radiation, was the cause of the small amount of summer ablation, as well as the abnormal conditions to be described later.

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Another effect of the reduced sunshine was the much smaller extent to which columnar disintegration of the ice surface occurred. Incipient disintegration was first noticed in October along certain bands in the ice behind Mawson. However, by the end of January, this had developed only in small localised areas. Most of the surface then consisted of short assymetric east-west trending ridges an inch or two high, with a sharp crest, and a steep or overhanging northern side, and a southern side sloping at about 45°.

During depoting operations ablation poles were installed at the Leckie Range and McLeod Nunataks, and were later measured during a sledging journey. At Leckie Range (altitude 3,900 feet) the ablationloss at a point half a mile north of the range was 4¾ inches of ice between the 21st September and the 30th December, 1958, a daily rate of 0.047 inches. At McLeod Nuntaks (altitude 3,700 feet), the average loss from four poles 200 yards north of the main group (but only twenty yards from large blocks of moraine lying on the ice) was ¾ inch between the 25th September and the 4th November, and 4 inches between the 4th November and the 11th December, 1958, equivalent to 0.062 inches per day for the whole period..

In the centre of Beaver Lake, the ablation from the surface (altitude just above sea level) (average of two poles) was:

	Total.		Per day.
27th September to 21st October	2¾	inches.	.115
21st October to 2nd November	¾	"	.063
2nd November to 9th November	¾	"	.107
Total 43 days -	4¼	"	.099

This is much higher than the loss of 2¼ inches at the 250 foot level at Mawson between 29th September and 10th November, presumably because of the high wind speeds characteristic of the Beaver Lake Area.

ACCUMULATION ZONE.

The only accumulation figures obtained during the year were along the southern seismic traverse, where poles installed by M. Mellor were remeasured by R. Blake and E.E. Jesson.

The accumulation at each locality is shown in Table 8.

TABLE 8.

ACCUMULATION SOUTH OF MAWSON (inches of névé)

Date	Location	Position	East	Centre	West	Average.
Nov. 17, 1958.	Drum 16	69°38'S 62°10'E	6	11⅝	16¼	11¼
" 21 "	Drum 11	70°00'S 62°09'E	-½	-1½	-½	-¾
" 29 "	Drum 8	70°13'S 62°09'E	9¾	12½	12	11¼
Dec. 2 "	Drum 4	70°31'S 62°08'E	14	16	18½	16
" 2 "	Drum 2	70°40'S 62°09'E	-¾	-¼	0	-¼
" 3 "	237 mile depot	70°49'S 62°09'E	7½	10	8¾	8¾

Thus, for the period February to December 1958, for a strip between 150 miles (altitude 8,500 feet) and 230 miles (altitude 9,600 feet) from the coast, the average accumulation was 7¾ inches of snow, equivalent to 3.1 inches (7.9 cm.) of water (assuming an average specific gravity of 0.4 for the névé).

In January 1958 Mellor spread dye over the surface at drums 4 and 16. Pits were later dug at these localities by R. Blake and E.E. Jesson. The dye layer was found only at the former locality, at a depth of 65 cm. in one pit, and 55 cm. in the other. A detailed discussion of the data obtained from these pits will be given by Mellor.

The great variation in the accumulation values, and the fact that in December 1958 the seismic party followed for several miles near 70°S tracks made the previous January, shows that snow does not accumulate on the plateau as a sheet of more or less uniform thickness. The impression gained by both the seismic and sledging parties was that snow precipitated in high winds accumulates as long whaleback dunes, which may reach heights of over ten feet and extend downwind for several hundred yards.

Under conditions of moderate to strong winds without precipitation, these dunes are eroded into sastrugi. Because the fine weather katabatic winds usually come from a different direction to those of bad weather, the sastrugi runs in a different direction to the dune, so that one flank of the dune is eroded to an almost vertical deeply dissected face, while the other side is hardly affected. Such conditions were common a few miles east of the Knuckey Peaks, where the sastrugi was about three feet high, and on parts of the seismic traverse where the sastrugi reached heights of six feet or more.

Under certain conditions (usually light to moderate winds with low drift) elongate accumulations form from drifting snow. In form, these often resemble sastrugi, but are softer and less compact in appearance, and may partly bury sastrugi cut in the hard névé. They may be elongated in the same direction as the sastrugi, or have an orientation differing by up to 40° from the line of the sastrugi. These accumulations (the writer prefers not to call them sastrugi, restricting this term to features purely erosional in origin) are not stationary, but migrate downwind and increase in size or dissipate with varying wind conditions.

Although there may be localised accumulations amongst the sastrugi, it is thought that drifting snow is not an important factor in the supply of material for accumulation at any particular locality.

The low sinuous dunes in the soft snow on the seaice at Amundsen Bay, and in the Tula Mountains may be the result of precipitation accompanied by light winds. On many of them, the leeward flank was rather steeper than the other, and it is likely that these transverse dunes are actually giant ripples, which migrate downwind during or shortly after formation; the sinuosity would then be the result of varying rates of movement along the length of the dune. By mid-November, they were immobilised by a harder crust a centimetre or so thick.

The conditions governing the formation of crescentic barchan dunes are not fully understood, but it is probable that the conditions postulated by Bagnold (1941) for the growth of sand barchans will apply also to snow. Briefly, he considers that sand barchans form by streaming of particles on either side of the obstruction caused by chance accumulation of particles on a flat surface, under conditions of nearly constant wind direction. A change of wind direction will rapidly destroy the crescentic shape.

The best developments of barchan dunes were seen from the air on the seaice south-west of Flat Island in early August, east of the Canopus Islets on the 18th August, and on the plateau west of Church Mountain on 15th August, 1958. The first two groups did not display any regular arrangement; the dunes near Church Mountain were formed to all degrees of perfection, from barely recognizable to perfect crescents, approximately ten feet from tip to tip. The more perfect ones were commonly arranged in lanes running downwind, with the apices of the individuals collinear; some of these lanes extended for several hundred yards. In cases parallel lanes were quite close, and only the width of a dune apart.

On the ground, scattered barchans were found in the western Tula Mountains and five miles west of the Leckie Range.

These dunes differed in shape from those figured by Moss (1938). The "horns" were longer, each tapering off to a fairly sharp tip, and the dune consequently had a crescentic, almost semicircular, plan, rather than the bommerang shape depicted by Moss (p.216). Each dune was about ten feet from tip to tip, and a couple of feet high at the highest point of the apex.

During a six-day blizzard, two feet of soft snow was deposited on the plateau a few hundred yards south of Fram Peak, and a few indistinct barchans were formed on the smooth upper surface of this snow.

In all three cases, the snow of the dune was much softer than the surrounding surface, and had a curious slippery feel underfoot, a sensation akin to that experienced when walking on wet greasy clay.

The southern seismic party recorded barchans at 69°52'S, 62°10'E (where they were twelve feet from tip to tip, and two feet high at the apex) at 70°23'S, 62°09'E (where they were the same height, but only six feet from tip to tip) and near 69°10'S, 61°35'E. In all cases there were only a few scattered individuals. Those at the last locality were of interest in that they were asymmetrical, with a western arm about twenty feet long, and the eastern one only twelve feet in length.

A record of sastrugi directions was kept during flights across the plateau, and on the southern seismic and sledging journeys. A study of these and the data obrained in previous years is being made (Mather and Goodspeed, 1959) in relations to the prevailing wind patterns of the area.

ICE RECESSION

Up to the middle of February, the ice recession cairns on Magnetic Flat were still snow covered, so could not be measured.

On the 11th November, a line of levels was run from the rock to the ablation poles at the 250 feet level. Another set was read on the 13th February. By plotting the heights and distances from a datum point, a profile of the surface is obtained for each case. Comparison of the two profiles suggests that despite an ablation loss of over five inches in the intervening period, there has been little nett lowering of the ice surface, i.e. the rate of ice supply by flowage is equivalent to the rate of loss by ablation, and consequently, the margin is stationary. Results are, however, still far from conclusive, and further readings are to be made by the present party.

PLATEAU TEMPERATURES

During the autumn seismic traverse between Mounts Henderson and Casey, a large number of measurements of ice and snow temperatures were made at depths of ¼, ½, 1 and 2 metres by leaving a lagged spirit or mercury thermometer in a SIPRE drill hole of the appropriate depth, and closing the hole with a piece of rag. When possible, readings were made at hourly intervals. When time allowed, temperatures in the seismic drill holes were measured at ten foot intervals by letting a string of thermometers "soak" in the hole for an hour or so.

At Shot Point 28 (altitude 1694 feet), which was drilled in ice, the following temperatures were obtained two hours after sunset:

Depth (feet)	Temp. °C.
40	- 15.1
50	- 15.0
60	- 15.0
70	- 14.9
80	- 15.3
90	- 15.4
Air temperature -	- 24.0°C
Surface temperature -	- 22.5°C

An hour later, the following figures were obtained:

Depth (feet)	Temp. °C
Top of hole	- 16.8
10	- 11.6
20	- 12.2
30	- 13.5
40	- 14.8
50	- 15.2

Air temperature - -24.1°C
Surface temperature - 22.6°C

An hour after sunrise the next day, temperatures were -

Depth (feet)	Temp. °C
Top	- 17.4
10	- 11.6
20	- 12.2
30	- 13.7
40	- 14.8
50	- 15.2

Air temperature - - 27.8°C
Surface temperature - 24.8°C

The temperature profile shows a rapid rise to ten feet, a gradual fall to forty feet, and a very gradual fall below that, so the wave of increased temperature due to the summer warm period had not penetrated much below ten feet into the ice at this altitude.

Under these conditions (viz. the coldest part of the borehole at the top) there is the possibility of some convective overturn of the air in the borehole during the time for which the thermometers must be left there, and consequently the figures cannot be regarded as completely accurate, especially as the thermometers were not necessarily in contact with the sideof the hole.

At Shot Point 27, where the surface is hard névé, (altitude 1734 feet) temperatures were -

Depth (feet)	Temp. °C.
10	- 16.3
20	- 16.6
30	- 17.2
40	- 17.4
50	- 17.4
60	- 17.6
70	- 17.7

i.e. once again there is a gradual fall below thirty feet.

At Shot Point 29 (altitude 1,644 feet), drilled in névé with some layers of ice, temperatures were -

40 feet	- 16.9°C
90 feet	- 17.2°C

The air temperature was - - 19.0°C

At depths down to 2 metres, the temperature , with very few exceptions, increased downwards. The exceptions occurred during periods of high atmospheric temperature, when there was a slight fall from the surface to ½ metre depth, then a rise to 2 metres.

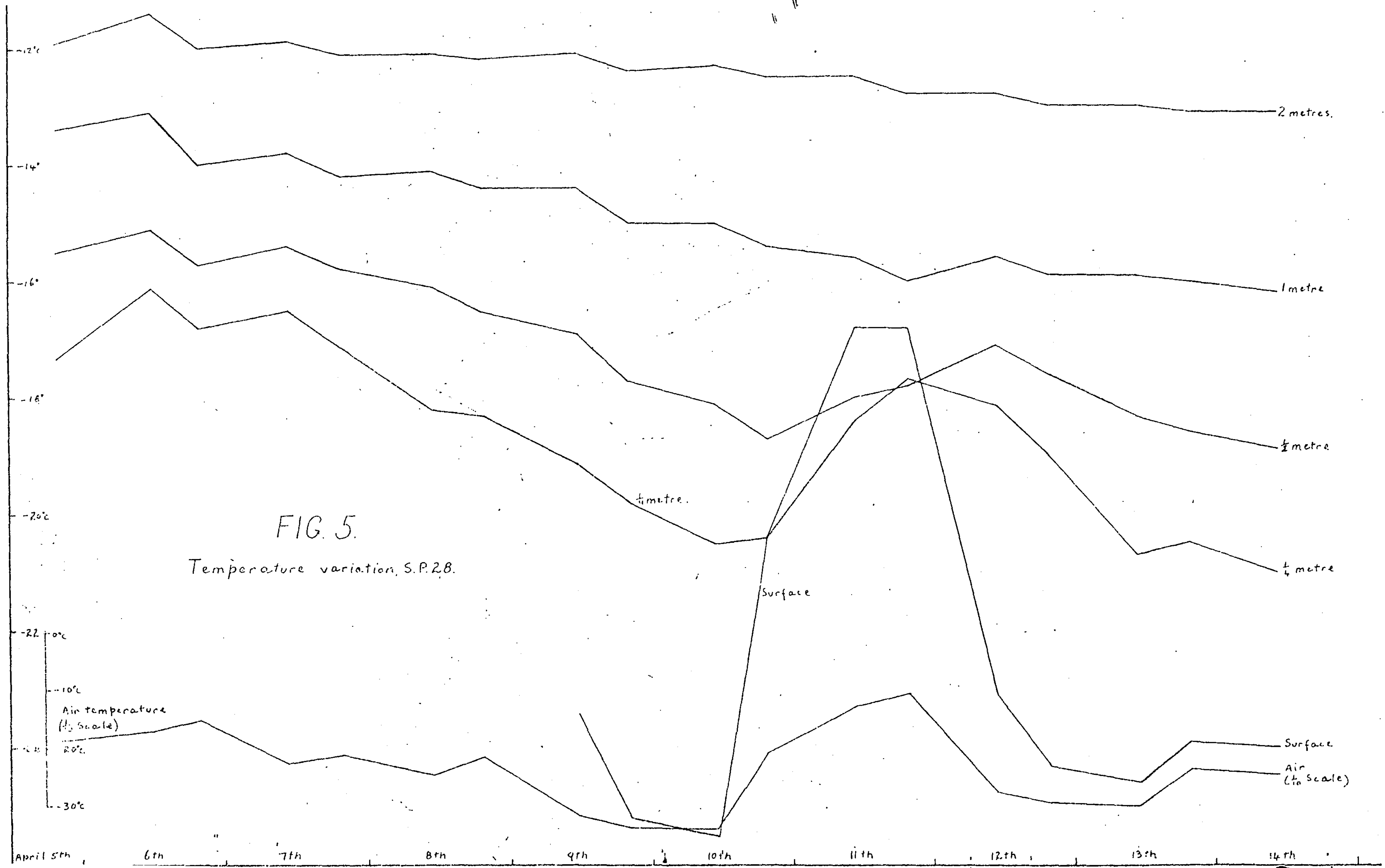


FIG. 5.

Temperature variation, S.P.28.

At 2 metres depth, the ice temperature varied only slightly with atmospheric fluctuations; at 1 metre, the changes are more apparent, while at ½ and ¼ metres, atmospheric changes are closely reflected, although at the ¼ and ½ metre depths, there is a lag of several hours between the time of maximum and minimum ice temperatures as compared with the time of greatest and least air temperatures. The figures obrained over a period of time at Shot Point 28 are shown in Table 9 and graphically in Fig.5. (Times shown are local time, viz. G.M.T. plus 7 hours or about 2¾ hours ahead of local mean time). Over the period, sunrise was about 1015 and sunset about 1915 hours, local time.

TABLE 9.

ICE TEMPERATURES, SHOT POINT 28.

		Temperatures °C below 0°C					
Date	Time	Air	Surface	¼ metre	½ metre	1 metre	2 metres.
April 5	2000	19.5	-	17.3	15.5	13.4	11.9
6	1200	18.6	-	16.1	15.1	13.1	11.4
6	2000	17.8	-	16.8	15.7	14.0	12.0
7	1100	21.3	-	16.9	15.4	13.8	11.9
7	2000	20.6	-	17.1	15.8	14.2	12.1
8	1100	22.2	-	17.2	16.1	14.1	12.1
8	1945	20.9	-	16.3	16.5	14.4	12.2
9	1130	25.7	23.4	19.1	16.9	14.4	12.1
9	2015	26.8	25.2	19.8	17.7	15.0	12.4
10	1100	27.0	25.5	20.5	18.1	15.0	12.3
10	2000	20.3	20.4	20.4	18.7	15.4	12.5
11	1100	16.4	16.8	18.4	18.0	15.6	12.5
11	2000	15.1	16.8	17.7	17.8	16.0	12.8
12	1100	23.9	23.1	18.1	17.1	15.6	12.8
12	2000	24.7	24.3	19.0	17.6	15.9	13.0
13	1100	25.0	24.6	20.7	18.3	15.9	13.0
13	2000	21.9	23.9	20.5	18.6	16.0	13.1
14	1100	22.2	24.0	21.0	18.9	16.2	13.1

The 2 metre temperature showed a gradual fall at all places where it was measured over a period of time, due to penetration of the winter cold wave. Thus at Shot Point 28 it fell from -12°C to -13°C in nine days; and at Shot Point 30, from -14.2 to 14.8 in four days.

The 2 metre temperature at Shot Point 30 was rather lower than at other places where it was measured. This was not due to large fluctuations of the air temperature during or before measurement - it was found at Shot Point 28 that air temperature changes much greater than those experienced later had almost no effect on the 2 metre temperature. Shot Point 30 was sited in a badly crevassed area, and movement of air in the crevasses may have allowed more rapid cooling of the ice in this area.

A profile at this point, and one at Shot Point 31 measured at comparable atmospheric conditions (overcast) is given in Table 10 and Fig.6. It will be seen that the slope of the two curves is almost identical.

TABLE 10.

Ice temperatures at S.P. 30 and S.P. 31 (°C below 0°C)

	S.P.31 8 pm. on 23/4/58)	S.P.30. (8.p.m. on 16/4/58)
¼ metre	17.9	20.0
½ metre	16.2	19.1
1 metre	14.8	17.4
2 metres	12.1	14.2
3 metres		12.9
6 metres		13.0
Air. temp.	19.1	

In ice, there is a diurnal temperature change down to at least 2 metres, the magnitude depending on the depth and the amount of cloud cover.

On a typical clear sunny day, the air temperature rises throughout the day until an hour or so before sunset, when it begins to fall rapidly. At ½, 1 and 2 metre depths, the temperatures show an almost parallel change, the magnitude decreasing with increased depth. The temperature at ¼ metres changes more rapidly, so that by local mean noon it is similar to that at ½ metre. The temperature changes on a bright sunny day (with low drift) are shown in Table 11 and Fig.7.

It is not clear why the ¼ metre temperature reached a maximum before the others. On other days, the maximum was reached at 3 p.m. or later. The dip in surface temperature is the result of that thermometer being in the shade of a vehicle at that time.

TABLE 11.

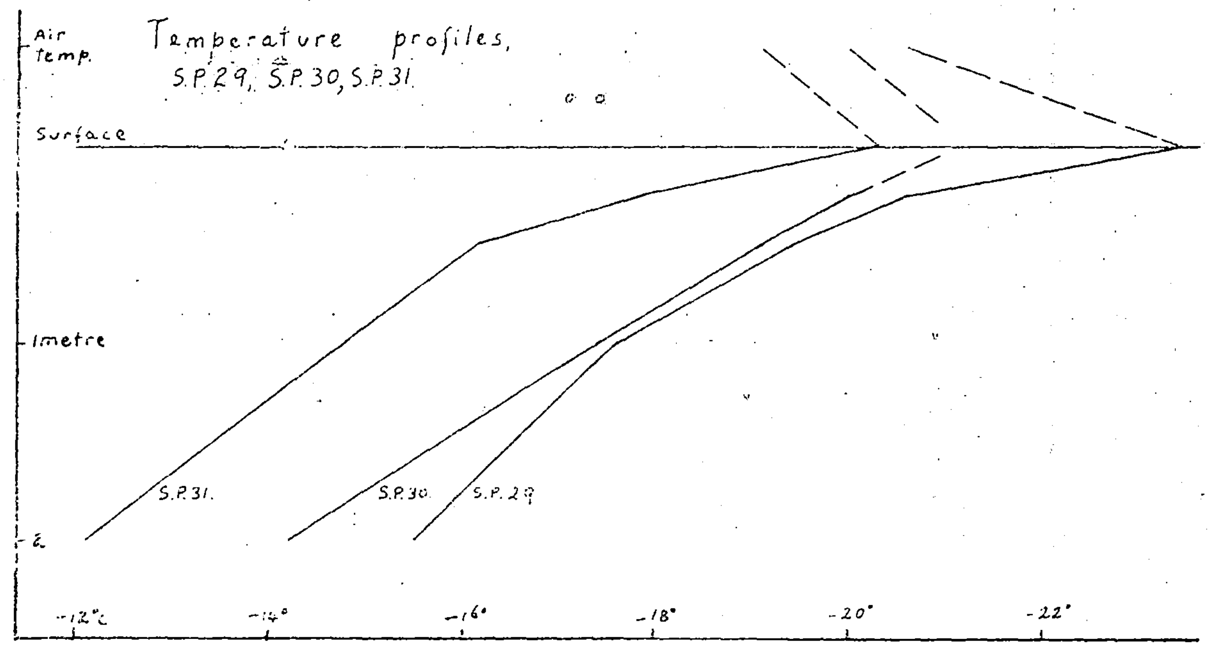
Diurnal temperature variation in ice, S.P.28 (12/4/58)

(°C below 0°C)

Local time	Air	Surface	¼ metre	½ metre	1 metre	2 metres
1100	23.9	23.1	18.1	17.1	15.6	12.8
1200	22.2	22.8	17.7	16.8	15.4	12.6
1300	20.9	22.0	16.9	16.3	15.1	12.3
1400	19.7	20.8	16.0	16.1	14.9	12.3
1500	19.0	20.2	16.2	16.1	14.8	12.2
1600	18.7	21.9	16.6	16.0	14.9	12.2
1700	18.1	19.8	16.6	16.3	15.0	12.4
1800	17.6	20.6	17.8	16.8	15.4	12.6
1900	21.1	22.7	18.5	17.3	15.7	12.9
2000	24.7	24.3	19.0	17.6	15.9	13.0
2100	25.9	24.8	19.2	17.6	16.0	13.1
2200	26.7	25.1	19.4	17.6	15.9	13.0
2300	27.7	25.3	19.4	17.6	15.8	13.0

On an overcast day all depths again show diurnal temperature changes, but to a much smaller extent, as shown by Table 12 and Fig.8. How much of this change is the result of the decreased incoming radiation, and how much to the smaller variation in air temperature, it is not possible to say.

FIG 6.



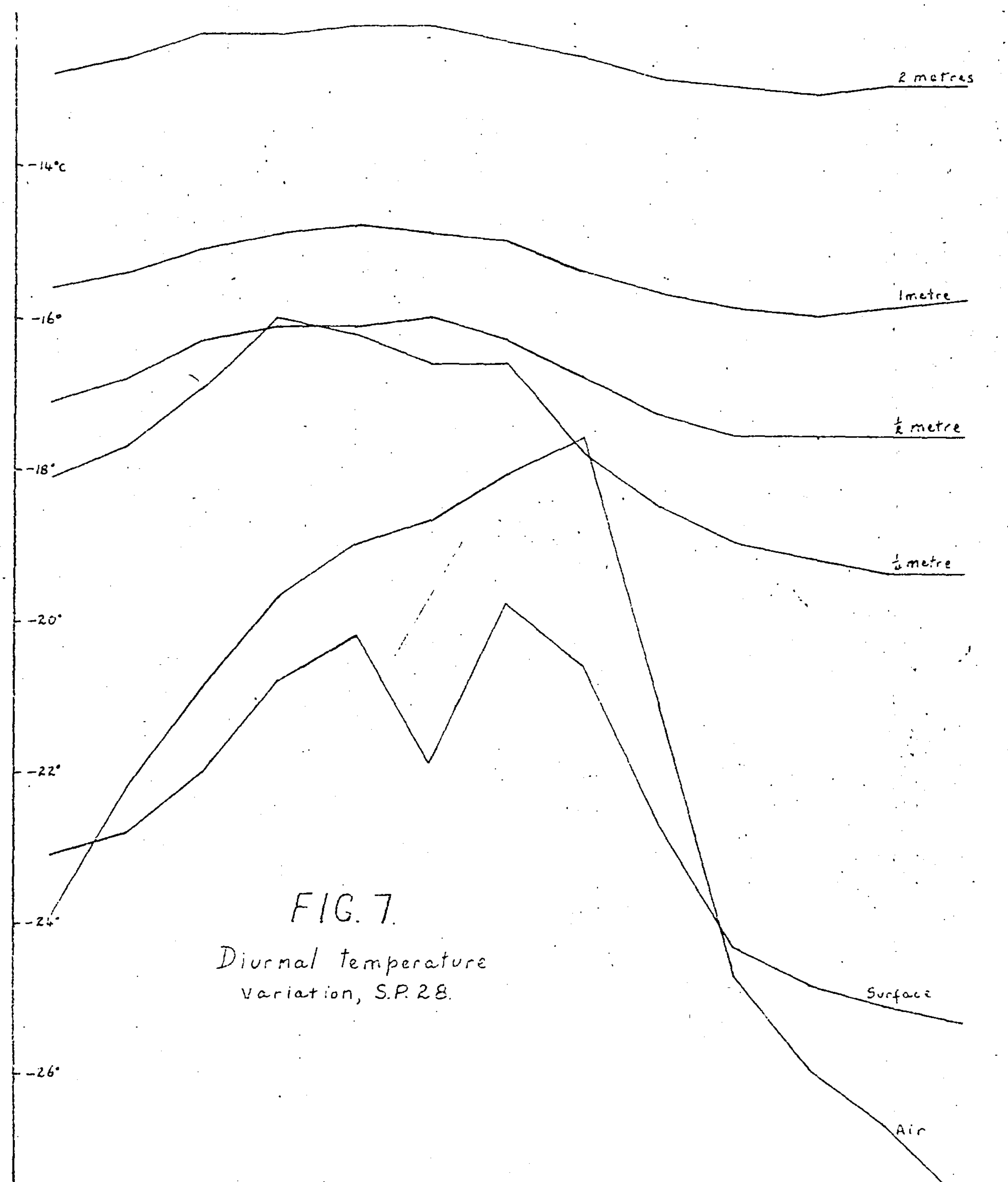


FIG. 7.
Diurnal temperature variation, S.P.28.

TABLE 12.

Diurnal temperature variation in ice, Shot Point 30 (19/4/58)
(^{o}C below $0^{o}C$)

Local time	Air	Surface	¼ metre	½ metre	1 metre	2 metres.
1200	[illegible]	[illegible]	18.9	18.5	17.5	14.6
1300	16.1	17.0	18.4	18.1	17.2	14.5
1400	16.1	16.9	17.7	17.5	17.0	14.4
1500	16.1	17.2	17.9	17.6	17.0	14.5
1600	16.7	[illegible]	17.7	17.6	16.9	14.5
1700	[illegible]	[illegible]	17.9	17.8	17.0	14.6
1800	16.9	17.8	[illegible]	18.1	17.3	14.6
1900	18.1	18.8	18.3	18.3	17.4	14.7
2000	18.6	19.7	18.5	18.4	17.5	14.7

Little data was obtained on the diurnal variation in neve. At S.P. 29, where the surface is neve with some layers of ice, the values in Table 13, shown in Fig.9 were obtained on a day overcast until 3 p.m. and then clear.

TABLE 13.

Diurnal temperature variation in snow, Shot Point 29 (15/4/58).
(^{o}C below $0^{o}C$)

Local time	Air	Surface	¼ metre	½ metre	1 metre	2 metres
0900	23.1	21.5	20.7	19.1	17.3	15.3
1000	24.2	22.4	20.7	19.1	17.4	15.3
1100	25.0	22.7	20.6	19.1	17.4	15.3
1200	23.9	21.2	20.4	19.1	17.4	15.3
1300	25.0	23.9	20.4	19.1	17.4	15.4
1400	21.4	22.1	20.2	19.1	17.4	15.4
1500	19.7	19.6	20.1	19.0	17.4	15.4
1600	19.4	-	20.1	19.0	17.4	15.4
1755	20.6	-	20.4	19.1	17.5	15.4
1900	18.9	23.1	20.6	19.2	17.6	15.4
2000	20.6	23.4	20.6	19.4	17.6	15.5

It can be seen that the variation below ½ metre is very slight. A profile of the temperatures measured at 8 p.m. is shown in Fig.6 for comparison with the profiles obtained in ice.

At Shot Point 27, temperatures were obtained in a pit in neve with ice layers and pellets, as follows:

Surface	-	11.9
1 foot (.3 metres)	-	14.0
2 feet (.6 ")	-	14.5
3 " (.9 ")	-	15.4
4 " (1.2 ")	-	15.3
5 " (1.5 ")	-	15.3
6 " (1.8 ")	-	14.9
Air temperature	-	8.3°C.

ICE MOVEMENT

During the autumn seismic and gravity traverse between Mt.Henderson and the Casey Range, movement of the glacial flow poles installed in 1958 was again measured, and, in addition the distances between the poles were chained along the original line. Remeasurement of these distances will show whether there is an important [illegible] component to the movement, and give a more accurate [illegible] of the flow distribution. The values of movement are shown in Table 14 and, together with the plateau surface and bedrock configuration in Fig.10. Ice thicknesses and relation of the bedrock surface to sea level ([illegible]esson 1959) are listed in Table 15.

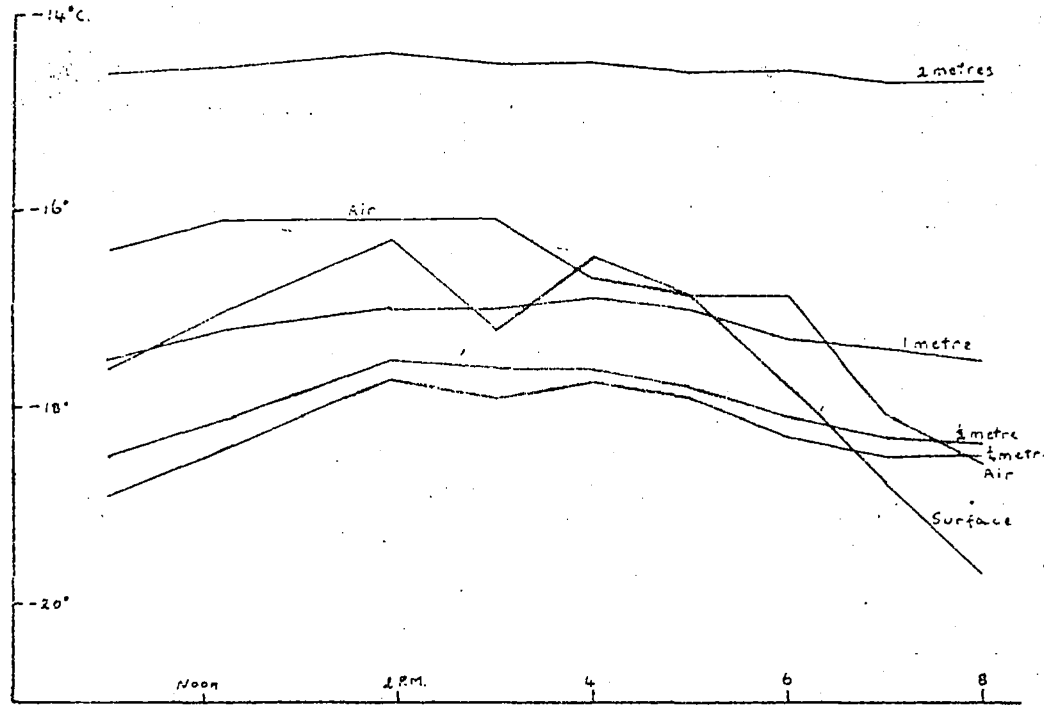


FIG. 8.

Diurnal Temperature Variation, S.P. 30.

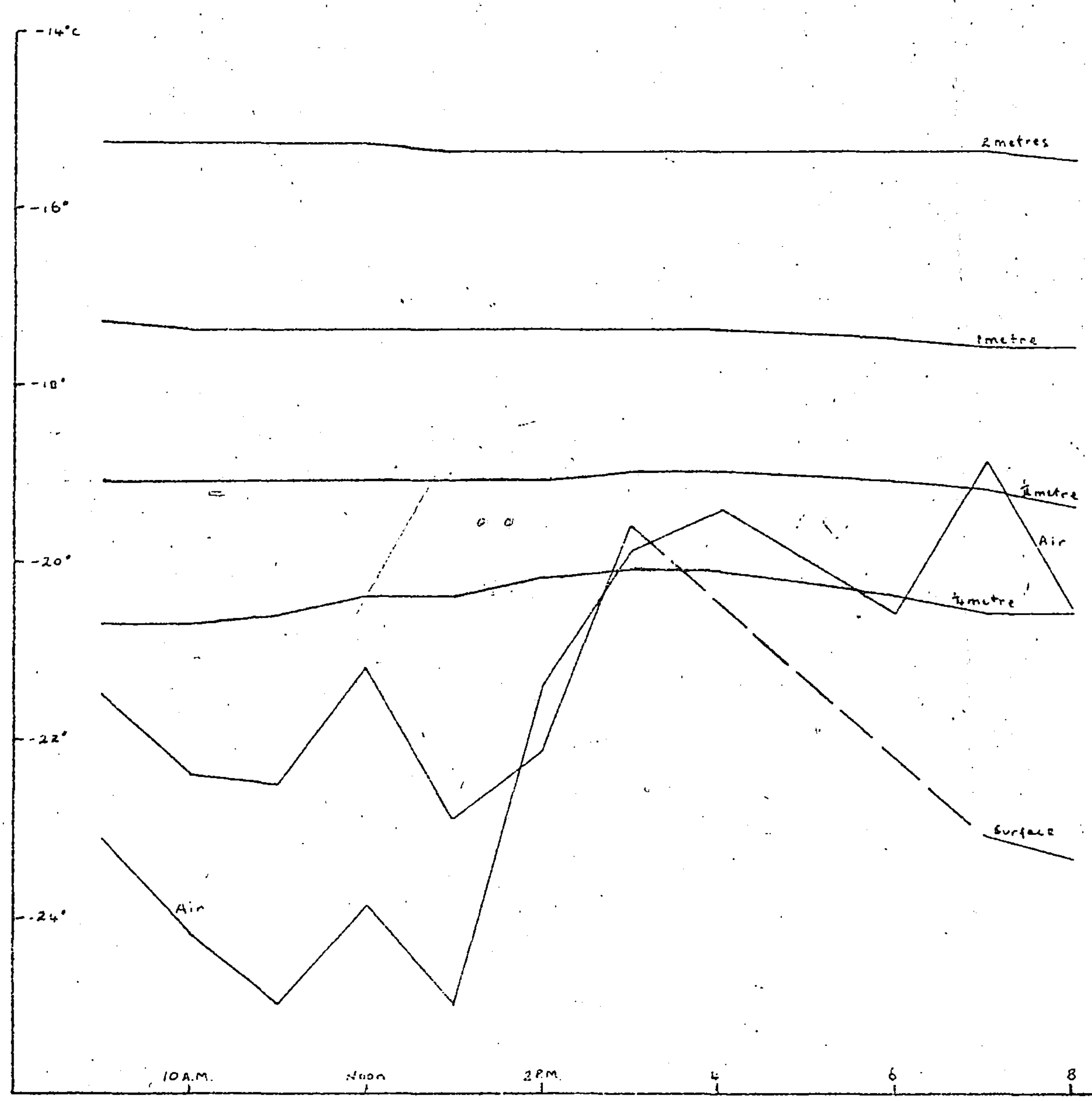


FIG. 9.

Diurnal Temperature Variation, S.P. 29.

The reference object referred to in Tables 14 and 15 is the highest point of the Fischer Nunatak; the distance was measured by triangulation from the plateau two and a half miles west of the point.

TABLE 14.

Ice Flow. Mt.Henderson - Casey Range.

Pole	Distance from reference object		Movement since May 1958.	Movement per day		Date measured.
						1959.
0		4177 ft.	28½ feet	0.09 feet	2.9 cm.	25th March.
1	1 mile	2777	40	0.12	3.7	15th April
2	1	5237	43½	0.13	4.1	"
3	2	5031	[illegible]	0.15	4.7	23rd April
4	3	3384	57½	0.17	5.3	"
5	3	4779	66½	0.20	6.1	"
6	5	1569	45½	0.14	4.2	"
7	5	4677	30	0.09	2.2	"
8	6	2843	34	0.10	3.1	"
9	7	1374	40½	0.12	3.8	"
10	7	4375	47	0.14	4.4	"
11	8	2878	45½	0.14	4.2	"
12	8	4869	49	0.14	4.2	9th May
13	9	3390	62	0.18	5.3	"
14	11	1879	67	0.19	5.8	"
15	12	3747	79	0.23	6.8	"
16	13	2580	81	0.23	7.0	"
17	14	1325	103	0.29	8.8	6th May
18	15	699	115½	0.33	9.9	9th May
19	15	4771	104½	0.30	9.0	6th May
20	16	2875	110	0.31	9.5	"
21	16	3885	121	0.35	10.4	"
22	16	4630	135	0.39	11.6	"

TABLE 15

Ice thickness and bedrock configuration, Mt.Henderson - Casey Range.

Point	Distance from reference object.		Bedrock Height above sea level.	Ice Thickness
S.P.27		4177 feet	348 feet	1386 feet
S.P.28	1 mile	4177	- 111	1805
S.P.29	2	4177	- 98	1742
S.P.30	3	3737	- 377	2045
G.7	4	1735	- 336	1927
G.6	4	4375	- 425	1956
G.5	5	1735	- 435	1932
G.4	5	4375	- 394	1866
G.3	6	1735	- 303	1789
G.2	6	4375	- 144	1622
G.1	7	1735	135	1367
S.P.31	7	4375	144	1324
G.8	8	1735	144	1280
G.9	8	4375	135	1319
G.10	9	1735	123	1320
G.11	9	4375	234	1262
G.12	10	1735	205	1269
G.13	10	4375	- 62	1503
G.14	11	1735	- 119	1623
S.P.32	11	4375	- 16	1506
G.15	12	1735	- 16	1429
G.16	12	4375	- 29	1436
G.17	13	1735	398	1166
G.18	13	4375	504	1094
G.19	14	1735	591	1041

(Table 15 Cont.)

Point	Distance from reference object		Bedrock height above sea level	Ice Thickness
G.20	14 mile	4375 feet	508	1090
G.21	15	1735	656	957
S.P.33	15	4375	751	879
G.22	16	1735	857	889

The rate of flow depends more on the position in relation to the nearby ranges, than on the bedrock topography. Well defined ice streams flow between Mt. Henderson and the Masson Range, and the David and Casey Ranges, the latter developing into the Forbes Glacier. Although there is quite a marked channel between Mt. Henderson and the Masson Range, the northward flow rate is not very great. The surface topography suggests that there is a barrier to the north of the flow-line here, and it is probable that the flow between pole 2 and near pole 6 has a considerable westward component.

When the daily flow rates are calculated for the two intervals between measurements of the flow in January and Autumn 1958, a considerable discrepancy between the two values for some points appears, and the differences are not systematic. This could be due to irregular movement of the ice, but only measurements over a number of years will show whether the rate of flow is constant or varies from time to time.

From Tables 14 and 15, the volume of ice moving across the flow line in a given time can be calculated. Nye (1951, p.652) has developed the expressions

$$u = \frac{\phi}{h} - \frac{V\pi}{2} + 2V\sqrt{1-\left(1-\frac{y}{h}\right)^2} \qquad (1)$$

where u = velocity down the slope (taken as normal to the flow line in this case).

ϕ = volume flowing in unit time across unit length of the flow line.

h = ice thickness.

and

$$V = -\left(\frac{\partial \phi}{\partial x} - \frac{\phi}{h}\frac{dh}{dx}\right) \qquad (2)$$

where $\frac{\partial \phi}{\partial x}$ is the ablation rate, and $\frac{dh}{dx}$ is the change in ice thickness along a line in the direction of flow.

At the surface $y = h$ and from (1),

$$u_h = \frac{\phi}{h} + 0.4292\,V \qquad (3)$$

Eliminating V between (2) and (3) and solving for ϕ

$$\phi = h u_h \frac{1 + 0.4292\,\frac{\partial\phi/\partial x}{u_h}}{1 + 0.4292\,\frac{dh}{dx}} \qquad (4)$$

From Shot Point 33, an ice thickness traverse was run normal to the flow line, so that here δx is known (using Jesson's preliminary figures). A mean value for ablation between the line and the coast can be found from Mellor's (1959) figures to be 45 cm. (= $17\frac{3}{4}$ inches) of ice. Equation (4) then becomes

$$\phi = 0.995 h u_h$$

i.e. $\phi = h u_h$ (nearly).

The volume of ice flowing across the line can thus be found by dividing the ice along the length of the line into a series of slabs, each corresponding in width to the distances between adjacent poles; the vertical cross-sectional area (parallel to the flow line) of these slabs can be found by interpolating ice thicknesses, and the volume flowing across the line by multiplying this area by the mean of the speeds at the appropriate poles.

A figure of 20.29 x 10^6 cubic feet per day is obtained for movement across a line 87000 feet long.

Assuming a specific gravity of 0.876 (the value used by Jesson when calculating the ice thickness) it can be calculated that the rate of ice flow across the measured line is equivalent to 2050 tons of water per foot per annum. This line is in the ablation zone and about eight miles from the coast. Using Crohn's figure for average annual ablation (12.4 inches per year, which is probably rather high), the annual loss from the surface of a strip eight miles long and one foot wide is found to be 1000 tons of water. Thus only 1000 tons of water in the form of ice reaches each foot of the coastline annually.

Calculations by Crohn** show that the annual accumulation between the Anare Nunataks and the coast exceeds the loss by ablation by about 7000 tons per foot of coastline. If the ice-cap is in equilibrium**, this amount will have to be removed by calving from the coastal ice cliffs.

The discrepancy between this figure of 7000 tons, derived from the accumulation - ablation measurements and the figure of 1000 tons calculated from the measurements of the ice thickness and flow rate, arises from the fact that ice streams are the most important factor in removing ice from the plateau. The rates of flow used in the calculations are characteristic of the "sheet" type of flow. The westernmost two poles measured are actually on the eastern margin of the Forbes Glacier, and show a rapid increase towards the west in the rate of flow. Because the surface is highly crevassed, the ice thickness here was not measured, and consequently these higher rates are not included in the calculations.

If the figure of 1000 tons of water per foot of coastline is taken as representative of the discharge by sheet flow, then the remaining 6000 tons per foot must be discharged by ice streams.

** In calculating the mass economy of the plateau, Crohn used 0.90 as the specific gravity of ice, rather than the 0.876 used by the present writer; this will be balanced by his use of 0.45 for the specific gravity of neve, whereas later work suggests that 0.40 is a more accurate value.

** Loewe (1956c) has suggested that the ice-cap as a whole may not be in equilibrium.

Zakiev and Bourlutchenko (1959) have calculated that along a 600 km. length of the Davis Sea coast, the proportions (by surface area) of ice, discharged by various means are:

Ice barrier	9.1%
Discharging	55. 9%
Shelf	35.%

The relative rates of discharge by ice barrier (i.e. sheet flow) and discharging (i.e. stream flow) are comparable to those deduced above for the Mawson area.

SEAICE.

Mawson:

A detailed log was kept of seaice conditions through the year. While the writer was away in the field, a very full account was kept by Flt.Lt.H.O. Wilson of the formation of the ice, and by Wilson and R.Arnell of part of the period of breakup.

By the end of February 1959, a considerable amount of spray ice had formed on the rocks around the harbour at Mawson, and pancake ice and sludge covered the surface of the sheltered inlet at the foot of Gauss Gully. Frazil ice was first seen on the harbour on the 2nd March, but was dissipated by wind within a few hours. This pattern of frazil formation and subsequent dispersion recurred almost every day in the succeeding three weeks, sludge forming on several occasions; pancake ice formed in the sheltered part of the harbour near the hangar on 18th March.

On the 21st March, frazil and sludge covered most of the harbour, and during the night of 22nd-23rd March ice formed to windward of the nearby islands; a strip of shore ice formed along the western side of the harbour; this was 30 to 45 yards wide along most of the length of West Arm, then narrowed to 1 to 5 yards, and extended in an arc from the tip of West Arm to the western end of Entrance Island. By evening, wind had broken up the strip between West Arm and Entrance Island. Most of the remaining ice in the harbour was broken up by wind and swell the next day, and on the 25th March, the final portion, which had attained a thickness of eight inches, was also blown out to sea. The ice between the islands east and north-east of the harbour continued to spread; on the 25th March, its thickness varied from three to eleven inches; by the 27th, the thickness had increased by an average of 3 inches. With the exception of the strip between Hump Island and East Arm, this ice was all blown out to sea by a blizzard on the 29th March.

Meanwhile, from the plateau near Mt.Henderson, it was observed on the 22nd March that seaward from Van Hulsen Island, a $\frac{7}{8}$ ice cover, with long north-south leads, extended to the horizon; on the 24th, this had decreased to a $\frac{5}{8}$th cover, and the shore lead had widened considerably, although the Flat Islands were all joined by ice but by the 25th, the ice had increased again to a $\frac{7}{8}$th cover.

On the afternoon of the 31st March, new ice reformed on the eastern side of West Arm, and by the 2nd April, had covered two-thirds of the harbour; four days later, the harbour was covered, with the exception of a small area near the hangar. The advancing front of this ice was an inch to an inch and a half thick; a distinct line remained on the surface where the advance stopped for some hours on the 3rd.

[illegible] day, the thickness was 6½ inches on one side of the [illegible], and 3½ inches on the other. The following day, the thickness at ten points in the harbour gave an average of 7½ inches with extreme values of 6 and 9 inches.

During the first two days of April, the ice advanced south-east from the Flat Islands to the northern tips of West Arm and Entrance Island. The freezeup was rather slower east of Mawson, but by the 4th April, ice cover was general, the only open water visible being a small coastal polynya along the west coast, two against the ice cliffs east of Mawson, and an area of water extending from south-west of Welch Island to the coast. At various times, other polynyas were formed by strong winds (including a large one north of the Flat Islands) but by the 10th April, as far as could be seen from the plateau behind Mawson, the ice cover was complete.

The last areas to freeze over were all areas where the wind was channelled down valleys in the plateau, and were, therefore, presumably prevented from freezing by the stronger winds coming from these valleys. H.O. Wilson has suggested the name "wind ponds" for these small polynyas.

Thereafter, the ice in the Mawson area continued to thicken to a maximum in mid October. Thicknesses were measured in the centre of the harbour, and at a point 200 yards west of the tip of West Arm (Table 16, Fig.11).

Initially the ice outside the harbour was the thicker; during winter, the thickness in the harbour increased more rapidly so that by Mid-August, it was the greater, and remained so until breakup. In the previous year Mellor found that the ice outside the harbour was the thinner by one or two inches throughout the year.

Check measurements were made at times at various points outside the harbour; with one or two exceptions, the thickness was always within ½ inch of that at the point 200 yards west of West Arm.

TABLE 16

Sea-ice Thickness, Mawson Area.

Date	Harbour	West of West Arm.	Date	Harbour	West of West Arm. Inches
April 7	9½ inches	–	August 6	48 inches	48¼
[illegible]	12½	–	13	50½	49½
13	14¾	–	20	51½	50½
15	16¼	–	29	54	52¾
17	17¾	–	Sept. 3	55	54
18	18¼	–	10	55¾	54
30	25½	27 inches	19	57½	56½
May 7	27½	29½	24	58½	57
14	29	30½	Oct. 1	60½	58
21	32¾	34	8	61	58½
28	34	–	15	62	59
June [illegible]	[illegible]	38½	22	61¾	59
[illegible]	[illegible]	40			
25	40	–			
July [illegible]	41	42¾			
[illegible]	41½	42½			
[illegible]	42¼	43¼			
23	43½	44½			
30	45½	46½			

In Fig.11 average temperatures at Mawson are also plotted. It will be seen that the rate of growth depends to some extent on the atmospheric temperatures. However, because the ice thickens mainly by accretion from below, temperature will have only a minor effect on the rate of increase, the dominant factor being seawater temperatures and currents.

During the year, ice thicknesses were also measured at the following places:

		inches.
30th May	Islands used as camp S.W. of Auster Rookery	31 "
3rd Aug.	1 mile N.N.E. of island called Mesteinen on Hansen charts	42½
3rd Aug.	1½miles south-east of same island	44½
3 rdAug.	1 mile east of Arrow Island	46
13th Sep.	Depot in Oygarden Group	59½
16th Oct.	Half way between West Arm and Flat Islands	54¼
16th Oct.	Half way between Flat Islands and Jocylyn Is.	55¼
22nd Nov.	North-east Amundsen Bay	56

For most of the winter, the ice was covered by snow, especially away from the coast, where sastrugi several feet high were commonly seen. Between Mawson and Taylor Glacier, much of the ice within half a mile or a mile of the coast was kept bare by wind turbulence near the plateau edge. Around Mawson part of this snow cover was permeated by seawater, so that patches of snow were, in effect, "welded" permanently to the seaice. Some of these patches (e.g. one in the harbour) were a couple of inches thick.

The first signs of deterioration of the ice appeared in September, when seaweed and dark rubbish on the ice began to melt in. About the same time, the lower part became rather porous, so that water quickly filled a hole drilled to within eighteen inches of the base of the ice.

By November, pieces of debris lay in water filled pot holes a couple of feet deep. Pools several inches deep formed even under patches of oil on the ice. The snow cover was stripped from the ice and the surface became dimpled by small pits which spread and deepened, so that in places it became cusped like the plateau. The ice was crazed by thin cracks; water welled up through the tide creeks around the edges in greater amounts, and did not refreeze; this was most marked in front of the hangar, and caused the termination of flying operations.

By the 12th December, the surface was covered by a white crystalline crust, and on the 27th December the ice took on a bluish-grey colour, giving the appearance of being completely waterlogged. On the 13th January, 1959, a pool formed in the south-east corner of the harbour, and although frazil and pancake ice formed on it at times, and its size varied, it remained open for some time.

The nett ice thickness decreased steadily, as shown below in Table 17 and Fig.11.

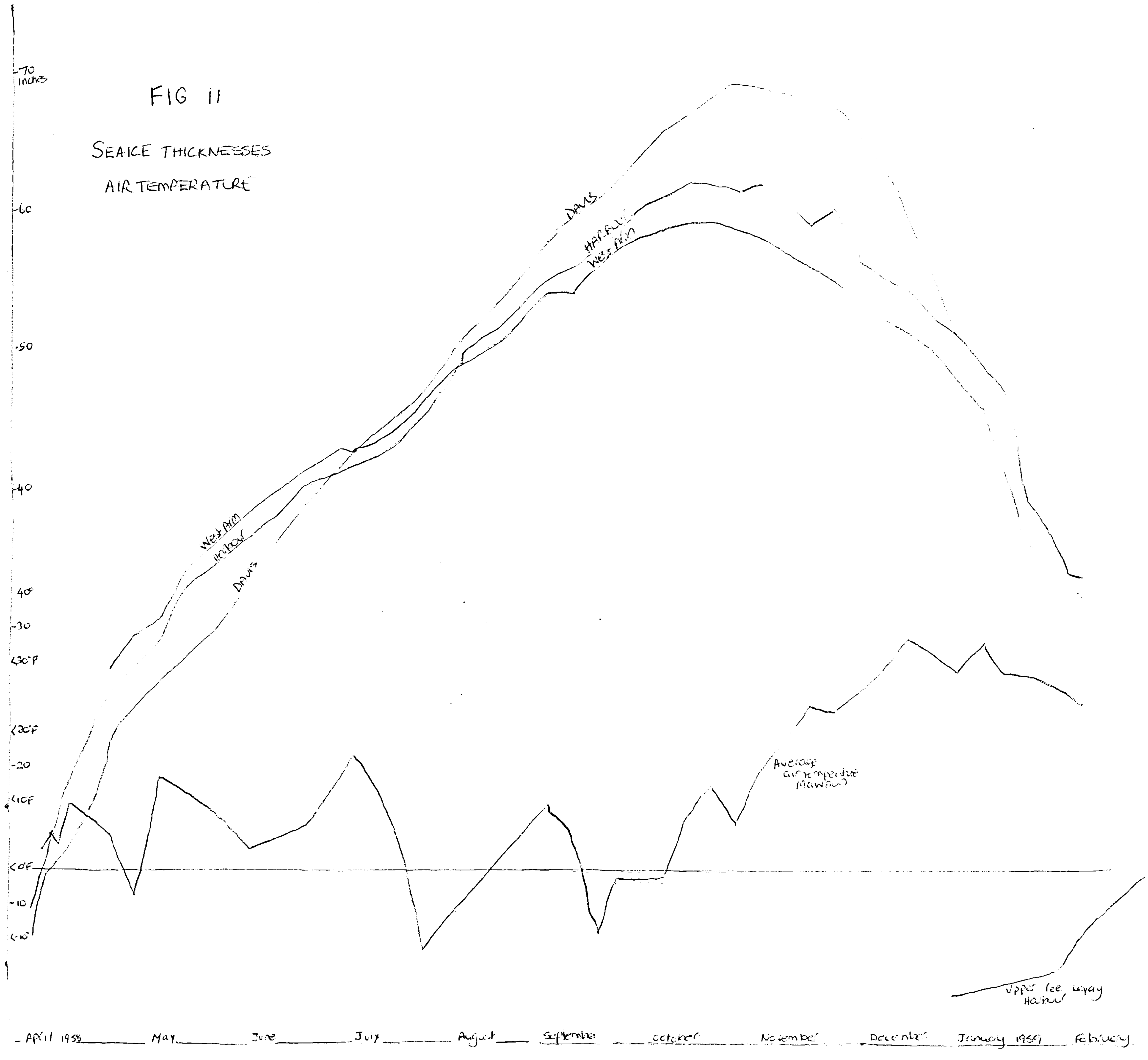


FIG 11
SEAICE THICKNESSES
AIR TEMPERATURE
70 inches
60
50
40
40°
30
<30°F
<20°F
20
<10°F
<0°F
10
<-10°
DAVIS
HARBOUR
West Arm
West Arm
Harbour
DAVIS
Average air temperature Mawson
Upper Ice Layer Harbour
April 1958
May
June
July
August
September
October
November
December
January 1959
February

TABLE 17

Seaice thickness, Mawson.

Date	Harbour	West of West Arm	Ablation	Thickness change by addition to base
Oct. 15	62 inches	59	1/2 (from Oct.8)	3/4
22	61 3/4	59	1/2 3/8	1/4 3/8
29	61 1/8	58 1/2	1/2	- 1/8
Nov. 5	61 3/4	57 5/8	3/4	0
12	60 1/8	56 3/4	1/4 1/8	- 7/8
19	58 3/4	55 3/4	Poles melted into ice	
26	60	54 3/4		
Dec. 3	56 1/4	53 1/2		
10	55	52		
17	54	51		
24	52 1/4	49 3/4		
31	51	47 3/4		
1959 Jan 8	48 1/2	45 1/2		
14	47	41 1/4		
21	39	36		
28	36 1/2	34 1/8		
Feb. 2	33 3/4	33 1/4		
6	33 1/4	32		

For a time, the decrease in thickness was due to ablation from the upper surface rather than rotting from below. From 22nd October to 12 November, the ablation loss was 1¾ inches and the nett decrease of thickness 2½ inches. The total ablation loss, measured 200 yards west of the tip of West Arm, was two inches between the 1st October, when the ice was stripped clear of snow, and the 12th November, when measurements became unreliable due to melting in of the poles.

In mid-November, the bottom two feet of the ice became soft and mushy, and shortly after, the ice divided into three layers; the top one was hard, the middle water or sludge, and the lower at first moderately hard, then later soft, porous, somewhat columnar ice. Large platy crystals projected down from the base of the top layer, or lay on the upper surface of the lowest layer. This partitioning was at first patchy and marked by a dark surface colour, so that it was possible for a ski-equipped Russian LI2 aircraft (similar to a D.C.3) to land north-west of the harbour as late as the 18th December. In a few places there was only a hard upper layer, an inch or two thick, with nothing but water beneath.

Thicknesses of these layers inside and outside the harbour are shown in Tables 18 and 19 respectively.

TABLE 18

Seaice layer thicknesses inside harbour, Mawson.

Date	Top	Middle	Bottom	Total.
Dec. 30th.	3 1/2	29	13 1/2	46
Jan. 28th 1959.	5	7–9	22 1/3–24 1/3	36 1/2
Feb. 2	6	5–8	22–24 1/2	33–[illegible]
6	7 3/4	5 1/4–6 1/4	21–23 1/2	[illegible]
11	8 1/2–9 1/2	3–4 1/2	17	29 1/2–30 1/2
24	11 3/4	?	?	?

TABLE 19.

Seaice layer thicknesses outside harbour. Mawson.

Date	Top	Middle	Bottom	Total
Nov. 19	24 (approx)	24 (approx)	12 (approx)	
Dec. 31	4	6	38	48
Jan. 17	3	10	27½	40½
20	5	3-10	16-23½	39-35
Feb. 2	6½	5-14½	16-23½	33½
6	7¼	5½-6½	18-19	32
11	9-10	4½-5	13½-14½	28½

In general, the hard crust was roughly uniform in thickness from place to place, while the middle and bottom layers showed considerable variation, especially in the early stages of the division.

Towards the end of January, there was a reversal in the general deterioration. On the 18th January, the frazil formed overnight on the pool below the camp did not dissipate, and thereafter, although the pool increased slightly in size, frazil covered at least part of the surface. Pancake ice formed on it on 27th January and during a blizzard from the 27th to the 29th January, the surface of this pool and the one below the hangar were completely covered by snow, under which ice formed; by the 6thFebruary, this ice was eight inches thick.

The "Thala Dan" broke into the harbour on the morning of the 4th February. New ice immediately began forming in the broken up area behind the ship. Forty-eight hours later, this varied from 2½ to 3¼ inches in thickness; on the 11th February, it was 4½ inches thick, and on the 24th, 10 inches.

The first signs of breakup of the seaice in the Mawson area were reported by the returning seismic party who, on the 15th January, 1959, saw two leads, running north-west and north-east from a point ten miles north of Mawson. By the 21st January, these had increased to a large Y shaped lead, one arm extending north-east for ten miles, the other broadening to the north-west horizon. By the 24th, the western arm had widened considerably, and was partly filled by pack, and the eastern arm also extended to the horizon; the southern end of the open water was near Gibney Island.

Three days later, after high winds, open water was eight miles north of Mawson, and extended from the north-west to the north-east horizon, with a polynya near Welch Island.

On the 1st February, after a blizzard, the ice edge ran from the coast west of Rookery Islands, thence six miles north of Mawson to beyond the Robinson Islands. On the 9th February, the seaward edge ran from Welch Island to the northern Flat Islands thence to Arrow Island and Rookery Islands; on the 11th, when the "Thala Den" sailed, the only ice remaining ran from the coast near the Canopus Islands thence along the seaward edges of this group, Welch Island, Jocylyn Islands, [illegible] Island, [illegible] Island and Nost Island to the coast. There were deep coastward embayments in the edge, where it was not protected by the islands.

B.H. Stinear reported that breakup of ice at the northern end of the harbour commenced on the 27th February, and final breakout took place rapidly on the 3rd March.

During 1958, breakouts were reported in the following areas:

13th April, west of Holme Bay. A shore lead, a couple of miles wide, extended along the part of the coast visible from north of the Masson Range, with several parallel leads to seaward. These were completely refrozen by 22nd April.

16th April, west of Welch Island; refrozen almost immediately.

10th May: Numerous leads and cracks among the icebergs near the Auster Rookery. All refrozen by 14th May, and no open water on the 29th May.

15th May: Open water reported around the Scullin Monolith. Open water occurred in this area every time it was seen through the year, the greatest extent being from near Stephens Island to east of Cape Darnley, on the 3rd August. When ice was seen in this vicinity, it always appeared thin, and was usually gone a few days later. The persistent open water, and the experiences of the party forced down near Mt.Rivett and of Dovers' party in 1954, show that this is an area of violent prevailing winds.

17th July: Open water extended to the horizon from north of Gibney Island tothe Stanton Group. Water sky had been seen to the N.N.W. of Mawson on the 17th May and was very strong after the 19th June. This area was completely refrozen on the 21st July.

25th September: Thirty miles north of the Stanton Group water with a thin ice cover extended thirty miles from east to west and fifteen from north to south. Open water was seen here on several later occasions, reaching to within thirty miles of Mawson. Water sky was seen from Mawson from the 23rd July on, in this direction.

9th November: An area of open water was seen in the south-east corner of William Scoresby Bay.

10th November: Complete breakout, with the edge about thirty miles offshore, from near Cape Boothby to north of Gibney Island, with a salient to within twenty miles of the coast, at the south-east corner.

9th December: From 10,000 feet above the Robinson Group, the eastern edge of the seaice was seen to run north from the coast at about 65½°E, curving around to the west about 67°S to meet the eastern edge of the breakout noted on the 10th November. Pack ice could be seen a few miles north of this fast ice.

<u>Davis</u>:

An account of seaice conditions and thickness was kept by P.B. Turner, who supplied the following information.

On the 9th March 1958, the bay in front of the camp was ice-free, but to the south, Heidemann Bay was completely iced in, and ice was forming to the north of the camp. By the 12th, ice extended to the horizon, with the exception of a few isolated areas, and by the 17th, the ice cover was complete, and the ice 4 inches thick.

Two days later, a number of breaks appeared, and the next day, open water was visible a mile from the station. On the 25th March, there was open sea a mile and a half from the station; the remaining ice was seven inches thick. On the 29th the ice was breaking up rapidly in blizzard conditions, and the following day, open water extended from the shore in front of the station to the south-west horizon.

Ice was reforming by the 3rd April, and by the 7th, the cover was again complete; the new ice was seven to eight inches thick, and remnants of the old ice, twelve inches. Thereafter, the ice near the station thickened steadily to a maximum in late October (Table 20, Fig. 11).

TABLE 20

Seaice thickness, Davis.

Date		Thickness
April	7.	7-8 inches
	11	12
	18	14½
	22	16
	25	17½
	29	21
May	2	23
	16	26½
	30	30
June	13	35
	27	39½
July	11	43
	26	46
Aug.	8	50½
	22	54
Sept.	5	58½
	20	61
Oct.	7	65⅓
	27	69
Nov.	15	68
	28	67
Dec.	13	61½
	31	51

In the period from the 11th April to the 15th November, the nett surface loss by ablation was ¾ inch.

Although the ice remained fast near the station, open water could be seen outside the nearby islands after blizzards.

From the air, a lead several miles wide could usually be seen running about four miles offshore of Davis, past the Rauer Group, to near the Svenner Group. The ice cover in Prydz and MacKenzie Bays was generally thin, and great expanses of open water were seen from the air on several occasions; in MacKenzie Bay, a strip of fast ice many miles wide remained along the western edge, from near Cape Darnley to the junction of the Amery Ice Shelf with the plateau.

On the 20th January, 1959, the edge of the fast ice lay along the seaward edge of the islands west of the station, and ran north-east from Magnetic Island. The ice towards the shore was very rotten. The average thickness broken by the "Thala Dan" increased from 33 inches near Turner Island to 45 inches near Bluff Island. In places, it was 60 inches thick. The outer part of this ice was quite hard; as the coast was approached the ice became more rotten. On the 17th January, after high winds on the previous two days, ice remained only between the coast and Trigwell, Flutter and Lake Islands.

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The work embodied in this report was made possible only by the team-work of all members of the 1958 expedition. The writer would, however, like to specifically acknowledge the help of: The surveyor, Mr. G.A. Knuckey, who made the surveys associated with the glaciological work, supplied much basic data, and assisted in many other ways; Messrs D.A. Brown and E. Burnett, for their geological observations in the Framnes Mountains; the pilots of the R.A.A.F. Antarctic Flight, Sqd.Leader I. Grove and Flt. Lt. H.O.Wilson, for observations related to various aspects of the work; and the men at Davis, Messrs M.J. Flutter, P.B. Turner, E.A. Trigwell, L. Gardner and F. Elliott, who collected water samples and made glaciological observations. While the writer was absent in the field during part of the periods of seaice formation and deterioration, a very full account of seaice conditions was kept by Flt.Lt. Wilson, and Messrs R.A. Borland and R.Arnel continued routine glaciological observations.

The Officer-in-Charge, Mr.I.L. Adams, at all times took an interest in the work, and to his encouragement and co-operation was due, in no small measure, the success of the year's operations.

During the preparation of the report, the writer was assisted by discussions with colleagues of the Bureau of Mineral Resources, especially P.W. Crohn, who read the manuscript, and with Dr. Uwe Radok, of the Meteorology Department, University of Melbourne, who gave helpful advice on glaciological matters. Messrs K. Bell and T.Trevallyn of the Division of National Mapping, gave assistance in connection with maps and aerial photographs.

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APPENDIX I.

Listed below are the co-ordinates (to the nearest minute) of features the positions of which were determined by astrofix or by triangulation from an astrofix. The magnetic declination where it was measured, is also given.

Feature	Position		Declination
Wilson Bluff	74°17'S	66°56'E	
Jennings Promontory	70°10'S	73°21'E	
Nunatak S. of Clemence Massif	72°18'S	68°30'E	
Grove Nunataks	72°53'S	74°53'E	
Amphitheatre Lake	68°06'S	48°45'E	52°W
Perov Nunataks	67°34'S	51°05'E	53½°W
Pythagorous Peak	66°59'S	51°20'E	
Mt. Rüser Larsen	66°47'S	50°40'E	
Mt. King	67°02'S	52°48'E	53½°W
McLeod Nunataks	67°29'S	52°42'E	55½°W
Knuckey Peaks	67°54'S	53°32'E	49°W (Anom
Mt. Channon	67°59'S	55°05'E	57½°W.
Leckie Range	67°56'S	56°29'E	59½°W
Fram Peak	68°03'S	58°28'E	60°W
Mill Peak	67°58'S	61°10'E	
Astrofix A58/15	66°57'S	51°31'E	54½°W

APPENDIX II.

Notes on Specimens from the Wilson Hills, Oates Land.

In February 1959 a party made a landing at Magga Peak, in the Wilson Hills area of Oates Land, and a number of specimens were collected by Mr.J. Hollin. He described the general features of the area as follows:

"This area is composed of metamorphic rocks, lineated* locally in a generally NNW-SSE direction (true) and similar in general appearance to those found at Wilkes Station, 1500 miles to the west".

"Drift: A thin cover, but reaches the highest summit, which has erratics. No special search was made, but no sedimentary rocks were noticed.

Glacial History: From the above, we may infer that at some time the local ice sheet was at least 500 feet thicker than it is today - probably more than 1000 feet. The highest raised beach was difficult to define here, because wasting on the steep slopes had blurred the usually sharp boundary between till covered areas above and wave cleaned areas below. The land has risen post-glacially somewhere between 72 and 96 feet above the current high water mark. The absence of transgressive till on the raised beaches immediately below the western corrie glacier suggests that this glacier has not, in post glacial times been much larger than it is now. The presence of lichens close to the glacier's snout suggests that it is not currently retreating. The glacier has probably been separated from the main ice sheet which delivered the erratics to the ridge behind it for a very long time. The area is well weathered, and blocks now emerging from the basal shears of this corrie glacier seem fresh and local."

Mr.Hollin's notes on the occurrence of the specimens, and the specimens themselves, make it clear that the rocks of the area are migmatitic in origin.

The host rocks appear to be fine grained feldspar-biotite schist (81)**; parts are coarser grained and banded (83), with thin feldspathic and quartzo-feldspathic veins, some of them ptygmatic, and pink garnets; "epidote(?) also noticed". A further stage in the development of the migmatites is a medium grained biotite-rich granite gneiss (84), which grades through granite with only moderate biotite but with ophitic hornblendes several inches in extent (85) to a massive (in the hand specimen, at least) pink, medium grained granite with little biotite, containing small irregular masses of magnetite (86). A white, similar looking granite (but with the magnetite occurring as small specks) "interfingers the neighbouring gneiss (interfingering generally parallel with gneissic lineation), but the contact is sharp and without local metamorphism".

Other specimens include a light grey medium grained, moderately banded biotite gneiss (96) with sphene and zircon(?), and a rather altered fine grained porphyritic

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* This probably refers to foliation; there is no sign of lineation in any of the specimens.

** Numbers are Mr.Hollin's field numbers.

pyritic dolerite (80), "probably from a dyke bearing 060° magnetic" (i.e. about NNW).

Moraine includes a fine grained gneissic biotite granite with small inclusions of amphibolite with some epidote (87), "not actually in situ but certainly local", a fine-grained feldspar-amphibole-biotite rock with phenocrysts (or porphyroblasts) of amphibole (99), and a pink aplite (97), "abundant in the drift and almost certainly in situ".

APPENDIX III

REPORT ON BRINE AND OTHER SAMPLES FROM ANTARCTICA

by A.D. Haldane

The following samples collected in Antarctica were submitted for analysis:

Lake Dingle, Vestfold Hills - 5 samples of brine collected over the period 19/4/57 to 23/12/58.

Lake Stinear, Vestfold Hills - 5 samples of brine collected over the period 14/3/57 to 23/12/58.

Club Lake, Vestfold Hills - 2 samples of brine collected over the period 28/9/57 to 2/1/58.

Deep Lake, Vestfold Hills - 5 samples of brine collected over the period 19/4/57 to 30/1/59.

Davis Station Anchorage - seawater sample, 17/2/59.

Beaver Lake, Prince Charles Mountains - 2 samples of water welling up through rafted zone and 2 samples of ice (as water) collected on 24/10/58 and 2/11/58.

Deep Lake, Vestfold Hills - soil sample taken 20 ft. above the lake level.

Analyses for the major constituents were made by S. Baker, W.J. Thomas and A. McClure. The results obtained are shown in Table 1. The difference resulting from the ionic balance of anions and cations has been attributed entirely to errors in the determination of sodium and is shown in Table 1 as "Na correction". The values for the concentrations of the various ions are those actually determined. The "Na correction" is given to avoid residuals in calculations based on the original data and with the exception of one sample from Lake Dingle is less than 1% of the total. That is, the sum of the analytical errors of all determinations is less than 1% of the sum of the ions determined. The average composition of seawater as given by Dittmar is included for comparison.

Table 2 shows the composition of the samples calculated as a percentage of the total dissolved solids and gives a direct comparison of all samples independent of the concentration. In these and all other calculations the corrected value for sodium is used.

Considering the brine samples from L. Dingle, L. Stinear, Club L. and Deep L. it will be seen that although there is some variation in the concentration of the brines from a given lake, the composition is remarkably constant. Further L. Dingle and L. Stinear show a marked similarity in composition as do Club L. and Deep L. However, the two groups are quite distinct in respect to both concentration and composition. This grouping is further demonstrated by the bromide concentration and Cl/Br ratios shown in Table 3.

It is possible that there is some seasonal variation in concentration of the brines. However, the data available are insufficient to clearly establish any such trends.

The seawater sample from Davis shows close agreement with Dittmar's average composition of seawater. The slightly higher percentage of sulphate and correspondingly lower chloride is in accord with the view that seawater in the arctic zones is enriched in sulphate.

From the data in Tables 2 & 3 for the two samples from Beaver L. it is obvious that both these are diluted seawater. The dilution ratios are 31.1 for the sample collected on 24/10/58 and 22.7 for that of 2/11/58 assuming pure water as diluent. The analyses of the water obtained from the ice samples taken at Deep L. show an extremely low salt content, because of this no significance can be attached to the results for the individual ions.

Analysis of the water soluble salts obtained from the soil sample taken above Deep L. shows a composition closely approximating that of the Deep L. brine, while the high total soluble salt content of 12.2% indicates saturation of the soils with brine at some time. It is also evident that no leaching has taken place subsequent to exposure of the brine saturated soil. Water percolating through a soil such as this would rapidly become saturated with sodium chloride, the major component of the soluble salts, while remaining unsaturated with respect to the more readily soluble magnesium salts. This would lead to differential solution of the components giving a product depleted in magnesium. At the same time the relatively insoluble calcium sulphate would remain as a residue so that the soluble salts would become enriched in calcium. The observed results do not support this.

It is impossible for the present soluble salt content to be the result of the accumulation of salts from the evaporation of sea spray as these would then have the same percentage composition as sea water. Further, leaching of a saline deposit formed in this way would give a residue containing sodium chloride with a high proportion of calcium sulphate and practically no magnesium. This is not in accord with the analytical results.

In order to compare the composition of the brines with that of seawater the individual results for each source have been averaged and are shown in Table 4.

In the concentration of sea water by evaporation bromide does not appear in the salts separating out before the final stages of the evaporation. In brine samples it is possible to assume that there has been no loss of the bromide ion. Potassium behaves similarly but may appear as complex salts in the solid phase before the final stages of concentration depending largely on the temperature of evaporation.

Assuming then that there is no loss of bromide ion it is possible to calculate the factor by which sea water has been concentrated to produce the present brines and at the same time determine the nature of the salts which have been deposited in the process. This has been done in Table 4. The concentrations of the ions are given in milli-equivalents/litre so that combination of anions and cations can be made directly.

The main feature of Table 4 relating to concentration and salt deposition are as follows:

	Concentration Ratio	Deposited	Amount g/litre of brine
Lake Dingle	6.8	Na_2SO_4	44
Lake Stinear	7.8	Na_2SO_4	53
Club Lake	11.0	Na_2SO_4	67
		NaCl	74
Deep Lake	11.0	Na_2SO_4	70
		NaCl	73

The amount above is the quantity deposited when a volume of sea water equal to the concentration ratio in litres is reduced to 1 litre.

In addition to the salts shown above small amounts of calcium carbonate and sulphate have been deposited. The approximate values are calcium carbonate 0.8 to 1.5 g/litre and calcium sulphate (as gypsum) 2-8 g/litre of brine.

The agreement between the determined concentration of potassium in the brine and the expected value calculated from seawater is good, giving further support to the calculation of the concentration ratios as reasonably accurate estimates.

The determined values for magnesium in the brines are consistently higher than the calculated values suggesting that the calculated concentration ratios are too low. However magnesium is one of the less satisfactory determinations in the presence of a large excess of sodium and an error of 6% in the determination of magnesium would fully account for the differences. In view of this and that the calculations are not claimed to have a high order of accuracy but are average values, the concentration ratios based on bromine are retained. Equating the magnesium values would increase the concentration ratios by only 6%, if the possibility of systematic analytical errors is ignored.

It is concluded that the present brines have arisen by the evaporation of water from seawater with sodium sulphate alone or with sodium chloride being deposited in the process.

TABLE. 1

Analysis of Water Samples and Brine - Concentrations of Ions in g/litre

Sample	Date	Ca, Sr	Mg	Na	K	HCO_3	SO_4	Cl, Br	Na Corr.	Total	T.S.S. 120°C.	T.S.S. 180°C.
	19/4/57	2.1	10.0	68.8	2.2	0.3	.9	138.0	-0.3	224.0	-	-
..ne,	27/6/57	2.1	9.9	70.8	2.2	0.3	.8	138.0	-2.3	223.8	-	-
.. Lake Dingle,	28/9/57	1.9	8.9	55.1	1.9	0.3	.5	109.8	-2.8	177.6	-	-
..stfold Hills	4/1/58	2.4	9.7	62.9	2.2	0.4	.9	140.1	+7.1	227.7	-	-
	23/12/58	2.0	8.7	62.1	2.0	0.2	.9	124.2	Nil	202.1	217.1	202.6
	14/3/57	2.1	10.5	74.8	2.3	0.3	.8	152.2	+1.7	246.7	-	-
..ne,	26/6/57	2.0	9.8	74.8	2.4	0.4	.6	150.0	+1.8	243.8	-	-
Lake Stincar,	28/9/57	2.0	10.6	72.8	1.9	0.4	.7	149.3	+2.0	241.7	-	-
..stfold Hills	2.1.58	2.1	10.8	68.9	2.4	0.4	.8	142.1	+0.6	230.1	-	-
	23/12/58	2.2	10.1	72.6	2.4	0.3	.9	146.5	+0.7	237.7	255.9	239.3
..ne,	28/9/57	2.0	14.6	74.8	3.7	0.4	.7	163.5	+0.6	262.2	-	-
.. Club Lake,	2.1.58	1.9	14.9	78.7	3.8	0.3	.9	167.0	-1.4	268.1	-	-
..stfold Hills												
	19/4/57	2.1	15.4	76.9	3.9	0.3	.7	170.0	+0.9	272.2	-	-
..ne,	28/9/57	2.2	15.3	72.8	3.8	0.4	2.9	164.0	+1.5	262.9		
.. Deep Lake,	2/1/58	3.0	14.8	74.7	3.7	0.4	2.8	162.0	-1.7	259.7		
..stfold Hills	23/12/58	2.3	14.0	74.5	3.8	0.3	3.2	161.6	+0.5	260.2	283.6	262.1
	30/1/59	2.2	14.8	76.4	3.9	0.3	3.1	167.0	+0.7	268.4	291.3	269.9
..awater, Davis	17/2/59	0.40	1.28	10.67	0.34	0.19	2.73	19.08	+0.02	34.71	36.75	35.13
..awater average	Dittmar	0.41	1.30	10.81	0.39	0.14	2.71	19.47	Nil	35.23	-	35.31
..ter ex Beaver L.	24/10/58	0.012	0.032	0.343	0.010	0.006	0.086	0.626	-	1.115	-	-
..ince Charles Mt.	2/11/58	0.016	0.044	0.470	0.010	0.008	0.130	0.850	-	1.528	-	-
..e ex	Normal	0.1 ppm.		0.003	0.002	Nil	0.004	0.004	-	-	-	-
Beaver Lake	"Blue"	0.1 ppm.		0.002	0.001	Nil	0.004	0.002	-	-	-	-

T.S.S. 120°C, T.S.S. 180°C - Total soluble salts dried at 120°C and 180°C

Na Correction - Difference of Σanions and Σcations.

Analysis of Water Soluble Salts in Soil from Deep Lake Vestfold Hills

	%(air dry)
Ca, Sr	0.12
Mg	0.83
Na	3.29
K	0.12
HCO_3	0.17
SO_4	0.19
Cl, Br	7.47
Total	12.19

TABLE 2

PERCENTAGE COMPOSITION OF SOLUBLE SALTS AS % OF THE SUM OF THE IONS

Sample	Date	Ca,Sr	Mg	Na	K	HCO_3	SO_4	Cl,Br	Ions g/litre	S.G. $^{20}/_{20}$	Sp. Cond.
	19/4/57	0.9	4.5	30.6	1.0	0.1	1.3	61.6	224.0		
Brine,	27/6/57	0.9	4.4	30.6	1.0	0.1	1.3	61.7	223.8		
ex Lake Dingle	28/9/57	1.1	5.0	29.4	1.1	0.2	1.4	61.8	177.6		
Vestfolds Hills	4/1/58	1.0	4.3	30.7	1.0	0.2	1.3	61.5	227.7		
	23/12/58	1.0	4.3	30.7	1.0	0.1	1.4	61.5	[illegible]	1.136	1.60×10^5
	14/3/57	0.9	4.3	31.0	0.9	0.1	1.1	61.7	246.7		
Brine,	26/6/57	0.8	4.0	31.4	1.0	0.2	1.1	61.5	243.8		
ex Lake Stinear	28/9/57	0.8	4.4	30.9	0.8	0.2	1.1	61.8	241.7		
Vestfold Hills	2/1/58	0.9	4.7	30.2	1.0	0.2	1.2	61.8	230.1		
	23/12/58	0.9	4.3	30.9	1.0	0.1	1.2	61.6	237.7	1.167	1.75×10^5
Brine,	28/9/57	0.8	5.6	28.7	1.4	0.2	1.0	62.3	262.2		
ex Club L.	2/1/58	0.7	5.6	28.8	1.4	0.1	1.1	62.3	268.1		
Vestfold Hills											
	19/4/57	0.8	5.7	28.6	1.4	0.1	1.0	62.4	272.2		
Brine,	28/9/57	0.8	5.8	28.3	1.4	0.1	1.1	62.4	262.9		
ex Deep Lake	2/1/58	1.2	5.7	28.1	1.4	0.1	1.1	62.4	259.7		
Vestfold Hills	23/12/58	0.9	5.4	28.8	1.5	0.1	1.2	62.1	260.2	1.171	1.72×10^5
	30/1/59	0.8	5.5	28.8	1.4	0.1	1.2	62.2	268.4	1.174	1.72×10^5
Seawater Davis	17/2/59	1.1	3.7	30.7	1.0	0.5	7.9	55.0	34.71	1.021	4.25×10^4
Seawater average	Dittmar	1.1	3.7	30.7	1.1	0.4	7.7	55.3	35.23	1.024	
Water ex Beaver L.	24/10/58	1.1	2.9	30.7	0.9	0.6	7.7	56.1	1.115		1.83×10^3
Prince Charles Mt.	2/11/58	1.0	2.9	30.8	0.7	0.5	8.5	55.6	1.528		2.45×10^3
Ice	Normal	Calculation of % composition not warranted									31
ex Beaver Lake	"Blue"										26
Soil, Deep Lake	-	1.0	5.8	27.0	1.0	1.4	1.6	61.2	12.2%		

Sp. Cond. - Specific conductivity in micro-mho at 20°C.

TABLE 3

[illegible] CONTENT AND Cl/Br RATIO [illegible]

Sample	Date	Br g/l	Cl/Br g/l
L. Dingle	23/12/58	0.44	283
L. Stinear	23/12/58	0.52	284
Deep Lake	23/12/58	0.72	223
	30/1/59	0.80	219
Seawater	17/2/59	0.67	282

TABLE [illegible]

AVERAGE COMPOSITION OF BRINES AND CONCENTRATION RATIO

Sample		Ca,Sr	Mg	Na	K	HCO_3	SO_4	Cl,Br	Total	Br Corr[d.]	Conc[n] ratio
	g/litre	2.10	9.44	64.28	2.10	0.30	2.80	130.03	211.05	0.46	
Lake Dingle	m.e./litre	105	776	2795	54	5	58	3675		5.75	
Vestfold Hills	Seawater x 6.81	135	717	3160	59	21	388	3664		5.75	6.81
	Excess m.e./litre	35	-ve	365	5	16	330	11		Nil	
	g/litre	2.08	10.36	74.14	2.28	0.36	2.76	148.02	240.00	0.53	
Lake Stinear	m.e./litre	104	853	3224	58	6	57	4163		6.59	
Vestfold Hills	Seawater x 7.80	154	821	3620	68	24	444	4197		6.59	7.80
	Excess m.e./litre	50	-ve	40[illegible]	10	18	387	34		Nil	
	g/litre	1.95	14.75	76.25	3.75	0.35	2.80	165.25	265.10	n.d.	
Club Lake	m.e./litre	98	1213	3316	96	6	58	4661			
Vestfold Hills	Seawater x 11.0	218	1159	5106	96	34	623	5919			11.0
	Excess m.e./litre	210	-ve	1790	Nil	28	565	1258			
	g/litre	2.36	14.86	75.44	3.80	0.34	2.94	164.92	264.66	0.74	
Deep Lake	m.e./litre	118	1222	3280	97	6	61	4652		9.27	
Vestfold Hills	Seawater x 10.97	217	1156	5090	95	34	624	5903		9.27	10.97
	Excess m.e./litre	99	-ve	1810		28	563	1251		Nil	
Seawater ex	g/litre	0.40	1.28	10.69	0.34	0.19	2.73	19.08	34.71	0.067	-
Davis	m.e./litre	19.8	105.2	464.4	8.7	3.1	56.9	538.1		0.845	

n.d. Not determined

-ve Negative

Br corr[d.] Br by analysis corrected to mean total of the ions

m.e./litre Milli-equivalents per litre.

PLATE I

Fig. 1. Mt. Riiser-Larsen (2865 feet), Amundsen Bay, from the south-west. Rocks, mainly quartz-feldspar gneisses, dipping to the right, and forming quasi-dip slopes. The notches on the skyline ridge on the right of the photograph mark shear zones. The camp is on an isthmus of shingle and boulders of a raised beach, rising 25 feet above the seaice in the foreground.

Fig. 2. Part of the Scott Mountains, Enderby Land, showing the approximate concordance of summit heights.

Fig. 3. A cirque, over 2,000 feet deep, on the northern side of Mt. Riiser Larsen. The pinnacles and stacks are typical of glacial sculpturing.

PLATE 2

Fig. 1. A terrace on the eastern side of Clemence Massif, Prince Charles Mountains. The steep slope is probably a fault scarp.

Fig. 2. A cirque cutting into an old erosion surface, east side of Patrick Point, Prince Charles mountains. The rocks are probably granite gneiss with bands rich in femic minerals. Lambert Glacier in foreground.

Fig. 3. Old erosion surface about 700 feet above sea level, Jennings Promontory, on the eastern side of the Amery Ice Shelf.

PLATE 3

Fig. 1. Moraine terraces, north-west Nye Mountains, Enderby Land. Amphitheatre Lake in right foreground. At the foot of the cirque, young moraine overlies older high level deposits.

Fig. 2. Moraine burying an old landscape, Prince Charles Mountains. The top of the line of bluffs represents an old erosion surface, uplifted by the Amery Fault; the fault scarp was notched by erosion, and the erosion surface subsequently buried under a thick deposit of moraine. Radok Lake in foreground.

Fig. 3. A terrace of moraine on the northern side of the Leckie Range, Kemp Land, with low level moraine along the foot of the range.

PLATE 4

Fig. 1. Honeycomb weathering of quartz-feldspar gneiss, south-west corner of Adams Fiord, Enderby Land.

Fig. 2. An erratic block of quartz-feldspar-garnet gneiss, about 1,000 feet above the present ice level, Leckie Range. The man on the left gives the scale. A flatly dipping fault filled with pegmatite can be seen in the hill to the right of the block.

Fig. 3. Trail of medial moraine running from the north-eastern tip of Wilson Bluff, southern Prince Charles Mountains.

PLATE 5

Fig. 1. Part of the Hansen Mountains, Kemp Land looking south. These are typical of the smaller isolated rock exposures of the interior of Enderby and Kemp Lands.

Fig. 2. One of the main peaks of the Grove Nunataks, looking east. The rocks are mainly gneissic granites, with migmatites on the right; to the left of the massif, a steep scarp in the ice, is due to damming by the mountains. An extensive moraine deposit occurs along the front of the mountain.

Fig. 3. Looking west up the deep water-cut gully between Radok Lake (in middle distance) and Beaver Lake. The rocks are sediments of the Amery Formation, which adjoin metamorphics (top right) along the Amery Fault on the far side of Radok Lake.

PLATE 6

Fig. 1. Almost horizontal current bedded sandstones of the Amery Formation, southern Beaver Lake; there is a mudstone band at the top of the scree on the right of the photo. The rafted ice along the foot of the cliff is due to tidal movement of the ice of the lake surface.

Fig. 2. "Sandstone dykes" in a gully in sandstone of the Amery Formation on the southern side of Beaver Lake.

Fig. 3. Slumping in normally current bedded sandstone of the Amery Formation, southern side of Beaver Lake.