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1965/239

GEOLOGICAL MAP OF THE SECTOR OF ANTARCTICA BETWEEN LONGITUDES 45°E AND 80°E (SCALE 1:1,000,000), WITH COMMENTARIES

by

D.S. Trail and I.R.McLeod

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FOREWORD

The geological map which forms part of this Record was prepared at the request of the American Geographical Society for the Antarctic Map Folio Series which the Society is compiling. The map covers the region which has been reconnoitered, and partly mapped at 1:250,000 scale, by Bureau geologists attached to the Australian National Antarctic Research Expeditions. This region extends from longitude 45°E to longitude 80°E, and south to latitude 75°S.

The map is at a scale of 1:1,000,000 and consists of two sheets. The sheets have been oriented with one side parallel to the Greenwich meridian on a polar stereographic projection, to conform to the other sheets in the Geological Folio.

SHEET 1

INTRODUCTION

The rocks of the sheet area are all high-grade metamorphics, mainly of the granulite facies.

Enderby Land was first sighted (at Cape Ann) in 1831, and Kemp Land in 1833. In December 1929 a Norwegian party landed on a skerry near Cape Ann, and in 1931 the British, Australian, New Zealand Antarctic Research Expedition mapped this coast and collected rocks from Scullin Monolith, Cape Bruce and Proclamation Island (Tilley, 1937). G.W. Rayner from the "William Scoresby" collected rocks at Bertha Island in 1936 (Rayner and Tilley, 1940). H.E. Hansen produced charts of the coast from aerial photographs taken by Lars Christensen's expedition in 1936-37; aerial photographs were again taken by the U.S. Navy (Operation Highjump) in 1947.

An Australian National Antarctic Research Expeditions party established Mawson in 1954. Reconnaissance geological mapping was begun that year and continued until 1961 (Stinear, 1956; Crohn, 1959; McLeod, 1959, 1964; Ruker, 1963). Geological mapping at 1:250,000 scale was carried out in 1961 (McCarthy & Trail, 1964) and 1965 (McLeod, et al., 1965). Sea-bottom sediment samples were collected in 1965 at several places between Edward VIII Gulf and Mawson (McLeod, et al., 1965).

Geologists of the Soviet Antarctic Expedition visited and sampled the Oygarden Group in 1957 and Mawson in 1959, and carried out geological mapping in western Enderby Land in 1962 and later years (Ravich & Voronov, 1958; Klimov, Dukhanin & Mitroshin, 1962; Klimov, Ravich & Soloviev, 1964).

GEOMORPHOLOGY AND GLACIAL GEOLOGY

Most of the inland rock exposures are sharp peaks or ridges, and are mainly ice-free, except for local accumulations in cirques and valleys. Many of the larger mountains display well-formed cirques, either abandoned or occupied by glacier remnants, and the ridges forming some nunataks appear to outline large cirques partly buried by the ice sheet.

Thick extensive deposits of moraine have been found in places, in addition to the small accumulations on and fringing the larger rock exposures. Large lakes occur on the surface of some of the thick deposits. Erratic boulders are scattered over most rock exposures for up to a few hundred metres above the ice sheet (600 metres at Leckie Range). Ice-cored moraine appears to be rare in both coastal exposures and inland nunataks. In parts of the Framnes Mountains and Tula Mountains, moraine has a coarsely-patterned surface of subconical mounds. In places on the coast, a polygonal pattern of channels a few inches wide and deep, containing only relatively coarse material, is developed on sheets of rock detritus.

A few well-defined raised beaches between Ufs Island and Kvars Promontory lie between 3 and 6 metres above present sea level. One or two appear to reach 15 metres above sea level. Raised beaches about 8 metres above present sea level have been noted in north-east Amundsen Bay.

GEOLOGY

The charnockite is essentially a relatively uniform hypersthene-quartz-feldspar rock, generally well-foliated, and banded in places. Parts, especially those east of about longitude $62\frac{1}{2}^{\circ}$E, are coarse-grained, with large feldspar porphyroblasts which commonly have a preferred orientation; inclusions of pyroxene granulite are widespread in this variety. Many charnockite specimens show evidence of cataclasis, mostly with accompanying recrystallization; in western Enderby Land especially, biotite and hornblende have commonly formed at the expense of the pyroxene.

The biotite-quartz-feldspar gneisses and migmatites of the coastal exposures are typically well-foliated, banded, garnet-bearing rocks. Sillimanite and cordierite are locally common; diopside-bearing rocks and clinopyroxene-scapolite rocks occur in some exposures; graphite is common at two localities. Discrete bodies of red granite are common in the biotite gneisses near Taylor Glacier. Fram Peak and the Hansen Mountains are dominantly composed of migmatitic biotite gneisses with subordinate quartzite. Marble was found at Fram Peak and near Mount Banfield. The Scullin Monolith is essentially garnet-biotite-quartz-feldspar gneiss, and Depot Peak is composed of similar rocks with sillimanite and garnet.

The banded gneiss is typically composed of bands of light quartz-feldspar rock with minor pyroxene alternating with dark bands of pyroxene-feldspar rock. Biotite and garnet occur in the light bands, and they contain sillimanite in places; the dark bands locally contain hornblende or garnet. Quartzites are locally abundant.

The quartz-feldspar gneiss is composed of quartz and perthite, with rare garnet, pyroxene, and plagioclase. Interbedded with it in subordinate amount are layers of feldspar-pyroxene gneiss containing antiperthitic oligoclase, orthopyroxene, and clinopyroxene. Fine-grained garnet-quartz-feldspar gneiss, garnet quartzite, and quartzite are common in places.

The thinly-banded pyroxene-quartz-feldspar gneiss forming the Casey Range contains garnet, sillimanite, and some biotite, and is interbanded with garnet gneiss and quartzite. Gneisses which crop out near Mount Kernot in Western Kemp Land are composed of thin bands of pyroxene-feldspar gneiss, commonly with garnet, alternating with thin bands of feldspar-garnet-pyroxene gneiss, quartz-feldspar gneiss with minor garnet, and quartzite.

The strongly-banded garnet-quartz-feldspar gneiss which forms the Leckie Range and Mount Channon, in western Kemp Land, contains minor biotite, and bands of pyroxene-bearing gneiss.

The unit shown as "Predominantly garnet-quartz-feldspar gneiss...." is made up of a variety of rock types, formed mostly by variation in mineral proportions. Garnet (almandine), though common, is not universally present. The rocks may contain, in addition to quartz and feldspar, one or more of orthopyroxene, clinopyroxene, biotite and hornblende, in some places as major constituents. Sillimanite occurs in small amounts in some varieties. Several small bodies of norite with a faint gneissic structure occur near the south-eastern extremity of Amundsen Bay. A band of anorthosite, at least several hundred feet thick, occurs at Amphitheatre Lake in the Nye Mountains. Small scale mapping by Russian workers delineated a zone, 10 km. wide, of "pyroxene-plagioclase schists and calciphyres" in the central Nye Mountains (Klimov, Dukhanin, & Mitroshin, 1962).

Hornblende-quartz-feldspar gneiss has been distinguished as a unit only in the Napier Mountains. The rock consists predominantly of perthite, quartz, and plagioclase, with minor hornblende and subordinate biotite.

First-hand information is not available on the rocks of the areas shown as "Undifferentiated metamorphics". Most have been seen from a distance and there is little doubt that they are metamorphic rocks.

Basic dykes, essentially labradorite and pyroxene, occur sporadically throughout the area; many have been metamorphosed, or show retrogressive mineral changes, especially of the pyroxene. Dykes of very coarse-grained biotite-quartz-feldspar pegmatite have been found at several places.

RELATIONS BETWEEN ROCK UNITS

The interrelations of the units are not well known. The charnockite is interbanded on a large scale with biotite gneisses east of Taylor Glacier, but Crohn (1959) considers that the contacts of the charnockite are intrusive. Bodies of biotite-quartz-feldspar gneiss and migmatite are common throughout the banded gneiss, and in the charnockite of the Framnes Mountains. The rocks at Twin Peaks and Edward Ridge seem to be intermediate between the quartz-feldspar gneiss and pyroxene-quartz-feldspar gneiss; the transition from banded gneiss to quartz-feldspar gneiss west of Edward VIII Gulf occurs between outcrops 7 km. apart.

At both McLeod Nunataks and Knuckey Peaks, bands of rock which would be classed as quartz-feldspar gneiss alternate with those resembling charnockite.

Samples of noritic aspect from within the charnockite near Mawson lend weight to the suggestion that it is a granitized basic igneous mass, but the local abundance of small bodies of biotite gneiss and of texturally distinct pyroxene granulite within the charnockite suggests that it may be a severely deformed and recrystallized - effectively mobilized - equivalent of the banded gneiss or quartz-feldspar gneiss.

Evidence of at least two episodes of metamorphism is widespread in the region. Many of the metamorphic rocks exhibit retrogressive mineral changes from granulite to almandine-amphibolite facies assemblages; many basic dykes cut across the foliation of the gneisses, and appear to have been metamorphosed themselves. Some specimens show signs of cataclasis in thin section. Mylonitic rocks in the charnockite are in places recrystallized and appear to be enriched in potash feldspar.

Ravich & Krylov (1964) give ages from 490 to 650 m.y. to samples of charnockite from Mawson, and ages of 535 to 615 m.y. to samples from the Oygarden Group. Presumably these date late episodes in the complex metamorphic history. Measured ages of about 480 m.y. are widespread in East Antarctica (Picciotto & Coppez, 1962).

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SHEET 2

INTRODUCTION

The rocks exposed in most of the sheet area are high-grade metamorphics. Low-grade metamorphic rocks and granite bodies occur in the south, and Permian sediments crop out in the centre and have been found in moraine in the south of the sheet area.

Klarius Mikkelsen landed at the Vestfold Hills in 1935. The coastline was charted from aerial photographs taken by Lars Christensen's expedition in 1936-37. Lincoln Ellsworth and Sir Hubert Wilkins visited the neighbourhood of the Vestfold Hills in 1939. Part of the coastline was photographed from the air during the United States "Operation Highjump" in 1947.

An Australian National Antarctic Research Expeditions (ANARE) party landed at the Vestfold Hills in 1954, and ANARE geologists reconnoitered these hills and other outcrops along the east side of Prydz Bay and the Amery Ice Shelf in 1956 and later years (Crohn, 1959; McLeod, 1959, 1964b; McLeod, et al., 1965). ANARE parties reached the Stinear Nunataks, north of the Prince Charles Mountains, in 1954, the mountains themselves in 1955, and extended the geological reconnaissance in succeeding years (Stinear, 1956; Crohn, 1959; McLeod, 1959, 1964b; Ruker, 1963; Trail, 1963b, 1964a).

Geologists of the Soviet Antarctic Expedition visited the Vestfold Hills and some of the other exposures along the eastern side of Prydz Bay and the Amery Ice Shelf in 1957 (Ravich & Voronov, 1958; Klimov, Ravich, & Soloviev, 1964).

GEOMORPHOLOGY AND GLACIAL GEOLOGY

The large nunataks in the Prince Charles Mountains have extensive summit plateaux up to 1,000 metres above the ice surface, and many have broad flanking benches. The plateaux, benches, and large cirques are commonly mantled by patterned moraine, overlain in places by hummocky ice-cored moraine, and by unpatterned moraine deposited by receding mountain or outlet glaciers. Exposures on the east margin of the Amery Ice Shelf, and around Beaver Lake, also have plateau summits. Crohn suggests that two erosion surfaces are present in the Vestfold Hills, 30 metres and 120 metres above sea level.

Raised beaches in the Vestfold Hills are located up to 15 metres above sea level. The saline lakes there, whose surfaces are as much as 50 metres below sea level, probably represent inlets of the sea isolated by falling sea level and subsequently concentrated by evaporation (McLeod, 1964a).

METAMORPHIC AND IGNEOUS ROCKS

Three units were distinguished by McLeod et al. (1965) in the Vestfold Hills: rather massive feldspar-quartz gneiss with little dark mineral (mostly pyroxene); quartz-feldspar gneiss with varying amounts of pyroxene and biotite and minor garnet; and thinly-bedded quartz-feldspar gneiss with varying amounts of garnet and pyroxene and minor biotite and diopside. Pyroxene is the predominant dark mineral in the gneisses of Mount Caroline Mikkelsen and nearby islands.

The garnet-quartz-feldsapr gneiss forming the exposures on the east side of Prydz Bay contains common biotite, and rare sillimanite, amphibole, and pyroxene. It is light-coloured, poorly banded in places, and commonly has a granitoid texture. In the Larsemann Hills it contains parallel veins of coarse massive granite a few metres thick. Migmatites are evident in the northern part of the Rauer Group.

The gneisses forming the northern Prince Charles Mountains are described by Crohn (1959) as mainly banded gneisses of mixed sedimentary and igneous origin. The igneous members generally have the composition of granite. The metasedimentary members contain, in addition to quartz and feldspar, garnet, sillimanite, biotite, and at Mount Bechervaise, some graphite. Banded pyroxene gneiss forms Mount Gardner.

Charnockite forming Jennings Promontory and Mount Loewe is a foliated rock with aligned coarse feldspar porphyroblasts.

Granite and migmatitic gneiss, which seem to be similar to the rocks in the northern Prince Charles Mountains, occur at Clemence Massif and the Grove Nunataks.

The biotite-quartz-feldspar gneiss of the Mawson Escarpment and some small nunataks west of the Lambert Glacier has a metamorphic grade in the lowest sub-facies of the almandine-amphibolite facies. Farther south again, the mountains flanking the Fisher Glacier are mainly composed of greenschist facies rocks, dominantly quartzite with mica or chloritoid, and mica-quartz schist; varieties of the schist contain feldspar, calcite, or garnet. Wilson Bluff is dominantly mica-quartz schist. Actinolite amphibolite forms a few thin concordant bands in the quartzite at Mount Menzies. Small exposures of marble lie near granite at Mount Dummett and Mount Bayliss, and marble occurs in moraine at the Goodspeed Nunataks and magnesian marble in moraine at Mount Rymill. Ferruginous schist crops out in the contact zone of the granite at Mount McCauley, and occurs in moraine at Mount Rymill. Moraine at Mount McCauley contains large boulders of hematite and fragments of hematite-quartz rock.

Although the low-grade gneisses and the schists are strikingly different in appearance, their mineralogy suggests that their grades of metamorphism are not very different. The occurrence of migmatite to the north and east of the low-grade almandine-amphibolite facies rocks suggests that the grade of metamorphism increases outwards, in these directions, from the greenschist facies rocks.

The large exposures of garnetiferous mica granite at Mount McCauley and Mount Dummett may be parts of the same mass. At Mount Bayliss a sheet of mica granite about 150 metres thick has a marked cataclastic foliation, and parts of it resemble the augen gneiss which forms Mount Bloomfield. Hornblende hornfels is associated with the granite at Mounts Dummett and Bayliss. Massive granite and several varieties of hornfels occur in moraine at Goodspeed Nunataks.

Pegmatite, aplite, and quartz veins occur in both the schists and the gneisses of the Prince Charles Mountains. Metamorphosed basic dykes have been found at several places, especially the southern Mawson Escarpment.

The many basic dykes in the Vestfold Hills range up to 15 metres thick, and some run for several miles. They are dominantly fine-grained dolerite. A small mass of norite also occurs in these hills, and specimens of olivine-bearing ultrabasic breccia, collected by N. Lied in 1961, may represent a minor intrusion.

Rocks classed as "Undifferentiated metamorphics" form nunataks which have not been inspected by a geologist. Many of these, from a distance, do not differ markedly from those examined.

PERMIAN SEDIMENTARY ROCKS

The Amery Formation (Crohn, 1959; McLeod, 1964b) appears to be at least 500 metres thick. It is composed mainly of current-bedded feldspathic sandstone, calcareous in part, made up of angular grains of quartz and feldspar in a clay matrix. Carbonaceous shale, coal seams, and beds of massive mudstone also occur. The coal is intermediate in rank between brown and black coal. Identifiable macrofossils have not been found, but plant spores give an upper Artinskian or Kungurian age for samples near the top of the sequence (Balme & Playford, 1958). The attitude of current-bedding indicates a sediment source west of Beaver Lake. Moraine at Mount Rymill includes boulders of red siltstone, some with bands of sandstone; the siltstone contains Glossopteris dated as Permian by Mary White (1962). It seems likely that the Lambert Glacier valley is the site of an ancient structural depression which was a locus of sedimentation in upper Palaeozoic times.

Crohn (1959) has estimated the throw of the Amery Fault, which bounds the Amery Formation on the west, as at least 1,000 metres. He suggests that block-faulting is widespread in the northern Prince Charles Mountains.

GEOLOGICAL HISTORY

Little is known of the metamorphic history of the region. Ages between 1525 and 1185 m.y. are given by Ravich & Krylov (1964) for specimens from the Vestfold Hills, samples from the Larsemann Hills give ages of 540 and 420 m.y., and charnockite from "Cape Jennings" gives 420 m.y. The relatively great age obtained for the rocks of the Vestfold Hills suggests that this area may have escaped the repeated metamorphic episodes which affected much of East Antarctica up to the latest widespread event around 480 m.y.

The schists and gneisses of the southern Prince Charles Mountains show the effects of two metamorphisms. The first was a regional episode in which schistosity or foliation developed. The second was predominantly thermal, and possibly accompanied the emplacement of the granites, though the sheared granite at Mount Bayliss and the basic dykes and sheets are affected by thermal metamorphism. The age of none of these events is known. They are probably no younger than the dates around 480 m.y. obtained for the latest metamorphic events in Queen Maud Land (Picciotto & Coppez, 1962), but any or all of them may be much older than this.

The unmetamorphosed dykes of the Vestfold Hills may be related in age to the Mesozoic dolerites of Victoria Land, but most dykes in the Prince Charles Mountains are to some extent metamorphosed and are therefore pre-Permian in age.

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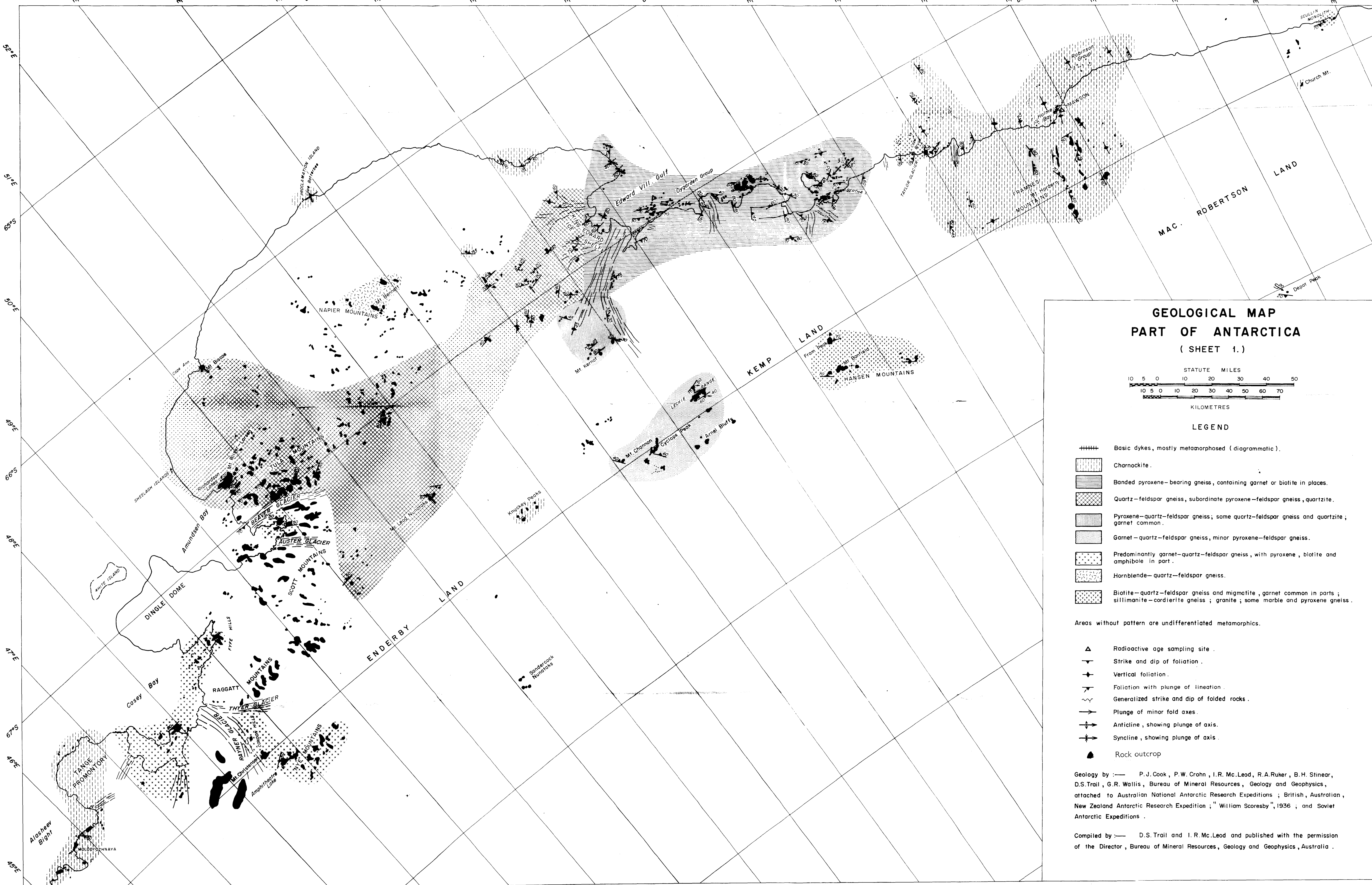

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