Geology of the Western Queen Maud Mountains

V. R. McGregor[1] and F. A. Wade[2]

Introduction

The western Queen Maud Mountains are topographically and geologically part of the Transantarctic Mountains and show many similarities to the mountains to the northwest and southeast. They lie between the Ross Ice Shelf to the northeast and the polar plateau to the south. The mountains within 20 to 55 km of the remarkably straight coast have angular forms typical of glaciated terrain, are rarely much higher than 2000 m, and are composed of metasedimentary and plutonic rocks. Behind them, impressive, commonly flat-topped mountains of gently-dipping sedimentary rocks and diabase sills rise to more than 4000 m. The mountains decrease in elevation southwest of the higher peaks and disappear beneath the ice of the polar plateau at elevations of 2600 to 2800 m. Several large glaciers from the polar plateau cut through the range. The Beardmore Glacier is the largest, and the Mill Glacier—a tributary of the Beardmore—and the Ramsey, Shackleton, Liv, and Bowman Glaciers are also important. Rock exposures are abundant near the mouth of the Beardmore Glacier, between the Keltie Glacier and the polar plateau, near the head of the Ramsey Glacier, along the sides of the Shackleton Glacier and its tributaries, and in the coastal mountains between the Shackleton and Strom Glaciers. Elsewhere there are extensive areas with few outcrops.

The geology of the map area has been studied by members of nine expeditions. In 1911, Amundsen's South Pole Party collected about twenty rock specimens from Mt. Betty, at the mouth of the Strom Glacier. The specimens were described by Schetelig (*1915*). In the summer of 1929-1930 a geological party from the first Byrd Antarctic Expedition briefly examined the coastal mountains between the Liv and Axel Heiberg Glaciers (Gould, 1931 and 1935), and collected some specimens which were described by Stewart (1934a, b, and c). Systematic mapping in the Queen Maud Mountains began when the 1959-1960 New Zealand Alpine Club Expedition under R. W. Cawley worked in the area around the Hood Glacier, east of the mouth of the Beardmore Glacier (Oliver, 1964a and c). The 1961-1962 New Zealand Southern Field Party led by W. W. Herbert traveled through the southern part of the map area; most of the party's geological work was done in the area around the Mill and Keltie Glaciers (Grindley *et al.*, 1964; McGregor, 1965a). In the same summer United States parties made geological observations in the course of other work in the northern part of the Dominion Range (Oliver, 1964b) and at the mouth of the Liv Glacier (Linder *et al.*, 1965). The Texas Technological College Field Party led by F. Alton Wade studied the northern part of the Shackleton Glacier area in 1962-1963, and in 1964-1965 used helicopters to extend their investigations over the entire central part of the map area. The 1963-1964 New Zealand Southern Field Party under V. R. McGregor examined the geology of the coastal ranges between the Axel Heiberg and Shackleton Glaciers (McGregor, 1965b; Barrett, 1965).

Stratigraphy

Three major rock units are exposed in the western Queen Maud Mountains: (1) an upper Precambrian and lower Paleozoic basement complex of metasedimentary and intrusive igneous rocks, (2) a cover of gently dipping upper Paleozoic and lower Mesozoic strata intruded by great quantities of Jurassic tholeiitic diabase and overlain by comagmatic flood basalts, and (3) young glacial deposits.

Two areally and lithologically distinct units of metasediments are present in the basement complex. Between the Beardmore and Kosco Glaciers all the metasediments belong to a metagraywacke sequence which has a minimum thickness of 3300 m. This unit is very similar in lithology to the upper Precambrian Goldie Formation of the Beardmore Group which crops out west of the Beardmore Glacier (Gunn and Walcott, 1962), and it is therefore proposed to include it in the Goldie Formation. The Duncan Formation, which crops out between the Liv and Strom Glaciers, is a thick unit of dark pelitic hornfels and schist and is tentatively correlated with the Goldie Formation.

The Taylor Formation comprises a thick sequence of quartzite, calcareous quartzite, marble, and felsic volcanics which crops out between the Kosco and Gough Glaciers. It is thought to be younger than the Goldie Formation. The Fairweather Formation and overlying Henson Marble crop out on both sides of the Liv and Strom Glaciers and are more strongly metamorphosed than the Taylor Formation, with which they are tentatively correlated. The Fairweather Formation has a strong cataclastic texture, and its original lithology is uncertain; it may have been derived from porphyritic, felsic, igneous rocks. The Taylor and Fairweather Formations and Henson Marble are tentatively correlated with the Lower to Middle (?) Cambrian Byrd Group of the area between the Byrd and Beardmore Glaciers (Laird, 1963). No contact between the Taylor and Goldie Formations is known, and at the only locality where the Fairweather Formation has been seen in contact with the Duncan Formation the rocks are strongly deformed schists and the stratigraphic relation between the two formations is uncertain. The metamorphic grade of the metasediments reaches hornblende-hornfels facies in the area around the Liv and Strom Glaciers and at the mouth of the Hood Glacier; elsewhere it may be low greenschist facies.

The metasediments have been invaded by large volumes of calc-alkaline intrusive rocks correlated with the Granite Harbour Intrusives of Victoria Land (Gunn and Warren, 1962; Grindley and Warren, 1964) and dated radiometrically as Ordovician to Silurian (McDougall and Grindley, 1965; Wade *et al.*, 1965). Granodiorite and adamellite are most abundant, but there is also some hornblende gabbro, diorite, and granite. The more calcic plutons are mainly older than the less calcic ones. Most of the intrusive rocks make up a large composite batholith, the Queen Maud Batholith, which extends almost continuously across the whole area where the basement complex crops out from the western side of the Beardmore Glacier to beyond the eastern edge of the map area. Small plutons of fine-grained tonalite and adamellite, the latter lithologically similar to the Hope Granite of the area west of the Beardmore Glacier (Gunn and Walcott, 1962; Grindley, 1963), cut the metasediments adjacent to the batholith in the eastern Duncan Mountains and elsewhere. Felsic dikes are abundant, and metamorphosed mafic dikes are common in some places.

The basement complex is truncated by a gently dipping erosion surface or peneplain which has a maximum observed local relief of about 3 m. The peneplain is overlain by at least 1800 m of continental and possibly some near-shore marine sediments, all correlated with the Beacon Group (Grindley, 1963; Grindley and Warren, 1964). The Beacon and Ferrar Groups sequence in the western Queen Maud Mountains closely resembles the one in the Queen Alexandra Range on the western side of the Beardmore Glacier (Grindley, 1963). Therefore, formation names used here are those introduced by Grindley for the Queen Alexandra Range.

In the Shackleton Glacier area the oldest Beacon unit is 62 m of gray to buff conglomerate, quartzitic sandstone, and conglomeratic quartzite. East of the Shackleton area the oldest Beacon strata are thin conglomeratic beds, probably tillite and glaciofluvial gravels, which fill depressions in the peneplain. The Mackellar Formation rests conformably on both the quartzites in the Shackleton area and the glacial conglomerates in the area to the east. It consists of as much as 140 m of dark, lacustrine sediments, mainly shale. The Mackellar Formation is overlain by some 650 m of the Buckley Coal Measures, which consist of about 200 m of lacustrine sandstone overlain—in many places unconformably—by fluviatile sediments. The upper part of the formation is a cyclic sequence of alternating sandstone and carbonaceous shale. In the Keltie Glacier area the Buckley Coal Measures contain coal seams as thick as 9 m and at least one good *Glossopteris* floral assemblage. Farther east, coaly strata are less common, and only poorly preserved fragments of glossopterids have been found. The overlying Falla Formation is about 565 m thick and consists of cyclically interbedded buff, cross-bedded sandstone, and gray or green-gray silty shale. Petrified logs, some apparently in position of growth, have been noted in both the upper and lower parts of this formation in the Shackleton Glacier area, and a sparse flora has been found in shales of the upper part of the formation at the head of the glacier. The Falla Formation may be the highest sedimentary unit exposed in most parts of the map area, but in the Dominion Range and at the head of the Shackleton Glacier it is succeeded by the lithologically similar Dominion Coal Measures, which are at least 380 m thick and contain an abundant Triassic flora. A Middle or Upper Triassic flora found in an erratic block of shale in the Grosvenor Mountains may have come from the Dominion Coal Measures.

The Beacon Group and, to a much smaller extent, the basement complex have been intruded by vast quantities of tholeiitic diabase correlated with the mid-Jurassic Ferrar Dolerites (Harrington, *1958*; McDougall, 1963). The diabase forms sheets which are approximately parallel to the bedding of the Beacon Group, and dikes of various thicknesses. The diabase sheets account for nearly half the post-peneplain sequence and form steep cliffs that dominate the landscape wherever they crop out. The southern nunataks in the area between the heads of the Mill and Shackleton Glaciers are composed of thick flows of tholeiitic basalt belonging to the Kirkpatrick Basalts. They are believed to be comagmatic with the Ferrar Dolerites and are included with them in the Ferrar Group (Grindley, 1963). All the basalt flows are amygdaloidal in their upper parts. The original thickness of the basalts was probably greater than the 600 m now exposed. No contact between the Kirkpatrick Basalts and the Beacon Group has been seen in this area.

Young glacial deposits are present both along the sides of the glaciers and near the coast. Compact tills are preserved near the heads of the larger glaciers and in places are some hundreds of meters above the present ice level. They were deposited when the polar plateau ice was as much as 300 m higher than at present but are not necessarily all the same age. Till deposits which are generally not so high above present ice levels are present along the walls of the glaciers and on extensive flat and gently sloping deglaciated areas, particularly in the vicinity of the Mill Glacier and the upper part of the Shackleton Glacier. Unconsolidated till and glacial striae have been observed hundreds of meters above the present level of the Ross Ice Shelf in the coastal ranges near the mouths of the Beardmore, Liv, and Strom Glaciers and must date from a time when the surface of the ice shelf was much higher than it is now. Ice-cored moraines cover the ice at the edge of the ice shelf at several places along the coast between the Strom and Shackleton Glaciers and are especially extensive in embayments on the eastern side of the Duncan Mountains.

Structural Geology

The basement complex metasediments have been moderately to intensely folded. In the Duncan Mountains the folds are isoclinal, with axes that plunge to north-northwest at 20° to 30°, and limbs that dip about 60° to northeast. East of the Shackleton Glacier and between the Ramsey and Beardmore Glaciers the average strike of bedding is approximately north, and dips are steep. In the Hood Glacier area the folds are isoclinal. Fold axes in the Taylor Formation on both walls of the Shackleton Glacier trend within about 45° of east, roughly normal to the strikes of the metasediments to the east and west. A north-trending belt of subvertical mylonites extends south from Waldron Spurs, east of the Shackleton Glacier, and separates the east-striking metasediments from north-striking metasediments to the east. In the middle part of the Shackleton area the east-trending folds are broad and open, with dips on the limbs of about 45°. Farther to the north they are isoclinal, and the limbs are nearly vertical.

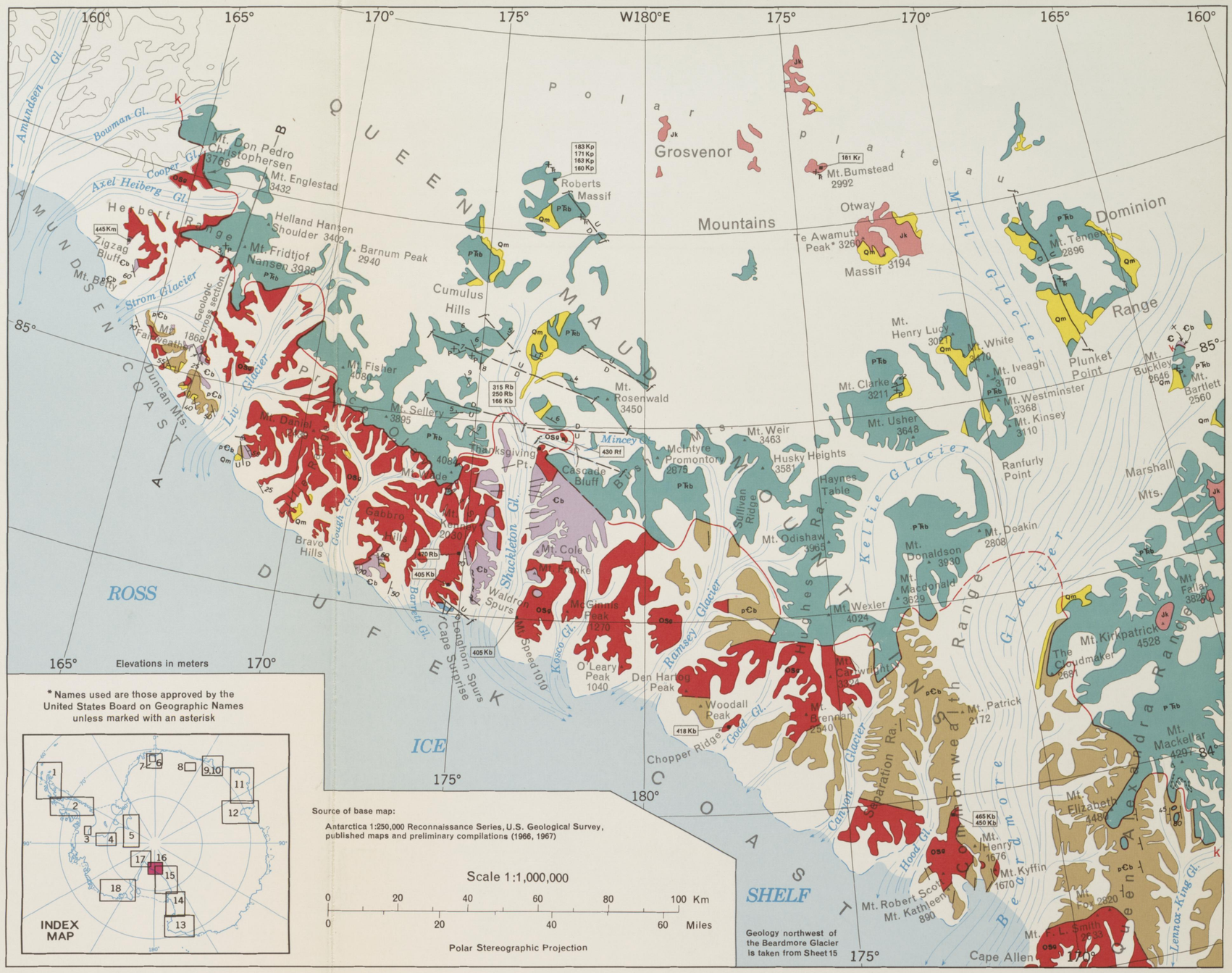
The Beacon Group generally dips gently to the south. Local variations in attitude are believed to be the result of irregular uplift of blocks by the larger diabase intrusions. Both the Beacon and Ferrar Groups have been displaced by faults that trend between north-northwest and west, roughly parallel to the axis of the Queen Maud Mountains. Most are normal faults, but a few reverse faults have been noted. The throw of the faults probably does not exceed 150 m, except in two cases. The throw of a major fault inferred near the margin of the Mincey Glacier may be as much as 1500 m. Beacon strata and diabase found at an altitude of 300 m at Cape Surprise, on the coast just east of the mouth of the Shackleton Glacier, must have been downthrown about 5000 m with respect to the rocks to the south by a fault which is inferred to have a strong sinistral transcurrent component (Barrett, 1965) and to be associated with a major fault zone just off the coast. The western Queen Maud Mountains are a major crustal block which has been upthrown along the coastal fault and tilted southward at a gentle angle.

Geologic History

In the late Precambrian a thick sequence of geosynclinal turbidite-type sediments was deposited and may have been folded before the deposition, possibly during the Early and Middle Cambrian, of a sequence of shallow-water marine sediments. During the Late Cambrian to Silurian Ross Orogeny both sequences were folded and later were intruded and metamorphosed by calc-alkaline intrusives of batholithic dimensions. Extensive erosion produced a peneplain on which over 1800 m of continental sediments were deposited during the late Paleozoic and early Mesozoic. In mid-Jurassic times vast quantities of basaltic magma were intruded into the sediments and extruded as great flows. The Queen Maud Mountains were uplifted by block faulting sometime during the Tertiary, and their form was greatly modified by glaciation during the Pleistocene.

Acknowledgment. The writers wish to thank Dr. R. L. Oliver for permission to use unpublished information on the Hood Glacier area.

[1]New Zealand Geological Survey
[2]Texas Technological College, Lubbock, Texas



* Names used are those approved by the United States Board on Geographic Names unless marked with an asterisk

Source of base map:

Antarctica 1:250,000 Reconnaissance Series, U.S. Geological Survey, published maps and preliminary compilations (1966, 1967)

Scale 1:1,000,000

0 20 40 60 80 100 Km
0 20 40 60 Miles

Polar Stereographic Projection

Geology northwest of the Beardmore Glacier is taken from Sheet 15

GEOLOGIC CROSS SECTION

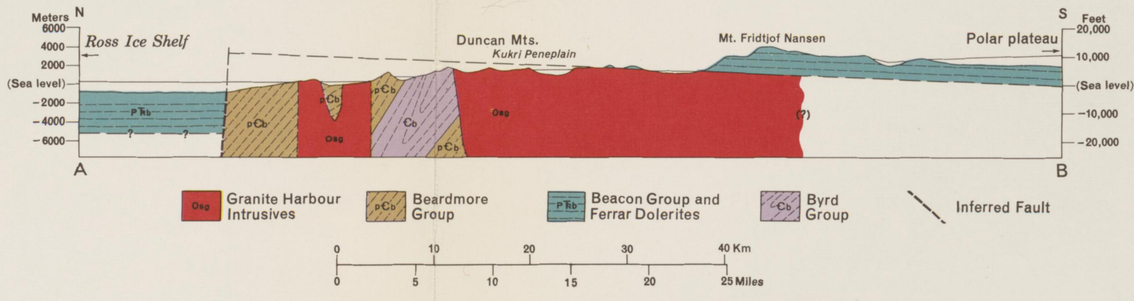


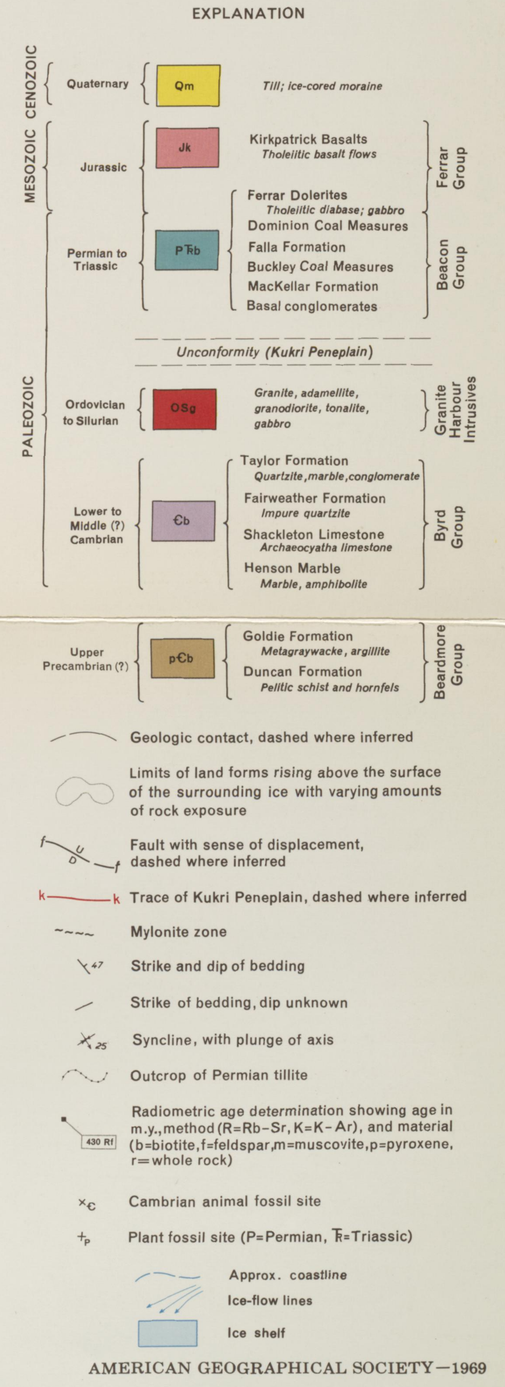
TABLE 1. RADIOMETRIC AGE DETERMINATIONS

Location	Lithology	Method and Material	Age (m.y.)	Ref.
Longhorn Spurs 84°39′S, 174°55′W	Adamellite gneiss	Rb-Sr Biotite	470	1
Between Hood and Beardmore Glaciers 83°57′S, 172°30′E	Granodiorite intrusive into Goldie Formation	K-Ar Biotite	465, 450	2
Zigzag Bluff 85°17′S, 163°20′W	Pegmatite dike cutting Fairweather Formation	K-Ar Muscovite	445	2
Cascade Bluff 84°58′S, 177°40′W	Monzotonalite	Rb-Sr Feldspar	430	1
Chopper Ridge* 84°14′S, 177°50′E	Granodiorite	K-Ar Biotite	418	1
Longhorn Spurs 84°34′S, 174°30′W	Adamellite	K-Ar Biotite	405	1
Mt. Speed 84°30′S, 176°30′W	Granite gneiss	K-Ar Biotite	405	1
Thanksgiving Point 84°57′S, 176°55′W	Leucogranodiorite	Rb-Sr Biotite K-Ar Biotite	315, 250 166	1
Roberts Massif 85°39′S, 177°W	Diabase	K-Ar Pyroxene	183, 171, 163, 160	1
Mt. Bumstead 85°39′S, 174°E	Basalt	K-Ar Whole rock	161	1

1. Wade *et al.*, 1965
2. McDougall and Grindley, 1965

*Name not yet approved by the United States Board on Geographic Names

EXPLANATION



References

Barrett, P. J. (1965) Geology of the area between the Axel Heiberg and Shackleton Glaciers, Queen Maud Range, Antarctica, Part 2—Beacon Group, *New Zealand J. Geol. Geophys.*, **8**, 344-363.

Gould, L. M. (1931) Some geographical results of the Byrd Antarctic Expedition, *Geogr. Rev.*, **21**, 177-200.

Gould, L. M. (1935) Structure of the Queen Maud Mountains, *Bull. Geol. Soc. Am.*, **46**, 937-984.

Grindley, G. W. (1963) The geology of the Queen Alexandra Range, Beardmore Glacier, Ross Dependency, Antarctica, with notes on the correlation of Gondwana sequences, *New Zealand J. Geol. Geophys.*, **6**, 307-347.

Grindley, G. W., McGregor, V. R., and Walcott, R. I. (1964) Outline of the geology of the Nimrod-Beardmore-Axel Heiberg Glaciers region, Ross Dependency, in *Antarctic Geology, Proceedings of the First International Symposium on Antarctic Geology, Cape Town, 16-21 September 1963*, edited by R. J. Adie, pp. 206-219, North-Holland Publishing Co., Amsterdam.

Grindley, G. W., and Warren, G. (1964) Stratigraphic nomenclature and correlation in the western Ross Sea region, Antarctica, in *Antarctic Geology, Proceedings of the First International Symposium on Antarctic Geology, Cape Town, 16-21 September 1963*, edited by R. J. Adie, pp. 314-333, North-Holland Publishing Co., Amsterdam.

Gunn, B. M., and Walcott, R. I. (1962) The geology of the Mt. Markham region, Ross Dependency, Antarctica, *New Zealand J. Geol. Geophys.*, **5**, 407-426.

Gunn, B. M., and Warren, G. (1962) The geology of Victoria Land between the Mawson and Mulock Glaciers, *New Zealand Geol. Surv. Bull.*, **71**, 157 pp.

Harrington, H. J. (1958) Nomenclature of rock units in the Ross Sea region, Antarctica, *Nature*, **182**, 290.

Laird, M. G. (1963) Geomorphology and stratigraphy of the Nimrod Glacier—Beaumont Bay region, southern Victoria Land, Antarctica, *New Zealand J. Geol. Geophys.*, **6**, 465-484.

Linder, H., de Hills, S. M., and Thiel, E. C. (1965) Basement complex in the Queen Maud Mountains, central Transantarctic Mountains, in *Geology and Paleontology of the Antarctic*, edited by J. B. Hadley (*Antarctic Res. Ser.*, Vol. 6), pp. 141-144, Am. Geophys. Union, Washington, D. C.

McDougall, I. (1963) Potassium-argon age measurements on dolerites from Antarctica and South Africa, *J. Geophys. Res.*, **68**, 1535-1545.

McDougall, I., and Grindley, G. W. (1965) Potassium-argon dates on micas from the Nimrod-Beardmore-Axel Heiberg region, Ross Dependency, Antarctica, *New Zealand J. Geol. Geophys.*, **8**, 304-313.

McGregor, V. R. (1965a) Notes on the geology of the area between the heads of the Beardmore and Shackleton Glaciers, Antarctica, *New Zealand J. Geol. Geophys.*, **8**, 278-291.

McGregor, V. R. (1965b) Geology of the area between the Axel Heiberg and Shackleton Glaciers, Queen Maud Range, Antarctica, Part 1—Basement complex, structure, and glacial geology, *New Zealand J. Geol. Geophys.*, **8**, 314-343.

Oliver, R. L. (1964a) The level of former glaciation near the mouth of the Beardmore Glacier, in *Antarctic Geology, Proceedings of the First International Symposium on Antarctic Geology, Cape Town, 16-21 September 1963*, edited by R. J. Adie, pp. 138-142, North-Holland Publishing Co., Amsterdam.

Oliver, R. L. (1964b) Geological observations at Plunket Point, Beardmore Glacier, in *Antarctic Geology, Proceedings of the First International Symposium on Antarctic Geology, Cape Town, 16-21 September 1963*, edited by R. J. Adie, pp. 248-258, North-Holland Publishing Co., Amsterdam.

Oliver, R. I. (1964c) Some basement rock relations in Antarctica, in *Antarctic Geology, Proceedings of the First International Symposium on Antarctic Geology, Cape Town, 16-21 September 1963*, edited by R. J. Adie, pp. 259-264, North-Holland Publishing Co., Amsterdam.

Schetelig, J. (*1915*) Report on rock specimens collected on Roald Amundsen's South Pole Expedition, *Avh. Norske Vidensk. Akad.*, **4**, 1-32.

Stewart, D. (1934a) The petrography of some Antarctic rocks, *Am. Mineralogist*, **19**, 150-160.

Stewart, D. (1934b) The petrography of the Beacon Sandstone in south Victoria Land, *Am. Mineralogist*, **19**, 351-359.

Stewart, D. (1934c) The petrography of some rocks from south Victoria Land, *Proc. Am. Phil. Soc.*, **74**, 307-310.

Wade, F. A., Yeats, V. L., Everett, J. R., Greenlee, D. W., LaPrade, K. E., and Shenk, J. C. (1965) The geology of the central Queen Maud Range, Transantarctic Mountains, Antarctica, *Texas Technological College, Res. Rept. Ser., Antarctic Ser. 65-1*, 54 pp.

AMERICAN GEOGRAPHICAL SOCIETY—1969