COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record No. 1969 / 144 054001

An Assessment of the Possibility of Mineral Deposits Occurring in Australian Antarctic Territory

by

I.R. McLeod

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INTRODUCTION

This paper is an attempt to asses the likelihood of the occurrence of mineral deposits* in Australian Antarctic Territory. At the outset, it must be emphasized that, at the present state of knowledge, such an assessment is little more than an educated guess. Our knowledge of the geology of most of the territory is only very general. Further, the factors bringing about the occurrence of mineral deposits anywhere are only imperfectly understood, especially at the regional scale. Deposits of some minerals, such as copper, lead, zinc and gold, can occur in a great variety of geological environments. Deposits of some other metals, such as tin, tungsten, nickel, platinum, and chromium are mostly associated with a particular kind of rock, but not all occurrences of that kind of rock will have associated deposits of the metal. Although many explanations have been suggested, geologists still are not certain why rocks of a particular region carry numerous mineral deposits while apparently similar rocks in an adjoining region do not. Therefore, even though the types of rocks which occur in a region and their relations to one other are reasonably well known (which is not the case for much of Antarctica) one cannot predict the extent to which the region will carry mineral deposits. Only after fairly detailed work has shown that the rocks of the region are mineralized can one give any estimate of the possibility of mineral deposits occurring, and of the type most likely to be found. In other words, a certain amount of knowledge is needed as a guide to forecasting. It must be remembered that while geological principles are now used for mineral exploration in Australia and other settled continents, these principles are applied with the background knowledge of the presence or absence of mineralization resulting from the painstaking activities of prospectors and miners over the last century and more. For Antarctica, this background knowledge does not exist.

If a deposit of a particular metal is to occur, two conditions must be satisfied: first, the rocks must contain a certain amount of the metal; and second, the metal in the rocks must be concentrated by some mechanism into a discrete body - almost invariably containing impurities - which is large enough to be mined. It may happen that the metal accumulates in part of the rock mass, but is still disseminated through that part. Then the metal may appear as scattered grains or thin veinlets of ore mineral** or as small sporadic concentrations, a few inches to a few feet in extent, of ore minenal which are far too small to be mined. Such occurrences are referred to here as "mineralization".

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* The sense in which "mineral deposit" and "mineralization" are used in this paper is described in the next paragraph.

** Most metals, in nature, are combined with other elements to form minerals. A particular metal may occur in many minerals; those minerals from which the metal man be most cheaply extracted are called ore minerals. The presence of such a mineral in a rock does not necessarily mean that an ore deposit is likely to be found in that rock. For instance chalcopyrite is the most important copper ore mineral, but also occurs in very minor amounts in many different kinds of rock.

The term "mineral deposit" is used here for a mass of ore mineral or a mixture of ore mineral and impurities which may be only a few feet wide, but whose largest dimension is measured in scores, hundreds, or even thousands of feet, i.e. which is large enough to warrant testing to find out if it is worth mining. Whether a deposit can be economically mined, i.e. whether it is an orebody, depends ultimately on the amount and grade of ore it contains. No attempt is made in this paper to set the levels of grade and tonnage which would make a deposit an orebody; they must be determined for each deposit, taking into account its location, availability of transport, expected mining and ore treatment costs, expected market price of the product in the foreseeable future, and so on. Thus a deposit at one locality might be economically workable, while an identical deposit at another locality is not. Economic factors are not taken into account in this paper; the discussion is in terms of mineral deposits as defined above. Nor are the problems inherent in prospecting, test drilling, and mining in Antarctica taken into account. The assessment is whether mineral deposits are likely to occur, not whether it is feasible to search for them, or, if they are found, to work them. A general assessment of the economic potentials of the Antarctic was published in "Antarctic Journal", May-June, 1969, pp. 61-72.

THE AREA OF ROCK AVAILABLE FOR MINERAL EXPLORATION

The area of the Antarctic continent, excluding ice shelves, is about 5,200,000 square miles. Of this, about 2 percent, i.e. about 100,000 square miles, is exposed rock. The remaining 98 percent of rock is covered by permanent ice which ranges up to 12,000 feet in thickness. The proportion of exposed rock in Australian territory is less than the continent-wide average, indeed is probably less than 1 percent of the area of the territory; that is about 25,000 square miles of rock is exposed. equal to approximately four 1:250,000 Sheet areas on the mainland of Australia.

Where the rock is thinly covered by permanent ice, geophysical prospecting methods can be used. These methods delineate features which might be mineral deposits. The nature of the features can only be found by test drilling; for this to be effective, the geophysical technique must fix the position of the feature within about 10 feet. At present, such techniques are effective only to a depth of about 300 feet below the surface.

This depth will increase as techniques are improved, but it will probably be many years before such techniques can be used to a depth of, say, 1000 feet. Ice with a thickness less than this occurs around the coast, and between the outcrops in area of exposed rock. The ice around most of the coastline probably becomes thicker than 300 feet within a mile of the coast, i.e. only a few thousand square miles of rock are covered by less than 300 feet of permanent ice. The area of such rock intervening between and around inland exposed rock areas is probable also a few thousand square miles. Thus only about 30,000 square miles of Australian Antarctic Territory is amenable to mineral exploration at present. This area would increase to about 50,000 square miles when geophysical methods can be used to a depth of 1000 feet.

KNOWN MINERAL DEPOSITS

The most important mineral deposits known in Antarctica are coal seams, occurring mainly in the Transantarctic Mountains. Thick seams of coal are known to occur in the mountains, but the ash content generally is high and the quality of most has been impaired by heating by later igneous intrusions. The degree of degradation differs from place to place, and it is possible that detailed work could reveal coal suitable for a particular requirement. Coal bearing rocks are relatively sparse in that part of the Transantarctic Mountains in Australian Territory, so the possibility of finding suitable coal is correspondingly decreased.

Numerous coal seams similar in age to those of the Transantarctic Mountains occur in sediments in the Beaver Lake/Radok Lake area in the northeast Prince Charles Mountains. Most seams are less than 2 feet thick, but one is 11 feet and another 9 feet thick. The quality of some of the coal at least is fairly good.

Thick beds of limestone, said to be of high purity, occur in the part of the Transantarctic Mountains in Australian Territory, and on the coast of George V Land.

The only metalliferous deposit yet reported in Antarctica is a quartz-pyrite vein deposit in the South Shetland Islands; it is said to contain reserves of "many thousands of tons", but has not been worked.

In conversation, a geologist of the Soviet Antarctic Expedition remarked that the expedition had found an "iron ore deposit" in the southern Prince Charles Mountains. He said that the deposit was extensive, but that the average grade was relatively low - less than 40%. An ANARE geologist found erratics in the southern Prince Charles Mountains which assayed 65% iron and which may have come from the deposit reported by the Soviet geologist.

KNOWN MINERALIZATION AND INDICATIONS OF MINERALIZATION

Small concentrations of manganese silicate minerals occur near Wilkes; a random sample assayed 39.1 percent Mn. Manganese silicate is not normally regarded as an ore of manganese.

A small erratic of bismuth sulphide was found in moraine near Mawson. The source of the fragment is unknown.

Small patches of rock in the central Rauer Islands contain disseminated flakes of molybdenum sulphide.

Thin bands and lenses, up to a few feet wide, of iron oxides occur in several places in Australian Antarctic Territory.

Small concentrations of hydrated sodium sulphate are found in rocky coastal areas.

Thin films of copper minerals have been found on rock surfaces at many places.

The rock at one place near Mawson contains small pods, less than 3 feet long, consisting of iron sulphides, copper iron sulphide, and rare molybdenum sulphide.

None of the occurrences of mineralization is of economic importance and none necessarily indicates that larger deposits will be found.

Indications of mineralization - minerals or features commonly associated with ore minerals in mineral deposits - but no ore minerals themselves, have been found at several places. The most significant of these is at Mount Bayliss, in the southern Prince Charles Mountains, where ferruginous box-works - structures indicating the former presence of ore minerals - and fluorite occur in quartz reefs near the contact of granite and marble. Fluorite is common in some granite erratics collected from the Goodspeed Nunataks, also in the southern Prince Charles Mountains, and is a rare constituent of granite at the head of Prydz Bay.

THE POSSIBILITY OF MINERAL DEPOSITS BEING DISCOVERED

As mentioned above mineral deposits and indications of deposits are known to occur at several places in Australian Antarctic Territory. It is statistically likely that further deposits exist, because of the area of rock exposed in the territory. The geological likelihood of deposits occurring is extremely difficult to assess, because of the great diversity of geological conditions in which mineral deposits occur elsewhere in the world, and because of the lack of detailed knowledge of the geology of some parts of the territory. However, in the following sections, an attempt is made to assess the possibility of mineral deposits occurring by pointing out the broad rock types which occur in Antarctica, and noting the prevalence of mineral deposits elsewhere in the world in similar rocks. The distribution of the various rock types is shown in generalized form in the accompanying sketch map.

However, it cannot be emphasized too strongly that while certain geological features seem to be a necessary condition for the occurrence of a particular type of mineral deposit, they are not a sufficient condition.

It is unlikely that important secondary mineral deposits occur. These are deposits which form or are concentrated from original, or primary, deposits or areas of mineralization by weathering - e.g. bauxite, some iron deposits - or by stream or wave action - e.g. alluvial deposits of tin or gold. Such deposits could have existed before the onset of glaciation, but would most probably have been removed and dissipated by the moving ice.

Metamorphic rocks

These are rocks which have been altered by heat and pressure to various degrees.

Granulites are those which have been most altered; the nature of the rocks from which they formed is largely conjectural. Much of Australian Antarctic Territory is occupied by rocks of this kind. Granulites are generally regarded as poorly prospective for mineral deposits. Granulite terrains commonly contain some areas of rocks less affected by heat and pressure or resulting from alteration of the granulite, which are rather more likely to contain mineral deposits. Nevertheless the possibility of discovering mineral deposits in regions of Australian Antarctic Territory occupied by granulites seems small.

Other highly metamorphosed rocks here include those less altered than granulites or those altered in a different way, and occurring over extensive areas. They are predominantly biotite-quartz-feldspar gneisses of various kinds, with or without garnet. They are more likely to contain mineral deposits than the granulites, but even so, the prospects of finding metalliferous deposits are not good.

Large areas of granitic rocks occur in the highly metamorphosed rocks at some places, but these are of a different, less prospective kind to the granitic rocks referred to later.

The manganese silicates at Wilkes occur in highly metamorphosed rocks.

The prospects of non-metallic deposits occurring are better. Such deposits could include aluminium silicate minerals, used in refractories; feldspar, used in ceramics; and garnet, used in abrasives.

Slightly metamorphosed rocks are those which have not been greatly altered; their precursors commonly can be recognised. Many important mineral deposits are known in such rocks, but are usually associated with particular rock varieties, especially those showing evidence of volcanic activity.

In the southern Prince Charles Mountains, these rocks are predominantly quartz-rich varieties, in which no evidence of volcanism has yet been found. Some bands have a high iron content. The iron deposit found by the Soviet Antarctic Expedition would be in such rocks.

Quartzite suitable for use in abrasives, refractories, or as chemical raw material could occur.

The slightly metamorphosed rocks at the head of the Denman Glacier were formed in part from basic volcanic rocks, and so may be more prospective. The area of exposed rocks is small, and associated plutonic rocks have not been reported. If they occurred, they would give hope of the occurrence of copper, nickel, cobalt, platinoid metals, etc.

The rocks in George V Land were originally clayey and sandy sediments, with some limestone, and do not appear to be prospective for metalliferous deposits except perhaps the limestones, which could possibly contain base metal deposits. The limestone is a potential resource.

Granites and Pegmatites

These rocks commonly have mineral deposits associated with them, the contained minerals and size of the deposits differing greatly from one mass to another. Deposits of most metals have been found associated with granites, the most directly associated being those of tin, tungsten, molybdenum, wolfram, bismuth, gold, etc.

Pegmatites, which are usually closely related genetically to granite, tend to carry deposits of less common metals such as beryllium, tantalum, columbium, lithium, etc, as well as non-metallic deposits such as feldspar, fluorspar, mica, etc.

In Australian Antarctic Territory, granites are known to occur in the southern Prince Charles Mountains, where indications of mineralization have already been referred to; at the head of Prydz Bay; near the head of Vincennes Bay; in part of the Windmill Islands; in parts of George V Land; and in the central Transantarctic Mountains.

Pegmatites (not shown on the accompanying map) have been found at various places throughout the territory. Most are small isolated masses, not the large masses or groups of pegmatites which would be more prospective.

Basic igneous rocks (not shown on map)

Rocks which are probably gabbro have been found near Amundsen Bay and in the Vestfold Hills. No ultrabasic rocks have been found associated with them. If such rocks do occur, they would be of interest in prospecting for nickel, cobalt, copper, and platinoid metals, as well as asbestos, talc, and magnesite.

Basalt dykes and sills occur at several places. They are most common in the Vestfold Hills and in the Transantarctic Mountains. They are of little interest for prospecting.

Volcanic rocks are known to occur only at Gaussberg, in a young volcanic cone. Sulphur and metals such as silver and mercury are associated with volcanic rocks in other parts of the world.

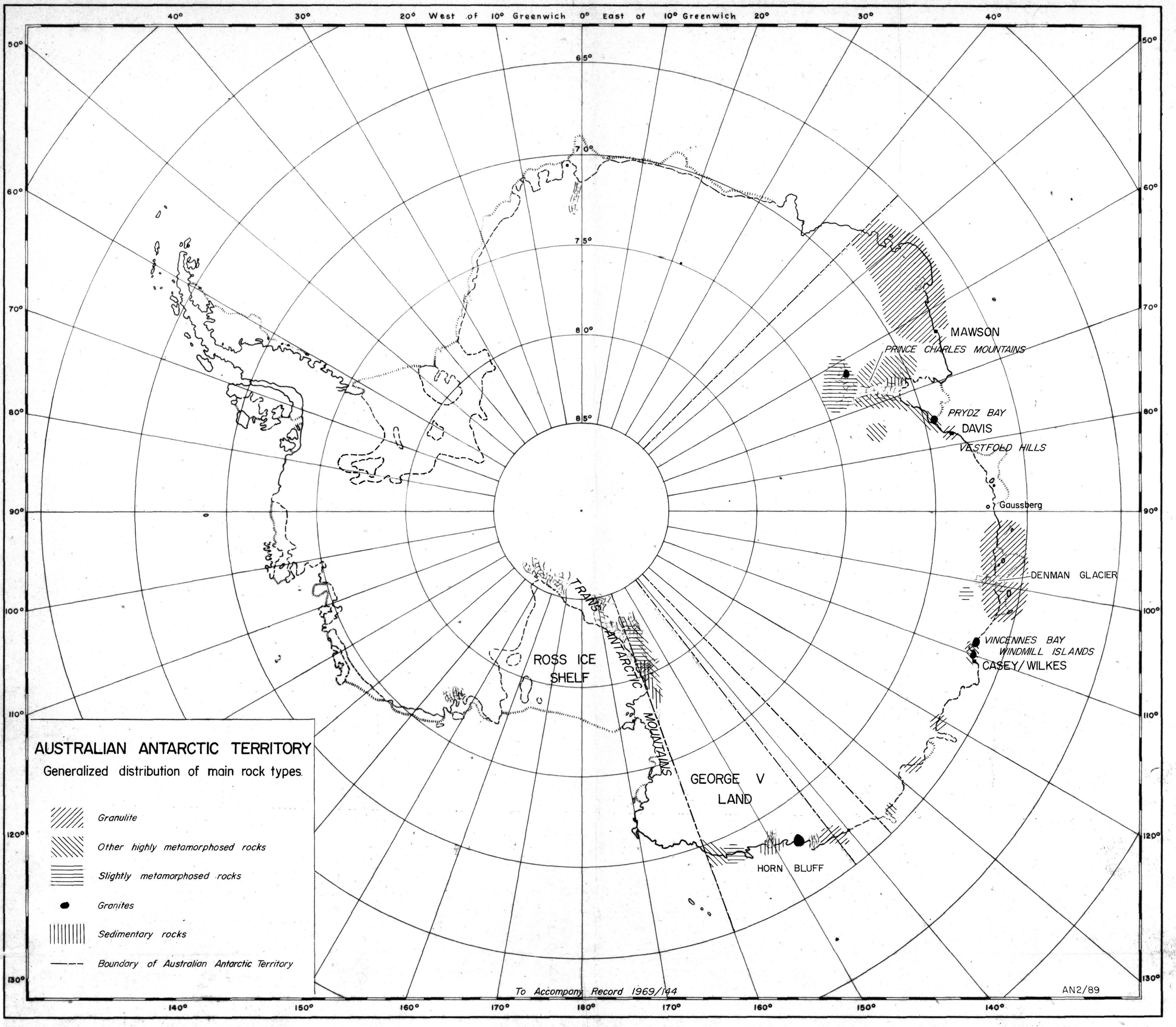
Sedimentary rocks

Sediments are known to occur in the Beaver Lake/Radok Lake area, near Horn Bluff, and in the Transantarctic Mountains. Erratics of sediments have been found in the southern Prince

Charles Mountains, but the source of these has not been discovered and may indeed be completely covered by ice. The occurrence of coal in these sediments has been referred to earlier. Other economic minerals which may be found include clays of various kinds, suitable for use as refractories, ceramics, etc. None of the sedimentary sequences seem prospective for petroleum; those at Beaver Lake/Radok Lake are probably all freshwater, and the sequence is thin; the others have been heavily intruded by igneous rocks.

Rocks of the continental shelf

The surface of the continental shelf is covered by glacial debris, and nothing is known of the underlying rocks.



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MAWSON
PRINCE CHARLES MOUNTAINS
PRYDZ BAY
DAVIS
VESTFOLD HILLS
Gaussberg
DENMAN GLACIER
VINCENNES BAY
WINDMILL ISLANDS
CASEY/WILKES
ROSS ICE SHELF
TRANS ANTARCTIC MOUNTAINS
GEORGE V LAND
HORN BLUFF
AUSTRALIAN ANTARCTIC TERRITORY
Generalized distribution of main rock types.
Granulite
Other highly metamorphosed rocks
Slightly metamorphosed rocks
Granites
Sedimentary rocks
Boundary of Australian Antarctic Territory
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