GEOLOGY OF THE SHACKLETON RANGE: A PRELIMINARY REPORT

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ABSTRACT. Some of the results of recent reconnaissance geological surveys revise and extend the previous work in the Shackleton Range (Stephenson, 1966). The three previously recognized major rock groups are re-defined and tentatively dated. Suggested regional correlations are reviewed and revised.

The Shackleton Range Metamorphic Complex, comprising schists and gneisses of greenschist to granulite facies, is intruded by a granodiorite dyke dated at 1,446±60 m. yr. (Rex, 1971). The Turnpike Bluff Group (of probable late Precambrian to Cambrian age) is composed of metasedimentary slates and quartzites which are subdivided into the Mount Wegener, Flett Crags, Stephenson Bastion and Wyeth Heights Formations. The Blaiklock Glacier Group, consisting of feldspathic sandstones and some conglomerates, is subdivided into the Mount Provender and Otter Highlands Formations. Erratic blocks, which are presumed to be derived from hidden intermediate strata of the Blaiklock Glacier Group, contain inarticulate brachiopods identified as obolids (Thomson, 1972) of Cambro-Ordovician age. Dolerite dykes were intruded during the Middle Ordovician and the Upper Carboniferous (Rex, 1971).

THE Shackleton Range (lat. 80°07′–80°50′S., long. 31°–19°W.) lies east of the Filchner Ice Shelf at the head of the Weddell Sea. During the Trans-Antarctic Expedition, 1955–58, P. J. Stephenson (1966) made a reconnaissance geological survey of the western part of the range in October 1957. Further geological exploration was carried out during the three summer seasons between November 1968 and January 1971 by field parties from the British Antarctic Survey scientific station at Halley Bay using U.S. Navy air support (Fuchs, 1969, 1970; Clarkson, 1971).

The Shackleton Range (Fig. 1) is an elevated mountain area lying between the major westward-flowing Slessor and Recovery Glaciers (Skidmore and Clarkson, 1972). Its surface relief is greatest in the west and south and decreases eastward to long. 19°W., where it is covered by the Antarctic ice sheet. The dominant feature in the range is a central snow plateau flanked by ice scarps with rock windows. Local drainage glaciers dissect this plateau and it is terminated in the west by Blaiklock Glacier. A pre-glacial peneplain, now largely eroded, is represented by discordant summit plateau levels along the southern side of the range.

STRATIGRAPHY

After the first geological reconnaissance of the western part of the Shackleton Range, Stephenson (1966) was able to distinguish three separate stratigraphical units:

i. Blaiklock Beds; an unmetamorphosed sedimentary sequence.
ii. Turnpike Metamorphics; closely folded and cleaved sedimentary rocks.
iii. Shackleton Metamorphics; intermediate and higher-grade metamorphic rocks.

Recent work and a consideration of more precise stratigraphical terminology (American Commission on Stratigraphic Nomenclature, 1961) have necessitated a re-definition and expansion of these terms (Table I). The Shackleton Range Metamorphic Complex has not yet been examined in sufficient detail for it to be subdivided, although this will probably prove necessary later.

The only observed contacts between the three rock groups are the two unconformities shown in Table I. The stratigraphical relationships between the formations of the Turnpike Bluff Group are tentative, based on lithological and structural evidence, as they are nowhere in contact (Fig. 1) and they are all, except the Mount Wegener Formation, presumed to be in fault contact with the Shackleton Range Metamorphic Complex. In the Blaiklock Glacier Group, the Otter Highlands Formation appears to be conformable with the Mount Provender Formation which in turn rests unconformably on the Shackleton Range Metamorphic Complex. The intermediate strata, presumed to lie beneath Blaiklock and Stratton Glaciers, are known only from erratics.

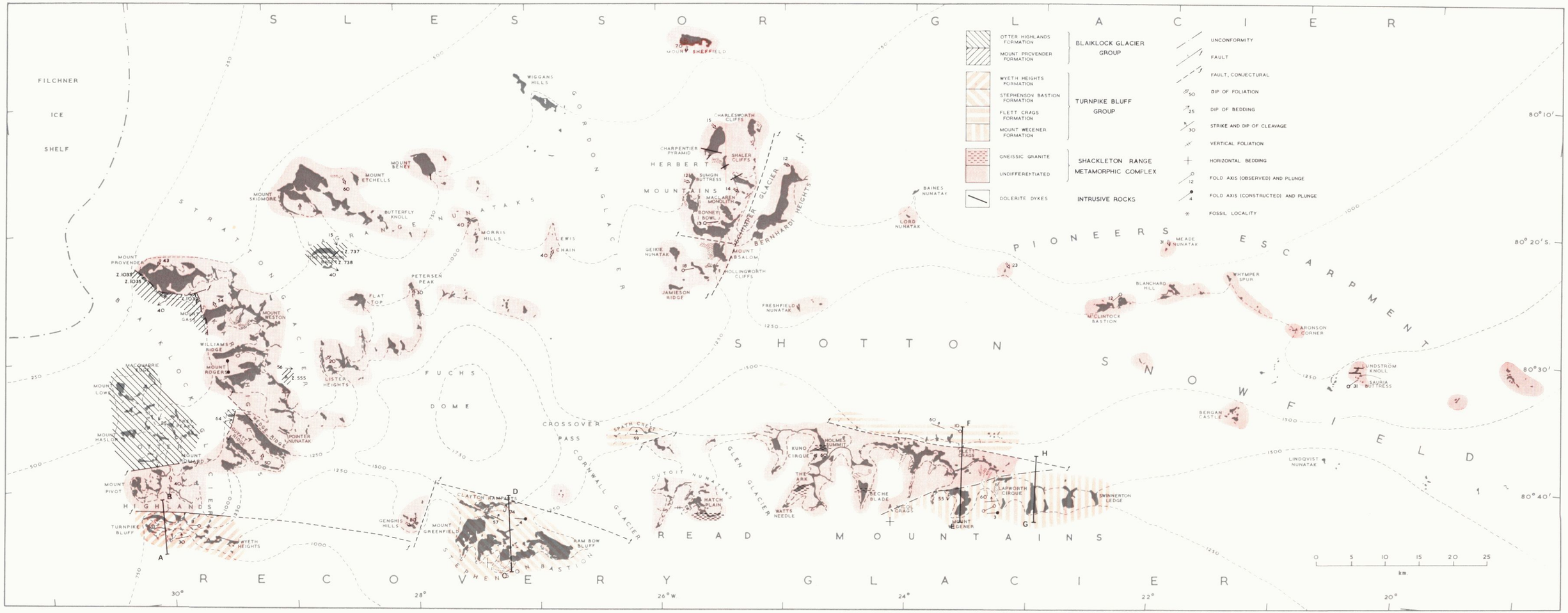

Fig. 1. Geological sketch map of the Shackleton Range, showing the positions of the four cross-sections in Fig. 4.

TABLE I. THE GENERAL STRATIGRAPHICAL SUCCESSION IN THE SHACKLETON RANGE

(The names of the groups and formations given in brackets are the equivalent names used by Stephenson (1966).)

	North-western Shackleton Range		*Thickness* (m.)	*Southern Shackleton Range*			*Thickness* (m.)
Ordovician to Cambrian	**Blaiklock Glacier Group** (*Blaiklock Beds*)	Otter Highlands Formation (*Upper group*)	>5,300				
		Intermediate strata	(?)				
		Mount Provender Formation (*Lower group*)	>760				
(?) Cambrian to late Precambrian						Wyeth Heights Formation	(?)
				Turnpike Bluff Group	(*Turnpike Metamorphics*)	Stephenson Bastion Formation	(?)>2,000
						Flett Crags Formation	(?)>1,500
						Mount Wegener Formation	(?)>2,500
	unconformity			*unconformity*			
Middle Precambrian	**Shackleton Range Metamorphic Complex**			(*Shackleton Metamorphics*)			

Shackleton Range Metamorphic Complex

The Shackleton Range Metamorphic Complex (named for its occurrence in the Shackleton Range) is exposed throughout the range except in the north-west and along parts of the southern margin. It forms the metamorphic basement of the range and its metamorphic grade ranges from greenschist to granulite facies (Turner and Verhoogen, 1960) with large areas of migmatization. The structural trend of the complex is predominantly west–east but, whereas some areas are strongly folded, others are relatively undisturbed.

The highest-grade metamorphic rocks, associated with granitic stocks and migmatites, occur along the southern part of the range from the central Otter Highlands through Fuchs Dome to the Dutoit Nunataks and the western Read Mountains. The dioritic gneisses, which are pale to dark in colour with a medium to coarse grain-size, have a strong foliation with orientated hornblende and biotite crystals. Garnetiferous varieties are common and those at Mount Provender contain garnet crystals up to 5 cm. in diameter. Pale-coloured granitic gneisses with a medium to coarse grain-size and a poor foliation are also widespread. These dioritic and granitic gneisses are frequently mixed to form migmatites, particularly along the southern parts of the range (Fig. 2).

Large granitic bodies of probable metamorphic origin, here termed gneissic granites, are found in the Dutoit Nunataks and the western Read Mountains. The two largest of these gneissic granite bodies form the 5 km. long southern scarp of Hatch Plain and 2 km. of the ridge between The Ark and Watts Needle. Much of the country rock around the latter is cut by granitic veins, 4 m. or more wide, forming *lit-par-lit* intrusions and joint-controlled injection gneisses. Some veins have sharp contacts with slightly chilled margins possibly indicating late syn-metamorphic intrusion. A buttress of gneissic granite in the escarpment north-west of Holmes Summit contains a xenolith of dioritic gneiss surrounded by a narrow metamorphic aureole. Pegmatite veins are rare.

Augen-gneiss, often migmatized by granitic veins, occurs at several localities in the western Read Mountains, and at Beche Blade it is closely associated with gneissic granite. On the ridge between Glen Glacier and Kuno Cirque, augen-gneiss is separated from dioritic gneiss by a thrust zone marked by a 1 m. thick mylonite. Pyroxene-gneisses are probably restricted to the Dutoit Nunataks, although these may be equivalent to a pyroxene-schist south of Mount Provender (Stephenson, 1966).

Calcareous metamorphic rocks are common in the central and northern Haskard Highlands, Lagrange Nunataks, Herbert Mountains and Pioneers Escarpment. They include metalimestones, marbles and calcareous schists.

Grey, fine-grained metamorphic limestones, composed largely of calcite with some tremolite, occur south-east of Butterfly Knoll. On the southern nunatak of Lewis Chain they are associated with white saccharoidal calcite-marbles and the lowest horizon is a brecciated limestone which may overlie a fault zone. At the southern end of Bernhardi Heights in the Herbert Mountains is an 800 m. thick sequence of alternating grey limestones and dark green or black amphibolites. Massive marbles occur at several localities, usually adjacent to gneisses. At Pointer Nunatak a cream marble is interleaved with granitic gneiss and at Mount Provender bands of marble are interbedded with dioritic gneiss. Between Mount Skidmore and Mount Etchells, a cream and green diopside-chrysotile-marble is surrounded by gneisses and amphibolites. An isolated body of tightly folded white marble with infolded bands and lenses of amphibolite forms Hollingworth Cliffs in the southern Herbert Mountains.

In the Haskard Highlands, from Mount Rogers to Williams Ridge, alternating calcareous schists and hornblende-schists are the major rock types. Calcareous schists are also common in the Herbert Mountains, particularly at Sumgin Buttress, and they probably form many of the outcrops along Pioneers Escarpment not yet visited.

Hornblende-amphibolites are common in many central and northern parts of the range; they are often interbedded with calcareous rocks but also frequently occur as lenses and bands in schists and gneisses. South of Sumgin Buttress, 300 m. of alternating massive amphibolites and garnet-amphibolites overlie calcareous schists. These rocks appear to be *para*-amphibolites representing iron- and magnesium-rich limestones, particularly where they alternate with metalimestones as at Bernhardi Heights, but some occurrences may be *ortho*-amphibolites.

Fig. 2. Migmatite in the Shackleton Range Metamorphic Complex on the west side of Stratton Glacier north of Pointer Nunatak. The hammer shaft is 36 cm. long.

Quartz-schists are present in many areas, particularly in the Herbert Mountains, but quartzites are comparatively rare. A distinctive green (fuchsite mica) quartzite first noted at Sauria Buttress on Pioneers Escarpment also occurs on Shaler Cliffs and at Mount Beney.

Garnet-mica-schists are common in the central Herbert Mountains. Friable schists with white mica and small garnets crop out on MacLaren Monolith and nearby ridges, and those with golden biotite and large garnets (1·0–1·5 cm. in diameter) also occur on Mount Etchells and at Blanchard Hill on Pioneers Escarpment. Sillimanite-, staurolite- and kyanite-schists are comparatively rare.

The Shackleton Range Metamorphic Complex appears to have been a thick pile of sedimentary rocks, many of them calcareous, which have been regionally metamorphosed. The grade of metamorphism is greatest along the southern parts of the range and decreases northwards as the rocks become more calcareous. An overall west–east structural trend is maintained and as yet no evidence of polymetamorphism has been observed.

Age and correlation

An undeformed granodiorite dyke intruding the gneissic granite on the south side of Hatch Plain has been dated at 1,446±60 m. yr. (Rex, 1971). A chilled margin to the dyke indicates that it cannot be older than the metamorphism, although it may be considerably younger. Thus, the last metamorphism of the complex is probably earlier than 1,446±60 m. yr. Apart from a dolerite dyke dated at 457±18 m. yr. (Rex, 1971) intruding schists at Lundstrom Knoll, no other age determinations are available for the complex.

The nearest similar rocks are found in Heimefrontfjella in western Dronning Maud Land (Worsfold, 1967; Thomson, 1968; Juckes, 1969) and in areas farther east (Roots, 1953, 1969). Detailed comparison between these rocks and those of the Shackleton Range is not possible at present but it seems likely that the Shackleton Range Metamorphic Complex represents part of the Antarctic shield.

Turnpike Bluff Group

The Turnpike Bluff Group (named for its occurrence at Turnpike Bluff, lat. 80°44′S., long. 30°10′W., where it was first described by Stephenson (1966)) is exposed in four principal areas along the south side of the Shackleton Range. The group consists mainly of quartzites and slates with minor conglomerate, sandstone and limestone horizons; it is of unknown thickness. As accurate correlation between the four areas is not possible, the group has been divided into four formations (Table I).

Mount Wegener Formation

Type locality. The westernmost ridge (from its foot to the summit plateau) of Mount Wegener, lat. 80°43′S., long. 23°40′W.

The Mount Wegener Formation is exposed on Nicol Crags and most outcrops farther east in the Read Mountains. At Nicol Crags up to 12 m. of horizontally bedded quartzite with some thin purple shales rest unconformably on gneisses of the Shackleton Range Metamorphic Complex. At the north-west corner of Mount Wegener (the type locality), a similar quartzite with shales overlies gneisses but it dips at 45° to the south (Fig. 3a). Contrary to an earlier report (Clarkson, 1971), the contact is primarily unconformable although there is evidence of minor thrusting. Above the lowest 75 m. of metasedimentary rocks (quartzites, sandstones and limestones) is an unknown thickness of folded strata. Thick competent beds of quartzite are broadly and recumbently folded (Fig. 3b), whereas the fine-grained sandstones have been tightly folded and have developed a slaty cleavage. Farther east of Mount Wegener, on the east side of Lapworth Cirque, occasional beds of pebbly conglomerate are assumed to be higher in the succession. These beds are also relatively competent and are not tightly folded. The top of the Mount Wegener Formation is not known but this formation is probably at least 2,500 m. thick.

Flett Crags Formation

Type locality. Flett Crags, lat. 80°39′S., long. 23°40′W.

The Flett Crags Formation is exposed in the nunataks north of the escarpment of the Read Mountains. A snow col in Flett Crags divides slates to the north from red granitic gneisses of the Shackleton Range Metamorphic Complex to the south. The contact is presumably a fault, relatively down-thrown to the north, but the type of faulting is uncertain. The formation consists mainly of slate with some competent bands of pebbly conglomerate and quartzite. The slates are usually tightly folded but the conglomerates and quartzites are virtually unaffected and dip steeply to the north, sub-parallel to the cleavage. The thickness of the formation is not known (but probably exceeds 1,500 m.) and the top presumably lies beneath Shotton Snowfield to the north. The presence of pebbly conglomerates and the relative absence of quartzites suggest that part of the formation may be equivalent to the upper part of the Mount Wegener Formation. An outlier of slate at Spath Crest cannot be reliably assigned to a particular formation but, because of its geographical position, it probably belongs to the Flett Crags Formation.

a

b

c

d

Fig. 3. a. A view eastward along the unconformity between shale and quartzite of the Mount Wegener Formation (W) and gneiss of the Shackleton Range Metamorphic Complex (S) at the north-west corner of Mount Wegener.
b. A major overfold in quartzite of the Mount Wegener Formation in the west face of Mount Wegener.
c. Slaty cleavage and original bedding in slate of the Stephenson Bastion Formation at the north-west corner of Mount Greenfield.
d. Massive quartzites of the Stephenson Bastion Formation in the western part of Stephenson Bastion. The exposed cliffs are approximately 80 m. high.

Stephenson Bastion Formation

Type locality. A north–south section across the col between Clayton Ramparts and the north-east corner of Mount Greenfield, lat. 80°44′S., long. 27°25′W.

The Stephenson Bastion Formation is exposed throughout Stephenson Bastion. The lowest bed of the formation is a metamorphosed pebbly conglomerate which forms Clayton Ramparts. It dips steeply northward and false-bedding structures indicate that it is overturned. Stratigraphically above this conglomerate (to the south) a pale quartzite and a thick sequence of tightly folded slates is exposed across a col below Clayton Ramparts (Fig. 3c). Above the slates is a thick (about 600 m.) sequence of sub-horizontal quartzites with some slaty horizons which forms a tabular massif between Ram Bow Bluff and Mount Greenfield (Fig. 3d). The presence of a single conglomeratic horizon at the base of the formation suggests a correlation with the highest pebbly conglomerate of the Flett Crags Formation, and the absence of such a thick sequence of quartzites in both the Flett Crags and Mount Wegener Formations probably indicates that the Stephenson Bastion Formation is younger than both of them. The total thickness of the formation is unknown but it probably exceeds 2,000 m.

Wyeth Heights Formation

Type locality. The south-west face of Turnpike Bluff, lat. 80°44′S., long. 30°10′W.

The Wyeth Heights Formation is exposed between Turnpike Bluff and Wyeth Heights. This formation comprises approximately equal amounts of slate and quartzite with some gradational interbedding as quartzose siltstones. Folding is ubiquitous and no estimate of the thickness can be made. The northern (upper) boundary of the formation lies beneath a snow col and it is presumed to be a west–east fault against the Shackleton Range Metamorphic Complex; the southern (lower) boundary lies beneath Recovery Glacier. The absence of conglomeratic horizons and of a great thickness of quartzite distinguish this formation from all other formations in the group so that the Wyeth Heights Formation is presumed to be the youngest formation of the Turnpike Bluff Group.

Structure

The structure of the Turnpike Bluff Group is complex, but fold axes (both observed and constructed) trend approximately east–west with a tendency to plunge slightly westward. These fold plunges indicate that the youngest strata occur in the Wyeth Heights Formation which agrees with the tentative stratigraphical younging direction (Fig. 4). However, as no way-up criteria were observed in the Flett Crags Formation, it is possible that this formation is overturned and is structurally equivalent to the rocks forming Clayton Ramparts.

Age and correlation

No direct age data, either radiometric or palaeontological, are available for the Turnpike Bluff Group as neither intrusions nor fossils have been found. However, this group rests unconformably on the Precambrian Shackleton Range Metamorphic Complex and it is presumed to be older than the Cambro-Ordovician Blaiklock Glacier Group (p. 9) by contrast with the relatively undisturbed nature of the latter. Thus, on purely negative evidence, the Turnpike Bluff Group is probably late Precambrian in age and may even be Cambrian in part.

Regional correlations have been attempted by several authors, and Craddock (1970*c*) has included the whole of the Shackleton Range within the margins of the "Ross orogen" along the Transantarctic Mountains. Gunn (1963) tentatively included the Turnpike Bluff Group in the "Ross System" [Ross Supergroup] and the group is lithologically similar to the Goldie Formation of the Beardmore Group (Gunn and Walcott, 1962; Laird, 1963), which resembles the Duncan Formation at the base of the Ross Supergroup in the Queen Maud Range (McGregor, 1965). In the Pensacola Mountains, Schmidt and others (1964) described similar tightly folded rocks of the Patuxent Formation, which Williams (1969) compared with the Turnpike Bluff Group, although the latter are more quartzose. Nelson and others (1967) suggested that the equivalent of the Patuxent Formation may occur in the core of the Ellsworth

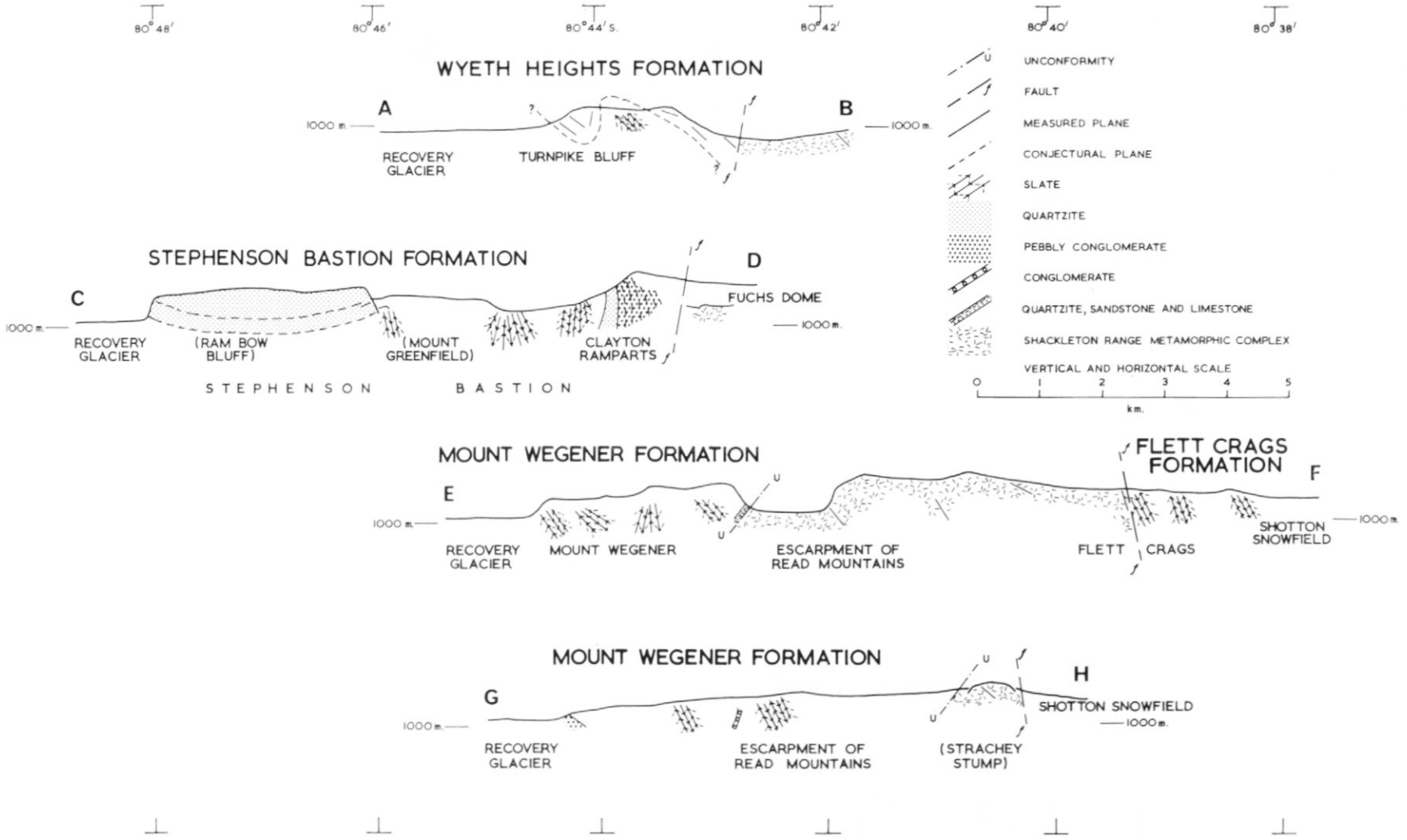

Fig. 4. Compo[illegible] south–north cross-sections through the Turnpike Bluff Grou[illegible] The positions of the sections are shown [illegible] Fig. 1.

Mountains so that the "lower group" (Craddock and others, 1964, p. 161) may be equivalent to the Turnpike Bluff Group.

However, if the Turnpike Bluff Group is a representative of the Ross Supergroup, its structural trend at right-angles to the "Ross orogen" is difficult to explain. This trend is similar to that in the Heritage Range of the Ellsworth Mountains which was affected by the "Ellsworth orogen" (Craddock, 1970*c*), but the orogenic belt swings parallel to the trend of the "Ross orogen" farther east as is shown by the trend in the Pensacola Mountains. Thus, at present, no reliance can be placed on the regional correlatives of the Turnpike Bluff Group, although lithologically comparable rocks have been described from other areas.

Blaiklock Glacier Group

The Blaiklock Glacier Group (named for its occurrence either side of Blaiklock Glacier) is exposed in the north-west part of the range in the Otter and Haskard Highlands, and in and alongside Stratton Glacier. This group, comprising a thick sequence of sandstones with some conglomerates, is subdivided into the Otter Highlands and Mount Provender Formations.

Mount Provender Formation

Type locality. The outcrop through the moraine west of Mount Provender, lat. 80°24′S., long. 30°05′W.

The Mount Provender Formation crops out through the moraine west of Mount Provender, in a small nunatak between Mount Provender and Mount Gass, and on the western end of Mount Gass.

At the type locality the formation rests unconformably on marbles and gneisses of the Shackleton Range Metamorphic Complex. At station Z.1033 the basal member is a sedimentary breccia or conglomerate with blocks of white marble and dark green gneiss up to 0·8 m. in diameter embedded in a purple-red matrix (Fig. 5); these blocks resemble the underlying

Fig. 5. Conglomerate of the Mount Provender Formation just above the unconformity with the Shackleton Range Metamorphic Complex at station Z.1033, 2 km. west of Mount Provender. (Photograph by R. B. Wyeth.)

basement rocks. About 100 m. farther south, at station Z.1035, the basal member comprises thinly interbedded red-grey slates, shales and coarse sandstones. At station Z.1039, between Mount Provender and Mount Gass, pebble-conglomerates with a red matrix grade upward into red-grey and green-grey grits. This crag is traversed by a small west–east fault with a downthrow to the south, and south of the fault no conglomeratic beds were observed. At the western end of Mount Gass, red-grey well-bedded sandstones with some pebbly beds abut against schists of the Shackleton Range Metamorphic Complex.

A nunatak (station Z.555) in Stratton Glacier, between Mount Rogers and Lister Heights, is composed of red-grey micaceous shales and minor quartzose pebble beds with a red matrix. These rocks have a closely similar lithology to those at Mount Provender and Mount Gass (see above) and they are presumed to belong to the Mount Provender Formation. No other outcrops of the Mount Provender Formation are known.

The contact between the Mount Provender Formation and the underlying Shackleton Range Metamorphic Complex is nowhere well exposed but Stephenson (1966, p. 38) considered it to be an unconformity except on the south side of Mount Gass, where his geological map (map 2, facing p. 16) indicates a fault. However, R. B. Wyeth (personal communication) concluded that this contact is an unconformity throughout because of the parallelism between the contact and the bedding in the overlying strata and because of the absence of any evidence of faulting, e.g. a fault breccia or fault-plane erosion. The irregular distribution of conglomerates and fine-grained sandstones near the contact may be due partly to the distance of the outcrops from the original shoreline and partly to deposition of conglomerate in localized channels in otherwise fine-grained sandstones.

Otter Highlands Formation

Type locality. The north-east face of MacQuarrie Edge, lat. 80°32′S., long. 30°03′W.

The Otter Highlands Formation is exposed in the northern part of the Otter Highlands north of lat. 80°39′S. The lowest beds of the formation are exposed at MacQuarrie Edge and Trey Peaks but the base lies beneath Blaiklock Glacier. The highest beds of the formation are exposed on Mount Haslop and on a ridge to the south, but the top of the formation is not known. The southern extent of the formation is presumably limited by a west–east fault, down-thrown to the north, between Mount Pivot and Mount Homard.

The majority of the sediments form a monotonous sequence of hard, grey-green feldspathic grits and sandstones; the paler horizons are more feldspathic, the darker horizons contain concentrations of heavy minerals, and both flaggy and massive beds occur. Intraformational folding is common but small folds are often confused by current- and false-bedding structures. In addition to grits and sandstones, the lowest members of the formation comprise compact even-bedded conglomerates with pebbles and small boulders of metamorphic rocks (mostly quartzites), thin beds of micaceous shales and sandstones and, at the bottom of the sequence, thick beds of calcareous grits and sandstones (Fig. 6).

A small outcrop at the north-west end of Wedge Ridge is composed of coarse conglomerate, consisting of metamorphic and sedimentary boulders in a reddish matrix, with beds of greenish sandstone and grit. The contact with the schists of Wedge Ridge is obscured by debris but it trends approximately north–south and is presumed to be a fault, down-thrown to the west. As these beds are lithologically comparable with those of MacQuarrie Edge, they are assigned to the Otter Highlands Formation.

The sedimentary rocks at The Dragons Back are composed of grey-green and purplish quartzo-feldspathic sandstones. Two small nunataks nearby are of paler, more feldspathic sandstone with some pebbly horizons (station Z.737) and a darker, fine-grained fissile sandstone (station Z.738). These rocks are lithologically comparable with the majority of the sandstones of the Otter Highlands and are included in the Otter Highlands Formation. No other sedimentary outcrops east of Stratton Glacier are known.

Thickness and structure

The maximum exposed thickness of the Mount Provender Formation is approximately 760 m. at the western end of Mount Gass but, as the top of the formation is not seen, this must be

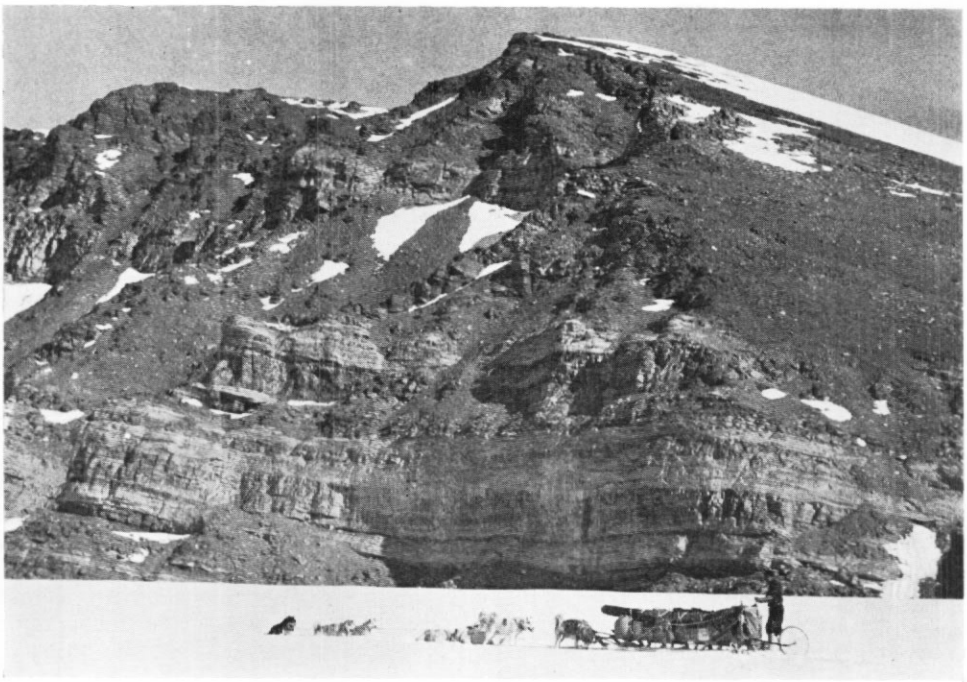

Fig. 6. The lowest exposed part of the Otter Highlands Formation in the north-east face of MacQuarrie Edge. (Photograph by R. B. Wyeth.)

a minimum thickness. The estimated thickness of the Otter Highlands Formation, discounting any major faulting which might be present, is approximately 5,300 m., which must be a minimum figure as neither the top nor the bottom of the formation is exposed.

The outcrops to the west of the Haskard Highlands dip to the south-west, whereas those to the east dip towards the south-east (Fig. 1), thereby possibly representing the limbs of an anticline plunging gently southwards. However, the simplicity of such a structure is probably modified by faulting which was not observed in the field.

Intermediate strata

Fossiliferous erratics of silty shale found in the moraine south of Mount Provender were assigned by Stephenson (1966, p. 39) to intermediate strata of the Blaiklock Glacier Group supposedly concealed beneath Blaiklock Glacier. This rock type has not been found *in situ* in the Shackleton Range but its nearest lithological equivalents are found among the sandstones of the Blaiklock Glacier Group. The importance of these erratics is their content of inarticulate brachiopods which represent the only fossils found in the Shackleton Range. The preservation of the material suggests that it is not far-travelled but its origin is unknown. However, it is not unreasonable to suppose that it belongs to the Blaiklock Glacier Group and, by structural inference, that the parent strata may lie beneath Blaiklock and Stratton Glaciers.

Age and correlation

No direct age data are available for the Blaiklock Glacier Group, although the Mount Provender Formation rests unconformably on the Precambrian Shackleton Range Metamorphic Complex. It is presumed to be younger than the Turnpike Bluff Group because of the more complex structure of the latter. A dolerite dyke intruding the Otter Highlands Formation at The Dragons Back has been dated at 297 ± 12 m. yr. (Rex, 1971), so that these rocks cannot be younger than Upper Carboniferous. The inarticulate brachiopods from erratic blocks have

been identified as obolids (Thomson, 1972), possibly belonging to the genus *Lingulella* which ranges in age from Lower Cambrian to Middle Ordovician. Thus, the age of the Blaiklock Glacier Group is most likely Lower Palaeozoic and probably Cambro-Ordovician, if the source of the erratic material has been correctly inferred.

The age and correlation of the Blaiklock Glacier Group has been problematical since its discovery in 1957. Stephenson (1966, p. 18) tentatively assigned this group to the Permian but later in the same paper he contrasted the group, on lithological and structural grounds, with the sedimentary rocks of the Beacon Supergroup (Devonian–Jurassic) in the adjacent Theron Mountains and Whichaway Nunataks, and suggested that they may well have been appreciably different in age (Stephenson, 1966, p. 42). Williams (1969) compared the Dover Sandstone (and possibly the Heiser Sandstone and the Elbow Formation) of the Neptune Range in the Pensacola Mountains with the Blaiklock Glacier Group, but the age (? Middle Palaeozoic) of these formations may be rather younger than the Blaiklock Glacier Group. Nelson and others (1967) suggested a comparison between the Lower Palaeozoic rocks of the Neptune Range and the rocks of the Ellsworth Mountains (presumably the Crashsite Quartzite) so that the latter may be equivalent to the Blaiklock Glacier Group. Although Craddock (1970*b*), on a composite geological map of the continent, tentatively included the Blaiklock Glacier Group with Upper Precambrian sedimentary and volcanic rocks of the Ellsworth Mountains, the Transantarctic Mountains and eastern Antarctica, this age seems to be too great for the Blaiklock Glacier Group and there does not appear to be a Palaeozoic equivalent in the Transantarctic Mountains.

In western Dronning Maud Land, Roots (1953) described slightly metamorphosed sedimentary and volcanic rocks of local origin. These rocks overlie basement rocks in the area of Borgmassivet and Ahlmannryggen but Roots gave no indication of their age. Neethling (1969) re-examined this area and described an upper sedimentary volcanic unit comprising "boulder-pyroclastic beds, intercalated andesitic volcanics and well-bedded arenaceous sediments. . . . The occurrence of algae (*Rifenites*) (Klimov *et al.*, 1964) dates these upper sediments, at least in part, as Late Precambrian or possibly Palaeozoic in age." (Neethling, 1969, p. 1156). Later, Roots (1969) named these rocks the Ahlmannrygg Group and suggested the same age as Neethling. South of Borgmassivet, at the south-western end of Kirwanveggen, the Urfjell Group has been correlated (Aucamp and others, 1971) with the post-Patuxent rocks (Nelson Limestone to Dover Sandstone) of the Pensacola Mountains and possibly the Blaiklock Glacier Group.

In general, correlation of all these rocks is difficult because of the relative lack of age data (both radiometric and palaeontological), the separation of the exposures and the frequently local origin of the sediments. The clastic content of the Blaiklock Glacier Group indicates a metamorphic source, the nearest and most obvious being the Shackleton Range Metamorphic Complex; like the sequences described by Roots (1953, 1969) and Neethling (1969) it may also be local in extent. Furthermore, the most likely equivalent formations contain volcanic units which are notably absent from the Blaiklock Glacier Group. However, it would appear that the closest equivalents of the Blaiklock Glacier Group are the Lower Palaeozoic rocks of the Neptune Range in the Pensacola Mountains and the Urfjell Group in Kirwanveggen.

Basic Intrusive Rocks

Dolerite dykes are known only along the northern parts of the Shackleton Range; between Mount Provender and Mount Gass, at The Dragons Back, Mount Beney, Charpentier Pyramid, Shaler Cliffs (Fig. 7), Bergan Castle and Lundstrom Knoll. Most of these rocks are medium-grained dolerites with altered pyroxene, although some of the narrower dykes are fine-grained. They show no general trend and only crop out over short distances. Two generations of intrusion have been recognized by K-Ar dating (Rex, 1971): 457 ± 18 m. yr. at Lundstrom Knoll in schists of the Shackleton Range Metamorphic Complex and 297 ± 12 m. yr. at The Dragons Back in an outlier of the Blaiklock Glacier Group. As yet, no correlation between the dated and undated dolerites has been made.

These two ages correspond to other isotopically determined events in western Dronning Maud Land, as shown by Picciotto and Coppez (1964), Picciotto and others (1964) and Ravich and Krylov (1964), and summarized by Craddock (1970*a*), but none of the determinations was

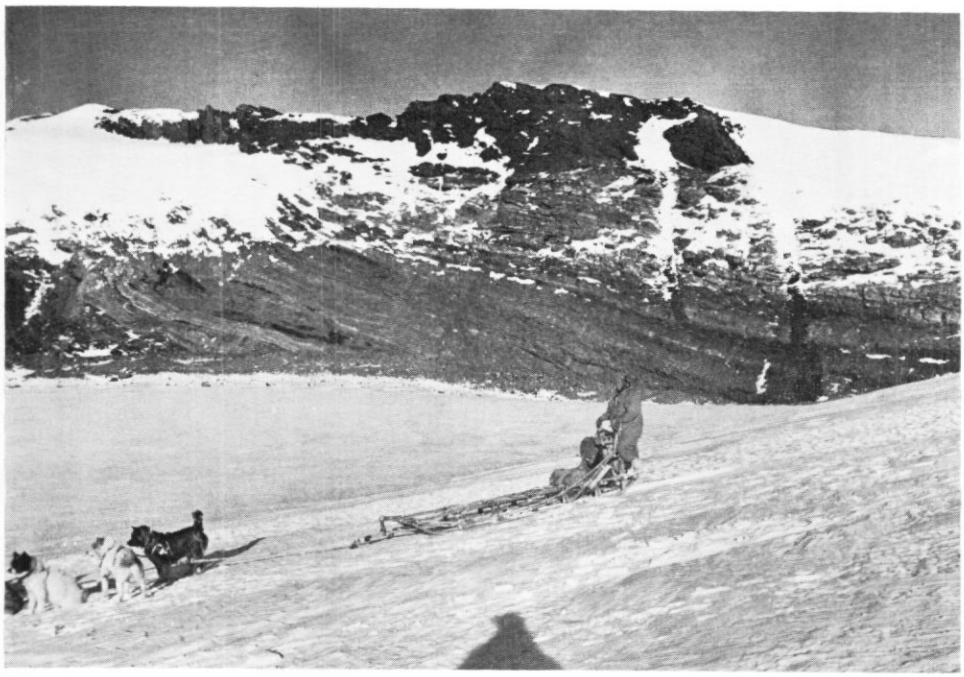

Fig. 7. A view east of twin dolerite dykes (right) intruding schists of the Shackleton Range Metamorphic Complex at Shaler Cliffs, Herbert Mountains.

made on dolerites. Thus, the present lack of further age data prevents any reliable conclusions being drawn.

Geological History

The Shackleton Range Metamorphic Complex represents a thick pile of sediments, partly calcareous, which was regionally metamorphosed during the Precambrian prior to the intrusion of a granodiorite dyke dated at 1,446±60 m. yr. (Rex, 1971). The major west–east structural trend of the range probably resulted from tectonic activity during this metamorphism. After an unknown interval of time a thick sequence of arenaceous sediments was deposited and folded along west–east axes by late Precambrian or Cambrian times to form the present Turnpike Bluff Group. The Blaiklock Glacier Group of quartzo-feldspathic sandstones was deposited in the north-west part of the range, probably during Cambro-Ordovician time, and later tilted to the south-west or possibly anticlinally folded about a north–south axis. Dolerite dykes were intruded during the Middle Ordovician and Upper Carboniferous.

A peneplain, preserved as summit plateaux in the southern parts of the range (Skidmore and Clarkson, 1972), was presumably cut after the deposition of the Blaiklock Glacier Group but its age is unknown. Consequently, it is also not known whether the range was a ridge during the Permian, when local representatives of the Beacon Supergroup were deposited in the nearby Theron Mountains and Whichaway Nunataks, or whether it has been subsequently upthrust and all later strata removed by the erosion cycle which cut the peneplain.

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