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THE GEOLOGY OF THE SOUTH ORKNEY ISLANDS

I. SIGNY ISLAND

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ABSTRACT

SIGNY ISLAND has been mapped on a scale of 1:12,500. The island is composed of schists of almandine grade, representing regionally metamorphosed sediments now largely quartz-mica-schists with subordinate amphibolites and marbles. A three-fold succession has been established through about 2,500 ft. of strata. There is no evidence of igneous activity before or after metamorphism.

The foliation and schistosity generally follow the bedding. A study of the macro-fabric indicates that the rocks are homo-axially folded with an almost north–south trend. Overfolds with a similar trend are visible on scales ranging from that of a hand specimen to that of a cliff face, but major fold nappes are not believed to be present. The fold direction is perpendicular to the trend of the Scotia Ridge and faults strike both north–south and east–west.

The rocks of Signy Island are similar to those of nearby Coronation Island, and Elephant and Clarence Islands (South Shetland Islands).

CONTENTS

I. INTRODUCTION

A. SOUTH ORKNEY ISLANDS

THE South Orkney Islands are a group of ice-covered islands situated in the South Atlantic Ocean in lat. 60° 30′ S., long. 45° 30′ W. They lie on the southern limb of the Scotia Ridge about 750 miles south-east of Cape Horn and 350 miles east-north-east of the tip of the Antarctic Peninsula. The nearest land is Clarence Island, the easternmost member of the South Shetland Islands, 220 miles to the west.

The group consists of four major islands and a number of smaller islets, of which the most distant are the Inaccessible Islands lying 20 miles west of Coronation Island. The group is elongated in an east–west direction and the two largest islands, Coronation and Laurie, have their largest dimensions, 30 and 15 miles respectively, in this direction.

The South Orkney Islands lie on the Scotia Ridge which trends 280° to 100° true in this vicinity (Herdman, 1948, p. 75–76; pl. XXIII). In discussing the results of soundings taken by R.R.S. *Discovery II*, Herdman indicated the existence of two parallel submarine ridges west of the South Orkney Islands. Elephant, Clarence and the other South Shetland Islands lie on the northern ridge, while Trinity Peninsula (Graham Land) and the South Orkney Islands lie upon the southern ridge. These two ridges are separated at their western end by the deep water of Bransfield Strait. This "deep", which can be traced to the south of Clarence Island, is correlated by Herdman with the "deep" situated about 30 miles north of the South Orkney Islands, where soundings of over 5,000 m. have been recorded. South of this deep, near Coronation Island, the ocean floor rises steeply with an average slope of 20° to the shallow water surrounding the islands. The shallow shelf extends south of the group for almost 100 miles before depths greater than 500 m. are recorded at the beginning of a southward slope into the Weddell Sea. A tabulated statement of the geology of the three limbs of the Scotia Ridge has been given by Joyce (1951, p. 85, 87–88) in the course of a theoretical discussion, but in the light of recent work there are clearly many factual errors.

The stratigraphy of the South Orkney Islands is summarized in Table I and the general geology is shown in Fig. 1.

TABLE I

STRATIGRAPHICAL SUCCESSION IN THE SOUTH ORKNEY ISLANDS

Age	*Group*	*Generalized Trend of Folds*	*Outcrop Areas*
? Cretaceous	Spence Harbour Conglomerate	E–W (insignificant)	East end of Coronation Island
	Powell Island Conglomerate	E–W	Powell Island
	Laurie Island Conglomerate	*Not known*	Laurie Island (?)
? Jurassic	Derived Series	*Not known*	Known only as boulders in conglomerate
? Carboniferous	Greywacke-Shale Series	NNW–SSE	Powell and Laurie Islands
? Precambrian	Basement Complex (metasediments)	N–S	Coronation and Signy Islands
Post-Basement Complex	Dolerites (not metamorphosed)	Dykes trend WNW–ESE	Intrude Basement Complex

The greater part of the South Orkney Islands is heavily glacierized. The only ice-free areas comprise the steep buttresses of the mountains, which are periodically swept free from rime and snow by avalanches, and a few lowland areas which nearly all occur on the smaller islands. Since the firn line may occur about 100 ft. above sea-level in some seasons, the snow cover on these lower islands may be substantially reduced by late summer. Ahlmann's (1948, p. 59–63) term, *transection glaciers*, might be applied but, in fact, the glaciers of the South Orkney Islands do not fit conveniently into any simple morphological classification.

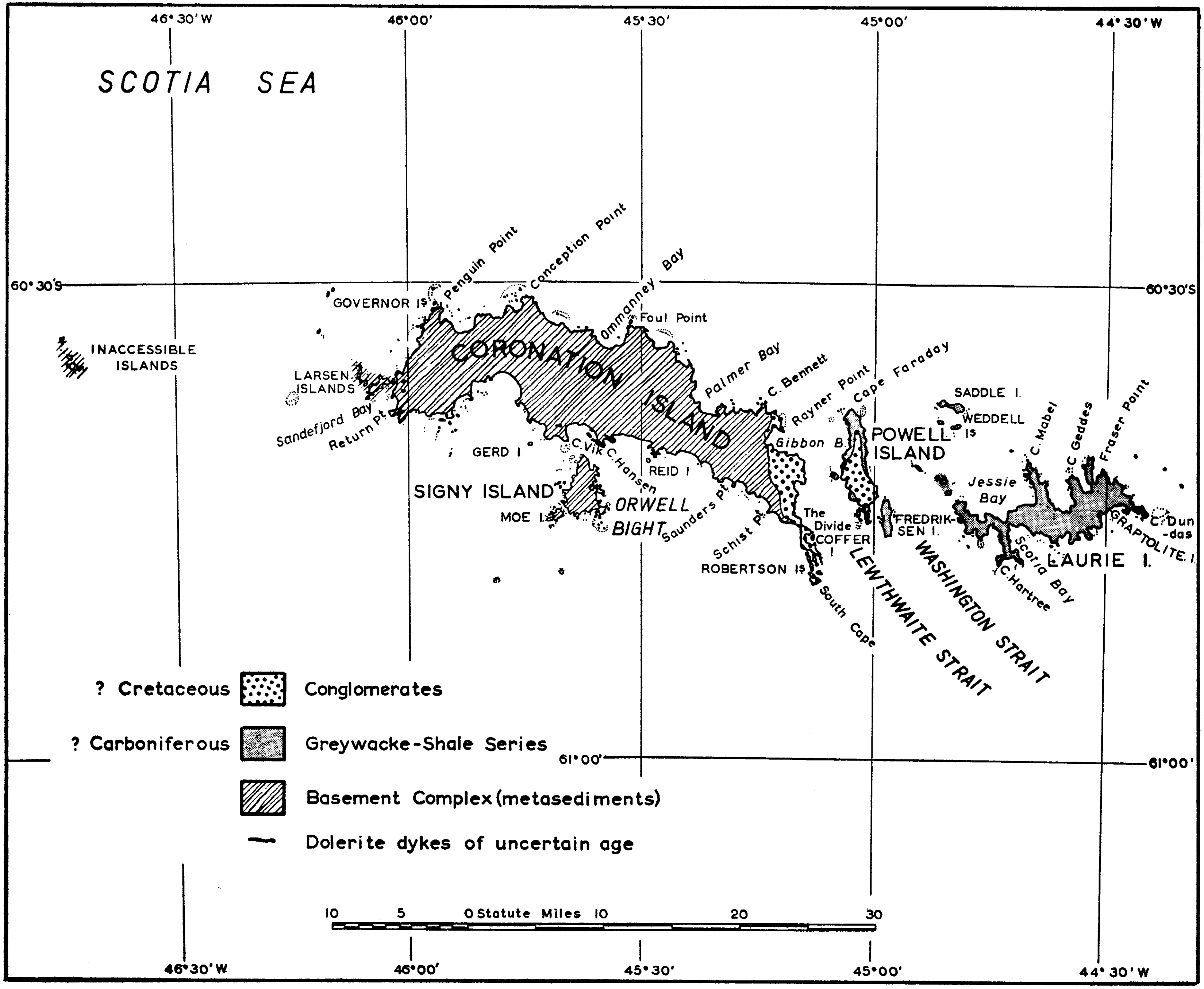

FIGURE 1

Geological sketch map of the South Orkney Islands.

Many examples of ice features are represented, ranging from the *glacier cap* of western Coronation Island to the many *cirque glaciers* of the mountainous parts of the islands. On all the larger islands the permanent ice reaches sea-level in many localities so that there are few continuous coastal sections of rock exposed.

It is perhaps relevant to mention that the weather normally encountered in the South Orkney Islands is a handicap to survey work. The average cloud base is at about 900 ft., so that when working in the mountainous interior of the islands three and a half days out of every five are spent in dense mist (*Annual Meteorological Tables for 1956*, p. 65).

Geological collections* from the South Orkney Islands are known to have been made by six parties. In 1838 Grange, who accompanied d'Urville (1842, p. 70, 316–17), collected some rocks from the Weddell Islands. The Scottish National Antarctic Expedition wintered on Laurie Island during 1903–04 and the results of their geological work were described by Pirie (1905, 1913). Fossils found in the Greywacke-Shale Series were referred to an Ordovician age but their identification and age has recently been queried (Adie, 1957*b*, p. 22). Metamorphic rocks collected from Signy Island in 1928 have been described by Holtedahl (1929, p. 99) and Barth and Holmsen (1939, p. 59). In January 1933 scientists from R.R.S. *Discovery II* collected specimens from the four principal islands of the group and from the Inaccessible Islands, and these have been described by Tilley (1935). Further geological collections were made during the fourth commission of R.R.S. *Discovery II* in 1937. Parties from the Falkland Islands Dependencies Survey have lived on the South Orkney Islands continuously since January 1946 when a station was established at Cape Geddes on Laurie Island. This station, which was transferred to Borge Bay on Signy Island in March 1947, has been occupied since that time.

B. Signy Island

1. *Physiography and glaciation*

Signy Island is a small island, the northernmost extremity of which, North Point, is situated rather more than 1 mile south of Coronation Island and midway along its southern coast. The island is roughly triangular in outline. Its dimensions are approximately 4 miles north to south and 3 miles along the southern coast. The area of the island is 7.7 sq. miles. At Tioga Hill (Plate IId), near the centre of the island, the land rises to 907 ft. above sea-level but elsewhere the separate summits seldom rise to more than 800 ft. The tops of the hills are generally flat or gently convex and, near the centre of the island, are connected by shallow cols which are only about 100 ft. lower than the individual summits. Consequently the main upland part forms a plateau which is more or less completely covered with a veneer of permanent ice.

The edges of the plateau are sharply defined and steep slopes, formed by cirque development, surround the high ground on nearly every side. The principal topographical features of both east and west coasts of Signy Island are small cirques separated by rugged frost-shattered spurs. Some of these, such as the amphitheatre east of Cummings Cove, still contain a lobe of permanent ice which shows signs of movement; other cirques, such as the one east of Port Jebsen, are virtually snow-free in summer. The majority of them have floors at 100 to 200 ft. above sea-level. Paal Harbour, on the east coast of Signy Island, is a fine example of a deeper cirque which is drowned to a depth of at least 60 ft.

The eastern edges of the main upland parts of Signy Island lie along a gently curving arc from Stygian Cove to Garnet Hill. In the extreme north this edge is defined by the sheer east face of Robin Peak, whose individual buttresses show evidence of glacial smoothing for only about 100 ft. above sea-level. Southwards, this edge is preserved in the broken cliffs north-east of Jane Peak, the eastern buttresses of Snow Hill and the cliffs overlooking the western side of Orwell Glacier and the western slopes of Moraine Valley. These features have been interpreted as an eroded fault scarp (p. 22).

Around the coasts of Signy Island there is a well-defined lowland, which is most extensively developed on the east coast from Stygian Cove southwards to Factory Cove, and in the extreme south-east of the island between Rusty Bluff and the Oliphant Islands (Plate Ib). The lowland is, for the most part, covered with glacial drift or frost-shattered debris. It is generally lower than 100 ft. in altitude with a few mamillations rising to 130–150 ft. On the west and south-west coasts this belt is narrow, discontinuous and often absent. In the north-western part of the island featureless drift-covered slopes form most of the terrain

* The history of geological investigations in the South Orkney Islands has been summarized by Adie (1957*a*, p. 509–10; 1958, p. 13–14).

below 300 ft. Along the west coast, however, there are many offshore rocks and small islets which rise to no more than 50–70 ft. above sea-level. The conspicuous bench on the north coast of Moe Island (Plate IId) is matched on Signy Island by the flat-topped peninsula of Porteous Point, which also occurs at 130–150 ft. (Plate IIa). None of the coastal lowland features on Signy Island can be described with certainty as raised beaches.

Little more than one-third of the island is covered by a permanent ice cap, although many large isolated snow drifts may persist for several years. The permanent ice is comparatively thin and in many places on the plateau the rock floor protrudes, so that every hilltop on the island is composed of solid rock. Consequently the ice cap is subdivided into a series of drainage basins which are so small that there is relatively little movement of the ice except in the two main glaciers. The greatest surface movement observed at the stakes on Orwell Glacier was 25 ft. during the period May 1949 to February 1950. The maximum movement recorded for the same time at a stake on McLeod Glacier was 30 ft. The latter glacier drains southwards from the central plateau and forms an almost continuous ice cliff nearly a mile long in Clowes Bay. Most of the other ice tongues which drain the central plateau appear to be practically stagnant, although there are a few small crevasses and some surface morainic material. During late summer (January to March) much of the winter snowfall melts from the lowland. The boundaries of the permanent ice, depicted on the geological map (in end pocket), are those observed during the three summers 1947 to 1950, with certain revisions in the south-west part of the island for 1955–56.

In the lowlands there are a few small streams which, despite the severity of the climate, may flow for a few weeks during the summer. The principal streams, which are shown on the map, are characteristically developed along the margins of the permanent ice, as in Moraine Valley. In several places there are small ponds, some of which are little more than melt-water accumulations in the lowest parts of snow-filled depressions, but these are ephemeral features which are not present every year. There are, however, a few larger ponds which fill depressions resembling kettle-holes in the glacial drift. The majority of these occur in the lowland areas of Three Lakes Valley, Moraine Valley and the amphitheatre east of Cummings Cove. In the last-named locality (Plate Ve) the highest pond has developed behind a former terminal moraine in advance of the present glacier which descends south-westwards from Tioga Hill. In Three Lakes Valley the ponds occupy featureless drift-filled depressions. These ponds support a dense population of fresh-water invertebrates, which suggests that they may have been permanent features for a long time.

All the glacial erratics found on Signy Island are locally derived schists, and conspicuous perched blocks of schist have been observed in the amphitheatre east of Cummings Cove and in Three Lakes Valley (Plate IIc). Large erratic blocks of coarse pink and grey granite occur on the beach near Berntsen Point, in shallow water in Cummings Cove and amongst debris of the former terminal moraine of Orwell Glacier near the mouth of Elephant Flats. These granitic erratics are clearly too large to be attributed to ballast dumped when Signy Island was frequented by whaling vessels, but it is possible that they could have been transported to their present positions by floating ice at a time when sea-level was somewhat higher than at present.

Apart from the drift deposits and erosional features which are characteristic of the ice-free lowlands, there are a number of features which indicate comparatively recent glacial retreat after the deglaciation of most of the present ice-free areas. Former terminal moraines, situated some yards in front of active moraines, occur in the amphitheatres east of Cummings Cove and north-east of Port Jebsen. The most convincing display of retreat phenomena occurs around the tidal pool known as Elephant Flats on the east coast of the island. The present frontal ice cliffs of Orwell Glacier (Plate IId), which are aground, are situated close under the eastern buttresses of Snow Hill and part of its moraine occupies the floor of Moraine Valley. Near the glacier front the moraine is composed of two zones, the higher and inner one (the present moraine) comprising raw glacial detritus. The outer zone, about 20 ft. lower in altitude at the crest, has been richly colonized by mosses and lichens. Elephant Flats is almost entirely enclosed by the drift-covered lowlands which are characteristic of this part of the island. The entrance to Elephant Flats is practically dry at low tide, when only about half the bay contains water (Plate Va). Since this bay is almost land-locked, marine erosion is negligible and the ice cliffs of Orwell Glacier show little sign of active undercutting by wave action. Soundings made in Elephant Flats at low-water spring tides gave a maximum depth of 12 ft. with a bottom of soft mud. The area which dries at low tide is studded with large glacial erratics whose disposition leaves little doubt that they represent a former terminal moraine of Orwell Glacier. The deeper part of Elephant Flats lies near the centre of the permanent water. Towards the ice cliffs of Orwell Glacier it is nowhere more than 3–5 ft. deep at low water. The top of another terminal moraine, lying about 100 ft. offshore from the present ice cliffs, is exposed at all stages of the tide and it has been partly colonized by mosses and lichens.

All these features may be related to different stages in the retreat of Orwell Glacier. After the retreat of ice from the lowland areas of the island, this glacier occupied the depression of Elephant Flats, and the rock-studded shallows around the edges of this bay represent the earliest terminal moraine which can be definitely attributed to any existing glacier on the island. The absence of other morainic ridges in Elephant Flats suggests that the retreat was rapid until the ice front lay only about 100 ft. in advance of the existing cliffs. At this stage the second recognizable moraine in the bay was deposited. The presence of two distinct zones of moraine along the present edge of the glacier suggests that the ice edge has not retreated significantly in recent years. No absolute chronology can be given to date this sequence of retreat stages but knowledge of the rate of colonization by mosses and lichens in this climate might be of value in suggesting a minimum age for the outer part of the present moraine. In this connection it should be noted that, where small nunataks pierce the present ice cap, the rock platforms or frost-shattered debris are richly colonized with *Usnea melanoxantha* and other lichens right to the edge of the permanent ice. Schytt (1953), who has observed similar lichen colonization on the nunataks of Dronning Maud Land, has concluded from this evidence that there is at present no measurable amount of ice retreat. Studies of the accumulation, ablation and glacier movement made at Signy Island during the period 1949–50 also tend to support this conclusion.

2. *General geology*

All the rocks exposed on Signy Island belong to the Basement Complex. In order of decreasing abundance they are garnetiferous quartz-mica-schists, foliated* amphibolites and marbles. The distribution of rock types is shown on the geological map (in end pocket) and the salient features are:

i. The presence of important outcrops of marble on the low ground forming the west and east sides of the island and on higher ground in the north.

ii. The presence of flat-lying amphibolites in the ice-free part of the central plateau of the island.

iii. The presence of extensive areas of quartz-mica-schists in the south-west and south-east.

With the exception of those occurring on Gourlay Peninsula, the marbles are always associated with amphibolites, and at many of the contacts between these two rock types a zone of exceedingly coarse hornblende-garnet rock and *hornblendegarbenschiefer* is developed. Garnet-hornblende-schists of this type (from the northern slopes of Snow Hill) have been described by Tilley (1935, p. 388).

3. *Geological work and reliability*

The present report is based on the work done from the Falkland Islands Dependencies Survey station. Rock collections were made by G. de Q. Robin in 1947 and A. G. Tritton in 1953. Reconnaissance mapping of the whole island was carried out on a scale of 1:12,500 by D. H. Maling between February 1948 and February 1950, and again independently by D. H. Matthews between December 1955 and March 1957. More detailed mapping was done by Maling in the area round Borge Bay and by Matthews in the south-west part of the island. The geological map shows the characteristics of the majority of the outcrops on the island but outside the limits of the areas mapped in detail few of the localities have been visited more than once by either individual, so that many possibilities of correlation remain unexplored. Fig. 2 indicates the relative reliability of the mapping.

Certain offshore rocks and islets have not yet been visited by a geologist, notably Mariholm south of Moe Island and the Flensing Islands off the north-west coast of Signy Island. Many other localities, such as Jebsen Rocks and the Oliphant Islands, have only been visited in winter when the snow accumulation prevented detailed mapping.

Because the structure of the Signy Island fold belt is so complicated and there are relatively few reliable mapping horizons, it is impossible at present to give a complete series of scale sections across the island showing the structure.

This report is intended to outline the salient points of the present geological knowledge of the island. Much detailed information which cannot at present be woven into a structural synthesis has had to be

* The nature of the foliation in the Basement Complex is discussed in Appendix A.

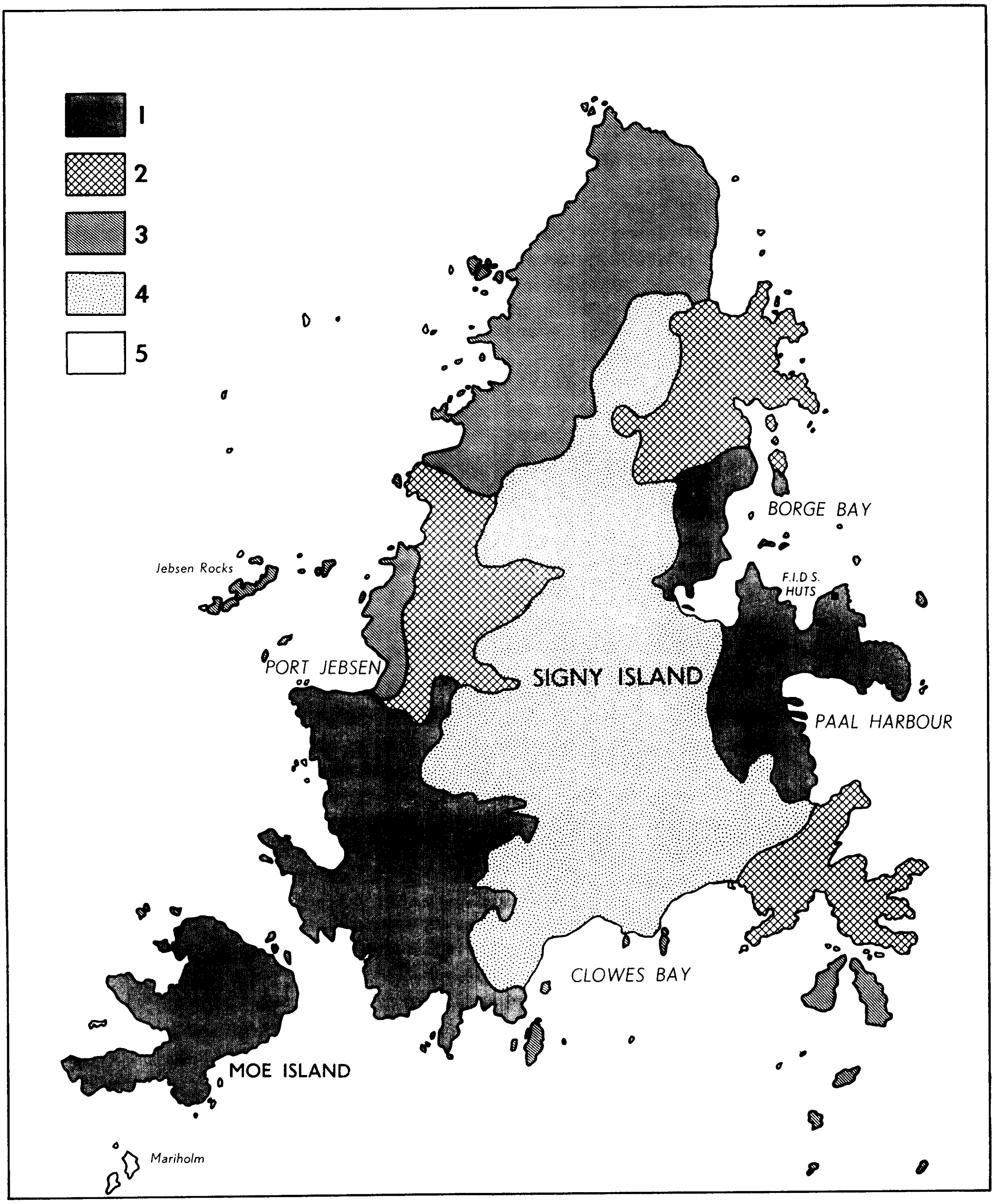

FIGURE 2

Sketch map of Signy Island indicating the reliability of geological mapping.

1. Areas mapped in detail.
2. Reconnaissance mapping with good agreement between Maling and Matthews.
3. Reconnaissance mapping with less satisfactory agreement.
4. Permanent ice.
5. Areas not visited by a geologist.

omitted. Further detailed mapping, coupled with petrofabric studies, would probably yield results of value to a study of the structural petrology.

II. STRATIGRAPHY

FROM detailed mapping in the south-western part of the island, it has been possible to construct 15 stratigraphical sections for different localities. Table II, which is based on these, shows the succession suggested for the area south and west of the ice cap as far north as Foca Point.

TABLE II

SUCCESSION FOR THE SOUTH-WEST PART OF SIGNY ISLAND

Series	Rocks	Thickness
Moe Island Series (> 1,000 ft.)	Quartz-mica-schists	
Amphibolite Series (440 ft.)	Calc-amphibolite	70 ft.
	Quartz-mica-schist	70 ft.
	Hornblende-schist	20 ft.
	Garnet-quartz-mica-schist	40 ft.
	Hornblende-epidote group (With three prominent quartzites 85 ft. apart symmetrically spaced about the centre)	230 ft.

Marble Series (upper part)

Confusion Point, north Gneiss Hills east face, and south Gneiss Hills south-east face	*North Gneiss Hills west face*		*Thulla Point to the mountain east of Jane Peak*	
			? fault	
Quartz-mica-schist with interbedded thin hornblende-schists, especially near top and bottom	Quartz-mica-schist	70 ft.	Quartz-mica-schist	20 ft.
	Quartzite	2 ft.	Quartzite	5 ft.
	Quartz-mica-schist	10 ft.	Amphibolite	10 ft.
	Marble	6 ft.	Marble (variable thickness)	~20 ft.
	Thin marbles and coarse hornblende rocks	50 ft.	Hornblende-schist	25 ft.
	Hornblende-epidote rocks	150 ft.	Chlorite-garnet-quartz-mica-schist	20 ft.
	Thin amphibolites and marbles in quartz-mica-schist	30 ft.	Quartz-mica-schist	70 ft.

Series	Rocks
Marble Series (lower part)	Includes several beds of marble whose thickness varies between 1 and 20 ft. in different localities. Succession not worked out.

A. MARBLE SERIES

The little-known strata beneath the Amphibolite Series are grouped together as the Marble Series. Provided that there is no inversion of the beds, the exposures on the flanks of Gneiss Hills belong to the upper part of this succession, whereas the rocks exposed in the knolls north of Port Jebsen belong to the lower part.

The succession in the upper part of the Marble Series* for three different localities is given in Table II. As yet no satisfactory succession has been established for the complicated exposures of the lower part of the Marble Series seen in the two large overfolds in the amphitheatre east of Cummings Cove and in the knolls north of Port Jebsen (Plate IIb).

Determination of the relationship between the Marble Series of the Cummings Cove–Port Jebsen area and the marbles and amphibolites exposed elsewhere must necessarily await solution of the structural problems. In the meantime, it seems reasonable to regard the marbles of the northern part of the island and those of the Three Lakes Valley–Snow Hill area as representatives of the Marble Series elevated by the

* On the geological map the Moe Island Series and the Amphibolite Series are clearly distinguished from the other quartz-mica-schists and amphibolites. The rocks of the Marble Series are not distinguished in this way but are shown with the colours for undifferentiated rocks (see Fig. 15).

southward plunge of the folds and by the east–west faults. No stratigraphical succession is yet available for the North Point rocks but their possible correlation with the Marble Series is mentioned on p. 23 in connection with Fig. 14a. The key to the relation between the two sides of the island is probably to be found in the little-known cliffs between North Point and Stygian Cove. The important marble outlier on the small island north of Confusion Point has been visited only by Tritton, but it can probably be correlated with the marbles in the amphitheatre east of Cummings Cove. Similarly, the thin marbles and amphibolites below Garnet Hill could possibly be correlated with the marbles exposed in the cliffs forming the north face of Snow Hill.

The conspicuous thick marbles are unsatisfactory as mapping horizons, because they thicken only in the noses of the recumbent folds and are either thin or absent on the limbs.

B. Amphibolite Series

Although they are highly folded, the calc-amphibolites at the top of the Amphibolite Series can be traced as an interrupted south-westerly dipping sheet over much of the south-west part of the island. These rocks are thinly bedded and varied. Muscovite-rich *hornblendegarbenschiefer*, garnetiferous amphibolites, thin beds of micaceous quartzite and lenticles of calcite are present but the dominant type is a green schist composed largely of felted needles of hornblende. The calc-amphibolite group is the most satisfactory mapping horizon found on the island. The hornblende-epidote rocks at the base of the Amphibolite Series are a second recognizable group characterized by the abundance of epidote, which not only occurs in almost monomineralic lenses and veins but is also widely disseminated throughout the rocks, giving them a distinctive yellow colour on weathering.

The thickness and succession between these two marker horizons in the Amphibolite Series is reasonably constant but below the hornblende-epidote rocks the measured successions in the upper part of the Marble Series do not agree with one another. There are three possible reasons for this discrepancy: on the east face of the northern Gneiss Hills the observed succession might be an inverted repetition of the overlying sequence on the lower limb of a large recumbent fold, or the succession might be displaced by many undetected low-angle faults parallel to the thrust planes near Confusion Point (Fig. 13), but it seems most likely that either an unconformity or a folded pre-metamorphic thrust plane separates the Amphibolite Series from the Marble Series.

C. Moe Island Series

With the exception of a thin amphibolite bed at the very base of the sequence, the rocks of the Moe Island Series on Moe Island are all quartz-mica-schists. Occasional biotite- and quartz-rich beds are the only variants in the sequence. The succession is well exposed and it is unlikely that marbles or amphibolites are present. Similar rocks, which crop out on Signy Island east of Moe Island, are also referred to the Moe Island Series. They cap the ridges of Jebsen Point and Pandemonium Point where they overlie the calc-amphibolites at the top of the Amphibolite Series. The flat-lying quartz-mica-schists of Tioga Hill are also referred to the Moe Island Series, because they overlie the calc-amphibolites on the spur north-west of Tioga Hill. A marble horizon which is not associated with amphibolites occurs in the schists on the east shore of Fyr Channel. These beds are believed to be at the base of the Moe Island Series.

D. Discussion

In mapping the east part of Signy Island a bed of micaceous quartzite, associated with an amphibolite bed in the sea cliff of Knife Point, has been used as a marker horizon. South of this, on Rusty Bluff, the rocks are relatively well exposed and only quartz-mica-schists with some quartz-rich bands have been recorded. These schists are about 1,000 ft. thick and on lithology alone it is tempting to correlate them with the Moe Island Series. In the south the flat-lying rocks of Gourlay Peninsula are also quartz-mica-schists with micaceous quartzites. Two marble horizons up to 1 ft. in thickness occur in these schists and they are associated with a poor development of hornblende-schists. The mica-schists on Gourlay Peninsula, which contain more frequent quartz-rich layers than the rocks of the Moe Island Series, cannot at present be referred to that series with confidence. However, it is relevant to recall the presence of a thin amphibolite at the north-east corner of Moe Island and a thin (4 in.) marble without amphibolite in the mica-schists near the base of the Moe Island Series on the north-east shore of Fyr Channel.

The schists of Rusty Bluff and Gourlay Peninsula could be provisionally correlated thus:

Moe Island Series	Quartz-mica-schists of the north face of Snipe Peak (Moe Island)	Schists of Rusty Bluff
	Quartz-mica-schists with rare amphibolites and marbles of the Fyr Channel area	Schists, marbles and amphibolites of Gourlay Peninsula

If this correlation is correct, then the position of the amphibolites exposed on Berntsen Point and Knife Point needs to be clarified. Possibly they are also equivalent to the amphibolites of the Fyr Channel area. On the geological map the mica-schists and amphibolites in the eastern part of the island have not been represented as part of the Moe Island Series but Figs. 14 and 15 show the relationship suggested here.

In his paper on the South Orkney Islands, Tilley (1935) reached the conclusion that "the metamorphic series represent a group of altered sediments ranging in composition from a pure carbonate through types representing marls to a dominant argillaceous facies". The present work confirms this conclusion. Throughout the island the foliated amphibolites are concordantly interstratified with other beds, including banded marbles and foliated micaceous quartzites which must have been of sedimentary origin. Many of the amphibolites are clearly associated with marbles, and of the others even the thinner members show considerable variation perpendicular to the bedding, which renders it improbable that they represent metamorphosed basic sills or lava flows.*

Whilst mapping in two areas on Signy Island the presence of metamorphosed igneous rocks was at first suspected.

In the cliffs surrounding the small cove immediately west of Confusion Point (station H.1396), more than 150 ft. of amphibolite rest on a thrust plane, which is exposed in the shore section as a surface parallel to the foliation of the underlying quartz-mica-schists. The amphibolites are affected by intense "wedge faulting". They show abnormally little foliation, except in the lowermost beds adjacent to the sheared rocks near the thrust plane. The debris at the foot of the cliffs includes large blocks of quartz-rich metasedimentary material but none of this has been found *in situ* in the lower half of the cliff. Under the microscope there is no significant difference between the mineralogy of these rocks and that of the hornblende-epidote group exposed elsewhere. It is now considered that the amphibolites represent the hornblende-epidote group at the base of the Amphibolite Series, which has been somewhat altered by intense faulting and locally thickened by repetition.

The second area, where *ortho*gneisses are possibly present, is in the amphitheatre east of Cummings Cove (Plate IIIa, b). Descending from the flat-lying bedded rocks of the hornblende-epidote group, which cap the south-west spur from the northern summit of Gneiss Hills, one crosses a band of severely crushed quartz-mica-schist (H.1407.1), below which are about 300 ft. of coarse gneissose amphibolites (H.1407.3, 1408.1). To the south, along the east wall of the amphitheatre, chaotically folded calc-hornblende-gneisses and hornblende-epidote-schists with dominant vertical banding are exposed. Microscopic examination has revealed no clear distinction between these rocks and the hornblende-epidote group, although one specimen (H.1408.1) is a unique coarse hornblende-albite rock. Shreds of marble occur in the cores of one or two overfolds and there are indications of repetition by step-faulting or landslipping parallel to the hillside in the bedded marbles and quartzites overlying the amphibolite complex near its southern end. It is now considered that these rocks belong to the same part of the Marble Series as those exposed in the west face of the northern summit of Gneiss Hills, but that they have been intensely disturbed by folding and step-faulting.

* cf. the account of the appearance of the epidiorite sills of Perthshire given by Barrow and others (1905, p. 14).

III. PETROLOGY

THE first recorded collection of rocks from Signy Island was made by Capt. S. Berntsen in 1928. These specimens were described by Holtedahl (1929, p. 99) as "coarsely crystalline limestone, garnet-bearing schists of various types as well as more compact gneissose rocks, all having a highly metamorphic character in common". A further collection by *Discovery* Investigations in 1932–33 was described by Tilley (1935) as comprising "a varied group of metamorphic rocks of sedimentary origin" including "a group of marbles, garnet hornblende schists, garnet hornblende biotite schists, and a series of quartzose mica schists often garnet-bearing—which are recorded as the common rocks of the island where visited".

The marbles, which are present both in the Marble Series and near the base of the Moe Island Series, are generally coarsely granular with the calcite exhibiting marked secondary twinning probably due to shearing. In the majority of the marbles examined the texture is irregular; large calcite crystals with bent twin lamellae are often set in a matrix of crushed grains. Both epidote and muscovite are present as minor mineral constituents. Some of the marbles are unusual in that calc-silicates may be present.

In the Marble Series, where pure marbles are intercalated with both amphibolites and quartz-mica-schists, there is clear evidence of fine interbedding of the purer marbles with the hornblendic rocks. These marbles often carry some garnet, sphene and epidote, whereas the amphibolites have appreciable amounts of biotite and an albitic plagioclase.

The amphibolites, which occur throughout the metamorphic sequence, vary widely in mineralogy from almost monomineralic hornblende rocks to those in which epidote is prominent. Garnet and biotite are frequently present in varying amounts and sphene is conspicuous as an accessory mineral. The plagioclase is usually albitic in composition and it is accompanied by quartz. The iron ore in these rocks is ilmenite and it is generally associated with sphene in the interstitial areas of the rock. In the hand specimen there is considerable variation in texture and the rocks range from the finest grain-size to coarse garnetiferous *hornblendegarbenschiefer*.

Quartz-mica-schists are common over the whole of Signy Island, but they are best developed in the Moe Island and Gourlay Peninsula areas. Again, there is some gradation into the amphibolites, giving rise to rocks that might be called garnet-hornblende-biotite-schists which often contain garnets up to 4 cm. across and green hornblende crystals 5–6 cm. in length. Two-mica quartz-schists are of frequent occurrence, but either muscovite or biotite may predominate in different parts of the sequence. The plagioclase in these rocks is in the albite-oligoclase range and there is an unusual abundance of recrystallized quartz in the matrix. Accessory minerals are rare.

The majority of the vein rocks which cut the metamorphic sequence are quartzo-feldspathic, though both discordant and concordant quartz veins and epidote veins have been recorded in the field. Garnet is a prominent constituent of some of the "pink" veins, especially where they are associated with the amphibolitic rock types.

From the petrography of the Signy Island metamorphic rocks, it is clear that they represent a regionally metamorphosed sequence of sediments which ranged in chemical composition from pure limestones through calc-argillaceous to argillaceous facies. It seems that fluctuating conditions existed in the depositional environment which gave rise to the intercalation of differing facies and the repetition of facies sequences.

The detailed petrography of these rocks is being investigated at present and this will be reported elsewhere at a later date.

IV. VEINS AND MINERALIZATION

THE veins which cut the schists of Signy Island are similar to those of Coronation Island and five types have been recognized.

Early concordant quartz veins. Lenticular bodies of quartzo-feldspathic material, elongated parallel to the *b*-axes of the schists, occur as concordant swellings in the foliation of the quartz-mica-schists and as mildly discordant veins, particularly in the rocks of the little promontories on the east shore of Fyr Channel.

Early discordant quartz veins. These are folded veins cutting the schists with marked discordance. The folding, often about axes parallel to *a*, is due to slipping between the foliation planes of the schists.

Late discordant quartz veins. These veins which cut the schists with marked discordance have not been folded. Petrographically, they resemble the early discordant veins but, although the quartz is strained, they have not been subjected to the *gleitbretter* folding which affects the veins of the second group.

None of the veins mentioned so far normally exceed 4 in. in width. An exceptionally wide-headed vein (belonging to the third group), composed of quartz with some iron pyrites and which is 3 ft. across near its top, was recorded on Moe Island.

Monomineralic segregation veins. Segregations and mildly discordant veins of epidote occur in the rocks of the hornblende-epidote group (p. 9).

Pink veins. Of more interest are the rocks described in the field as pink veins and pink gneisses, which are composed of pink garnet disseminated throughout a quartz mosaic. They are frequently foliated and contorted so that fine-grained hand specimens simulate pink granite-gneisses (H.1126.2). They occur only in the vicinity of the calcic rocks, amphibolites and marbles.

At the head of the valley south of Jane Peak these veins occur as contorted lenticles which are either concordant with or mildly discordant to the foliation in the contorted hornblendic rocks (Plate IVd). Here they are associated with narrow discordant purplish veins composed of quartz, wisps of mica and a little calcite. They probably follow re-sealed movement surfaces.

Concordant pink lenticles are developed elsewhere either as concentrations of garnet in the quartz-rich folia of the schists (e.g. H.1127.1) or in the quartzitic beds, which occur in the hornblende-epidote group (H.1388.7). It is exceptional for the quartz-garnet rocks to form thick beds, but a good example occurs on the slopes east of Fyr Channel in the calc-amphibolites. This bed, which is 6 ft. thick, is composed of quartz and comparatively coarse euhedral garnet, and it is cut by a network of late quartz veins.

All of these vein rocks could have been formed more or less *in situ* by a chemical re-arrangement of the constituents of the schists. There is no sign of magmatic action on Signy Island.

The extraordinary abundance of sphene in the rocks of Signy Island is discussed elsewhere. Iron pyrites is common in all the rocks but there is no other sign of mineralization.

V. MACRO-FABRIC

THE attitude and significance of the foliation, lineation and jointing are discussed in this section. An explanation of the terminology used both in this report and on the geological map is given in Appendix A. Observations on the macro-fabric elements are not uniformly distributed over the island. Most of the lineations and joints were recorded in the south-west part of the island (Fig. 3), whereas observations on the foliation were more evenly spread.

In most cases the lineation measured was the direction and plunge of the axes of the small folds in the foliation of the schists. The small folds (axial-plane separation $\sim$0·5–1·0 cm.; long limb height $\sim$ 3–5 cm.; short limb height = 1–2 cm.)* are most frequently little recumbent folds in the foliation of the quartz-mica-schists, but more open folds occur and in some amphibolites (e.g. H.1140.1) there are repeated

* For the method of specifying dimensions of asymmetrical folds see Matthews (1958).

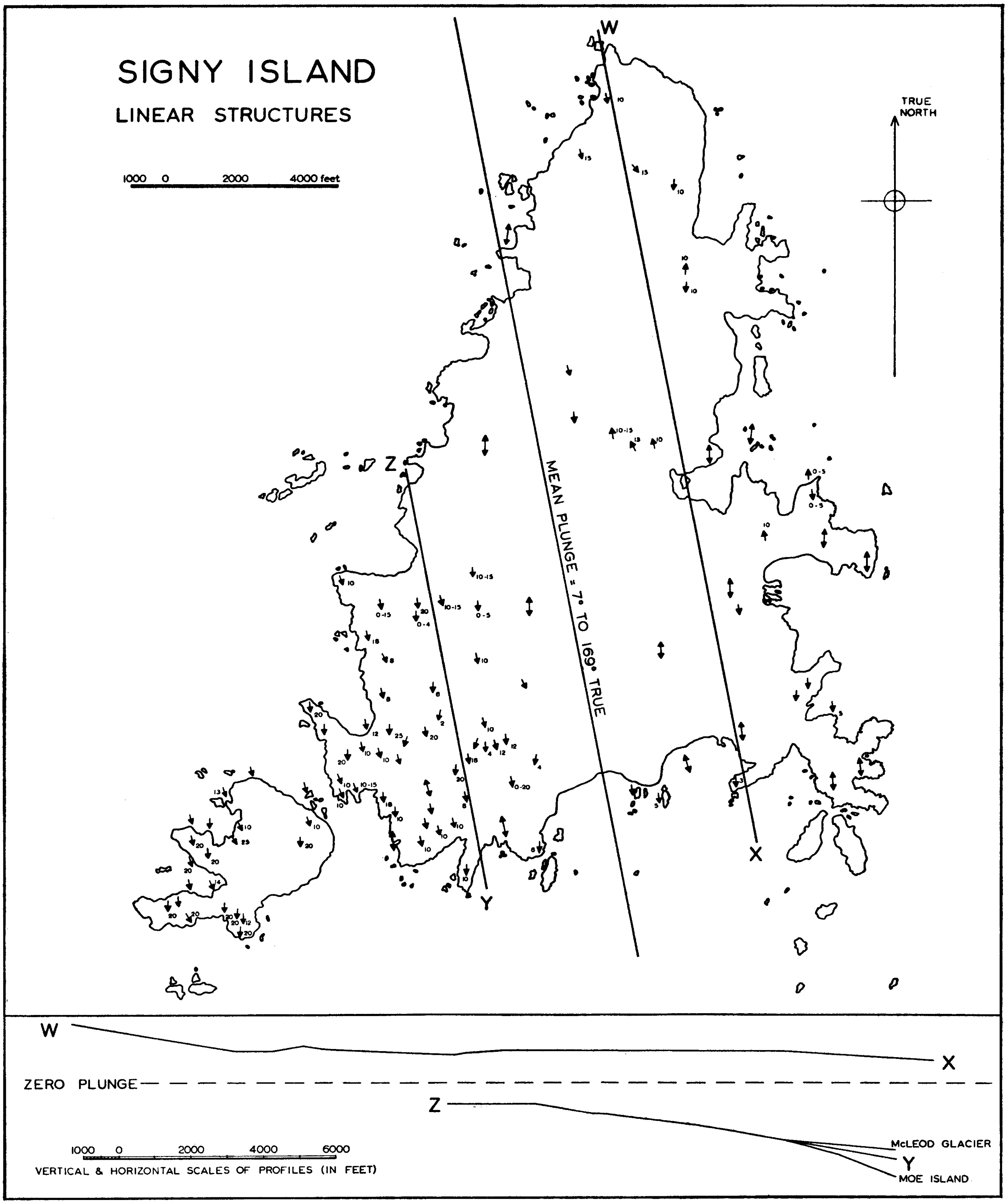

FIGURE 3

Outline map of Signy Island showing recorded lineations. The idealized profiles show axial plunge deduced from lineations.

angular "house-roof" folds (amplitude = 0·5–1·5 cm.; wave-length = 1–3 cm.). Other linear structures parallel to the small-fold axes are: the lines of the intersections between individual quartzo-feldspathic folia and the schistosity surfaces, the cleavage prisms formed in quartz-rich schists where the foliation trend is not parallel to the schistosity (e.g. on the promontories east of Fyr Channel), and the axes of minor folds.

The total area of Signy Island was divided into 15 sub-areas, for each of which the macro-fabric elements were plotted separately on a Lambert equal area projection. With the exception of the anomalous Gourlay Peninsula area, no significant differences were found between the individual diagrams. Fig. 4a and b are composite diagrams showing the relation between the foliation and the lineation for the whole area. It will be seen that the poles to the foliation are disposed in a broad girdle whose pole, π, corresponds quite well with the maximum concentration of the lineation. It may therefore be concluded that the main folding on Signy and Moe Islands is homo-axial and is associated with a mean *b*-lineation plunging 7° in a direction 169° true.

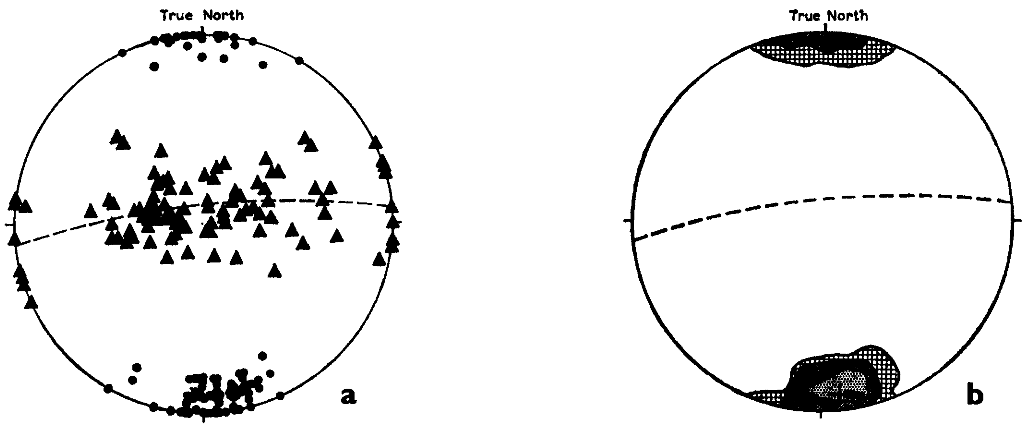

FIGURE 4

Composite fabric diagrams for Signy and Moe Islands. Equal area projection of the lower hemisphere.

a. Poles to foliation on Signy Island (solid triangles); trace of π-plane (pecked line); poles of lineation on Signy and Moe Islands (dots).

b. Trace of π-plane (pecked line); π-pole (cross). Contours for lineation at intervals of 2, 6, 11 and 25 per cent per 1 per cent of area.

The broadness of the girdle in Fig. 4a suggests that, in addition to folding about north–south axes, other factors affect the attitude of the foliation. The idealized profiles of the plunge shown in Fig. 3 suggest that there is some slight folding about axes perpendicular to the lineation, but these profiles are based on somewhat scanty information. More direct evidence is available on Gourlay Peninsula.

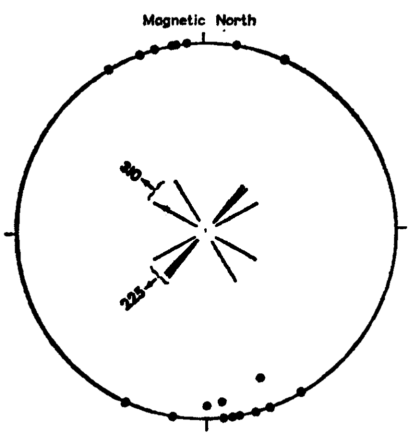

FIGURE 5

Poles of lineation (dots), and warp axes on Gourlay Peninsula. Stereographic projection of the lower hemisphere.

The Gourlay Peninsula area is unique in that there has been no major or minor folding about the north–south axes. The rocks are dominantly flat-lying and are cut by numerous low-angle faults. The usual north–south lineation is represented by occasional small folds in the micaceous rocks, by quartz rodding in the foliation planes of the quartz-mica-schists and by a grooving of the foliation surface of the micaceous quartzites, but the lineation here has a greater variation in azimuth than in any other sub-area (Fig. 5). Over the whole peninsula, but particularly at Pantomime Point, open folds or warps are dominant and they have an amplitude up to 20 ft., a wave-length of about 50 yd. and a maximum dip of 15°. The warping occurs about two horizontal axes trending 225° and 310° true, and it forms conspicuous elliptical domes and basins in the thin quartzites and marbles. Warping about these axes has been recorded sporadically in the highly folded rocks elsewhere on Signy Island.

It is possible that these open folds are of importance over the whole island and may result in a variation of plunge to north and south on all scales. The dominant warp axis, trending 220° true, is that of a very diffuse girdle which might be inferred from the projection of the joints and movement planes of both Signy and Moe Islands (Fig. 8). A possible relation between the warping and the movement surfaces is shown diagrammatically in Fig. 6. The warp axis trending 310° true may perhaps be a genuine axis of flexure contributing to the broadening of the girdle in Fig. 4a.

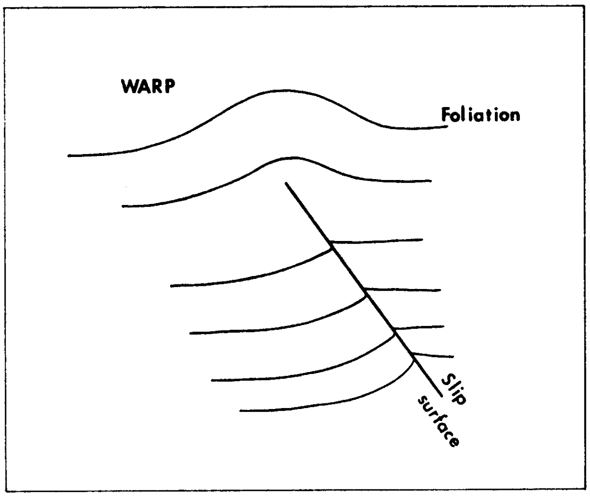

FIGURE 6

Diagram showing the postulated relationship between observed movement planes and open cross-folds. The section is perpendicular to the warp axis trending 220° true.

The orientation of the lineations recorded is shown in Fig. 3, together with two profiles constructed from them. While these profiles were being used for the construction of sections it was noticed that the trend of the lineations recorded in the northern part of Signy Island is slightly different from that in the more thoroughly investigated southern part. The northern half of the island is the area largely occupied by rocks which may belong to the Marble Series. Moreover, it was found that the construction of sections for the North Point area (Fig. 14a) was facilitated by assuming a zero rather than a 10° south-westward plunge indicated by the lineations recorded in the schists. This accords with the observation that the few major folds in the marble whose axes have been determined show almost no axial plunge. So far as is known, this is true of the major overfolds in the amphitheatre east of Cummings Cove, of the major overfold in the knolls north of Port Jebsen, and of the folds in the Three Lakes Valley area. Further careful investigation may reveal a systematic discrepancy between the axes of major folding in the Marble Series and the fabric of the schists, either in consequence of the disconformity beneath the Amphibolite Series or as a result of a second folding affecting the minor structures of all the schists. It might also be possible to delimit the Marble Series in terms of its fabric, a technique employed, for example, by Knopf (1954) in the Taconic and underlying rocks of Dutchess County, New York State.

The attitude of the joints was measured in the course of the mapping in 1956 but the method of sampling was neither statistically sound nor were sufficient joints measured. As on Coronation Island, by far the most common joints on Signy Island are cross-joints sub-perpendicular to the lineation. It is well known that cross-joints of this type are not precisely perpendicular to the *b*-lineation (cf. Weiss, 1954, p. 9). A particularly clear example of this consistent slight departure from the *ac*-plane is shown in Fig. 7.

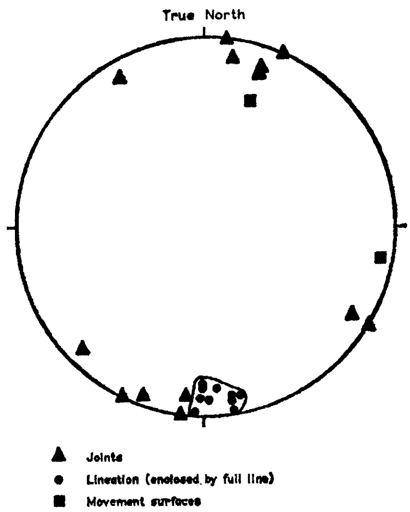

FIGURE 7

Poles to joints, lineation and movement surfaces for the sub-area between Cummings Cove and Confusion Point. Equal area projection of the lower hemisphere.

The poles to the joint and movement surfaces are shown in Fig. 8. Many of the steep joints falling within the field of the lineation are clearly cross-joints but the poles near the primitive circle in the south-south-west octant cannot be of this type. The movement surfaces shown include low-angle faults at Gourlay Peninsula but those faults shown on the geological map are excluded. The poles to the movement surfaces lie on a broad band trending north-west to south-east.

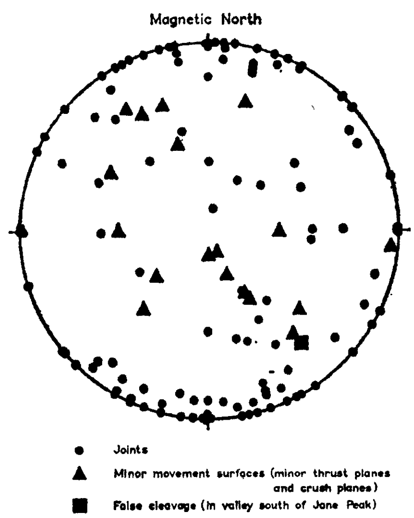

FIGURE 8

Composite diagram showing poles to joints and movement surfaces for Signy and Moe Islands.

VI. STRUCTURE

In the following section a few of the major structural features of Signy Island are described and some aspects of a structural synthesis are mentioned.

A. Folding

Major and minor recumbent folds abound on Signy Island. They are conspicuously defined by the bands of white marble in the cliff faces and they can easily be detected by mapping the foliation of the amphibolites and mica-schists, which can seldom be traced for more than a few yards before the dip increases towards the axis of a fold. Often only the noses of the major folds are exposed and, as has already been mentioned, the principal structural problem is whether to regard any of the visible fold closures as evidence for the presence of major fold nappes or as mere crumples analagous to those which can be seen on a small scale in any hand specimen. The following paragraphs, together with Figs. 9–12 and Plates III–V, illustrate some of the most conspicuous folds in the marbles, amphibolites and quartz-mica-schists.

Of the many examples of recumbent folding in the marbles, those at the following three localities are the best known.

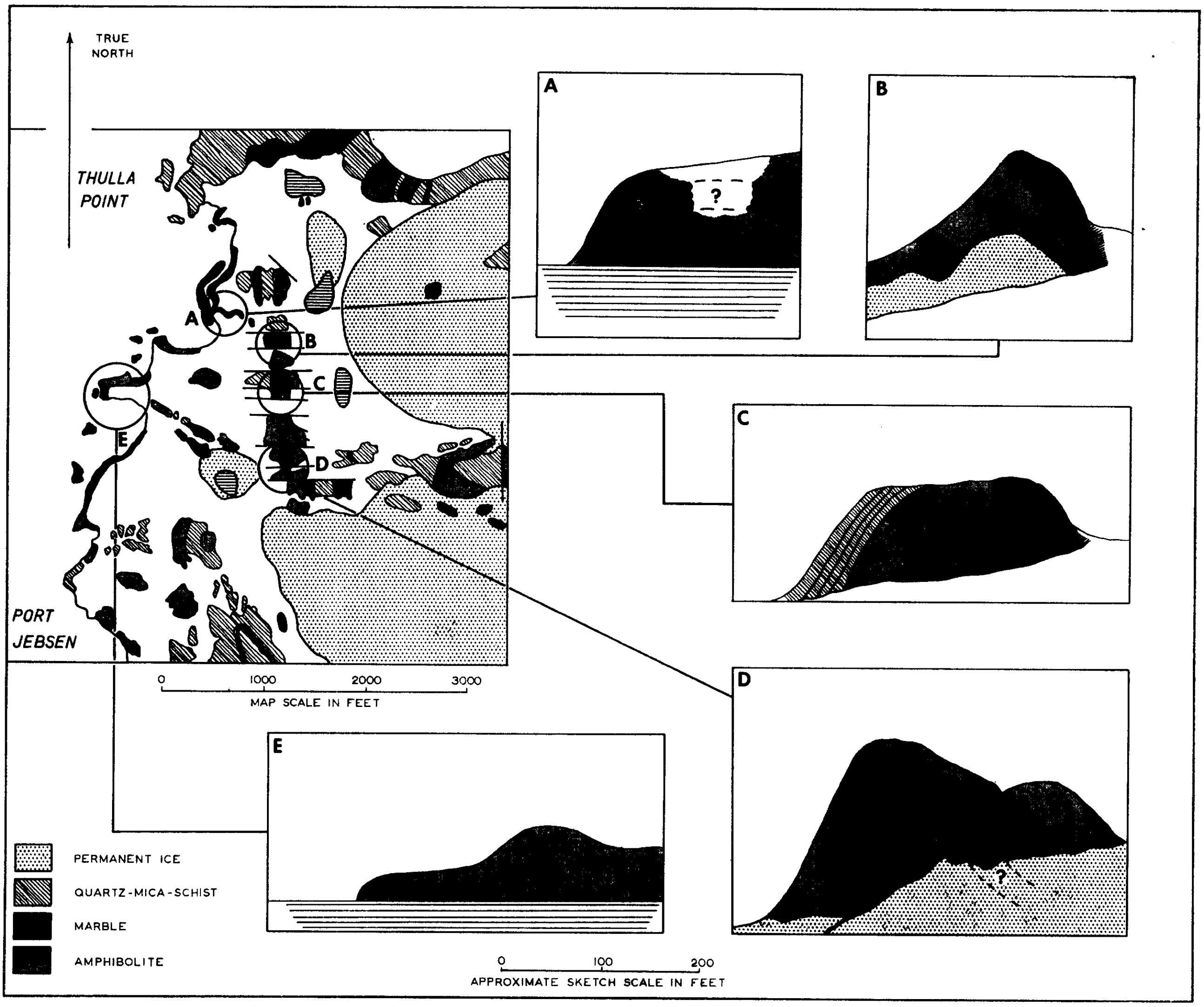

FIGURE 9
The structure of the knolls north of Port Jebsen.

Fig. 9 illustrates the structure of the knolls north of Port Jebsen, where a recumbent fold (with axial-plane separation (short limb) of the order of 50 ft.) is exposed in a series of elongated knolls separated by narrow drift-filled trenches. The fold axis trends north–south and the fold crest is displaced both laterally and vertically by small faults trending 120° true. The failure of the main marbles to re-appear on the west face of the southernmost knoll suggests a monocline or even a recumbent fold (Fig. 9D, in which the structure is simplified). Plate IVa shows a part of the southernmost knoll.

Two overfolds in marble are exposed in the amphitheatre east of Cummings Cove. The interpretation of the southern one is doubtful as the pattern of the outcrops may have been determined by landslipping (p. 8; Plate IIIa), but the northern fold is better exposed and sections complicated by faulting and thrusting are visible at both ends of the outcrop. Fig. 10 illustrates the probable interpretation of the structure while Plate IVb and c show two views of the fold.

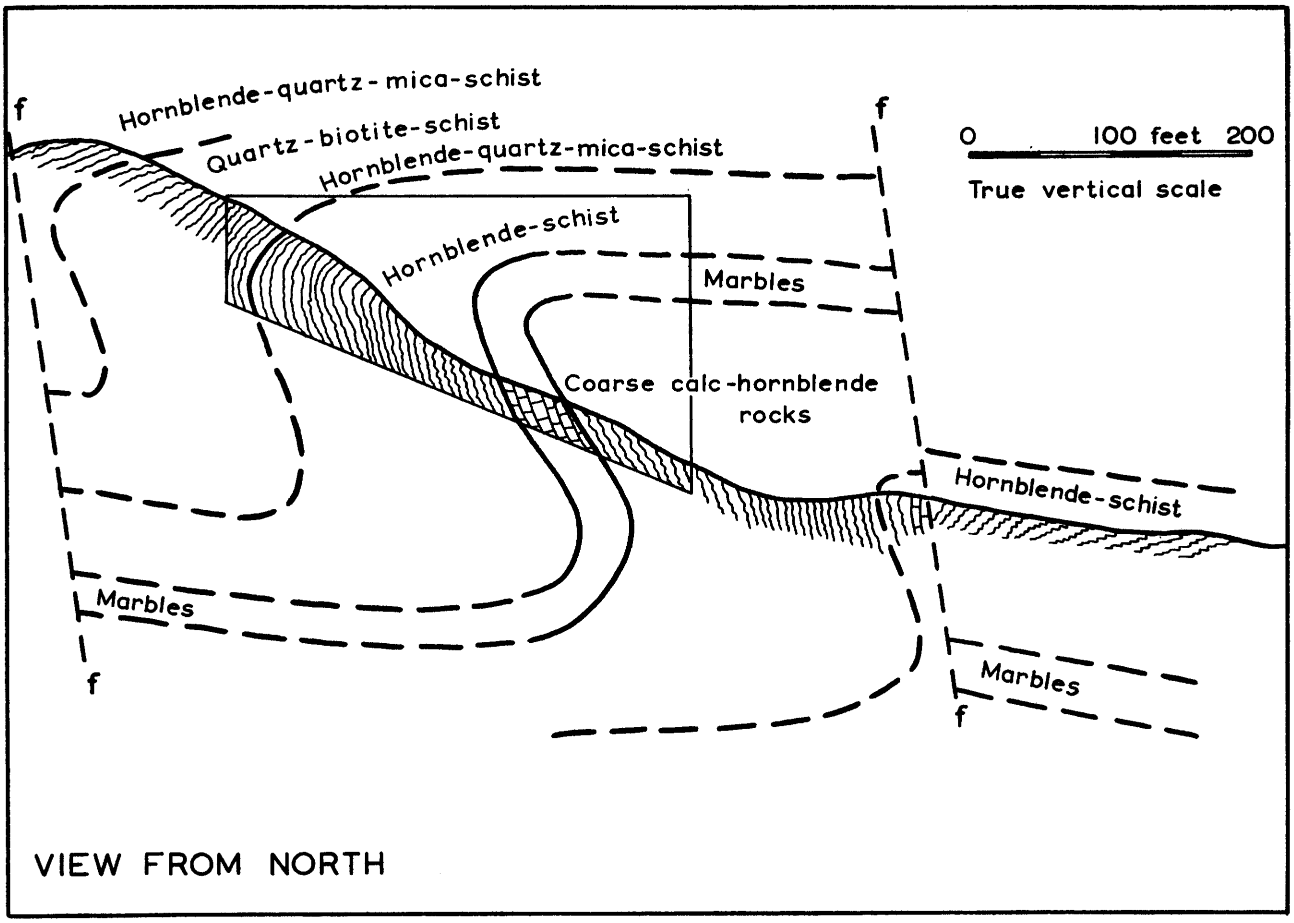

FIGURE 10

Interpretation of the structure of the northern overfold in the amphitheatre east of Cummings Cove. The quadrilateral indicates the part of the section illustrated in Plate IVc.

Thick marbles crop out on the eastern side of the island in the valley south of Jane Peak and in the low ground north of Elephant Flats. Plate IVd shows the folding in the conspicuous marble at the head of the valley south of Jane Peak. Several thinner marble sheets crop out farther down the valley, and in the steep buttresses forming the north face of Snow Hill they give an impression of an overall westward dip in spite of the complications introduced by recumbent folds and numerous faults.

In the low ground north of Elephant Flats there are five elongated ridges in which marbles and quartz-mica-schists are exposed (Plate Va, c). These conspicuous ridges are believed to be the crests of overturned folds in one or more marble sheets. A little farther north, the knolls east of Three Lakes Valley are composed of quartz-mica-schists interbedded with thin marbles and amphibolites. Good coastal sections of these rocks are exposed on the rocky peninsulas near Balin Point where they are complicated by intense wedge faulting which splits them into rhombic prisms elongated parallel to the fold axes. Fig. 11 illustrates the overall structure deduced for this area. Here, the axial planes of the major folds dip to the east, whereas elsewhere on the island they dip westward.

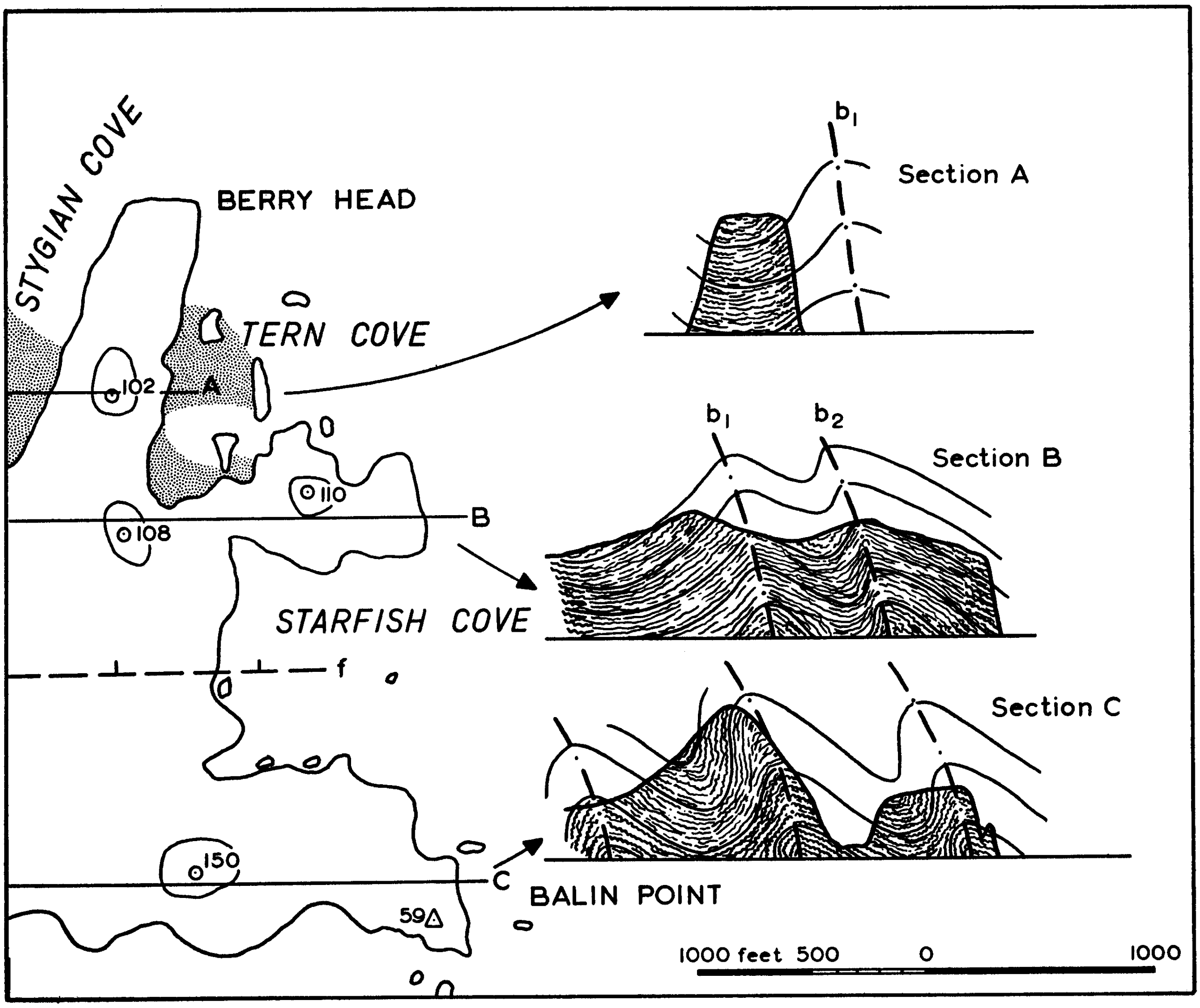

FIGURE 11

Sketch map and diagrammatic sections illustrating the structure of the area north of Balin Point. Vertical exaggeration of the sections is approximately x 4.

In the higher parts of the succession the prominence of the folding decreases. The massive rocks of the hornblende-epidote group appear in major folds in all their outcrops except the one on the western spur of Snow Hill. Plate IVe and f give some details of the outcrop of hornblende-epidote rocks in the floor of the cirque due east of Snipe Peak.

The more thinly bedded rocks of the calc-amphibolite mapping horizon are always highly contorted (overturned folds with axial-plane separation up to 25 ft. being common, in addition to violent minor folding) but the folding is clearly of secondary importance, because these rocks can be traced as a south-westerly dipping sheet on both Jebsen Point and Pandemonium Point, and as a flat-lying sheet on the flat-topped hill east of Jane Peak and the north-west spur of Tioga Hill. Folding in the calc-amphibolites and interbedded quartzites is shown in Plate Vb.

With the exception of a large anticline exposed between Borge Bay and Paal Harbour, folds are less easy to trace in the quartz-mica-schists than elsewhere because only one distinctive mapping horizon has been recognized. On both the eastern part of Moe Island and the adjacent part of Signy Island the quartz-mica-schists of the Moe Island Series are relatively uncontorted, showing for the most part open flexural minor folds and a prevailing south-westerly dip. The quartz-mica-schists on Jebsen Point and at the tip of Porteous Point are contorted, and a belt of partially crushed and contorted rocks with a dominant vertical foliation crosses the western half of Moe Island. This has been interpreted as a west-facing monocline (Fig. 12) but, owing to the absence of satisfactory mapping horizons, the true structure has not been determined in the field.

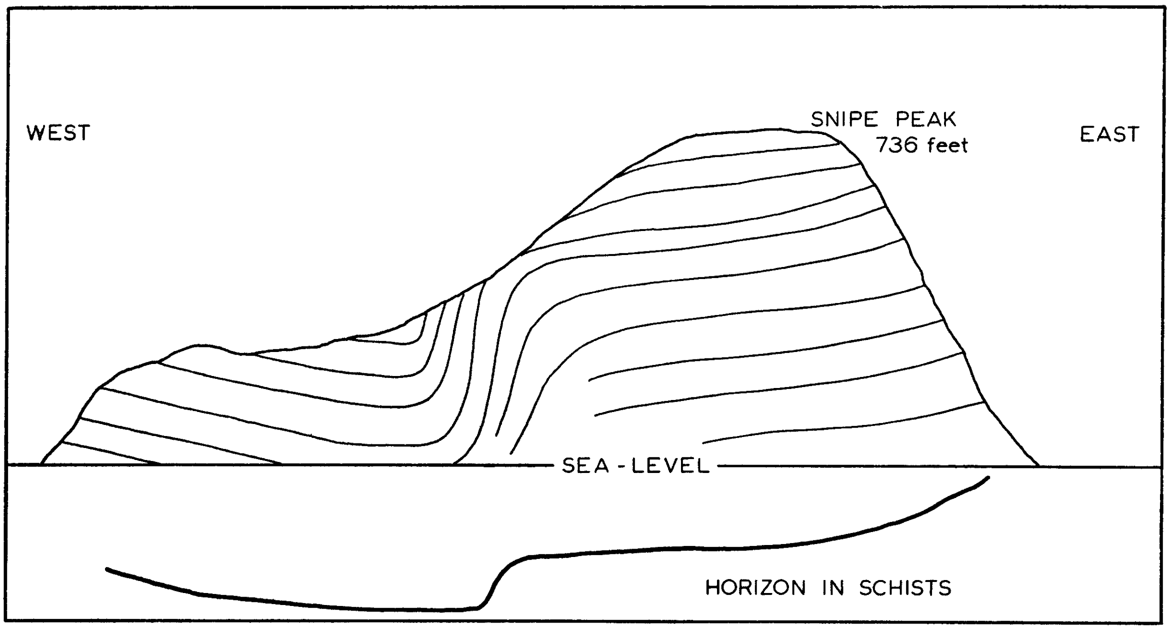

FIGURE 12
Idealized structure of Moe Island showing the trend of the foliation.

In the south-east part of Signy Island, between Borge Bay and Gourlay Peninsula, the quartz-mica-schists (tentatively assigned to the Moe Island Series) dip at low angles and are largely flat-lying. A few minor overfolds have been recorded in these schists, particularly in the vicinity of the amphibolites mentioned below. Minor monoclines in the quartzites on Rusty Bluff face westward. The anomalous structure of Gourlay Peninsula has already been discussed (p. 15) in connection with the macro-fabric. The ice-free area which extends from Rusty Bluff to Berntsen Point, including the northern and eastern shores of Paal Harbour and the southern shores of Borge Bay, is almost entirely composed of quartz-mica-schists. It has been noted (p. 9) that a convenient mapping horizon, first identified at Knife Point, has been used to interpret the structure of this part of the island. This micaceous quartzite horizon possesses a distinctive rhomboidal fracture on weathered outcrops, and at the type locality it is overlain by amphibolite. At Mooring Point and Billie Rocks the quartzite dips eastward. East of the small north–south fault near Knife Point it is continuously exposed and can be followed southward along the cliffs west of Factory Cove. From Knife Point, where it occurs at the high-water mark, it rises to a height of about 200 ft. at the head of Factory Cove without any evidence of faulting. The quartzite can be followed intermittently to a maximum height of nearly 350 ft. across the crags south of the old station hut, where it is associated with thin amphibolites similar to those of Knife Point. To the east of these cliffs the slopes are covered with scree and there are few exposures. The micaceous quartzite and associated amphibolites re-appear at about 200 ft. on the crags forming the spur north-west of Observation Bluff. Eastward it descends across slopes which are predominantly scree-covered until it reaches sea-level in the coastal cliffs due north of Observation Bluff.

The continuity of this horizon and the apparent absence of other structures in the quartz-mica-schists suggest that the overall structure of the peninsula between Borge Bay and Paal Harbour is that of a gentle northward-plunging anticline, the axis of which is approximately aligned in a north-north-east to south-south-west direction.

B. FAULTING

A few minor faults which were proved in the field are shown by solid lines on the geological map. They either trend approximately east–west or north–south. It is clear that faults play an important part in the structure of the island, and a careful study of the map reveals that the majority of outcrops must be associated with faulting. The fragmentary nature of the calc-amphibolite sheet in the area south-east of Cummings Cove, and the isolated marble knoll and the marble overfold on the southern slopes of the amphitheatre east of Cummings Cove are cases in point. The system of inferred faults shown on the map in this area is not completely satisfactory but no other consistent arrangement has been worked out from the existing mapping. It is possible that there is a south-westerly dipping thrust plane from Cummings Cove to Confusion Point.

The presence of approximately east–west faults in the Three Lakes Valley area may be postulated with confidence. Faults of this nature are probably responsible for the *en échelon* arrangement of the marble ridges west of Borge Bay (Plate Va). Fault breccia has in fact been recorded at the north end of one of them. East–west faulting is also invoked at the northern end of Three Lakes Valley (Fig. 11) and on the north ridge of Jane Peak, where the crest of a recumbent fold in amphibolite is displaced. Faults also separate the individual exposures on the slopes south-west of Stygian Cove.

Low-angle faults on Gourlay Peninsula have already been mentioned (p. 15). A small thrust has been observed at Foca Point and minor thrusts are evident in many outcrops (e.g. Fig. 13), but the presence of major thrust planes cannot be proved.

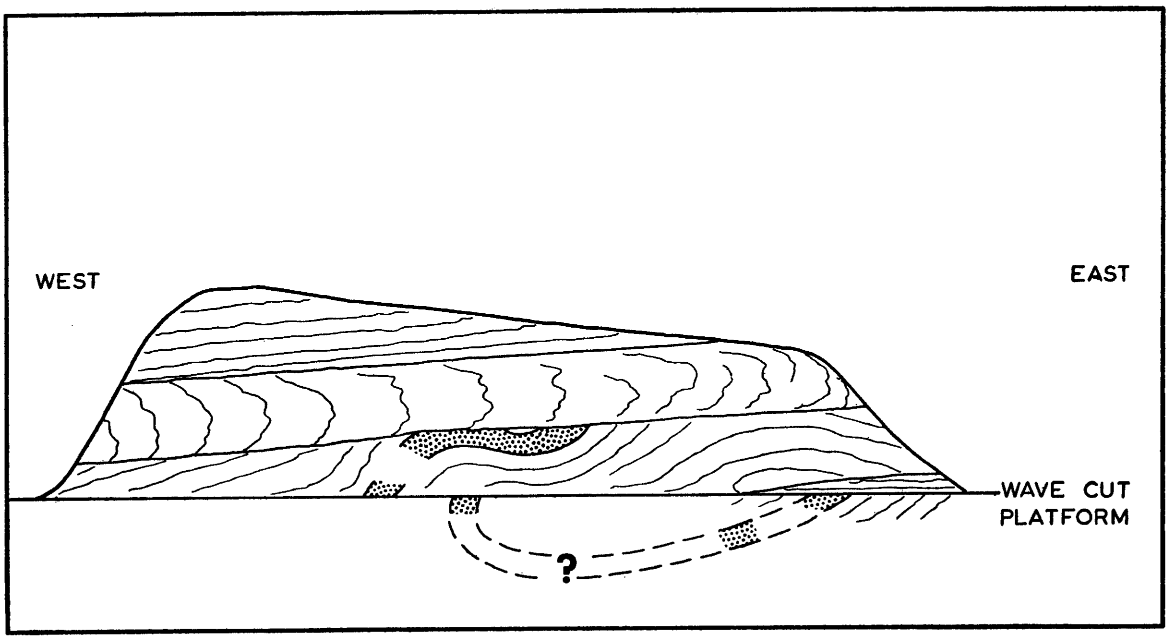

FIGURE 13

Sketch of the southern end of the headland forming the west side of Clowes Bay, showing thrust planes and the trend of foliation in the quartz-mica-schists. The bed ornamented with dots is quartzite. The length of the section is about 150 yd. and the height is about 100 ft.

Certain major faults, inferred from the geological map but not shown there, are illustrated in Fig. 15. An east–west fault truncating the northern end of the recumbent fold in marble in the knolls north of Port Jebsen may be correlated with the fault which brings the calc-amphibolites into contact with the hornblende-epidote group on the north face of Snow Hill, and it is perhaps *en échelon* with a fault terminating the Borge Bay marbles at the entrance to Elephant Flats.

A major fault probably terminates the flat-lying outlier of marble at the south end of the line of knolls in the small valley north-west of Tioga Hill. A comparable fault must again elevate the marbles between the hornblende-epidote rocks of the Jebsen Point–Tioga Hill col and the northern marble overfold in the amphitheatre east of Cummings Cove.

An east–west fault must pass south of Jane Peak, if the overfolded marbles and amphibolites exposed near the summit are to be correlated with those in the valley to the south.

On p. 4 it has been suggested that the topography along the eastern edge of the central plateau (Plate Ia) can be interpreted as a fault scarp trending southward as far as the east face of Snow Hill and thence through Moraine Valley to the south coast west of Lenton Point. This inferred fault is also shown in Fig. 14a and b.

Some major discontinuity probably separates the quartz-mica-schists exposed between Drying Point and Gourlay Peninsula from the marbles and amphibolites of Three Lakes Valley and Balin Point.

There must be a major dislocation through Normanna Strait separating Signy Island from Coronation Island. The nearest equivalent of the homo-axial fold belt on Signy Island is in the mountains north of Cape Vik on Coronation Island. *Hornblendegarbenschiefer* similar to those on Signy Island occur near Penguin Point. The nearest part of Coronation Island, where the Signy Island fold belt might be expected, is Cape Hansen, 2 miles north-east of North Point. On Cape Hansen, however, the flat-lying quartz-mica-schists display a macro-fabric which is strikingly different from anything on Signy Island. Soundings in Normanna Strait indicate depths of more than 100 fathoms (183 m.), which may be due to erosion along this inferred fault line.

C. INTERPRETATION OF FIELD EVIDENCE

This section must be regarded as being the most controversial part of this report, because most of the deductions were made at a fairly late stage in the work in England and there has been no opportunity of testing them in the field. It must be emphasized that, whereas the field evidence permits reasonably adequate interpretation of the structures for limited areas, it is not yet possible to agree a structural interpretation for the whole island. There are only two horizons which are sufficiently persistent and easy to recognize for use in mapping and neither of them can be regarded as satisfactory, because the relationship between them has not been clearly established.

The interpretation must therefore be based upon measurements of the structural elements observed at isolated outcrops of sometimes intensely folded rocks. All the field evidence has been plotted on the geological map but the inferred overall structure is illustrated in Figs. 14 and 15.

Any interpretation of the geology of Signy Island clearly depends upon the extent to which it can be shown whether faulting or folding was the dominant structural influence. At this stage, therefore, the evidence already presented will be reviewed to show the extent to which various interpretations may be regarded as valid.

It has been stated (p. 18) that the rocks of the lower part of the succession exposed in the northern and central parts of Signy Island are intensely folded. Numerous outcrops reveal the closures of recumbent folds, often conspicuous where they occur in the marbles. In addition to the folds described on p. 17–21, there are recumbent folds exposed in the spur south-west of North Point, on Jane Peak (Fig. 14c) and on the southern slopes of the Robin Peak plateau. In all these localities only the noses of the folds are exposed and the limbs must be inferred. It is necessary to determine whether these fold closures indicate the presence of large-scale recumbent folds with extensive inverted limbs which may confuse the stratigraphical succession, or only indicate large-scale crumples (overturned monoclines) of no stratigraphical significance. No positive relict sedimentary structures have been recognized on Signy Island and therefore possible inversion of the metamorphic sequence cannot be detected. The anomalous succession (Table II) in the east face of Gneiss Hills can possibly be interpreted as an inversion but a more likely explanation has already been given (p. 9).

The striking persistence of some of the fold closures seems to suggest that the overfolds are important structures. The line of the recumbent fold in the Marble Series north of Port Jebsen re-appears in the amphitheatre east of Cummings Cove, although these two localities are separated by a large area occupied by the Amphibolite Series. If this represents a down-faulted block, neither marginal fault can be seen in the field and this interpretation to account for the absence of overfolding in the cirque of Port Jebsen and the ridge to the south must therefore be treated with reserve. The recumbent folds in the upper slopes of Jane Peak may be regarded as a continuation of those exposed on the snow field to the south of Robin Peak. Here, however, the intervening ground is so deeply dissected and poorly exposed that alternative explanations are possible.

In three localities the field evidence suggests that the observed folds are only crumples. Several marble sheets which have a general westerly dip are exposed on the ridges projecting westward from the Robin Peak plateau. There is intense minor folding which is similar to the recumbent folding recorded elsewhere in the Marble Series. The section through this area (Fig. 14a) has been drawn assuming that the fold axes trend 174° true and are horizontal. The index letters, w–z, given in the northern part of the geological map provide a tentative correlation for the individual marble sheets, but it should be emphasized that this is only partly based on recognition in the field.

In the cliffs fringing the valley north of Snow Hill there is also local overfolding (p. 18). Nevertheless, the general dip is westward and the folds are subordinate structural features.

In the south-west part of the island, between Jebsen Point and the north-west spur of Tioga Hill, the calc-amphibolite horizon is clearly a crumpled sheet with a westerly dip. On Tioga Hill the foliation is horizontal. On the eastern summit of Snow Hill the top and bottom contacts of the hornblende-epidote group are also horizontal. The calc-amphibolites on the flat-topped hill west of Jane Peak are similarly disposed. Detailed mapping between Snow Hill and Porteous Point therefore indicates that the Amphibolite Series and the Moe Island Series represent a crumpled sheet which rests unconformably upon the Marble Series and dips towards the west or south-west.

It is concluded that there is no large-scale inversion of the beds among the rocks above the unconformity in the south-west, or among the rocks referred to the Marble Series in the north and west, but that the observed recumbent folds represent only large crumples. This conclusion has been applied to the highly folded rocks of the Marble Series in the knolls north of Port Jebsen (Fig. 9) and in the amphitheatre east of Cummings Cove (Fig. 10).

It has been shown that none of the major folds can be certainly proved to represent continuous structures. In each of the localities described they are lost before any certain relationship can be established between them and adjacent structures. Moreover, in other localities the crumpled nature of predominantly gently inclined beds has been described (Figs. 9, 10, 11). This has an important bearing on the fundamental concept of the structure of Signy Island, for, if the belts of recumbent folding were indeed continuous, they would be interpreted as being the exposed parts of deeper fold structures. Since the continuity of the fold axes cannot be proved, the observed folds could well be minor features superimposed upon a comparatively simple system of relatively undisturbed sheets separated by major faults.

In the south-western part of Signy Island detailed mapping has revealed the presence of numerous faults. It is possible that faulting is equally important elsewhere on the island, where mapping has been less intensive. It has, however, been shown that few vertical sections can be measured with reliability owing to the possibility of undetected disturbance by faulting or thrusting. Not one of the major faults shown in Fig. 15 and described on p. 21–22 has been established from unequivocal field evidence. None of the faults can be traced continuously for more than a few yards in this terrain. However, no coherent interpretation of the structure of Signy Island can be produced without the introduction of some major tectonic dislocations.

The respective correlations of the rocks in the eastern parts of Signy Island with the Moe Island Series (p. 10), and the calcareous rocks with the Marble Series (p. 9) have already been discussed. These correlations imply north–south faulting on the eastern side of the island (p. 21–22), separating rocks of different lithology and structure on opposite sides of Moraine Valley (Figs. 14, 15).

The stratigraphical evidence for the presence of an unconformity separating the highly folded Marble Series from the strata above is given on p. 8. There is no complete agreement about the further significance of this discontinuity.

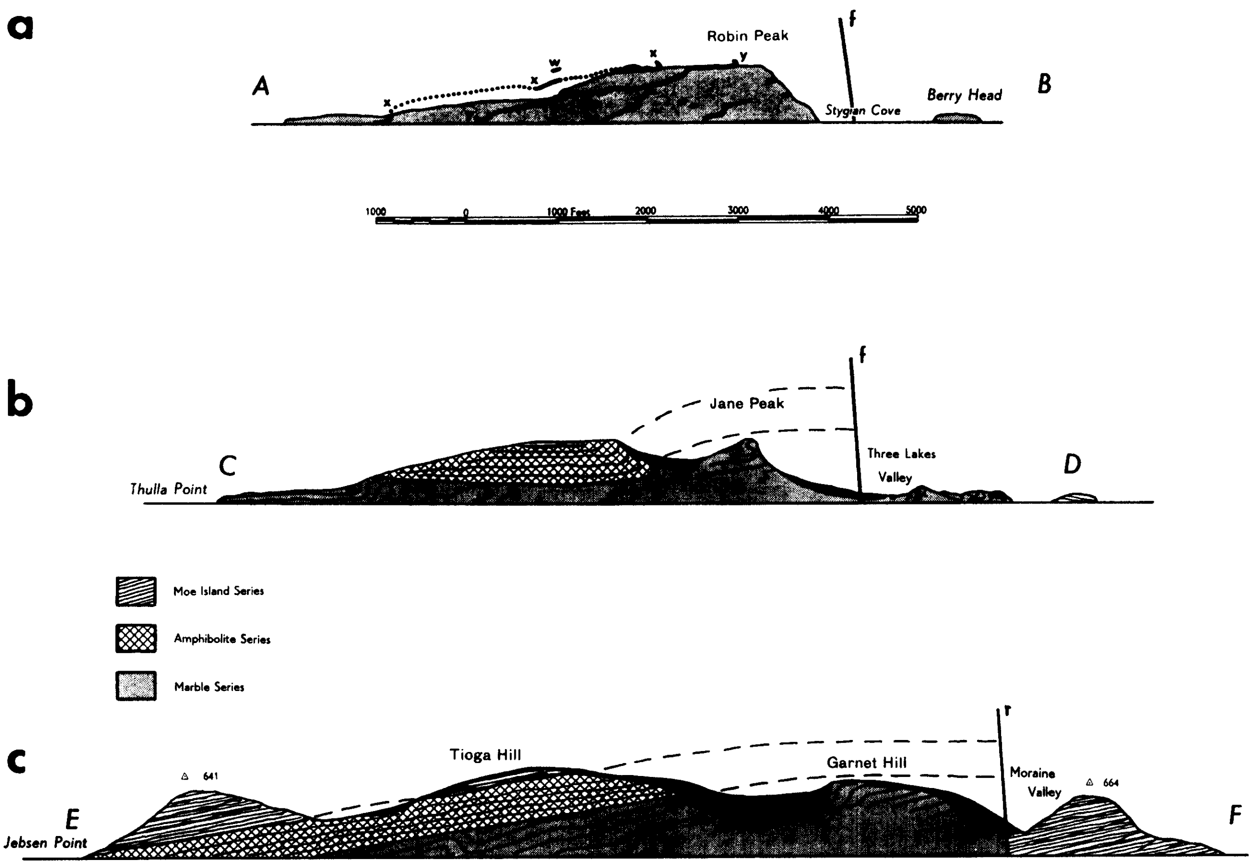

FIGURE 14

Sections illustrating the structural interpretation of Signy Island.

a. Scale section across the northern part of Signy Island drawn along the line A–B in Fig. 15. Information from the outcrops in the northern part of the island has been projected on to the line of section, assuming that the fold axes trend 174° true and have zero plunge. The letters w–z on the section correspond to those on the geological map and indicate provisional correlations of the marble outcrops (black).

b and c. Sketch sections illustrating the proposed stratigraphic correlations and large-scale structures. The ornamentation is conventional but it is intended to indicate the direction of overturning of the major folds and the nature of folding in the Marble Series. Sections b and c are along the lines C–D and E–F in Fig. 15. Horizontal and vertical scales are approximately equal. Permanent ice is in black.

Maling regards the rocks above the unconformity in the south-west part of the island, the quartz-mica-schists of the Thule Islands and the area south of Borge Bay as having a distinctly simple tectonic style characterized by monoclinal folds and by a north-north-east plunging anticline. He concludes that *Signy Island comprises three distinct structural units*, the first of which is the folded Marble Series and may consist of many rock types not differentiated on the geological map. These represent the core of the island, and their recumbent folds could possibly be interpreted as part of a deeper structure representing an early phase of folding. Secondly, there are the comparatively undisturbed rocks of the Moe Island Series and the Amphibolite Series, which comprise the succession resting unconformably on the Marble Series in the western part of the island. The Moe Island Series may well be represented in the south-east and eastern part of the island by the quartz-mica-schists which have lithological and structural similarities, but no discernible stratigraphical connection with them. The third unit occurs in the northern part of the island, where there are certain structural similarities to the Moe Island Series, but where the lithology is characteristic of the Marble Series. Both of these units show comparatively little folding apart from monoclinal flexures and minor crumples.

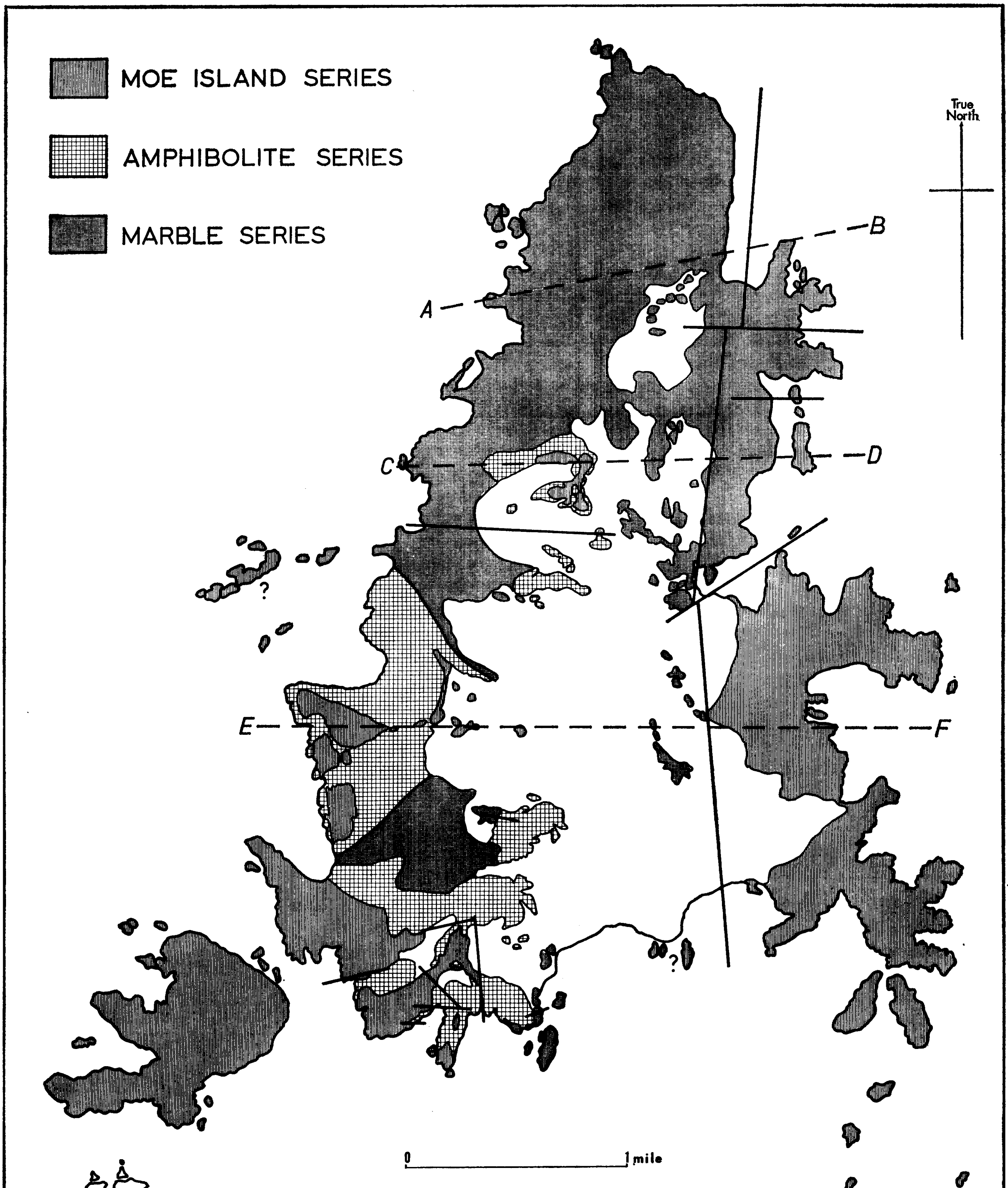

FIGURE 15

Geological sketch map of Signy Island showing the proposed stratigraphical correlations and inferred major faults (p. 21–22). The lines A–B, C–D and E–F represent the sections of Fig. 14.

Matthews regards the folding in the Moe Island Series, both in the south-western and eastern areas (p. 20), as large-scale structures superimposed upon minor folds which are essentially similar to those recorded elsewhere on the island. In the quartz-mica-schists and micaceous quartzites referred to the Moe Island Series, flexure and slip between the foliation planes are important factors in the mechanism of folding (Plate Vd). It has been shown that there are differences between the styles of folding in the rocks at the top and at the bottom of the succession (p. 17–21). At the top of the succession, in the relatively flat-lying quartzites and quartz-mica-schists, shearing is important, whereas in the lower part of the succession, in the calcareous and pelitic schists, disharmonic and flowage folding is dominant. He considers that this contrast in structure can be attributed to facies differences in the original sediments and therefore it is not evidence for an earlier period of violent earth movements affecting the Marble Series. He concludes that *the rocks of Signy Island belong to a single structural unit.* They originally comprised pelitic and psammitic sediments overlying, probably unconformably, a pelitic and calcareous sedimentary sequence. The tectonic forces that accompanied regional metamorphism resulted in slightly different styles of folding in the rocks of each group. The overall structure in both is essentially that of crumpled sheets arched over the centre of the island. The extreme south-eastern part of the island is an anomalous area (p. 20) which does not fit in with these conclusions.

Both Maling and Matthews agree that the individual structures appear to be truncated by faults or even thrust planes, the movements along which are clearly later than any other features of the structure. The present pattern of outcrops is therefore largely defined by a fault system which is not yet properly understood.

VII. CONCLUSIONS

THE rocks of Signy Island are sediments which have been regionally metamorphosed and are now represented by a series of schists of albite-epidote-amphibolite facies (Turner and Verhoogen, 1951, p. 461) in which garnetiferous quartz-mica-schists predominate. There is no sign of post-metamorphic igneous activity.

The following three-fold succession has been established for part of the island:

Moe Island Series (> 1,000 ft.)	Quartz-mica-schists with rare amphibolites and marble near the base (p. 9). [Perhaps originally greywackes.]
Amphibolite Series (440 ft.)	Amphibolites and quartz-mica-schists. [Originally argillo-calcareous sediments.]
	? *Unconformity*
Marble Series (⩾300 ft.)	Amphibolites, quartz-mica-schists and marbles. [Originally interbedded argillo-calcareous sediments and pure limestones.]

More than 1,000 ft. of quartz-mica-schists with rare amphibolites (Berntsen Point and Knife Point) and marbles (Gourlay Peninsula) near their base remain unplaced either at the top or bottom of the succession (p. 9). They have been tentatively correlated with a part of the Moe Island Series.

The schists display bedding foliation. They are folded about axes trending 170°–350° true, at right-angles to the trend of the Scotia Ridge. Minor transverse folds (p. 23) do not obscure this north–south trend. The principal faults probably trend approximately east–west and north–south.

The construction of reliable scale sections for the whole island is not yet possible but two sketch sections are given in Fig. 14. The rocks, particularly those belonging to the Marble Series, are affected by overfolds, tentatively interpreted as large-scale crumples of only local significance rather than as the noses of recumbent fold nappes. Faulting appears to have been important in determining the present pattern of outcrops. The overall interpretation of the structure has been discussed on p. 22–26.

Two hundred orientated specimens are available but the elucidation of the tectonic and metamorphic history by the methods of petrofabric analysis has not yet been attempted. The solution of this problem in the South Orkney Islands would undoubtedly contribute to the knowledge of the history of the Scotia Ridge.

The rocks of Signy Island are similar in metamorphic grade to those of Coronation Island and they clearly belong to the same sub-division of the Basement Complex. Most of the rock types of Signy Island can be matched there. However, amphibolites are relatively rare on Coronation Island, and the coarse marbles and associated hornblende-garnet rocks of the Marble Series are not known to occur anywhere there except at Penguin Point. Structurally, Signy Island is comparable with the homo-axial fold belt of the mountains north of Cape Vik and not with Cape Hansen, the part of Coronation Island closest to Signy Island.

The nearest land to the South Orkney Islands is the Elephant and Clarence Islands group of the South Shetland Islands. In many respects the metamorphic rocks of Signy Island can be compared with the high-grade *para*schists of Lookout Harbour and Cape Bowles, Elephant Island, described by Tilley (1930) p. 57–61) and discussed by Tyrrell (1945, p. 78).

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APPENDIX A

Nomenclature and Map Symbols

The *foliation** displayed by the schists in the South Orkney Islands is believed to be "bedding foliation" (Fairbairn, 1935, p. 592; Mead, 1940, p. 1020–21), either "primary bedding foliation", or "secondary bedding foliation" developed parallel to slip surfaces between the bedding planes of the original sediments by metamorphic differentiation during flexural folding. This is the mechanism of Class I or perhaps Class II of the classification suggested by Turner (1948, p. 278).

The term *schistosity*, as used here, indicates the plane of fissility in the rocks that is due to parallel planar orientation of the minerals. This fissility is normally parallel to the foliation in the quartz-mica-schists and foliated amphibolites. In the great majority of cases the attitude of this plane of fissility, parallel to the foliation, was the structural element measured in the field. The symbols for schistosity are consequently the commonest on the map. However, in a few localities where minor or small folding is conspicuous, the overall trend of the foliation is not parallel to the schistosity. In these places the plane of fissility is parallel to the longer limbs of the small folds in the foliation and cuts across the short reversed limbs of the folds. It is therefore comparable to a false cleavage (fracture cleavage) or even, in some extreme cases, to an axial-plane cleavage, at places believed to be near the noses of major recumbent folds. The attitude of this cleavage plane is indicated on the map by the symbol for schistosity. In the cases where the plane of fissility and the overall trend of the foliation are different, a second symbol is used on the map to represent the foliation trend. This second symbol is also used on the map in a distinct though similar sense to indicate the dip of the contact between beds of differing lithologies. This is the bedding dip in metasediments.

The terms used to describe the scale of the folds are those defined by Matthews (1958). The term "small fold" refers to crumples in the foliation of the schists seen within the compasss of a hand specimen. "Minor folds" are those seen in a small exposure, while "major folds" occupy whole cliff faces (cf. the folds shown in Plates IVd, Vd). "Large-scale folds" can be determined only in the mapping of relatively large areas (cf. Fig. 14).

APPENDIX B

Reliability of Topographical Mapping†

Since the compilation of the published geological map has been dependent upon the reconciliation of the observations of four different people (only one of whom was a qualified surveyor) working at Signy Island during three different periods, it is desirable to record the accuracy, reliability and limitations of the present topographical base map.

The inadequacy of the existing map of Signy Island (inset on Admiralty Chart 1775) was recognized by G. de Q. Robin soon after the F.I.D.S. station was established on the island in March 1947. During the following winter and summer, Robin carried out a plane-table survey of Signy Island, Moe Island and the offlying rocks and islets. The control for this survey was provided by plane-table triangulation, with a short base line measured along the rough, boulder-strewn beach on the eastern side of Factory Cove. The survey was made at a scale of 1:25,000 and was completed in early February 1948. This map of the island was subsequently published at the reduced scale of 1:50,000 as an inset to D.C.S. 701 (South Orkney Islands, 1:500,000). To avoid confusion with later maps, Robin's original 1:25,000 survey is referred to as *Map A*.

Planimetric control

Between February 1948 and February 1950, D. H. Maling continued survey work from Signy Island. Although the main task in these years was to make an adequate map of Coronation Island, several triangulation stations were established on Signy Island. The majority of these were situated for the purpose of base-line extension and in order to obtain good intersecting rays on the more distant peaks of Coronation Island. In order to do this, 13 trigonometric stations were established on Signy Island or neighbouring rocks and islets. These were nearly all situated round Borge Bay and on the higher summits visible from Borge Bay. Observations were made using a Watts Mark IV Pilot Balloon micrometer theodolite, reading to 0.01°, which was not intended for topographical surveying. Owing partly to the limitations of the equipment and partly to the inexperience of the observer, the angles were read on one face only and inadequate precautions were taken in levelling and centring the theodolite and in setting up beacons. The large number of individual readings which were made from each station on different occasions partly compensated for these disadvantages.

During 1949 the glaciological programme necessitated the accurate fixing of 20 bamboo stakes on different parts of the Signy Island ice cap. This involved a certain amount of additional triangulation and several stations were occupied in the south-west part of the island for this purpose alone. Altogether 21 triangulation stations and 21 intersected points were established on Signy Island. The base line used in this triangulation was measured on the young sea ice between Billie Rocks and Bare Rock in Borge Bay during June 1948. Only one measurement of the distance was made before the ice broke up.

In 1950–52, J. J. Cheal was the surveyor at Signy Island. He was better equipped than his predecessors and used a Wild T2 theodolite for the control survey. During these years he was able to establish a number of trigonometric stations on Coronation Island but, on Signy Island, he only occupied eight stations, all of which had served in the earlier triangulation. Cheal was able to make a more satisfactory series of base-line determinations on the sea ice of Borge Bay and he was able to demonstrate that an error of 60 ft. in booking made during the 1948 measurement had invalidated all the computations derived from it.

* The term *foliation* is used in this report in the "limited sense favoured by British geologists" (Fairbairn, 1949, footnote on p. 5), and not in the wider sense favoured by American authorities (e.g. Turner, 1948, p. 275). The limited sense of the word has been defined by Harker (1950, p. 203).

† Since the time the topographical base map of Signy Island was compiled, the island has been photographed from the air by helicopter. These aerial photographs have revealed certain inaccuracies in the base map which are not discussed in detail in this report.

Planimetric detail

The basic mapping of detail was carried out by Robin during 1947–48 and since that time comparatively little surveying of detail has been carried out. It should be noted, however, that the following additional information has been used in the present compilation:

Map B. Signy Island, 1:25,000, drawn by R. M. Laws as a direct tracing of *Map A*, but containing the detailed topographical drawing of cliff faces by Laws during 1948–50.

Map C. A plane-table survey of the neighbourhood of Borge Bay, Paal Harbour and Orwell Glacier made at a scale of 1:6,250 by Maling in January and February 1950. This work had been begun by Robin 2 years before but was incomplete. The area of the survey was increased to take in the whole of Orwell Glacier and Garnet Hill, where many of the glaciological observations had been made.

Map D. A manuscript geological map at 1:12,500 drawn at Signy Island by Maling. It was based on an enlargement of Robin's original manuscript, but adjusted to fit the trigonometric control (which was subsequently shown to be inaccurate).

Map E. A very detailed plane-table survey of Gourlay Peninsula at a scale of 1:2,500 made by Cheal in 1950–52.

Compilation of planimetric detail

The compilation of the present map is founded primarily on the triangulation around Borge Bay made by Cheal. In order to extend this control to the remainder of the island, the whole of Maling's network has been recomputed on plane rectangular coordinates, using Cheal's base-line measurements. Comparison has been made of the lengths and azimuth of those sides which are common to both triangulation figures. Seven triangulation stations which are common to both surveys have been used. This provides 21 sides for which the coordinate bearings and distances have been computed. The mean error for the length of these sides is 5·7 ft., with a standard deviation of ± 4·3 ft. The mean error in azimuth for the directions of these sides is 00·7°, with a standard deviation of ± 0·05°. The mean values for individual triangulation stations are given in the table below.

MEAN DIFFERENCES IN LENGTH AND AZIMUTH OF SIDES, BASED ON COORDINATE DIFFERENCES BETWEEN TRIGONOMETRIC POINTS COMMON TO SURVEYS OF D.H. MALING AND J. J. CHEAL, SIGNY ISLAND 1948–51

Trigonometric Station	*Mean Difference in Lengths of Sides of Triangles*	*Mean Difference in Azimuth of Sides of Triangles*
A. Cairn on Berntsen Point	6·3 ft.	0·11°
B. Summit of Jane Peak	3·2 ft.	0·06°
D. Summit of Robin Peak	4·5 ft.	0·07°
F. Cairn on Bare Rock	5·2 ft.	0·05°
G. Cairn on Billie Rocks	5·3 ft.	0·07°
J. Summit cairn on Observation Bluff	7·8 ft.	0·06°
M. Cairn on Balin Point	8·1 ft.	0·10°

Since the differences in the lengths of triangle sides all lie within the plotable error of 0·01 in. at the map scale of 1:12,500, it is felt that the additional triangulation stations and intersected points can be fitted to Cheal's control without introducing appreciable errors. The true azimuth and geographical coordinates are based on the observations and computations of Cheal. His observations, made at the site of the old station hut (situated 500 ft. north-east of the hut shown on the map) give the following coordinates for that position:

lat. 60°43′29″S., long. 45°34′59″W.

Magnetic variation has been computed from the mean of seven prismatic compass observations made between different triangulation stations during the years 1948 and 1949. The variation of 3°11′ East is taken as representative for December 1948.

A certain amount of difficulty has been experienced in reconciling the detail shown on the final compilation, which was made at the publication scale of 1:12,500. The areas which were covered by the large-scale surveys (*Maps C and E*) were compiled first by using photographic reductions of the plans and fitting these within the new control. No difficulty was experienced with the area included in *Map C*, because there is abundant trigonometric control within the area and the original plane-table sheet still showed the rays drawn in the field. The only control point within the area of *Map E* was a semi-graphic intersection of Pantomime Point. It was necessary to plot a grid overlay according to the coordinates of this single station and then fit the detail within this plan to the master grid of the whole island. The remainder of the detail was compiled from two sources: the first was a photographic enlargement of *Map B* to 1:12,500; the second was *Map D*. Separate plots of the coastline were made from both these sources. Proportional adjustment was made to reconcile the coastline with the changed positions of the triangulation stations.

On the west coast, where trigonometric control is very sparse, discrepancies having the order of 700 ft. occurred between two positions of the same point derived from each source. The worst discrepancies were found in the extreme south-west of the island where it was necessary to adjust for changes in azimuth as well as for simple scalar changes.

When the compilation of the coastline had been completed for each source map, a mean line between the two outlines was taken to represent the best compromise. Using this as a guide to the positions of the main bays, points and offlying rocks, the details of the coast were drawn according to the outline of *Map B*. The same technique was used for plotting the positions of the remaining detail, such as contours, ponds and drainage. The boundaries of the permanent ice and main rock outcrops were then sketched within this detail with the help of photographs which provide almost complete ground cover of Signy Island.

Height control

The height control on Signy Island is almost entirely based on trigonometric heights. The heights of Billie Rocks and Bare Rock, as determined by levelling during the measurement of the 1948 base line, were used by Maling as data. Unfortunately no attempt was made at that time to relate these observations to the tidal changes which were taking place between the measurements. Cheal based his datum on the height of the barometer cistern (71·9 ft. a.s.l.) in the old station hut which was determined by levelling by the Hydrographic Unit which visited Signy Island for a few days in 1951. Unfortunately there is no evidence that anything more than an arbitrary datum was established on this occasion and there is no record of any tidal measurements having been made at this time.

The altitudes recorded on the present map are based on the datum used by Cheal. Since the old station hut has now been dismantled, there is no way of checking their accuracy apart from the re-observation of all stations from a new datum.

From the observations carried out in Scotia Bay, Laurie Island, it is known that the tidal range in the South Orkney Islands is of the order of 6–8 ft. for ordinary tides. A few broken observations made by the late C. J. Skilling at Signy Island in 1949 confirm that ordinary tides in Borge Bay have a range of 5 ft. It is presumed, therefore, that the altitudes which have been determined from the present datum lie within 10 ft. of mean sea-level. Most of the altitudes obtained by theodolite lie within 15 ft. of those determined by Robin using an Indian clinometer. For this reason the heights of plane-table stations, which were determined by Robin and which have not been visited again, are assumed to be correct.

In addition to the spot heights determined during basic survey work, a number of additional observations have been made to determine the altitude of glaciological stations on the ice cap (by theodolite) and important outcrops (by Abney level, Indian clinometer or aneroid). These have been recalculated using the distances measured from the new 1:12,500 compilation and the existing contours have been modified where necessary to incorporate this information.

For the purposes of geological mapping, Maling used a manuscript enlargement of Robin's original survey (*Map A*), whereas Matthews used a photographic enlargement of *Map B*. The compilation of the present base map was completed a few weeks before Matthews returned from Signy Island and all subsequent work has been carried out on "true-to-scale" (Ordoverax) prints of the manuscript.

All the compass resections observed during geological mapping have been re-plotted on the new base map and, where possible, these have been used to check the planimetric and altimetric accuracy of the detail. A number of minor corrections have been made in the south-west part of the island and other inconsistencies have been resolved by asking for additional observations to be made and for the results to be sent by radio.

The location of the coast of Moe Island has been plotted from the compass bearings observed by Matthews from many places in the south-west of Signy Island. Although the detail of Moe Island agrees well with the additional observations made during 1955–56, the precise position and orientation of this island relative to Signy Island is one of the most doubtful features of the present map.

APPENDIX C

LIST OF PLACE-NAMES AND THEIR COORDINATES

Except where otherwise indicated, all features in the following list can be located on the 1/500,000 map of the South Orkney Islands and the 1/50,000 inset of Signy Island. Only the mid latitude and longitude of each feature is given.

Balin Point	60°42′S., 45°36′W.	
Bare Rock	60°43′S., 45°35′W.	
Bennett, Cape	60°37′S., 45°14′W.	
Berntsen Point	60°43′S., 45°36′W.	
Berry Head	60°42′S., 45°36′W.	
Billie Rocks	60°43′S., 45°36′W.	
Borge Bay	60°43′S., 45°36′W.	
Bransfield Strait	—	1/500,000 Sheets A & B.
Clarence Island	61°08′S., 54°06′W.	1/500,000 Sheet B.
Clowes Bay	60°44′S., 45°37′W.	
Coffer Island	60°45′S., 45°09′W.	
Conception Point	60°31′S., 45°44′W.	
Confusion Point	60°45′S., 45°38′W.	
Coronation Island	60°38′S., 45°35′W.	
Cummings Cove	60°44′S., 45°41′W.	
Divide, The	60°45′S., 45°10′W.	
Drying Point	60°43′S., 45°36′W.	
Dundas, Cape	60°44′S., 44°24′W.	

Elephant Flats	60°43′S., 45°37′W.	
Elephant Island	61°10′S., 55°14′W.	1/500,000 Sheet B.
Factory Cove	60°43′S., 45°37′W.	
Faraday, Cape	60°38′S., 45°04′W.	
Flensing Islands	60°42′S., 45°41′W.	
Foca Point	60°42′S., 45°40′W.	
Foul Point	60°33′S., 45°31′W.	
Fraser Point	60°41′S., 44°31′W.	
Fredriksen Island	60°45′S., 45°00′W.	
Fyr Channel	60°44′S., 45°41′W.	
Garnet Hill	60°44′S., 45°38′W.	
Geddes, Cape	60°42′S., 44°35′W.	
Gerd Island	60°40′S., 45°46′W.	
Gibbon Bay	60°40′S., 45°12′W.	
Gneiss Hills	60°44′S., 45°39′W.	
Gourlay Peninsula	60°44′S., 45°36′W.	
Governor Islands	60°31′S., 45°57′W.	
Graham Land	—	1/500,000 Sheets A–D.
Graptolite Island	60°44′S., 44°28′W.	
Hansen, Cape	60°40′S., 45°36′W.	
Hartree, Cape	60°48′S., 44°44′W.	
Inaccessible Islands	60°34′S., 46°44′W.	
Jane Peak	60°43′S., 45°38′W.	
Jebsen Point	60°43′S., 45°40′W.	
Jebsen, Port	60°43′S., 45°40′W.	
Jebsen Rocks	60°43′S., 45°41′W.	
Jessie Bay	60°44′S., 44°43′W.	
Knife Point	60°43′S., 45°36′W.	
Larsen Islands	60°36′S., 46°05′W.	
Laurie Island	60°44′S., 44°37′W.	
Lenton Point	60°44′S., 45°37′W.	
Lewthwaite Strait	60°42′S., 45°08′W.	
Mabel, Cape	60°41′S., 44°40′W.	
McLeod Glacier	60°44′S., 45°38′W.	
Mariholm	60°45′S., 45°42′W.	
Meier Point	60°38′S., 45°54′W.	
Mirounga Flats	60°42′S., 45°37′W.	
Moe Island	60°45′S., 45°41′W.	
Mooring Point	60°43′S., 45°36′W.	
Moraine Valley	60°43′S., 45°37′W.	
Nivea, Mount	60°35′S., 45°29′W.	
Normanna Strait	60°41′S., 45°38′W.	
North Point	60°41′S., 45°38′W.	
Observation Bluff	60°43′S., 45°36′W.	
Oliphant Islands	60°45′S., 45°36′W.	
Ommanney Bay	60°33′S., 45°34′W.	
Orwell Bight	60°44′S., 45°25′W.	
Orwell Glacier	60°43′S., 45°38′W.	
Paal Harbour	60°43′S., 45°35′W.	
Palmer Bay	60°37′S., 45°21′W.	
Pandemonium Point	60°44′S., 45°39′W.	
Pantomime Point	60°44′S., 45°36′W.	
Penguin Point	60°32′S., 45°56′W.	
Porteous Point	60°44′S., 45°41′W.	
Powell Island	60°41′S., 45°03′W.	
Raynor Point	60°39′S., 45°12′W.	
Reid Island	60°41′S., 45°30′W.	
Return Point	60°38′S., 46°02′W.	
Robertson Islands	60°47′S., 45°10′W.	
Robin Peak	60°41′S., 45°38′W.	
Rusty Bluff	60°44′S., 45°37′W.	
Saddle Island	60°38′S., 44°50′W.	
Sandefjord Bay	60°37′S., 46°03′W.	
Saunders Point	60°42′S., 45°20′W.	
Schist Point	60°44′S., 45°15′W.	

Scotia Bay	60°46′S., 44°40′W.	
Scotia Sea	—	
Signy Island	60°43′S., 45°38′W.	
Snipe Peak	60°45′S., 45°41′W.	
Snow Hill	60°43′S., 45°37′W.	
South Cape	60°48′S., 45°09′W.	
South Shetland Islands	—	1/500,000 Sheets A & B.
Spence Harbour	60°42′S., 45°10′W.	
Starfish Cove	60°42′S., 45°37′W.	
Stygian Cove	60°42′S., 45°37′W.	
Tern Cove	60°42′S., 45°37′W.	
Three Lakes Valley	60°42′S., 45°37′W.	
Trinity Peninsula	—	1/500,000 Sheet B.
Thule Islands	60°42′S., 45°37′W.	
Thulla Point	60°43′S., 45°40′W.	
Tioga Hill	60°44′S., 45°39′W.	
Vik, Cape	60°40′S., 45°41′W.	
Washington Strait	60°45′S., 44°55′W.	
Waterpipe Beach	60°43′S., 45°37′W.	
Weddell Islands	60°39′S., 44°51′W.	

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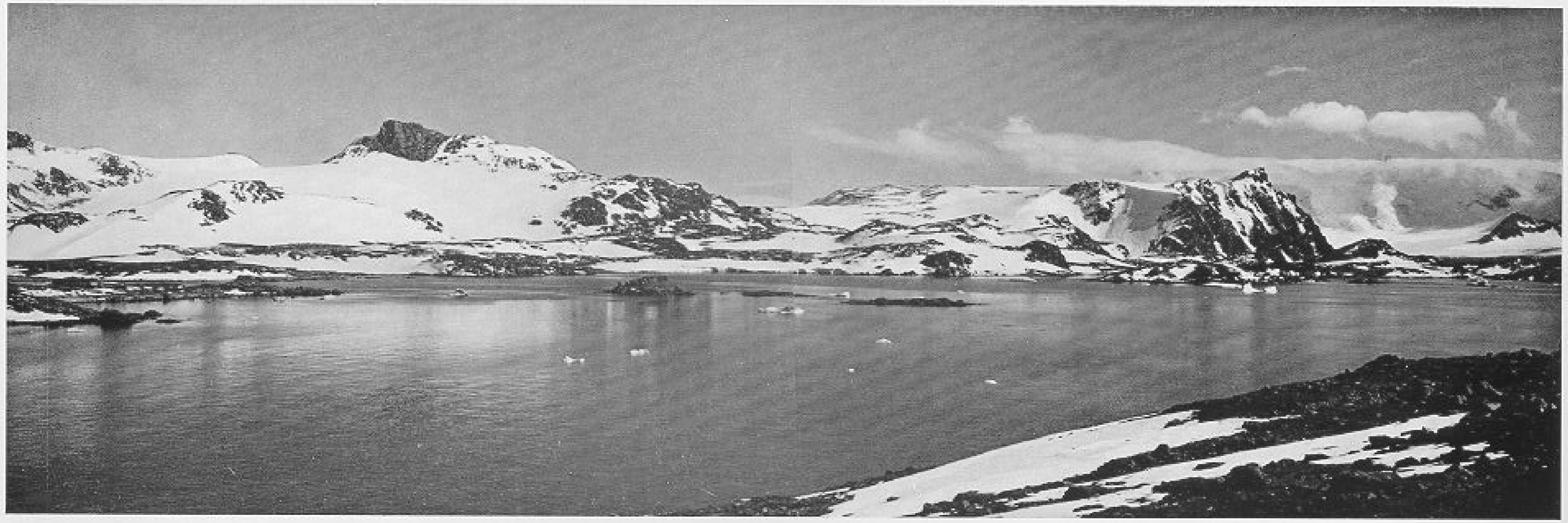
PLATE I

a. The northern part of Signy Island viewed from the vicinity of the original Falkland Islands Dependencies Survey station hut. The two main summits are Jane Peak (left) and Robin Peak (right).

b. Panorama of the south-east part of Signy Island viewed from Rusty Bluff, and showing Gourlay Peninsula and the Oliphant Islands.



a

b

PLATE I

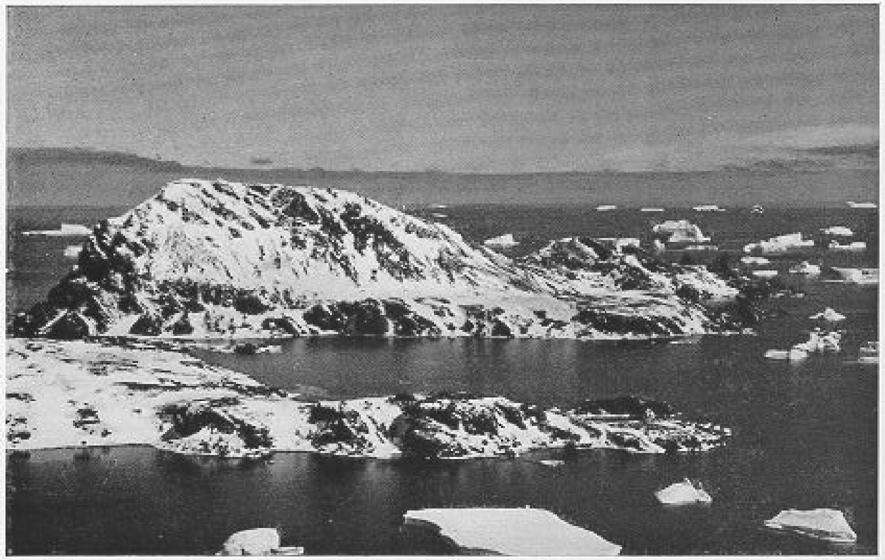
PLATE II

a. Moe Island and Porteous Point viewed from the hill south of Port Jebsen.

b. Southward view of the western slopes of Signy Island from the vicinity of Thulla Point, showing the line of knolls north of Port Jebsen.

c. Erratics of quartz-mica-schist on a glaciated pavement of marble north of Elephant Flats. In the background are the ice cliffs of Orwell Glacier. Photograph taken on 1 November 1949.

d. Southward view of the ice cap of Signy Island from the summit of Robin Peak. The highest point near the centre of the photograph is Tioga Hill. Snipe Peak on Moe Island is the flat-topped rock summit on the right. The lower slopes of Orwell Glacier appear on the extreme left of the photograph. Photograph taken during the winter months.



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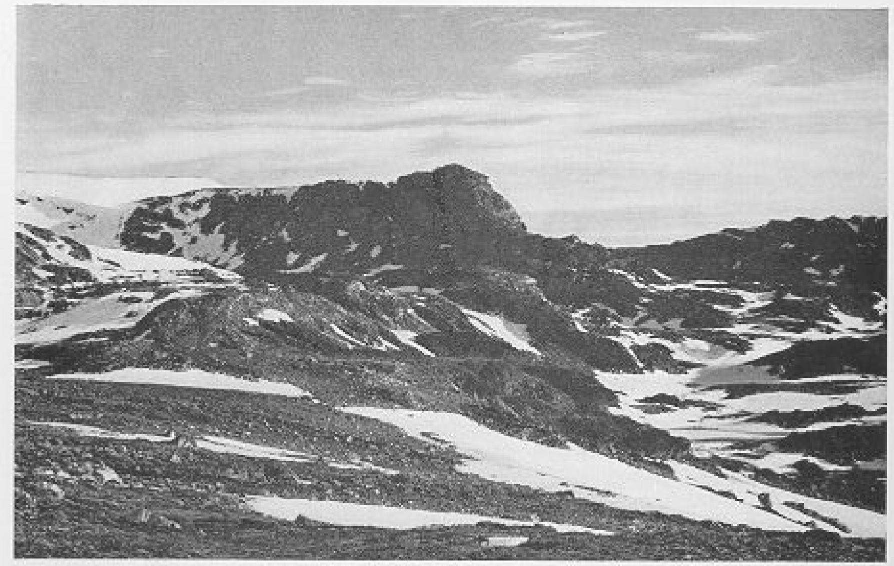

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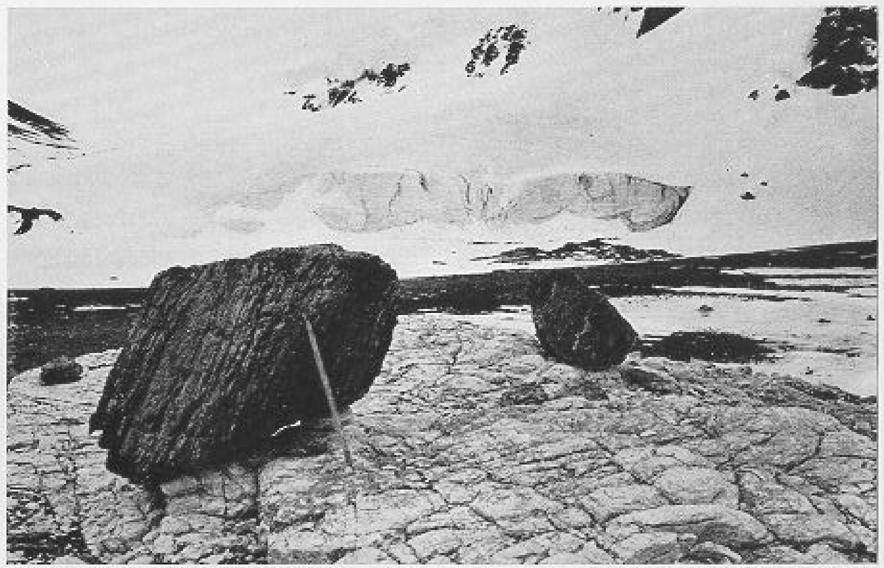

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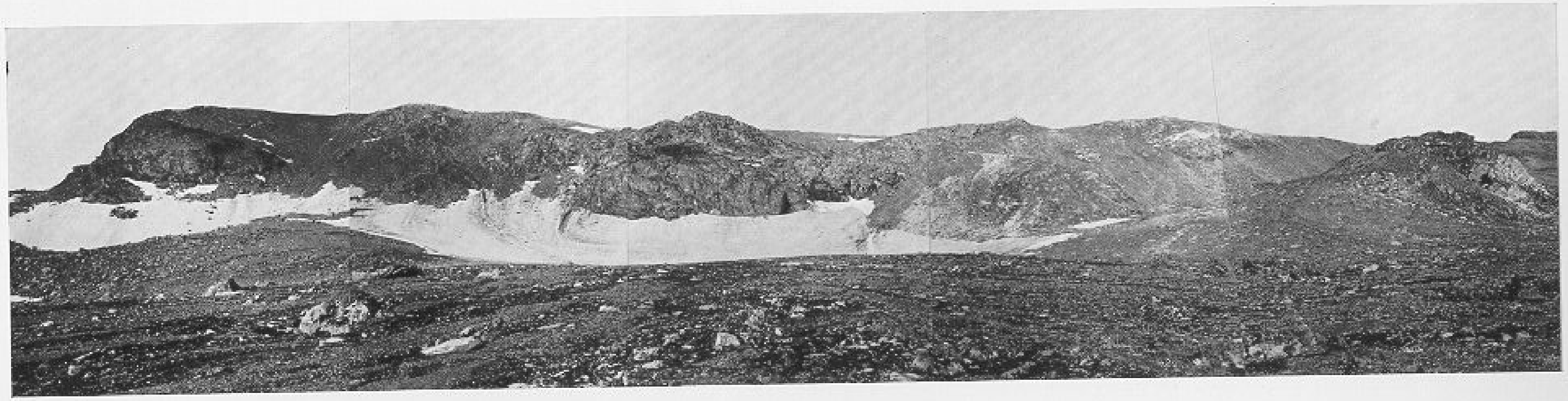
PLATE II

PLATE III

a. Panorama of the south and east walls of the amphitheatre east of Cummings Cove.

b. Sketch illustrating the geology of the area shown in Plate IIIa.
a, b, c. Sites of measured sections (Table II); HEG. Hornblende-epidote group; QMS. Quartz-mica-schist; M. Marble; A. Amphibolite; CA. Calc-amphibolite; Q. Quartzite; HS. Hornblende-schists above and below the overfolded marble; H.1407. Collecting station referred to in the text.
The northern summit of Gneiss Hills is on a bearing of about 095° true, and the southern summit on a bearing of 150° true. The hilltop capped by the Moe Island Series at the right-hand end of the panorama bears 215° true.



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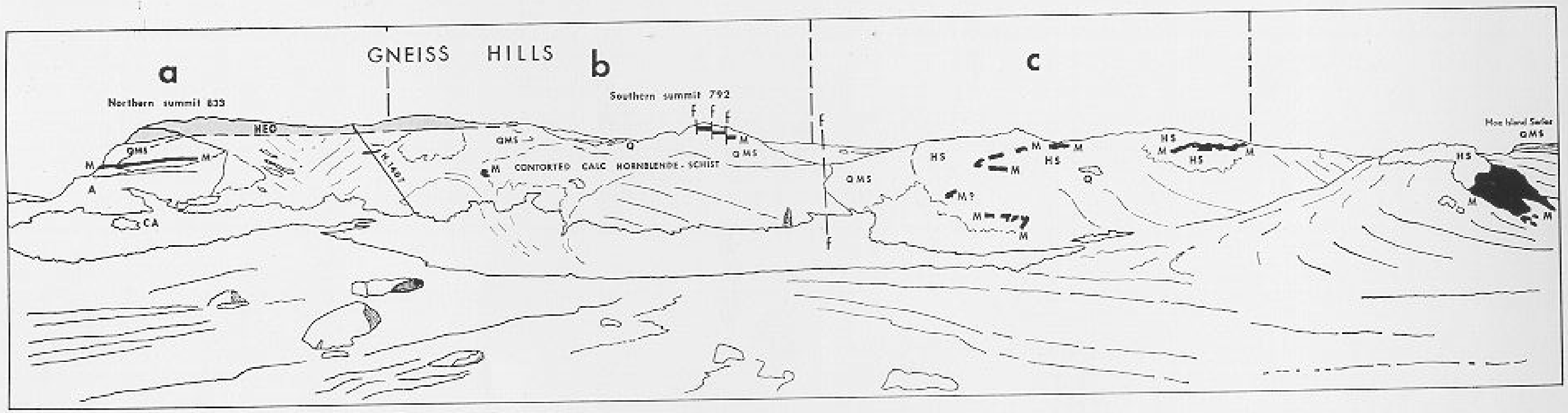


GNEISS HILLS
a
b
c
Northern summit 833
Southern summit 792
NEO
QMS
M
A
CA
Q
F
CONTORTED CALC HORNBLENDE - SCHIST
HS
M?

b

PLATE IV

a. Faulted contacts in the knolls north of Port Jebsen. Part of the north face of the southern knoll looking south-eastwards. The thick marble against the skyline at the summit of the knoll is the one shown in Fig. 9d. The rock face is about 20 ft. high along the line of the fault.

b. The overfold in the north-east corner of the amphitheatre east of Cummings Cove. Part of the west face of the outcrop looking 070° and upwards. The cliff face in the background is about 100 ft. from the conspicuous marble to the highest point of the skyline.

c. The overfold in the north-east corner of the amphitheatre east of Cummings Cove. Part of the north face of the outcrop looking 200° (cf. Fig. 10). The line of section in Fig. 10 represents the top of the scree.

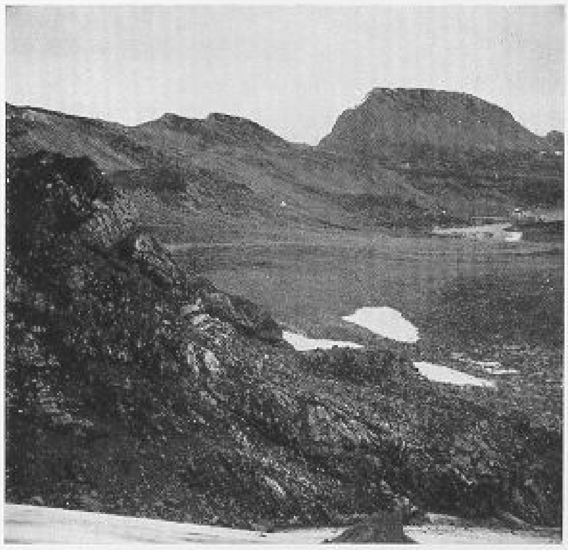
d. Folds in the marble at the head of the valley between Snow Hill and Jane Peak. In the foreground there are minor folds in marbles interbedded with amphibolites. In the background, about 400 yd. from the camera, there is a major overfold in the marble. The crest of the fold is at an altitude of 525 ft. and the marble outcrop is 70 ft. in vertical thickness where the cliff is silhouetted against the snow. Looking 180°.

e. The outcrop of the hornblende-epidote group in the floor of the cirque on the east side of Fyr Channel. Hornblende-epidote-schists occur in the core of the fold. The outcrop in the foreground is about 12 ft. high. Looking southwards.

f. The outcrop of the hornblende-epidote group in the floor of the cirque on the east side of Fyr Channel. There is a sheared contact between the quartzite on the lower limb (below) and the quartz-epidote-schist (above) in the core of this minor fold. Looking eastwards.

a

b



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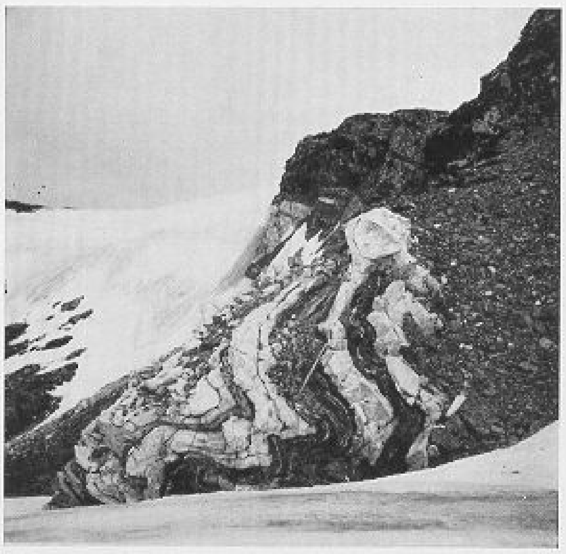

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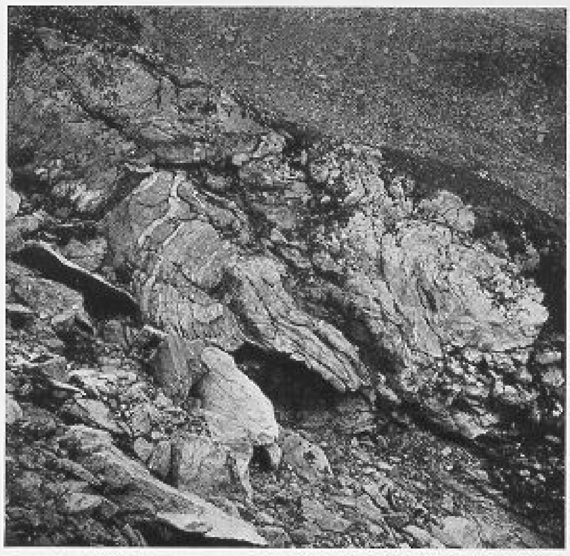

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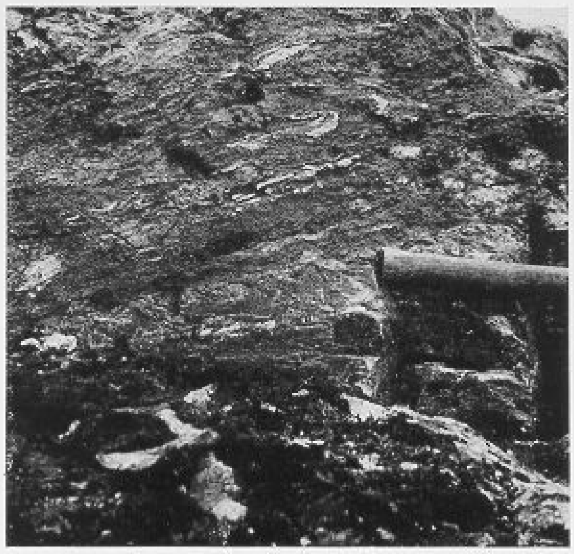

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PLATE V

a. Elongated ridges of marble in the lowland west of Borge Bay, viewed from the ice cap south-east of Jane Peak. The Thule Islands are on the left (bearing 070°) and Berntsen Point is on the right (bearing 115°) behind the boulder-strewn entrance to Elephant Flats. Coronation Island is in the background.

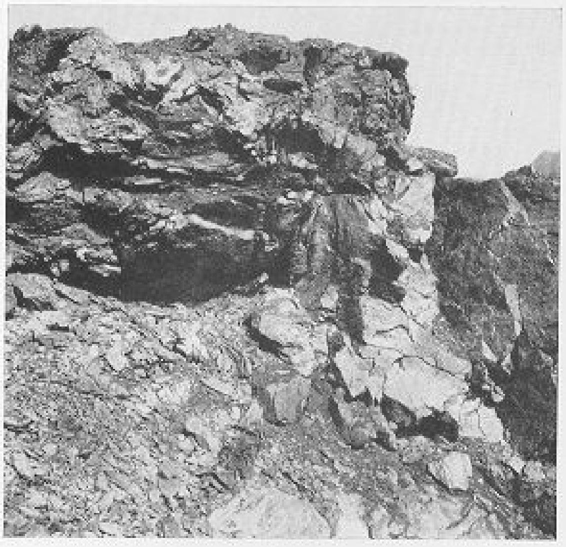
b. Folding in schists of the calc-amphibolite group on the east shore of Cummings Cove, looking southwards. The height of the outcrop is about 20 ft.

c. Overfolded front of the marble ridge which is 60 yd. south-west of Waterpipe Beach, Borge Bay, viewed from the north-east.

d. Small folds in garnetiferous quartz-mica-schists on Berntsen Point, viewed normal to the fold axes.

e. The amphitheatre east of Cummings Cove viewed from the col between the two summits of Gneiss Hills, showing moraine-dammed lakes on the drift-covered floor of the cirque.

a



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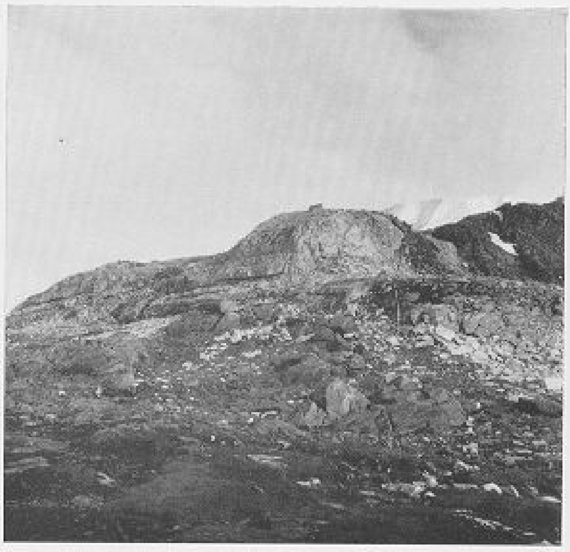

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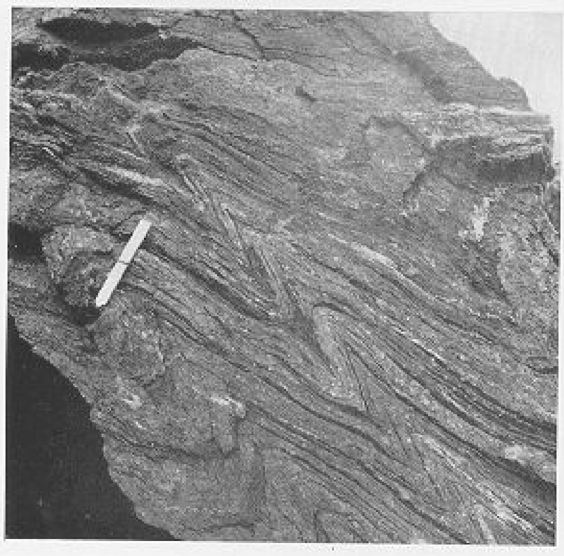

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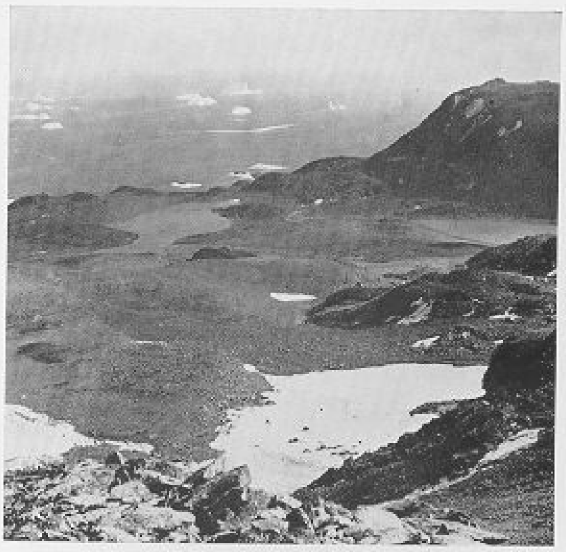

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