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BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

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GEOLOGICAL INVESTIGATIONS ALONG THE ANTARCTIC COAST BETWEEN LONGITUDES 108°E and 160°E, 1960 AND 1961.

by

I.R.McLeod

The information contained in this report has been obtained by the Department of National Development, as part of the policy of the Commonwealth Government, to assist in the exploration and development of mineral resources. It may not be published in any form or used in a company prospectus without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

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Results of age measurements by the Geochronology Section, Geophysics Department, Australian National University, on three rock samples were received after this Record had been completed. The measurements were made by the potassium-argon method, and are considered to be accurate to within 5 percent. The results are as follows:

Sample	Name	Location	Age (million years)
SQ48-49/11/1	Biotite adamellite	Hudson Island, Davis Islands, Vincennes Bay.	1070
SR56-57/7/1	Garnet-sillimanite-quartz-feldspar gneiss	Easternmost of Aviation Islands, Oates Land.	417
SR56-57/8/1	Banded feldspar-biotite gneiss.	Parkinson Peak, Wilson Hills, Oates Land.	450

The age of 1070 million years for the Davis Islands adamellite agrees well with the age of 1060 million years (Starik, et al, 1959) for leucogranite from the Windmill Islands (Grierson Oasis), 25 miles to the northeast. Granitic rocks of similar age occur also at the Vestfold Hills (Langenesset Oasis) (1070 million years) and Obruchev Hills (66°33'S, 99° 47'E) (1070 million years), respectively 900 and 250 miles to the west, and the Albov Rocks (1020 million years), in Porpoise Bay, 550 miles to the east.

The ages of 417 and 450 million years of the Oates Land specimens also agree with ages of 425 to 500 million years found for rocks of the Wilson Hills area by Starik, et al, (1959). Rocks with an age of about 450 million years are widely distributed in East Antarctica, indicating widespread orogenesis during the Ordovician.

SUMMARY

An account is given of the results of reconnaissance geological work along the Antarctic coastline during Australian National Antarctic Research Expeditions relief voyages in early 1960 and early 1961.

The predominant rock type is fine-grained banded, and medium-grained quartz-biotite-feldspar gneiss, which occurs at the Wilson Hills, Davis Bay, the Windmill Islands and Frazier Islands, and southern Vincennes Bay. Quartzo-feldspathic veins of several kinds are common in parts of these gneisses. The mineral composition of the gneisses indicates derivation from essentially quartzo-feldspathic sediments by high grade regional metamorphism.

Massive granitic rocks were found at the Windmill Islands and southern Vincennes Bay. A foliated granite, possibly of metamorphic origin, was found at the Henry Islands. Charnockitic rocks were found at the Windmill Islands and Chick Island. Basalt dykes intrude the metamorphic rocks at the Wilson Hills, Windmill Islands, Frazier Islands, and southern Vincennes Bay.

In addition to the foregoing rock types, trachyte and red and purple indurated sandstone were found in moraine.

INTRODUCTION

This report describes the results of geological work by the writer as a member of the Australian National Antarctic Research Expeditions during relief voyages by the M.V. "Magga Dan" in January to March 1960 and January to March 1961. While the prime purpose of these voyages was to relieve stations occupied by A.N.A.R.E., an additional objective was to undertake geological and cartographic work along little known parts of the coastline of the Australian Antarctic Territory.

To this end I examined all known rocky areas* (with the exception of the Albov Rocks, a small group of islands in Porpoise Bay) on the Antarctic coast between the Davis Islands, near the head of Vincennes Bay (108½°E) and Lewis Island in Davis Bay (134½°E); I also made a brief reconnaissance of part of the Wilson Hills, an extensive mountainous area in about 159°E, and briefly examined Petrel Island, on which the French station Dumont d'Urville is located. The scale of the work ranged from reconnaissance in the areas of extensive rock exposures to detailed examination of some of the small isolated islands.

A brief account of the geology of these areas, as well as a narrative of each voyage, has already been given (McLeod, 1960; 1961). This report gives details of the geology of each area visited, and a summary of the regional geology; petrographic reports by Australian Mineral Development Laboratories are appended.

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* Major localities mentioned in the text are shown on Plate III at the end of the report.

WILSON HILLS

The Wilson Hills in Oates Land are a group of rocky ridges and peaks between the Pennell Glacier (Longitude 157¼°E) and a large glacier at 161½°E; they extend inland at least 40 miles (Plate 1 and Fig.1).

Fig.1. The Wilson Hills, looking south. Cook Ridge rises from the sea on the left hand side of the photo; Stanwyx Ridge is the long ridge of exposed rock to the right of the centre of the photo. (G 4529)

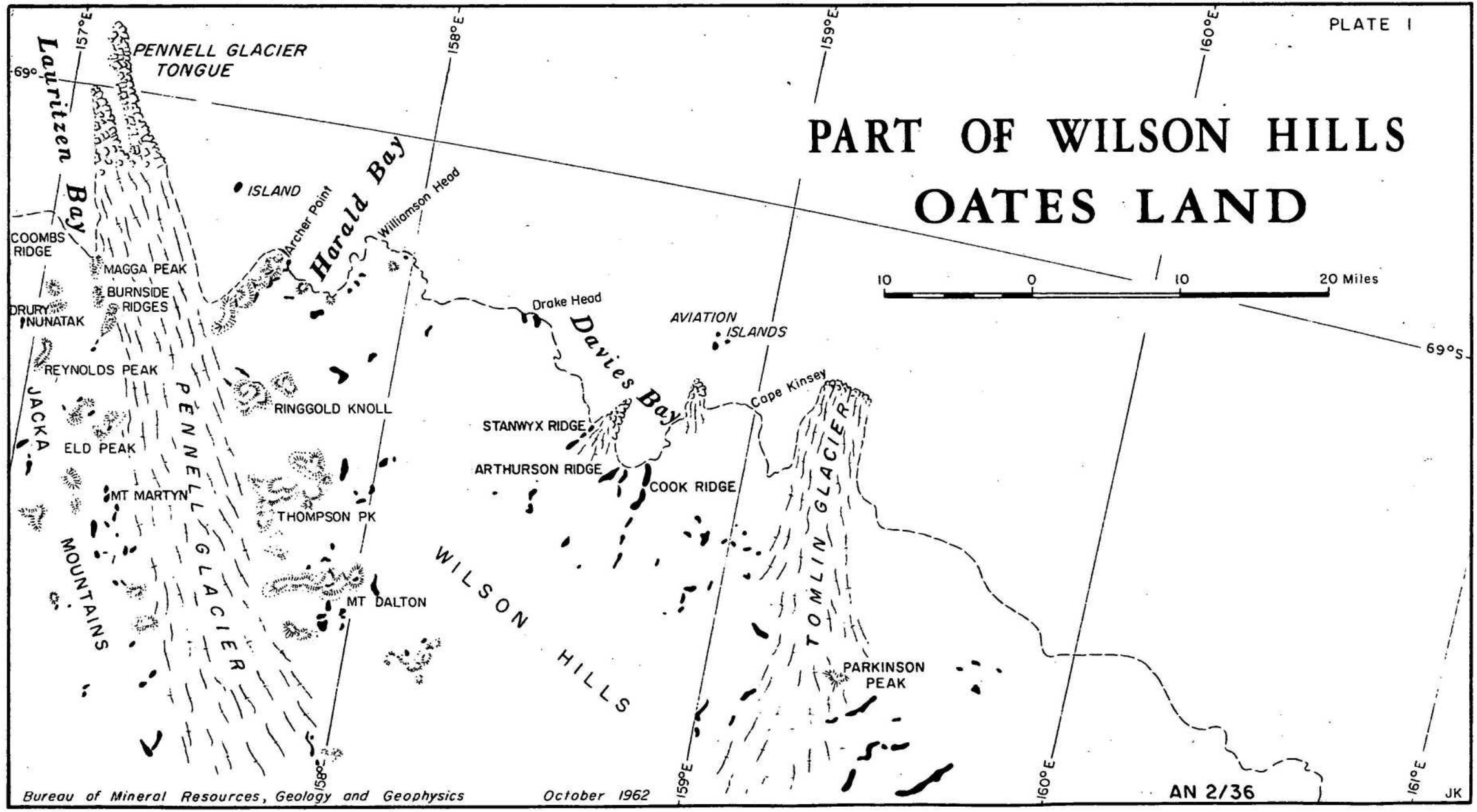
Individual exposures range from small peaks and headlands to large massifs many square miles in area. Many of the features of lower relief are almost covered by snow, only their crests and projecting lateral arêtes being visible. In the central part of the hills particularly, the relief consists predominantly of north-east trending ridges. The mountains are very rugged; the sides of most are steep or precipitous, and the summits are sharp peaks or jagged ridges. Cirque glaciers are not common in the area visited, but several abandoned cirques were seen, some still partly occupied by masses of stagnant ice.

No direct evidence of major faulting was seen. However, between the Pennell and Tomlin Glaciers at least, step faulting on lines parallel to the coast (i.e. trending south-east) is indicated by distinct stepped increases in the heights of the ridges which here trend normal to the coast; the respective breaks in altitude are approximately collinear from one ridge to another. From the coast inland, at least three steps can be distinguished, at heights of approximately 500, 2000 and 3000 feet. Aerial photographs of the area east of the Tomlin Glacier show two distinct scarps in the surface of the ice sheet, trending south-east and about 20 miles long; these are probably due to faults in the underlying rock. The long, straight course of the Pennell Glacier probably marks an important north-north-west trending line of weakness.

Seven localities near the coastline between 153°E and 165°E were visited by geologists of the Soviet Antarctic Expedition in 1958. (Klimov, 1960; Soloviev, 1960). A brief report (Klimov and Soloviev, 1958) mentions "gabbro-dolerite" at 68°33'S, 153°45'E (Scar Bluff - Mount Obruchev of the Russians); "phyllite-like shales with intercalations of grey lime-shales" near 69°13'S, 156°00'E (Mount Berg of the Russians, probably Mount Dwyer); "crystalline schists, enriched

PLATE I

PART OF WILSON HILLS
OATES LAND



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with biotite" and "biotitic gneisses" at 69°18'S, 158°01'E (possibly Ringgold Knoll) in the western Wilson Hills; "biotite-amphibolic granitoids" on the east side of Rennick Bay, and "porphyry-like granites" on the west side; "massive biotitic granites, and granosyenites" at 70°33'S, 163°40'E; and "alternating micaceous quartzite sandstones and micaceous shales" at 70°41'S, 164°47'E.

Soloviev (1960) draws the boundaries of the high-grade metamorphics of the Wilson Hills along the Pennell Glacier (about 157½°E) and due south from Rennick Bay (about 161½°E); he considers these boundaries "have a tectonic (faulted) character and are determined clearly". I consider that in the absence of further evidence, the position of the western boundary, at least, is debatable, because high-grade metamorphic rocks occur at Magga Peak on the western edge of the glacier, and on air photos the mountains west of the Pennell Glacier have the same appearance as those east of the glacier, which consist of high-grade rocks.

In March, 1960, A.N.A.R.E. made landings at three places in the Wilson Hills (Parkinson Peak, Cook Ridge and Stanwyx Ridge) and on the Aviation Islands, 5 miles off-shore. Specimens collected by A.N.A.R.E. from Magga Peak in February, 1959 are also described here.

Parkinson Peak

Parkinson Peak is an isolated peak approximately 3450 feet above sea level, situated in 69°30'S, 159°30'E. The rocks forming the peak are banded gneisses with numerous veins of acid rock.

The banded gneiss is predominantly a fine-grained rock composed of plagioclase, quartz and biotite (7290)*. The banding, due to concentration of the biotite along certain layers, is developed to various degrees of perfection ranging from barely distinguishable to sharply defined bands a couple of millimetres thick. Parts of the rock do not display any banding, but even so possess a slight foliation due to parallelism of the biotite flakes. Medium-grained plagioclase crystals are scattered through parts of the rock, and thumbnail-sized concentrations of biotite occur in a few places. The chemical composition of a specimen of the gneiss is given in Appendix II.

Quartzo-feldspathic veins up to half an inch thick and composed of medium-grained feldspar and quartz are very common in the banded gneiss. Some have a thin fringe of biotite; a few contain big augen-like feldspar crystals. Most of the veins are only a few yards in length. They are generally concordant with the banding of the gneiss, but in places break across it to form an irregular network of veinlets.

In addition to these veinlets, which are in general uniform in texture and composition, irregular masses of pink granitic rock form an important proportion of the country rock. Most of these masses are vein-like in outline, but many are very irregular in size and shape. Their texture is generally coarse, but shows considerable local variation. The mineral composition, too, displays some variety, in some instances changing rapidly within a distance of a foot or two. Most of the masses contain feldspar, quartz and biotite (e.g. 7288); the biotite commonly occurs as clots a couple of inches across, or as schlieren a few inches long; in some parts moderate amounts of muscovite are present. The masses also contain a small amount of rose-coloured garnet, either as scattered rice-sized crystals, or more commonly as small aggregates of crystals rimmed by or closely associated with biotite.

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* Numbers are those of thin sections in the Bureau of Mineral Resources collection. With the exception of those shown in square brackets, petrographic descriptions are given in Appendix I.

Another fairly common type of vein in the banded gneiss is fine-grained and consists of feldspar and quartz with a little chloritised biotite and associated garnet. Some hand specimens of this rock have a granulated appearance.

Most of the quartzo-feldspathic veins and granitic masses are roughly concordant with the banding of the gneiss, but discordant representatives are not uncommon (Fig.2).

Figure 2. Veins of coarse pink granite in feldspar-biotite gneiss on Parkinson Peak; the small dark patches in the granite are biotite clots. Fine-grained quartzo-feldspathic veins can be seen cutting the granitic masses. (G 4521)

On a macroscopic scale, the veins have a sharp contact with the gneiss.

Several straight, sharp-edged, parallel-sided dykes of biotite granodiorite (7289) cut the gneiss and veins. These dykes are either parallel to the banding of the gneiss, or cut across it at an acute angle. One of the dykes is in turn intruded by a thin aplite vein. The origin of these dykes is in some doubt. The field evidence suggests that they are intrusive, but microscopic examination of the rock indicates a metamorphic origin. The examination of the peak was brief and neither data nor specimens sufficient to provide a complete answer were collected. There is however a third possibility (which I favour on the present evidence), that the dykes are rheomorphic, and represent material mobilised by intense metamorphism and injected in much the same way as an ordinary igneous rock.

The general strike of the gneiss is 110° and the dip 80° to the south*. In many places the gneiss is tightly folded, the folds having

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* All bearings are relative to true north.

a distance of 6 inches or so from crest to crest and an amplitude of a couple of feet (Fig.3).

Figure 3. Irregular masses of granitic material in tightly folded feldspar-biotite gneiss on Parkinson Peak. (G4517)

All the rocks on the peak are very closely jointed, indicating that the area has undergone a certain amount of stress. A band of mylonite a couple of feet wide, and striking about south-east, was found on the northern side of the peak.

Slight copper staining of the rocks was seen at a few places; a few specks of pyrite were also found.

Cook Ridge

Cook Ridge is a prominent ridge extending south from the south-east corner of Davies Bay at approximately 69°20'S, 159°30'E for a distance of about 3 miles (Fig.4);

Figure 4. Cook Ridge, with an abandoned cirque on the northern face of the northernmost peak (left). The ridge is typical of this part of the Wilson Hills. (G 4520)

beyond this it merges with the surface of the ice sheet. A few prominences mark its southward continuation. Ice covers most of the ridge and with few exceptions the rock exposures are projecting arêtes and parts of the crest.

Only the ridge north of the northernmost peak (which rises to 2000 feet) was examined. The rocks here consist mainly of light-coloured, medium-grained, massive garnetiferous granite gneiss containing plagioclase, quartz, biotite and garnet (7291)*. Biotite flakes are nearly always associated with the garnet crystals and the garnet content shows considerable variation from place to place; it is almost absent from parts of the rock, especially those which are finer-grained than usual. The amount of biotite present also differs from one part of the rock to another, but not to the same degree as the garnet.

In this medium-grained rock (which is itself rather variable in texture) are irregular patches a foot or so across of coarse-grained granite gneiss (Fig. 5).

Figure 5. Patches and veins of granitic gneiss in feldspar-biotite gneiss near the north end of Cook Ridge. (G 4523)

This contains the same minerals as the medium-grained rock, but garnet and biotite are rather more common. The association of garnet and biotite is particularly striking, the two forming aggregates a centimetre or so in diameter. The biotite also forms platy aggregates several centimetres across containing little or no garnet.

Scattered through the granite gneiss are remnants, a few feet in extent, of fine-grained to medium-grained, banded feldspar-biotite gneiss containing sporadic small, pea-sized clusters of pink garnet and equally small aggregates of fine-grained biotite flakes. Sharp-margined veins of the garnetiferous granite gneiss extend through the

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* This specimen has rather less garnet than the typical rock.

banded gneiss; most, but not all are parallel to the banding. The banded gneiss is also irregularly invaded by quartz-feldspar masses, ranging from fine-grained to very coarse-grained in texture. In places, veining of the banded gneiss is so extensive that only small irregular remnants are left; most of these have a streaked-out appearance.

Two dykes of granite (7292) each about 20 feet wide and striking north-north-east, were seen cutting the gneisses. The texture in each is massive and medium-grained. Macroscopically, their margins are gradational from granite to gneiss over a distance of a few centimetres, and the marginal parts of the granite are faintly banded parallel to the edge of the dyke.

A few straight, parallel-sided pegmatite dykes a few inches wide intrude the gneisses. These pegmatites consist of creamy-coloured perthite, a little quartz, scattered red-brown garnets and rare biotite, with a thin central zone of sericite. A few veins of feldspar, aplite and blue quartz were also seen.

The strike and dip of the foliation of the banded gneiss differs considerably from one remnant to another, and even from one part to another of the larger remnants. The general strike appears to be about east-west, and dips range from 20° to 60° to the south; it is evident that the rocks have undergone intense folding.

A single dyke of basalt (7293) was seen, 3 feet wide, striking 120° and probably dipping vertically. The rock is porphyritic, with a few phenocrysts of pyroxene and plagioclase and one (a xenocryst?) of quartz, and with calcite-filled vesicles common in parts of the dyke.

Stanwyx Ridge

Stanwyx Ridge is about 5 miles west of Cook Ridge, and extends south-west for a couple of miles from the south-western side of Davies Bay. It is ice-covered for most of its length. A brief examination was made of the northern end of the ridge.

The rocks are banded gneisses (7294) similar in the hand specimen to those on Cook Ridge, but veining is much less common, and expanses of banded gneiss do not contain any veins at all. Medium-grained garnetiferous granite gneiss with little biotite and generally only a small amount of garnet is the most common vein rock, forming veins half to one inch wide along the foliation of the banded gneiss. Other veins consist of fine-grained aplite, while others are entirely feldspar.

The banded gneisses appear to be contorted into tight folds several feet across, with the axial planes striking about east-south-east and dipping north at 60° to 80°.

Aviation Islands

The Aviation Islands are a group of four small islets four miles north of the coast, at about 69°10'S, 158°50'E. Each is only a couple of hundred yards across, and the highest (the westernmost)

is only about 200 feet high (Fig.6).

Figure 6. Aviation Islands, looking about east. The large mass of granitic rock can be seen on the island on the left. (G 4364)

The rocks are dominantly fine-grained biotite-quartz-feldspar gneisses (7286) with minor amounts of sillimanite and rare garnets. Banding of the light and dark minerals is not nearly as prominent as in similar rocks on the mainland. Small tight folds are visible in places, and ptygmatic veins are fairly common.

These gneisses are cut by numerous veins of light-coloured fine-grained to medium-grained granite, consisting of white and clear feldspar, quartz and biotite, with rare sericite and a few thumbnail-sized phenocrysts of feldspar (some displaying extremely fine albite twinning) which in places form knots several inches in extent; the proportion of biotite varies from vein to vein. At first glance the rock appears to be massive, but close examination shows that many of the biotite flakes have the same orientation. Most of the veins are only a few inches wide (Fig.7).

Figure 7. Granite veins in feldspar-biotite gneiss on the westernmost of the Aviation Islands. (G 4524)

The larger ones are rather irregular in width, and range up to about 6 feet. Some veins, especially the narrower ones, are straight, others are irregular in direction; most transgress the banding of the gneiss. On a macroscopic scale, their edges are well-defined.

These veins of medium-grained granite are cut by veins of, or contain irregular lenses of, coarse-grained, light coloured granite [8378], composed mainly of white potash feldspar, with less quartz, some biotite, and, rarely, plagioclase and muscovite. The amount of quartz and biotite differs from place to place but is commonly small - feldspar forms about 90 per cent of some parts of the veins; sillimanite and small masses of cordierite* [8549] occur in places. The texture is uneven, with a considerable range in grain size. Some of the feldspars are more than an inch across; most of these larger feldspars contain small blebs of quartz, probably in optical continuity.

The veins of medium-grained and coarse-grained granite are particularly numerous on the westernmost of the islands; they are much less common in the gneisses of the other three islands.

The gneiss on the westernmost island contains a discordant, lens-like body about 10 feet wide. This has straight sharply-defined edges and consists of biotite, quartz and plagioclase (7186). Although it has a similar mineral content to the enclosing gneiss, the texture is distinctive. The origin of the body is uncertain. The impression gained in the field was that it represents a dyke which was metamorphosed along with the enclosing rocks, but both field and microscopic evidence are inconclusive.

The easternmost island of the group consists mainly of medium to coarse-grained granitic-textured gneiss (7285), principally plagioclase and quartz with some mica and sillimanite, and scattered small clusters of pin-head sized red garnets. Parallelism of the feldspar laths results in a good foliation, enhanced in places by thin streaks of biotite. A few coarser-textured patches consist of feldspar, biotite and phlogopite(?). Several sharp-margined inclusions of dark, fine-grained rock were seen; these are probably mainly biotite and feldspar, and contain lath-like feldspar porphyroblasts up to an inch long. The chemical composition of a specimen of this gneiss is given in Appendix II.

This coarse-grained gneiss is cut discordantly by a dyke 5 feet wide of medium-grained granite, identical (in the hand specimen at least) with the medium-grained granite veins cutting the banded gneiss on the other islands. The dyke is fairly straight with well-defined edges.

Several dykes of biotite-rich granodiorite up to a foot wide also occur on the easternmost island. They consist of fine-grained to medium-grained plagioclase, biotite and quartz. A notable feature of these dykes is the pronounced parallelism of the biotite flakes. One vein of coarse-grained iron stained quartz was found.

Because of the folding in the gneisses, the strike is not constant, but the general strike appears to be about 130° and the dip 60° to 80° to the south. Joint planes are fairly widely spaced, except on the island adjacent to the easternmost one; on this island, they are close together, and form two principal systems, one striking parallel to the foliation of the gneiss (i.e. striking 130° and dipping south at 70°), and the other striking normal to the foliation and dipping vertically.

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* A notable feature of this rock is that the cordierite in it is optically positive. Optically positive cordierite is characteristic of gneisses from moraine in the Commonwealth Bay area, some 450 miles to the west (Tilley, 1940), and also of boulders dredged from the sea floor by both the Australasian Antarctic Expedition and the British, Australian and New Zealand Antarctic Research Expedition (W.B. Dallwitz, personal communication).

Magga Peak

Magga Peak, situated at the head of Lauritzen Bay on the western flank of the Pennell Glacier, is part of the Jacka Mountains rather than of the Wilson Hills. I did not visit it, but an A.N.A.R.E. party landed in February, 1959, and rock specimens collected by Mr. J. Hollin (glaciologist at Wilkes during 1958) was passed on to me for examination. Hollin describes the general features of the area as follows :

> "This area is composed of metamorphic rocks, lineated* locally in a generally north-north-west - south-south-east direction and similar in general appearance to those found at Wilkes Station, 1500 miles to the west.
>
> "Drift: A thin cover, but reaches the highest summit, which has erratics. No special search was made, but no sedimentary rocks were noticed.
>
> "Glacial History: From the above, we may infer that at some time the local ice sheet was at least 500 feet thicker than it is today - probably more than 1000 feet. The highest raised beach was difficult to define here, because wasting on the steep slopes had blurred the usually sharp boundary between till covered areas above and wave cleaned areas below. The land has risen post-glacially somewhere between 72 and 96 feet above the current high water mark. The absence of transgressive till on the raised beaches immediately below the western corrie glacier suggests that this glacier has not in post glacial times been much larger than it is now. The presence of lichens close to the glacier's snout suggests that it is not currently retreating. The glacier has probably been separated from the main ice sheet which delivered the erratics to the ridge behind it for a very long time. The area is well weathered, and blocks now emerging from the basal shears of this corrie glacier seem fresh and local."

Hollin's notes on the occurrence of the specimens, and the specimens themselves, make it clear that the rocks of the area are similar in general, if not in detail, to those which I saw in the Wilson Hills.

The host rocks appear to be fine-grained feldspar-biotite gneiss (81)**; parts are coarser grained and banded (83), with thin feldspathic and quartz-feldspathic veins, some of them ptygmatic, and pink garnets; "epidote(?) also noticed". A further stage in the development of the acid veins is a medium-grained biotite-rich granite gneiss (84), which grades through granite with only moderate amounts of biotite but with ophitic hornblendes several inches across (85) to a massive, pink, medium-grained granite with little biotite, containing small irregular masses of magnetite (86). A white, similar granite (but with the magnetite occurring as small specks) "interfingers the neighbouring gneiss (interfingering generally parallel with gneissic lineation), but the contact is sharp and without local metamorphism."

Other specimens include a light grey medium-grained, imperfectly banded biotite gneiss (96) containing sphene and zircon(?), and a rather altered fine-grained porphyritic pyritic dolerite (80), "probably from a dyke bearing 060° magnetic" (i.e. about north-north-west true).

Moraine includes a fine-grained gneissic biotite granite containing small inclusions of amphibolite with some epidote (87), "not actually in situ but certainly local", a fine-grained feldspar-amphibole-biotite rock with phenocrysts (or porphyroblasts) of amphibole (99), and a pink aplite (97), "abundant in the drift and almost certainly in situ".

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* This probably refers to foliation; there is no macroscopic sign of lineation in any of the specimens.

** Numbers are Mr. Hollin's field numbers.

DUMONT D'URVILLE

The French station Dumont d'Urville is situated at 66°40'S, 140°01'E. Here I met Professor Bellair of Paris University, who had spent a week examining the geology of Petrel Island, on which the station is built, and had reached the following conclusions:

The bulk of the rock is a close-jointed migmatite (derived from arenaceous sediments) with veins of grey granite. The least altered material is a fine-grained quartz-feldspar-biotite-(pyroxene or hornblende) rock, streaked out and pinched into nodules up to six inches across (producing a type of boudinage structure). Most of the rock is an intimate association of this and thin layers of pinkish-grey granite with a very irregular closely folded foliation. Several small concentrations of hornblende or pyroxene occur.

Cutting this migmatite are bands of massive, pink medium-grained to coarse-grained granite consisting of potash feldspar, quartz and biotite; some contain thin irregular schlieren of dark country rock. A few bands are 10 feet thick, but most are less than 2 feet. Some are parallel to the foliation of the migmatite, but many cut sharply across it. The width and direction of the bands is irregular, but the edges are everywhere sharply defined, with no evidence of plastic deformation of the migmatite.

Several erratics contain pink feldspar porphyroblasts up to 3 inches across in a matrix of quartz, feldspar and biotite. Some contain also thumbnail-sized porphyroblasts of reddish-brown feldspar. Although similar rock has not been found in situ Professor Bellair thinks it may represent apophyses from the pink granite.

The time interval between formation of the migmatite and emplacement of the pink granite is not known. Professor Bellair planned to have thorium and potassium-argon age measurements made on rocks from both suites.

Other rocks in the moraine include red, slightly metamorphosed quartz sandstone, and a fragment of rhyolite possibly related to the pink granite. In the area around Dumont d'Urville, island summits are grouped about two levels (at 10 and 40 metres (i.e. about 30 and 130 feet) above sea level). Several small faults and one large one had been found.

DAVIS BAY

Davis Bay is situated near the western side of the Dibble Iceberg Tongue at about 66°10'S, 134°05'E. It contains several small islands, of which the largest, Lewis Island, is the site of an A.N.A.R.E. automatic weather station. The only previous report on the geology of the area is one by McLeod (1959).

Lewis Island

Lewis Island is a small dome-shaped island thirty yards from the edge of the continental ice cap on the eastern side of Davis Bay, in 66°06'S, 134°22'E. It is about 300 yards long, 200 yards wide and 90 feet high and is connected by a partly submerged rock shelf to rock exposures in the adjacent cliffs of the ice cap.

The rocks forming the island consist of a grey medium-grained biotite granodiorite gneiss and banded biotite-feldspar gneiss; the granodiorite gneiss is predominant. The biotite-feldspar gneiss forms bands through the granodiorite gneiss; the bands are up to 5 feet wide but are generally thinner and rather discontinuous. The division between

the two gneisses is generally well defined. In several places the granodiorite gneiss contains streaked-out elongate biotite-rich inclusions, many with a ½ inch wide rim of feldspar.

The banded biotite-feldspar gneiss is a fine to medium-grained rock, composed mainly of feldspar and biotite, with small nests of epidote and scattered grains of pyrite. The biotite content ranges from less than 10 to 50 or 60 percent of the rock. This variety produces a marked banding, which is further emphasised by thin parallel layers of coarser felsic material.

The granodiorite gneiss [4556] consists of andesine, quartz, biotite and perthite, with accessory pyrite, magnetite, spinel, sphene, calcite, clinozoisite and muscovite; the last three and some of the magnetite are concentrated along lines of granulation and may have been produced by alteration during crushing of the rock. Perthite is generally present in only small quantities, but in places is common as pink crystals, up to an inch across; the rock containing these is richer than usual in biotite. Along lines of cataclasis in the rock the grain fragments (mainly quartz) have been partly recrystallised so that their boundaries are highly sutured.

Narrow pegmatite veins occur, composed of white plagioclase and pink potash feldspar, with some quartz, brown garnet, biotite or hornblende, magnetite and pyrite; the quartz and feldspar are zoned in some of the wider veins. A few of the veins contain white feldspar only. These acid veins are straight and sharp-edged; they trend both across and parallel to the foliation of the gneisses.

In a few places are narrow zones consisting of a network of thin epidote veins. Veinlets and knots of white quartz with small brown garnets, and of clear quartz with sporadic pyrite, also occur.

The strike of the gneisses is a constant 070°, and they dip to the south at 50° to 70°.

A short distance below the summit of the island (i.e. 85 feet above sea-level) is a small flat area of rounded boulders. These could be a moraine deposit but the high degree of rounding, rarity of facetting, regularity of size (most are between 6 and 12 inches in diameter) the flatness of the exposure, and rarity of other moraine on the island suggest that the boulders were wave rounded during a period of higher sea-level.

Ice polished surfaces were seen at several places on the island.

Anton Island

Anton Island, a small island about 5 miles north-east of Lewis Island, is made of pinkish-grey porphyritic adamellite gneiss (5566). This consists of tabular pink feldspars up to an inch long, comprising about 25 percent of the rock (although it is the dominant feldspar in places), set in a medium-grained matrix of ferromagnesian minerals and feldspar. Both the matrix and phenocrysts are well foliated; the foliation strikes 020° and dips at 45° to the west.

Several pegmatite veins (composed of pink perthite, biotite and quartz) and thin straight feldspar veins, cut across the granite. A few thin shear zones parallel the foliation.

Jointing is widely spaced. The rock slabs have been smoothed, presumably by ice, but no polishing or moraine was seen.

Several other small islands are scattered about this part of Davis Bay. Most are less than 20 yards across, and all are completely covered by a vertical-sided cap of frozen sea spray and accumulated snow, rising to 20 feet above sea-level. The rock exposed at the base of this cap appears to be adamellite gneiss like that on Anton Island.

HENRY BAY

Henry Bay is an indentation in the coastline at about 66°50'S, 120°40'E, near the western side of the base of the Dalton Iceberg Tongue.

The coastline here is formed by a low-lying ice shelf, which, about a quarter of a mile inland, rises steeply for 100 feet or so. However, this rise is not the edge of the icecap, because remnants of icebergs jut above the surface of this higher area, and frozen sea can be seen in crevasses more than half a mile from the open sea. Another scarp several miles further south may represent the edge of the icecap.

At the edge of the ice shelf are two small groups of rock exposures, the Henry Islands, almost at the head of Henry Bay, and Chick Island, 8 miles to the north-east, the site of an A.N.A.R.E. automatic weather station. These are the only rock outcrops known on the coast for almost 300 miles to the west and 150 miles to the east.

The area was visited by the Soviet Antarctic Expedition early in 1958. In a brief account of their findings (Klimov and Soloviev, 1958), Chick Island is described as "intrusive charnockite" and Henry Islands as "porphyry-like pyroxene-containing granitoids". (Their "pyroxene" is probably hornblende). Starik, et.al. (1959) give the age of "charnockite" from Henry Bay as 660 and 720 m.y.

Chick Island

Chick Island consists of two tor-like masses of rock about 50 yards apart, each about 70 yards long, 20 yards wide, and rising about 50 feet above sea-level (Fig.8).

Figure 8. Charnockitic adamellite, Chick Island. Inclusions in the adamellite can be seen in the centre and left of the photo. The triped and hut are part of the automatic weather station installation. (G 4365)

A third exposure almost covered by snow and only a few square yards in area lies between these two.

The rock is a uniform, dark, coarse-grained charnockitic adamellite (5567), containing feldspar, quartz, pyroxene and hornblende, rare poikilitic biotite and very rare red garnet. It has a slight foliation, due to alignment of the feldspars, which strikes 090° and dips within a few degrees of vertical.

Inclusions are moderately common, ranging from less than an inch to 10 feet across, but generally only a few inches in extent. Some are circular in outline, but most are elongate and oriented parallel to the foliation; nearly all have well-defined edges. The most common type is a fine-grained granulite, consisting of various proportions of feldspar and pyroxene; some are banded, but the banding is not parallel to the foliation of the adamellite. Other varieties consist of pink feldspar, quartz, small amounts of hornblende and biotite, and rare garnets; these are massive and range in texture from aplitic to pegmatitic; many of the coarser ones are several feet in extent. Other inclusions are mineralogically like the adamellite but are finer grained, or are similar in texture to the adamellite but have few dark minerals; most of these are massive, but some have a gneissic texture. A few brown coloured, isolated, rounded feldspar crystals, 3 to 4 inches across could be either xenocrysts or phenocrysts. One thin, pink coarse-grained feldspar-quartz vein cuts the adamellite.

Jointing is developed on cubic lines, with two vertical sets and one near horizontal set. The best-developed vertical set strikes north-north-west, with joints 2 to 6 feet apart; the second set is normal to this, with joints 10 to 20 feet apart, and the horizontal joints are about 20 feet apart. Ice-polished surfaces persist on the rock; most of them are remnants which have survived exfoliation.

The origin of the charnockitic adamellite could not be ascertained. The petrographic description assumes that it is a metamorphic rock. However, field evidence, such as its homogeneity, massiveness, and the "igneous-looking" aspect of the inclusions, suggest an intrusive origin. The rock is similar to the Mawson Granite, which has been shown to be intrusive (Crohn, 1959). Without knowing the regional geological boundary relations of the adamellite, it will be virtually impossible to determine its genesis with any certainty. However, despite the presence of apparently primary hornblende and biotite in the Chick Island adamellite, which indicates the presence of a moderate amount of water, I tend to favour an origin similar to that suggested by Crohn for the Mawson Granite, viz. partial mobilisation and subsequent injection of material under conditions of extreme metamorphism. The hornblende rims around the biotite could have been formed either during the decline of this metamorphic episode or they could be the result of a later, less intense metamorphism.

Henry Islands

This group consists of two main outcrops about 50 yards in diameter and a quarter of a mile apart, and several smaller exposures grouped

around each of these (Fig.9).

Figure 9. The Henry Islands, looking west. The smooth surface of the icecap can be seen on the skyline, rising above the flat shelf ice (foreground and middle distance) surrounding the islands. (G 4526)

The main islands rise about 30 feet above the low-lying shelf ice which completely surrounds them.

The rock forming all the exposures is a medium-grained, pinkish-grey hornblende-biotite granite (5568), consisting of pale pink feldspar phenocrysts in a medium-grained aggregate of biotite, hornblende, quartz and feldspar. A very poorly defined lineation due to parallel orientation of the large feldspar grains strikes 160°. A suggestion of vertical foliation is present in a few parts of the rock.

Inclusions are common; most are small, usually less than a foot across. Some are equant, either rounded or with fairly sharp corners; others are lenticular and aligned parallel to the foliation of the granite. The most numerous type is banded feldspar-biotite gneiss (usually containing a little hornblende). The edges of these inclusions are sharply defined, and the banding does not show any preference for parallelism to the lineation of the granite. Other inclusions are similar mineralogically, but are massive looking, with no banding; a few contain medium-grained feldspar porphyroblasts. The edges of some of these inclusions are ill-defined, suggesting partial assimilation. The granite also contains a few small patches of fine-grained pink feldspar flecked with biotite; these have irregular but well-defined edges.

Several long, straight, thin veins, composed either of alaskite, coarse-grained feldspar, or biotite, cut across the granite.

The granite is broken by widely spaced vertical joints, a major set striking north-west and a minor set normal to this. The rock surface has been rounded, smoothed, and in places polished by

ice (Fig.10), but no glacial striae were found.

Figure 10. Ice-smoothed granite slabs, Henry Islands. Several thin feldspar veins can be seen in the centre of the photo. Small dark inclusions can be seen in the rock on the right of the photo. (G 4522)

The origin of this granite, like that of the Chick Island adamellite, is in doubt, and for the same reasons, probably cannot be elucidated. In this case the petrographic evidence for a metamorphic origin is stronger, but even so, I feel that the evidence is not conclusive for either a metamorphic or palingenetic origin for the rock.

BALAENA ISLANDS

This group of islands is situated at 66°00'S, 111°05'E, some 20 miles north-east of Wilkes, and consists of five small islands a couple of miles from the coastline. Various islands of the group were visited by A.N.A.R.E., the Soviet Antarctic Expedition and the United States "Deep Freeze I" expedition in 1956, and by American parties after the establishment of Wilkes.

In a very brief description of the geology Robertson (1961) remarks that the group consists of a grey medium-grained biotite granite.

Thompson Island, the largest of the group, consists of a greenish-grey, equigranular, medium-grained, altered biotite adamellite (5574) with a very poorly defined foliation (in many places more a lineation) striking 080° and dipping south at 20°. Specks of pyrite are fairly common and a few garnet grains are present. In a few places a poorly defined but regular banding is produced by slight differences in concentration of the dark minerals. The rock contains small fine-grained feldspar-biotite inclusions, and a few thin fine-grained biotite-rich schlieren. Thin epidote veins occur along some of the joints in the adamellite.

The adamellite is cut by numerous straight, parallel-sided, sharp-edged pegmatite veins, ranging in width from a couple of inches to a foot or so. They are coarse-grained and consist of creamy coloured

perthite (commonly sericitised), quartz, biotite and rare magnetite. In places these veins swell into irregular, very coarse-grained masses, the largest of which is 8 feet across; the feldspar is sericitised, and quartz commonly forms one or more knots in many of the masses; pyrite and calcopyrite are common in some. The edges of even the large masses are commonly well-defined but some show a tendency to grade into the adamellite, which here is irregular textured and rather coarser than normal - however, the edge of the pegmatite is still traceable.

High readings were obtained over this island during an airborne scintillation counter survey by A.N.A.R.E. in 1956. However I found no abnormal radioactivity in any of the rock types, and it seems safe to ascribe the high readings to the mass effect of the accessory minerals in the adamellite.

No glacial erratics were seen on this island.

The island at the southern end of the Balaena group is composed of a quite different rock type, viz. an equigranular medium-grained gabbro composed of labradorite and clinopyroxene (5575). In places the pyroxene forms small aggregates a couple of inches in diameter.

Several zones of shearing are present, each marked by numerous, closely spaced, parallel, epidote-filled joints, and in a few cases also by chloritisation of the pyroxene of the gabbro. Most of these zones strike 125° and dip at 85° to the south, but several strike 030° and dip vertically. Copper staining is common in the western part of the island.

The intrusion of this gabbro may, or may not, be the cause of the alteration of the feldspar and femic minerals in the adamellite forming Thompson Island; there is no certain evidence.

Several erratics were found on the island, including boulders of red or purple quartzite (9530) similar to that found on the islands in Vincennes Bay, and one of a medium-grained biotite granite in which all the minerals except quartz have been uniformly and heavily permeated by a purple stain, possibly manganese compounds.

FRAZIER ISLANDS

This small group of islands, about 10 miles west-north-west of Wilkes, was first visited by A.N.A.R.E. in 1956. Nelly Island, the largest of the group, is made up of uniform, fine-grained, finely crenulated feldspar-quartz-biotite gneiss. In the northern part of the island, dark biotite-rich bands alternate with light-coloured fine-grained quartz-feldspar bands containing sporadic garnets. Biotite is most abundant in the north-west part of the island. Here also the gneiss contains two lenses, up to 8 feet wide and 12 feet long, of very coarse pegmatite. The general strike of the gneiss on the island is 120°; it dips at 60° to the south.

WINDMILL ISLANDS

The Windmill Islands occupy an area of some 150 square miles on the north-east coast of Vincennes Bay. Wilkes station, in the north of the group, is situated at 66°15'S, 110°31'E.

The area was first visited in 1947, when personnel of the United States Navy "Operation Windmill" landed on several of the islands. As far as I know, there is no published description of any geological work done at the time. In January 1956, members of A.N.A.R.E. landed on some of the islands in the north of the group. There was no geologist in the

party, but rock specimens were collected and sent to the Bureau of Mineral Resources. Several airborne scintillation counter runs were flown, but no formal report was prepared on the results. The Soviet Antarctic Expedition examined the area, which they refer to as the Grierson Oasis, early in 1956 (Ravich, 1960; we do not have a translation of this paper). In a preliminary report (Ravich and Voronov, 1958) the islands of the northern half of the group are described as consisting of "pyroxene - and amphibolite-pyroxene melanocratic plagiogneisses and crystalline schists in one or other stage of migmatisation" while those of the southern half "are formed by charnockite granitoids and seem to be in part coarsely plutonic". Dolerite dykes are said to be numerous; in fact they are uncommon. Starik, et al (1959) and Starik et al (1960) list the results of age measurements on granitic rocks collected from unspecified places in the Windmill Islands; their ages range from 765 to 1020 m.y., with a grouping about 900 m.y.

At almost the same time, the area was revisited by the United States in "Operation Deep-Freeze I", and Wilkes station was set up a year later. During 1958, members of the United States party at Wilkes examined and mapped the islands. Robertson (1961) described the area as consisting of Precambrian metamorphic "migmatised biotite, hornblende, or magnetite-garnetiferous gneisses with intercalated bands of pegmatite in various habits" intruded by a stock of diorite, syenite and granite.

Because of the short time available, I did not attempt any systematic mapping, but examined representatives of all the rock types described by Robertson. (See Plate 2.)

Most of the islands of the group form a north-south belt close to the coast, with the Frazier and Donovan Islands comprising two small groups to the north-west. Although many of the rock exposures are partly (and some completely) surrounded by ice, the low topographic level of this ice and the presence of a long line of shear moraine (which probably marks the edge of the icecap) several miles inland from the sea suggests that this ice is actually very thick bay ice trapped and immobilised by the numerous islands and probably resting on the bedrock. The outcrops forming Clark, Bailey and Mitchell Peninsulas and Robinson Ridge are consequently regarded as part of the Windmill Islands.

The highest points in the group are about 300 feet above sea level, but as Robertson (1961) has pointed out, many summits have an altitude of about 250 feet. The relief is only moderate, consisting of shallow valleys floored with detritus, many containing permanent snow drifts (Fig.11).

Figure 11. Odbert Island, showing typical Windmill Islands scenery - a shallow valley, partly filled by moraine and exfoliated rock detritus, with steep rocky sides, and a rather flat summit to the ridges. The rock is gneissic porphyritic adamellite. (Photo by B.H. Stinear.) (G 4528)

This permanent snow cover is most extensive in the northern part of the group, particularly on Clarke and Mitchell Peninsulas. There are several raised beaches (Fig.12).

Figure 12. A raised beach, marked by a terrace of rounded boulders, about 90 feet above sea-level, on the north side of Robinson Ridge.
(Photo by B.H. Stinear) (G 4527)

A line of shear moraine forms a prominent feature a mile or so inland from Clarke, Bailey, and Mitchell Peninsulas. This moraine probably represents the line of demarcation between the slowly moving ice sheet and the (probably) immobile ice partly enclosing the "islands".

The effects of frost action are very marked; many boulders, even those of massive rock, are disintegrating by repeated exfoliation and frost shattering.

Clark Peninsula

Clark Peninsula, on which Wilkes station is situated, consists of several rocky masses wholly or partly surrounded by ice, the whole forming a peninsula a couple of square miles in area. The country rock is predominantly banded gneiss, invaded by large irregular masses of pegmatite.

The banded gneiss is a fine to medium-grained rock composed of feldspar, quartz, hornblende and biotite (5572). Segregation of the light and dark minerals has formed well-defined bands less than an

inch wide (Fig.13).

Figure 13. Banded gneiss near Wilkes on Clark Peninsula. Thin quartzo-feldspathic bands and lenses are common to the right of the seated figure. (Photo by B.H. Stinear.) (G 4519)

These bands may be enhanced by slightly coarser quartzo-feldspathic veins more or less parallel to them; most of these veins are only a couple of inches thick but some are as much as a foot thick. In places the light-coloured bands display boudinage structure near thin mylonite zones parallel to the banding. Lines of white feldspar porphyroblasts probably denote incipient production of banding in the gneiss. Parts of the gneiss which are not banded generally contain a scattering of reddish-brown garnets.

Veins of creamy-coloured pegmatite up to 50 feet wide are common; most are irregular in width. They generally follow the banding of the gneisses, but cut across it in places. Parts of the pegmatite consist of medium-grained feldspar with only minor quartz, and trails and nebulous patches of reddish-brown garnet. Other parts are made up of quartz-feldspar intergrowths in units up to a foot across; patches of fine-grained, almost rhyolitic-textured, material, elongated in the direction of strike, occur in this coarse pegmatitic rock.

A few thin veins of red coarse-grained granite were found in the gneiss.

Pyrite and chalcopyrite are relatively abundant in the gneiss and pegmatite, and copper staining is a common feature, particularly in the gneiss.

In several places in the station area, long straight veins of muscovite pegmatite with a north-west strike cut across the other rocks. These veins were emplaced along faults. The displacement of the faults is not known, but drag on each side shows that the horizontal component of movement was right-handed.

The general strike of the rocks in the north-western part of the peninsula is east-west, with dips of 60° to 80° to the north. A folded zone, of which the major unit is a syncline overturned to the north, occurs along the northern side of the peninsula on which the station is built.

A mass of tephroite ($MnSiO_4$) about ten feet across occurs east of the station, near the geomagnetic hut. Rhodonite ($MnSiO_3$) and the manganese garnet spessartite are common in the margins of the mass. Assays of a sample selected at random from the main tephroite mass gave -

Mn	39.1 percent
Fe	1.91 percent

A detailed description of the mineralogy and occurrence of this mass has been given by Mason (1959).

Small veins and patches of rhodonite occur in strongly folded banded biotite-feldspar gneiss south of the four Jamesway huts east of the main station area. Several thin iron-stained quartz-rich veins with pyrite specks are associated with this occurrence.

Beall Island

Beall Island, a few miles south-west of Clark Peninsula, consists of gneiss like that of Clark Peninsula, but with a higher proportion of acid material. The typical vein rock is a medium-grained plagioclase - quartz-garnet rock, not a pegmatite. The gneiss strikes about 090°; dips are very irregular.

Several vertical basalt * dykes (5573) a few feet in width strike 130°; several narrow shear zones in the gneiss strike in the same direction.

Several pieces of highly saussuritised gabbro were found amongst the moraine on the island.

Warrington Island

The rock on Warrington Island is a light-coloured, medium-grained equigranular granodiorite consisting of plagioclase and quartz with scattered phenocrysts of potash feldspar containing numerous quartz inclusions. Chlorite, magnetite and, rarely, red garnet occur in small amounts as faint bands through the otherwise massive rock; these bands strike 090°, and dip south at 70°. Thin sharp-edged veins of coarse-grained feldspar and biotite run both along and across the banding. The margins of some of these show a slight concentration of biotite. A few thin veins of red alaskite containing some red garnet also cut the granite.

Much of the island is covered by moraine. The debris ranges in size from sand to boulders four feet across, with a few larger boulders.

Several valleys running west-north-west across this island and adjoining Pidgeon Islet may represent shears.

Ardery Island

The rock on this island is a uniform, dark-coloured, medium-grained porphyritic charnockitic adamellite (5570) which consisted originally of andesine, potash feldspar, quartz and pyroxene (which is partly altered to hornblende and biotite). The feldspar phenocrysts, up to 1 inch long and $\frac{1}{2}$ inch wide, form 5 to 10 percent of the rock. They show a rough platy parallelism striking 115° and dipping south at 80°. The dark minerals of the rock tend to form small patches elongated in the same direction.

A few small inclusions occur, round or oval in outline, with sharp edges and composed predominantly of hornblende.

The age of rock from this island (called "quartz diorite" by Robertson) was found to be 1075 ± 25 m.y. (Cameron, Goldich and Hoffman, 1960).

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* This name is preferred to dolerite because of the fine grain size of the rock.

Odbert Island

Odbert Island is made up of gneissic porphyritic adamellite (5569) containing feldspar phenocrysts up to an inch long. Parallelism of these phenocrysts and of biotite-rich lenses up to a foot long produces a foliation striking 085° and dipping south at 85°. The adamellite is cut by several straight, parallel-sided, medium-grained veins composed of plagioclase, quartz and a small amount of biotite. These veins strike about east-west; they are nearly vertical or nearly horizontal.

Despite a close aerial examination, the altered diabase dykes described by Robertson were not seen. However, in the position of the northernmost of these dykes, there are two masses of dark, fine-grained to medium-grained rock each very irregular in shape, and about 10 feet wide and 20 to 30 feet long. They are cut by numerous coarse-grained feldspar-quartz veins, and by medium-grained granite veins, some of which carry small amounts of magnetite. The rock forming these masses is a granoblastic to poikiloblastic aggregate of labradorite, greenish-brown hornblende, orthopyroxene, clinopyroxene and magnetite (8379). Most of the clinopyroxene occurs as remnants of large grains now partly replaced by the hornblende and magnetite. These remnants could originally have been phenocrysts in a dolerite, but this and the apparently similar chemical composition are the only evidence that the rock was originally a dolerite.

The country rock on Odbert Island is similar in mineral composition and macroscopic texture to that forming Ardery Island, and indeed, Robertson equated the two. However, they differ in that the Odbert Island rock contains perthite, and has pyroxene (augite and not hypersthene) present in much smaller amount. Another, and possibly significant difference is that the Ardery Island rock has the typical dark colour of charnockites (here due primarily to brown feldspar) while the Odbert Island rock has the grey colour of a normal granite, with white or pale grey feldspars.

Robinson Ridge

Robinson Ridge, a small promontory of rock and ice projecting from the coastline in the central part of the Windmill group, consists of granodiorite flanked by quartz-biotite-feldspar gneiss. The gneiss is strongly banded, with well-defined bands, from $\frac{1}{2}$ to 2 inches wide, of plagioclase and quartz with minor biotite alternating with similar bands of plagioclase and biotite with minor quartz; the biotite is completely chloritised. There are many small, tight folds in the gneiss; on the southern side of the ridge it has a general strike of 130° and a dip of 60° to the south.

The granodiorite is a medium-grained rock not unlike the adamellite on nearby Odbert Island. A vertical foliation striking 095° is brought out by alignment of small elongate concentrations of biotite, scattered feldspar phenocrysts and small lenticular inclusions of fine-grained feldspar-biotite rock. Near the contact with the gneiss the quartz diorite is darker, richer in biotite, and almost quartz-free.

The impression gained in the field was that the granodiorite was intruded into the gneisses. Over a distance of 30 feet from the contact the gneiss is commonly rather coarser than it is further from the contact and it contains a network of veins of coarse-grained granite and also veins and masses of biotite-rich quartz diorite.

Near the northern contact, a thin sinuous pegmatite vein cuts the gneisses. There, too, a small body of massive unaltered amphibolite occurs in the gneisses.

Ford Island

Ford Island consists of several varieties of granite, which appear to have been emplaced as separate phases. The most common type is a porphyritic granite, with tabular potash feldspar phenocrysts in a fine to medium-grained matrix of feldspar, quartz, biotite and accessory red garnet and magnetite. Most of the rock is stained a buff colour by limonite. The phenocrysts generally make up about 20 percent of the rock, but in a few places they form only 5 percent and garnets and limonite staining are almost absent. A junction between the typical granite and the phenocryst-poor type is sharp, with stringers of the former in the latter.

Other varieties found were a coarse-grained alaskite composed of pink feldspar and quartz, and a rock not unlike some found on Herring Island, with brown feldspars and a faint greenish-blue tinge to some of the quartz. No sign of chilling was observed at contacts between different types. In general the feldspar phenocrysts in all the types of granite have a similar appearance independent of the nature of the ground mass.

Parallel orientation of the feldspar phenocrysts in the porphyritic rocks produces a vertical foliation striking 020°. Several small irregular veins of pegmatite were found; one of these was rich in muscovite.

The degree of weathering is rather high; much of the rock is lightly permeated by limonite, and the feldspar phenocrysts stand up in relief on exposed surfaces.

The bulk of the rocks on Ford Island do not have a close resemblance to any of the other granitic rocks in the Windmill Islands; in hand specimen at least they most resemble the adamellite forming Warrington Island. However, all the intermediate to acid, igneous-looking rocks of the Windmill Islands probably represent parts of the one stock-like intrusive body, or, at least, are phases of the same igneous episode.

In 1956, uniformly high scintillation counter readings were observed over this island during an airborne scintillation counter survey by A.N.A.R.E. According to Mr. Law, the counting rate changed abruptly over the coastline. Examination with a portable ratemeter in 1960 showed that background counts were slightly higher here than in other parts of the area, but no evidence of any concentration of radioactive minerals was found. The high scintillation counter readings can be attributed to the total effect of minor accessory minerals in the granite.

Herring Island

Herring Island is made up of dark fine-grained to medium-grained charnockitic granulite (5571) consisting of plagioclase, pyroxene and hornblende, and of coarser more granitic-looking gneiss consisting of brownish feldspar, quartz and rare biotite.

Generally the granulite has a uniform texture. In some places small coarse-grained masses of feldspar and biotite occur, while in others the biotite is concentrated in small pea-sized blebs; sillimanite(?) is locally abundant. The gneiss has a poorly defined foliation striking 160° and dipping east at 80°. A variety with less biotite contains small elongate lenses of feldspar or masses of pink granite with chloritised biotite, and has a lineation plunging south at 70°.

In the southern part of the island the "granite" gneiss contains bands of massive, brown, charnockitic-looking rock with brown feldspar, pale greenish-blue quartz and minor biotite. In this brown rock there are irregular masses of lighter coloured rock, with more biotite but no quartz, and with a foliation striking 010° and dipping 80° to the east. Feldspar-pyroxene veins also occur in this brown rock.

Plate 2

WINDMILL ISLANDS

Geological sketch map showing areas examined on the ground and from the air

110°10' 110°20' 110°30' 110°40'

66°15'

66°20'

66°25'

66°30'

66°35'

Frazier Islands

Donovan Islands

Berkley I

CLARK PENINSULA

WILKES

BAILEY PENINSULA

Beall I.

Pidgeon I

Midgley I

Warrington I

MITCHELL PENINSULA

SHEAR MORAINE

Ardery I

Odbert I

ROBINSON RIDGE

Ford I

Cloyd I

Holl I

O'Connor I

Werlein I

Herring I

Peterson I

Browning I

Boffa I

VANDERFORD GLACIER

- Banded quartz – feldspar – biotite gneiss
- Do. with granitic and pegmatitic veins
- Granite, granodiorite
- Quartz diorite
- Charnockitic rocks
- Dolerite dyke
- Edge of exposed rock
- Ice coast
- Strike and dip of foliation
- Moraine

Scale

1 0 1 2 3 miles

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G 50

A vein of graphic pegmatite ranging from one to five feet in width, with an unusually high ratio of quartz to feldspar, has invaded the gneiss.

In several places the gneiss contains green copper staining.

Shear moraine

This is a line of morainal debris a couple of miles inland behind Clark, Bailey and Mitchell Peninsulas and Robinson Ridge (Fig.14).

Figure 14. Shear moraine behind Clark Peninsula, looking south. The dark line in the far distance is part of the moraine. (G 4525)

A description of the various rock types present has been given by Robertson (1959).

The only additional type found by the writer is a pink blasto-porphyritic or porphyroblastic rock with small quartz grains in a very finely crystalline groundmass (9528); epidote is common along joints. The rock has evidently been metamorphosed, probably thermally. Its original nature is obscure. It could have been a sediment, but could also have been a quartz porphyry or similar igneous rock.

SOUTHERN VINCENNES BAY

Two groups of rock outcrops occur near the head of Vincennes Bay, about 60 miles south-west of Wilkes. One of these, the Hatch Islands, consisting of several small islets, was not examined. Visits were made to Ivanoff Peninsula and to the Davis Islands, some 20 miles to the north-west.

Ivanoff Peninsula

Ivanoff Peninsula is situated at 66°50'S, 109°06'E. As far as I can ascertain, no geological work had previously been done in the area. The outcrop is about 300 yards long and 150 yards wide, and rises about 100 feet above sea level. It is joined to the edge of the continental ice sheet by a narrow low-lying isthmus strewn with moraine.

The rocks are predominantly medium-grained grey pyroxene granodiorite gneiss (5562) consisting of feldspar, quartz, pyroxene and biotite. This contains lenses and layers of fine-grained banded biotite-feldspar gneiss

consisting of plagioclase, biotite and quartz, with banding in which the bands range from a couple of millimetres to several centimetres in width; reddish-brown garnet is common in parts of this gneiss. Some biotite-rich layers of the banded gneiss contain thin anastomosing veins of red feldspar; this gneiss rock is generally rather coarser than the gneiss and contains large red garnets. Many of the lenses of biotite-feldspar gneiss do not show any banding, but contain feldspar porphyroblasts similar to the feldspars in the granodiorite gneiss.

The proportion of granodiorite gneiss to banded gneiss differs from place to place, but on the whole the former is predominant. Although the granodioritic bands generally conform to the foliation of the banded gneiss, transcurrent offshoots are not uncommon; the margins of these offshoots are irregular, with fingers projecting along the foliation of the banded gneiss. In places the granodiorite bands pinch and swell irregularly, producing a form of boudinage structure.

Ptygmatic feldspar veins and long, thin, straight, parallel-sided veins of fine-grained quartz and feldspar cut across both granodiorite gneiss and banded gneiss.

The gneisses strike 120° and dip south at 30°.

On the north-west side of the peninsula, several dykes of light-coloured fine-grained garnet granite, made up of feldspar, quartz, pink garnet and biotite, cut the migmatites. One of these, four feet wide, is in turn cut by a dyke of pegmatite containing pink and white feldspars, quartz and some biotite plates; this dyke sends thin tongues into the garnet granite.

A single dyke of porphyritic basalt, five feet wide and striking east-south-east, was found intruding the gneisses.

Bands of shear moraine are beautifully exposed in the ice cliffs on the southern side of the isthmus (Fig.15).

Figure 15. Bands of shear moraine in the cliffs at the edge of the icecap, Ivanoff Peninsula. (G 4518)

At the time of the visit (mid-February) water was running down these cliffs and long icicles hung from the overhanging portions. Morainal debris is piled along the foot of the cliff. Some boulders of this

debris are up to six feet across, but most are less than one foot in diameter, and sand and rock flour are common. The material at the foot of the cliff is angular, but most of the boulders on the flat low-lying isthmus are rounded, indicating wave working in the past during a higher sea level.

The most common lithological type in the moraine is a pinkish-coloured, coarse-grained biotite granite with large feldspar phenocrysts and relatively abundant zircon; this rock was not found in situ on the peninsula. Remarkably, the granodiorite gneiss and biotite-feldspar gneiss which form the peninsula are rare in the moraine, although fine-grained massive biotite hornfels occurs. A notable rock type is a red or, less commonly, purple fine-grained equigranular feldspathic sandstone (9533), most fragments of which appear to have been slightly metamorphosed. Several pieces of trachyte were found also; these consist either of plagioclase phenocrysts in a reddish-brown, fine-grained matrix which seems to be almost all feldspar, or of uniformly fine-grained material (5563, 5564) with few or no phenocrysts.

Davis Islands

The Davis Islands lie near the coast on the west side of Vincennes Bay in position 66°40'S, 108°26'E. There appears to be no previous report on the geology of the islands.

The group consists of half a dozen islands, the largest of which (Hudson Island) is a mile long and a quarter of a mile wide; the others are much smaller.

Hudson Island is made up of several types of granite. Predominant is a massive porphyritic biotite adamellite /5565/ with pink feldspar phenocrysts in a medium-grained matrix. Inclusions display all stages of granitisation from fine-grained biotite-rich rock to rock with a granite texture but finer-grained than the host rock; howe ver, the edges are all well defined, with no macroscopic gradation from inclusion to country rock. The chemical composition of a specimen of this rock is given in Appendix II.

A second type of granite is similar mineralogically to the one described above, but has a more equigranular texture because it contains a much smaller proportion of phenocrysts. Another variety which occurs east of the highest point of the island is a pink coarse-grained hornblende-biotite granodiorite with abundant accessory rutile (?) and few inclusions. Its dark mineral content varies considerably, and parts of this rock are composed almost entirely of quartz and feldspar.

In the central part of the island the porphyritic granite is irregularly intruded by a red medium-grained granite containing scattered plates of partly-altered biotite. Nearby a coarse-grained rock consisting of red feldspar phenocrysts in a biotite-rich matrix forms a veinlike body up to ten yards wide, which has eroded much faster than the surrounding porphyritic granite.

Contacts between the various types of granite show no sign of chilling.

In places, the porphyritic biotite granite has a poorly defined foliation; near the western end of the island, this strikes 110° and dips south at 80°. A few veins of white quartz, and shears a foot or so wide containing much epidote, strike about north-east.

The granite slabs are well polished, and on many surfaces glacial striae and chatter marks are beautifully developed; these striae reveal that ice movement was towards the north.

Moraine is not common. Notable amongst the erratics are boulders of red indurated sandstone, identical to the boulders in moraine on Ivanoff Peninsula. Many show signs of slight metamorphism (9530, 9531, 9532).

Several small lakes occur on the island. A water sample collected from the westernmost of these lakes was analysed with the result:

Na^+	0.135 gm/litre	Cl^-	0.280 gm/litre
K^+	0.0037	SO_4^{--}	0.064
Ca^{++}	0.01	HCO_3^-	0.007
Mg^{++}	0.02	Calculated total salts	0.520 gm/litre
		Salts at 180°	0.514 gm/litre

The other islands of the group were examined closely from the air; they appear to consist of granitic rocks identical to those on Hudson Island.

REGIONAL CONSIDERATIONS

This section is to some extent a generalised summary of the detailed descriptions given above. Some remarks on the genesis and geological relations of the major rock types are included, but I would emphasize that these are extremely tentative - the distances between outcrops and the reconnaissance nature of most of the work preclude the drawing of firm conclusions at this stage.

Banded gneiss

In one form or another, this rock type has a very widespread distribution; it occurs at the Wilson Hills, Lewis Island, the Windmill Islands, and Ivanoff Peninsula.

Plagioclase, quartz and biotite are universally present in the banded gneiss, and garnet commonly occurs in minor amount; the plagioclase is andesine or a more sodic variety. This mineral assemblage denotes an essentially non-calcareous character for the parent material of the gneisses.

In the Wilson Hills the banded gneiss is irregularly invaded by numerous granitic veins of various types, in places to the extent that it persists merely as small remnants. Despite the intense veining, few examples of a macroscopic gradation from vein rock to gneiss were seen. Although the vein margins are not knife-edged, they are quite well defined and any gradation into the gneiss must take place over a distance of less than a millimetre. The difficulty on deciding on an igneous or metamorphic origin for these veins has already been pointed out.

Whether the rocks of the Wilson Hills are part of the shield area of Antarctica or whether they belong to the metamorphic suite of the Ross System in Victoria Land can only be resolved by further work. Present indications are that they can be correlated with the Ross System. Gravity and magnetic observations near the coast indicate a major structural break roughly coincident with longitude 155°E, about 50 miles west of the Wilson Hills. Oushakov (1960) considers that this break marks the transition from the shield area of East Antarctica to the Caledonian(?) fold zone bordering the Ross Sea. Seismic work (Crary and van der Hoeven, 1961) has revealed that the rock surface beneath the icecap slopes westwards from the mountains of Victoria Land, reaching sea level about 100 miles west of the mountains. Absolute ages between 450 m.y. and 500 m.y. obtained by Starik, et al (1959) and Starik et al (1960) also suggest that the rocks of Oates Land can be correlated with the Ross System. On the other hand, high grade metamorphic rocks have a measured age of about this magnitude at many places in the shield area, particularly where low-grade metamorphic rocks also occur in the region. It is quite

possible that the measured age of the high-grade rocks does not denote the time of their formation, but merely represents the impress of the later metamorphism which formed the low-grade rocks.

The banded gneiss of Clark Peninsula in the Windmill Islands differs from that of the Wilson Hills in containing significant proportions of potash feldspar and hornblende; the myriad small granitic veins, so obvious in the Wilson Hills, do not occur at Clark Peninsula, or on Beall Island. The retrogressive mineral changes in the banded gneiss on Clark Peninsula suggest either a later, milder metamorphic episode or a prolonged waning in intensity of the metamorphism which formed the gneiss. The large pegmatite dykes could have been injected under either of these conditions.

The gneisses on Lewis Island and Ivanoff Peninsula are distinctive in that discordant granitic veins are very uncommon. At both places the banded gneisses are subordinate to medium-grained granitic-textured, poorly-foliated gneiss which forms layers alternating with the banded gneiss; the bands of each are quite distinct, but one type grades into the other by a change in the number and thickness of the bands. Locally, especially on Ivanoff Peninsula, the margin of the granitic gneiss cuts across the strike of the banded gneiss, or the banded gneiss contains small vein-like offshoots of granitic gneiss. At both places, the banded gneiss and the granitic gness seem to be similar mineralogically, except that biotite is only a minor constituent of the latter. Although the petrographic evidence suggests that the granitic gneiss is of metamorphic origin, the nature of the boundaries between it and the banded gneiss suggest that it possessed some mobility; possibly this was little more than partial refusion in situ. However, once again the evidence is inconclusive.

Granitic rocks

Massive granitic rocks of igneous aspect were found on Warrington, Ford, and Odbert Islands and Robinson Ridge, all in the Windmill Islands, and on the Davis Islands.

The granitic rocks on the different islands of the Windmill group are all broadly similar, and are probably parts of one intrusive body, although, as Robertson has pointed out, the granite of Ford Island may be a later intrusion.

The granite of the Davis Islands was not seen in contact with any other rocks, and consequently its geological relations could not be ascertained. A specimen has been submitted to the Australian National University for age determination, and this velue, when available, may give an indication of the regional relationships of the granite.

The only other large granite body found was that forming the Henry Islands. The uncertainty regarding the genesis of this rock has already been discussed.

Charnockitic rocks

The term charnockite has been applied in this report only to those rocks which not only contain significant amounts of orthopyroxene, but also are characterised by brown feldspar (both potash and plagioclase) and blue quartz. In the hand specimen the rock has a distinctive dark colour quite at variance with its granitic composition. Such rocks were found only on Chick Island and on Herring, Ardery and Ford Islands in the Windmill Islands. The genesis of the Chick Island rock has already been discussed. Little can be said about the genesis of the occurrences in the Windmill Islands. They may be related to the stock of granitic rocks, possibly representing a separate intrusive phase.

Basalt dykes

Basalt dykes were found in situ on Cook Ridge, Beall and Nelly Islands, and Ivanoff Peninsula; a basalt erratic was also found on Magga Peak. The basalts appear to be normal, predominantly plagioclase - pyroxene rocks, except that the presence of biotite and the almost completely altered state of the pyroxene in the dyke on Cook Ridge suggest that the basalt here has undergone slight metamorphism since its emplacement.

There is no firm indication of the age of these basalts, or of their ages relative to each other. Large dolerite sills of probable Jurassic age are common in the ranges of Victoria Land, and Starik, et al (1959) found the age of a thick dolerite sill at Scar Bluff (their Mount Obruchev) 100 miles west of the Wilson Hills, to be 170 m.y. i.e. Jurassic. On the other hand, McKelvey and Webb (1961) mention basic dyke swarms which intrude the pre-Beacon rocks but not the Beacon Group in Victoria Land and are therefore presumably pre-Middle Palaeozoic in age.

Trachyte

Trachytic rocks were found only as erratics in the moraine on Ivanoff Peninsula. They are presumed to be of volcanic origin because of their very fine grain. As far as I know, this is the first record of trachytic rocks from this region of Antarctica.

Sediments

These too were found only in morainal deposits, occurring on Ivanoff Peninsula and Hudson and Thompson Islands. Specimens were also found in the Windmill Islands by Robertson and at Durmont d'Urville by Professor Bellair.* This apparent concentration in moraine in the Vincennes Bay area would suggest that the parent formation is inland from this area. However, this is the only area between Durmont d'Urville and the Bunger Hills where outcrops are large enough to carry morainal deposits of any extent.

Most of the specimens are sandstones; one is microconglomerate containing fragments of quartz, feldspar and granite. Feldspar occurs in small to moderate amounts in all the sandstones and is common in the micro-conglomerate. A notable feature of all the specimens is their red (or less commonly, reddish-purple colour. Another ubiquitous feature is a certain amount of secondary silicification, ranging from almost imperceptible (in the hand specimen) to outgrowths on the quartz grains resulting in the formation of a firmly bonded mass which breaks across the quartz grains. This silicification could be a result of diagenesis; but it could also have been produced by slight metamorphism of the original sediment. In connection with thin sections 9530 and 9533 (which were cut from rocks showing, in the hand specimen, the strongest silicification), Mr. McCarthy of the Australian Mineral Development Laboratories writes: ".....Because of the petrogenetic difficulties, (i.e. when does metamorphism begin and diagenesis cease) and mineralogocal considerations (an assemblage in which diagnostic metamorphic minerals, as distinct from authigenic minerals and detrital minerals, are not present), field relations or fabric analysis are generally superior to mineralogy for differentiating the types of quartzites. The rocks lack any preferred mineral orientations and, as you relate, are erratics. Therefore mineralogical evidence appears to be the only type available. Just one mineral, sericite, seems likely to produce results. Both rocks contain newly crystallised sericite; it appears to be of three types:- 1. Formed by alteration of feldspar, 2. formed by crystallisation or recrystallisation of detrital argillaceous mud in intergranular areas and, 3. formed by replacement of portions of rounded quartz grains. Type 3 is only present in specimen 9530. If sericite of types 1 and 2 is considered to be authigenic, then specimen 9533 has probably been silicified

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* A suite of sedimentary rocks was also collected from the moraines of Commonwealth Bay by the Australian Antarctic Expedition (Mawson, 1940).

without metamorphism; research by Yoder and Eugster indicated that muscovite is an authigenic clay mineral in many sediments. Authigenic growth of muscovite is probably inadequate to explain the replacement of quartz by unoriented aggregates of sericite in specimen 9530. Hydrothermal alteration appears unlikely as the rock shows no zonal alteration. Metasomatism and/or metamorphism seem the most likely processes. Metamorphism, if it accompanied silicification of specimen 9530, was only an incipient type."

The only known in situ occurrences of sedimentary rocks in the Wilkes Land region of Antarctica are those at Amundsen and Sandow Mountains, two small nunataks south of the Bunger Hills and 250 miles west of the head of Vincennes Bay. Veronov, Klimov and Ravich (1959) describe the rocks here as slightly metamorphosed argillites, siltstones, sandstones and conglomerates of possible late Precambrian age. They appear to be similar to the rocks found as erratics on the islands in Vincennes Bay. An interesting feature is that the sediments on Mount Sandow are underlain "with a stratigraphic break" by greenschists, and Robertson (1961) found erratics of greenschist in the Windmill Islands.

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APPENDIX I.

Petrographic Descriptions

Representative specimens were examined petrographically by W.R. McCarthy of the Australian Mineral Development Laboratories. His report is quoted in Part I. In some rocks the petrographic evidence conflicted with the field interpretation of the mode of emplacement. The appropriate specimens were re-examined by H.W.Fander and W.R.McCarthy. Relevant portions of their comments are quoted in Part II. The differences are discussed in the main part of this Record.

Part I

5562 Ivanoff Peninsula

This is a biotite-pyroxene-quartz-plagioclase gneiss. Texture is metamorphic and the rock is assigned to the almandine-amphibolite facies. The major constituents are plagioclase (andesine Ab 63 An 37 - about 45 percent of the specimen), quartz (about 25 percent), and antiperthite. Grains are xenoblastic in habit, although a few of the andesine crystals assume a subhedral shape, and range in diameter from 7.3 mm. to .3 mm. with an average of 1.5 mm. Some of the andesine is zoned, shows myrmekitic intergrowths, and some has inclusions of plagioclase, quartz and rarely biotite. Antiperthite has a patchy pattern and appears to have a replacement rather than exsolution origin. Pyroxene is hypersthene, has xenoblastic habit, and forms about 5 percent of the rock. Biotite is present as interstitial lath-like crystals.

Apatite and zircon occur in accessory amounts generally as inclusions in biotite.

5563 Ivanoff Peninsula

This is a trachyte. Fine-grained laths of albite with interstitial opaques, and a few fine crystals of a mineral with medium birefringence comprise the rock. The interstitial opaque mineral is most likely hematite. The rock is red coloured and many of the plagioclase laths have a partial coating of goethite. The mineral with medium-birefringence is probably a pyroxene - - perhaps diopside.

The essentially monomineralic composition of the specimen indicates that the rock cooled rapidly allowing little time for the crystallization of ferromagnesian minerals.

The rock is quite similar to trachytes from Wooltana in South Australia.

5564 Ivanoff Peninsula

This is a trachyte. The rock is composed primarily of fine-grained laths of albite with an unidentifiable mineral present in interstices. Some of the laths of albite radiate from a common centre but most are directionless. The unidentifiable mineral is light green coloured and probably a ferromagnesian mineral but no further determination is possible because of its cryptocrystalline nature. Magnetite is scattered through the rocks like many extremely fine beads. Some of the andesine laths have a partial coating of goethite.

5566 Anton Island

This is an altered granitic rock. The major constituents are plagioclase (forming about 40 percent of the specimen), microcline (about 30 percent), and quartz (about 15 percent). In hand specimen, pink coloured phenocrysts of microcline, light green coloured plagioclase, and translucent quartz are set in a matrix of dark ferromagnesian minerals. Microcline is unaltered and the phenocrysts reach 2.2 cm. in length. One phenocryst of orthoclase is present. Plagioclase is altered and most is now an aggregate of fine sericite; sometimes it also has inclusions of chlorite and epidote. Plagioclase grains have an average diameter of

1.3 mm., are anhedral, and from determinations of partially altered grains, is andesine (Ab 68 An 32). Chlorite, penninite the iron rich variety, forms about 10 percent of the rock and most has formed retrogressively from biotite. Green coloured hornblende and epidote occur in accessory amounts and are normally intergrown with chlorite.

Accessory sphene, zircon, apatite, and opaques occur and generally are associated with chlorite.

The genesis of this rock is not evident from microscopic examination - - either a metamorphic or igneous origin is possible. If field relations favour an igneous origin then the rock would be an adamellite or if instead a metamorphic origin is more probable then it would be a gneiss of the almandine-amphibolite facies.

5567 Chick Island

This is an altered biotite-pyroxene-hornblende-orthoclase-microcline-plagioclase charnockite. Assignment of the rock to a metamorphic facies is tentative because the mineral assemblage is not definitive; the mineral assemblage has similarities with those of the almandine-amphibolite facies and the hornblende-granulite subfacies. It is assigned to the almandine-amphibolite facies because of the hydrous mineral biotite which is apparently a part of the original mineral assemblage - - not a retrogressive mineral. Major constituents are plagioclase (about 40 percent of the specimen), microcline (about 35 percent) and quartz (about 15 percent). The texture is heteroblastic and the rock is primarily coarse grained with an average grain diameter of 2.0 mm., but finer grained minerals occur in interstices. Plagioclase is twinned and untwinned, the untwinned portion is oligoclase and the twinned crystals are sodic andesine. Feldspar is xenoblastic and along crystal boundaries myrmekitic intergrowths are common. Quartz is interstitial to feldspar as are the ferromagnesian minerals. Pyroxene is hypersthene and generally occurs as corroded appearing crystals enclosed by hornblende. Dark green and dark brown hornblende is the most common ferromagnesian mineral and is apparently present both as retrograde mineral from pyroxene and as a primary metamineral constituent. Biotite is red-brown and apparently primary.

5568 Henry Island

This is a epidote-clinozoisite-hornblende-biotite-quartz-feldspar gneiss and assigned to the almandine amphibolite facies. Major constituents of the rock are feldspar (about 80 percent), quartz (about 10 percent), ferromagnesian minerals and accessories (about 10 percent). Microcline and perthite are the major feldspar and andesine (Ab 67 An 33) is also present. Feldspar is xenoblastic, grains reach a diameter of 6.8 mm. and grains with a diameter greater than 3.0 mm. form the major portion of the feldspar. Biotite and hornblende occur in about equal quantities, are anhedral, and occur between grains of feldspar as fine to coarse-grained aggregates. Quartz and accessories occur with the ferromagnesians.

Zircon and apatite occur primarily as inclusions in hornblende and biotite. Epidote and clinozoisite are present as inclusions within, or crystals adjacent to ferromagnesians and feldspar, but are generally associated with the ferromagnesians. Sphene is present equally as inclusions in feldspar or in association with hornblende and biotite. Opaques are rare and occur with the ferromagnesians.

5569 Odbert Island

This is a pyroxene-hornblende-biotite-quartz-feldspar gneiss and assigned to the almandine-amphibolite facies. Texture is heteroblastic with coarser grained feldspar and quartz partially enclosed by finer grained ferromagnesians and some fine-grained quartz and feldspar. Feldspar (microcline, perthite and andesine, Ab 60 An 40) forms about 75 percent of the rock; sodic feldspar and andesine are present in about equal quantities. Feldspar grains reach 5.8 mm. in diameter and most of it is coarser than 1.8 mm., some of the plagioclase is zoned, grains are xenoblastic and many show myrmekitic intergrowths. Hornblende and biotite are generally interstitial to feldspar. Pyroxene forms less than one percent of the rock, is augite, and some of it has retrograded to hornblende. Apatite, zircon and opaques occur in accessory amounts and are associated with the ferromagnesians.

5570 Ardery Island

This is a hornblende-biotite-pyroxene-quartz-feldspar charnockite and assigned to the granulite facies. Texture is heteroblastic with large feldspar porphyroblasts enclosed by finer crystals of ferromagnesians, feldspar and quartz. Feldspar is andesine (Ab 58 An 42, forms about 45 percent of the rock), and orthoclase (forms about 30 percent), has xenoblastic habit, shows myrmekitic intergrowths, reaches a grain diameter of 7.0 mm., and most is coarser grained than 1.8 mm. Andesine and orthoclase both have inclusions of quartz.

Ferromagnesians form about 8 percent of the specimen and pyroxene is the most abundant. Pyroxene is anhedral and most is hypersthene with minor amounts of enstatite and augite. Most of the hornblende is uralitic and has formed retrogressively from pyroxene. Biotite appears also to have formed retrogressively from pyroxene.

Apatite is present in accessory amounts, zircon is rare, and both are present as inclusions in hornblende or biotite. Opaques are a common accessory and occur as globular-shaped bodies adjacent to, included within, or partially surrounding ferromagnesians.

5571 Herring Island

This is a hornblende-pyroxene-labradorite granulite and assigned to the hornblende granulite subfacies. Under older classifications the rock would have been termed a "basic charnockite". The texture is granoblastic and most grains have a tendency to be equant. A few labradorite (Ab 44 An 36) grains reach a diameter of 2.0 mm. but most grains have an average diameter of about 1.0 mm. Labradorite forms about 55 percent of the specimen and ferromagnesians the remainder. Pyroxene and green-brown hornblende are present in about equal quantities. Pyroxene is augite, enstatite and hypersthene with hypersthene the most common and augite a close second in abundance. Quartz is rare as is biotite which is probably retrogressively formed from hornblende.

Accessories are opaques, apatite and zircon. Opaques are common and associated with the ferromagnesians as equant globular-shaped bodies. Apatite and zircon are rare accessories.

5572 Wilkes

This is an altered mica-hornblende-quartz-feldspar gneiss and assigned to the almandine-amphibolite facies. Several laminae-like quartz-feldspar segregations cut the rock and the ferromagnesians show definite alignment with the laminae. Rounded and broken zircons are present and it is evident that this is a granitized sediment. The rock is medium-grained except for coarse quartz in the laminae. Feldspar is microcline, antiperthite, and andesine (Ab 55 An 45); andesine is the most abundant. Andesine is altering to a fine-grained sericite and clinozoisite.

Biotite and hornblende are present as unaltered and partially altered anhedral crystals. Biotite has altered to chlorite which is in turn being converted to epidote. Hornblende has altered to both chlorite and epidote. Most of the biotite, hornblende and plagioclase show considerable alteration and it is evident that the rock has undergone considerable P/T readjustment after reaching almandine-amphibolite grade.

Opaques, probably magnetite and pyrite, occur as medium-grained globular-shaped bodies and are common accessories. Apatite is present in accessory amounts.

5573 Beall Island

This is a pyroxene-labradorite dolerite. The rock has diabasic texture and the interstitial material between laths of labradorite (Ab 33 An 67) is pyroxene. Pyroxene is too fine grained for positive identification; however it may be augite. While most plagioclase is present as subhedral to anhedral laths, some is present as equant, zoned crystals.

Opaques, forming about 3 percent of the rock, are present in the interstices as tabular to globular-shaped bodies. The major opaque is magnetite; pyrite is probably the second and rarely occuring one.

5574 Thompson Island

This is an altered biotite-quartz-feldspar gneiss and assigned to the almandine-amphibolite facies. Feldspar is the major constituent of the rock (microcline and antiperthite about 45 percent - - andesine, Ab 65 An 35, about 25 percent) and grains range in diameter from 7.0 mm. to 1.1 mm. - - average about 1.8 mm. Most of the feldspar is present as ragged grains with an equant tendency and differential alteration of potassic and calcic feldspar is striking; potassic feldspar is relatively little altered while plagioclase now has many inclusions of sericite and more rarely epidote or clinozoisite. Quartz is fine to coarse-grained and forms about 20 percent of the rock. Biotite is now rare and it is evident that chlorite, the other ferromagnesian, has formed by alteration of biotite. A portion of the chlorite may have originated as an alteration of other ferromagnesians although no remanants of them are now present in the rock. The last retrogressive minerals to form were epidote and minor amounts of clinozoisite which generally occur as ragged grains in chlorite. They have apparently formed from chlorite and calcium - - calcium made available by alteration of plagioclase and which has then migrated to the chlorite by some processes of diffusion.

Sphene is a common accessory which occurs as fine to medium-grained, poikiloblastic, shapeless crystals. Zircon and apatite occur in accessory amounts and generally as inclusions in sphene or chlorite. Opaques occur as globular-shaped bodies associated with sphene and/or chlorite.

5575 Island near Thompson Island

The "country rock" is a basic intrusive. The rock is medium to coarse-grained with the plagioclase generally medium-grained and pyroxene present as coarse-grained aggregates. The rock is a gabbro. Texture is sub-diabasic - - pyroxene tends to be interstitial to plagioclase; apparently both minerals were crystallizing simultaneously as pyroxene is not clearly interstitial. Plagioclase is labradorite (Ab 33 An 67) and generally lath-like, but equant crystals occur. Pyroxene is generally anhedral and two varieties occur; augite and probable clinoferrosilite.

7285 Aviation Islands

This is a garnet-sillimanite-quartz-feldspar gneiss and assigned to the almandine-amphibolite facies of Fyfe, Turner and Verhoogen (G.S.A. Mem. 73, 1958). It cannot be termed a granodiorite because it was a sediment before metamorphism as shown by rounded zircon crystals, broken monazite crystals, and by the occurrence of the normally metamorphic minerals garnet and sillimanite. If no evidence existed for a sedimentary origin, the rock would be a granite rather than granodiorite.

The rock has a porphyroblastic texture with feldspar - - microcline - - porphyroblasts forming about 65 percent of the specimen. Porphyroblasts range in diameter from 3 cm to 1 mm and average 1.5 cm, are poikiloblastic with inclusions of plagioclase, biotite and muscovite, and show Carlsbad twinning. Some plagioclase porphyroblasts (oligoclase) occur as anhedral crystals but most are enclosed by microcline. Most of the plagioclase shows myrmekitic intergrowths as do the border areas of some microcline porphyroblasts. Biotite is foxy-red, has inclusions of zircon with surrounding pleochroic halos and is interstitial. Quartz is present as medium-grained, crystals with crenulated borders, and it forms about 25 percent of the specimen.

Garnet is a rare accessory. Sillimanite occurs as fine crystals (fibrolite) associated with muscovite. Apparently a portion of the muscovite is altering to fibrolite. Monazite occurs as rare, fine crystals, which are sometimes included in biotite.

7286 Aviation Islands

The rock is a mica-quartz-plagioclase gneiss and assigned to the almandine-amphibolite facies. Sub-parallel laths of biotite, rounded zircon inclusions in biotite, quartz inclusions in feldspar all attest to the metamorphic genesis of the rock. In order to determine what relation this rock has to the host rock a sample across the contact of the two is necessary. Possibly this is a metamorphic differentiate of the gneiss.

The texture is porphyroblastic with porphyroblasts of plagioclase forming about 70 percent of the specimen. Plagioclase is andesine (Ab 57 An 43), much is zoned, and the grains range in diameter from .3 to 1 mm and average .6 mm. Quartz is generally fine-grained and still finer-grained quartz with an average diameter of .04 mm is present in interstices and as inclusions in plagioclase. Biotite is interstitial, fine to medium grained, and forms about 3 percent of the specimen.

The rock has been metasomatized. Fine, acicular muscovite is present as inclusions, oriented with cleavages, in plagioclase. The zoning of the plagioclase is probably also the result of metasomatic additions to the rock.

7287 Aviation Islands

This is a fibrolite-mica-quartz-plagioclase banded gneiss and assigned to the sillimanite-almandine subfacies of the almandine-amphibolite facies. Biotite gives the rock its banding, is present in layer-like concentrations, and individual crystals show a parallelism to the banding. Plagioclase occurs as xenoblastic porphyroblasts ranging in diameter from .1 mm to 1 mm, and average .4 mm, which form about 50 percent. Multiple twinning is only present in several grains and they are andesine (Ab 68 An 32). The remainder of the plagioclase has a lower R.I. than quartz and while some is apparently twinned it is very indistinct. Quartz forms about 40 percent of the specimen and is generally finer grained than plagioclase. Fibrolite is present in "wisp of hair-like" aggregates which often extend from mica into quartz and plagioclase.

Zircon occurs in accessory amounts, as fine euhedral to subhedral crystals, and often is found as inclusions in biotite. Apatite is also present in accessory amounts.

No garnet was visible in the thin section or hand specimen.

7288 Parkinson Peak

This is a mica-quartz-microcline-plagioclase rock. It is composed primarily of large crystals of microcline, many showing Carlsbad twinning, which form about 70 percent of the specimen and range in diameter from 10 mm to 1 mm with an average diameter of 3.5 mm. About 15 percent of the specimen is composed of plagioclase (oligoclase Ab 75 An 25) and much is zoned.
Most of the plagioclase and microcline are anhedral and many crystals have inclusions of biotite, muscovite, or quartz; microcline often has plagioclase inclusions. Quartz is generally interstitial, forms myrmekitic intergrowths with plagioclase, and comprises about 10 percent of the specimen.

No garnets were seen in section or hand specimen.

From crystal form, inclusions of quartz in plagioclase, and general texture this "vein" rock appears to be metamorphic. The rock would then be a gneiss and assigned to the almandine amphibolite facies. The rock then is probably a metamorphic differentiate, but here again a sample across the "vein" contact is necessary for a more definite generic assignment. It is possible that this replacement type of "vein" is a similar but larger scale veining as seen in the hand specimen for 7290. In this case, considerable K and Na metasomatism must accompany the replacement in order to account for microcline.

7289 Parkinson Peak

This is a mica-quartz-plagioclase rock. Plagioclase and quartz are the major mineral constituents and the crystals range from 3.5 mm to .4 mm in diameter and average 1.5 mm. Both minerals have a poorly developed crystal habit and are anhedral; some of plagioclase approaches subhedral habit. Plagioclase is andesine (Ab 63 An 37), is commonly zoned, and forms about 65 percent of the specimen. Biotite occurs as corroded appearing, tabular crystals in the interstices. Muscovite is a rare accessory.

The rock has been altered. Plagioclase is cloudy appearing in plain light and some biotite has been altered to iron rich chlorite (penninite).

The genesis of this rock is uncertain from microscopic examination. The rock possesses both igneous and metamorphic textural affinities. However, the overall textural aspect is metamorphic. Again samples across the "dyke" and country rock contacts are necessary to establish clearly the metamorphic or igneous origin of the "dyke" rock.

7290 Parkinson Peak

This is a banded mica-quartz-feldspar gneiss and assigned to the almandine - amphibolite facies. Biotite gives the rock a schistosity. Bands are light and dark coloured and range from 5 mm to 2 mm thick; they are composed of biotite, quartz and feldspar (dark bands), and quartz and feldspar (light bands). The major constituents of the rock are plagioclase and quartz which range in grain diameter from .5 mm to .1 mm and average .3 mm. Plagioclase forms about 55 percent of the rock, has a lower R.I. than quartz. Biotite and muscovite together comprise about 5 percent of the sample and biotite is more common. Micas occur as lath-like crystals, or tabular "swiss-cheese appearing" sheets.

Zircon and apatite occur in accessory amounts as anhedral crystals; apatite is more common.

The rock has been altered. Feldspar is cloudy appearing in plain light and a portion of the biotite has been altered to iron rich chlorite (penninite).

A vein, about 2 cm thick containing quartz, feldspar and mica, cuts the banding at about 70 degrees.

The mineral assemblage of the vein-like body is similar to the enclosing rock. However, contrasted to the schistosity of the host rock, the minerals of the vein-like body show only slight, if any, preferred orientation. A slight amount of dilation has occurred along "vein" borders but no sharp boundary between "vein" minerals and rock minerals exists and the "vein" minerals appear quite metamorphic in habit. It is thought that the "vein" material is a replacement body originating at a joint.

7291 Cook Ridge

This is a garnet-mica-quartz-feldspar gneiss and assigned to the almandine amphibolite facies. Quartz forms about 35 percent of the specimen and is present as anhedral, elongated crystals, some of which extend to 6.6 mm. Plagioclase is andesine (Ab 68 An 32) and occurs as grains ranging in diameter from 3.3 mm to .8 mm and average 2 mm. Some plagioclase shows myrmekitic intergrowths. Biotite forms about 2 percent of the rock and occurs as interstitial aggregates of tabular crystals. Muscovite is rare and present as small crystal inclusions in plagioclase or associated with biotite.

Pink coloured garnet, probably almandite, is a rare accessory. Zircon is present in accessory amounts and normally occurs as subhedral to euhedral inclusions in biotite.

Penninite, the iron rich chlorite, is present in small amounts and occurs as an alteration of biotite. Much of the plagioclase is altered and cloudy appearing in plain light.

7292 Cook Ridge

The major constituents of the rock are quartz, plagioclase and orthoclase. Orthoclase forms about 45 percent of the specimen and has two habits; it is present as subhedral crystals or large (exceeding 6 mm in diameter) poikilitic crystals with inclusions of quartz, plagioclase and mica. Plagioclase forms about 40 percent of the rock, has a lower R.I. than quartz, is anhedral to subhedral, most is zoned, and the crystals range in diameter from .4 mm to 1.6 mm with an average of .8 mm. Subhedral to anhedral crystals of quartz form about 10 percent of the specimen. Biotite forms about 2 percent of the rock and occurs as lath-like crystals in the interstices. Muscovite is rare and may indicate that the rock has been subjected to K metasomatism as fine crystals occur in plagioclase in cleavage planes. Penninite occurs rarely and as an alteration product of biotite. Some of the plagioclase is altered and cloudy appearing in plain light.

The rock is most likely igneous and a granite.

7293 Cook Ridge

This is a black coloured, vesicular basalt. It is composed of fine to cryptocrystalline laths of plagioclase with fine-grained interstitial pyroxene. Fine, acicular to tabular biotite is scattered throughout. Plagioclase is labradorite (Ab 45 An 55) and forms about 55 percent of the specimen. The thin section has about ten phenocrysts of which the majority are pyroxene, probably augite, and several are plagioclase and one is quartz. The vesicles contain calcite and in several cases they are rimmed with cryptocrystalline silica and filled with calcite.

An opaque mineral, most likely magnetite, is disseminated throughout, and forms about 2 percent of the specimen.

7294 Stanwyx Ridge

This is a garnet-biotite-quartz-feldspar gneiss and assigned to the almandine-amphibolite facies. In hand specimen, the rock has fine laminations of light and dark minerals giving it a banded appearance. Feldspar and quartz are the major constituents and they range in grain diameter from 1.1 mm to .15 mm with an average .4 mm. Feldspar, andesine (Ab 57 An 43), forms about 55 percent of the specimen and quartz about 35 percent; both are generally xenoblastic in habit, although a few grains of andesine are subhedral. Biotite is evenly distributed as lath-like crystals, often with pleochroic halos, and forms about 7 percent of the specimen. Garnet, probably almandite, forms about 1 percent of the specimen and occurs as anhedral crystals in patches with fine-grained quartz, andesine and biotite.

Zircon, apatite and an opaque mineral occur in accessory amounts.

9528* Shear moraine

The rock may be termed an epidote-quartz-feldspar hornfels. It has a porphyroblastic or blastoporphyritic texture, with large crystals of microcline and, more rarely, quartz; the grains of both minerals have sutured margins. The finer crystals which enclose these have a hornfelsed texture - in a very general sense, the quartz appears as poikilitic inclusions in a mosaic of interlocking feldspar crystals. Estimated proportions of mineral constituents are epidote (5 percent), quartz (30 percent), and feldspar (65 percent). Two generations of epidote are apparent, the first is scattered through the matrix as fine to medium grains, and the second occurs as fine-grains in fractures which randomly cut the rock. Feldspar is microcline (which occurs in the matrix as well as porphyroblasts reaching a maximum diameter of 1.2 mm) and probable albite (present only in the fine-grained matrix). Apatite and sphene occur as rare accessory minerals.

9529 Hudson Island

The rock is a low grade metamorphosed sediment and probably metamorphosed under syntectonic conditions - - therefore assigned to the greenschist facies. The unmetamorphosed sediment was probably an impure chert or less likely an argillaceous siltstone. Chlorite, epidote, and fine dust-like material have a poorly preferred orientation.

The specimen has a porphyroblastic texture with porphyroblasts of feldspar (orthoclase and albite) in a matrix of fine-grained to micro-crystalline silica, chlorite, sericite and epidote. Silica forms about 90 percent of the rock. Several rounded grains of zircon occur.

The rock has several cross-cutting veins of quartz; some carbonate and orthoclase are also present in the veins.

9530 Thompson Island

This rock is quartzite composed of rounded to well-rounded quartz grains (80 percent) and altered feldspar grains (20 percent). The grains are well-sorted (grain diameter range is 0.9 mm to 0.2 mm and average diameter is 0.7 mm). Secondary overgrowths of quartz, in optical continuity with quartz grains, cements the grains.

Feldspar grains are almost entirely altered to aggregates of sericite and kaolinite. Rare grains of tourmaline also occur.

Red colour of the quartzite is the result of hydrated iron oxide (goethite?) coatings around quartz and feldspar grains. The coating shows grain boundaries before overgrowth of secondary quartz.

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* This description is modified slightly from Mr. McCarthy's account.

9531 Hudson Island

This is a metamorphosed, sheared sediment; metamorphism is low grade. The original sediment appears to have been composed of clastic quartz, less abundant feldspar and composite grains of quartz and feldspar which range in diameter from less than 0.0625 mm to 1.5 mm. Clastic fragments appear to have formed about 40 percent of the rock. Matrix of the rock apparently was of carbonate and argillaceous material. The unmetamorphosed sediment was probably a greywacke.

At present, the rock is composed of broken and unbroken quartz and feldspar grains in a matrix of epidote minerals. Shear planes cut the rock and are responsible for the crushing and fracturing of a large portion of the clastic sedimentary grains; the rock in its present state is probably best termed a cataclasite (or metagreywacke). Epidote minerals are clinozoisite (most abundant) and pistacite. Most of the epidote is fine-grained, but in the more highly disturbed portions some is coarser (medium-grained). Sphene is a common accessory mineral, zircon a rare accessory.

9532 Hudson Island

The rock is a slightly recrystallised arkose. It is composed of poorly-sorted quartz (about 75 percent) and feldspar (about 25 percent). A few large clasts of feldspar (up to 7 mm in diameter) occur amongst grains ranging from about 1.3 mm to about 0.1 mm which have a matrix of fine-grained quartz and feldspar.

Alteration of feldspar (microcline, orthoclase and plagioclase) has been varied. Some clasts are still quite unaltered while varying degrees of sericitisation and/or less commonly chloritisation are seen in others. Some original tabular crystals of biotite have altered to chlorite and under high magnification these altered biotite crystals are seen to contain thin laths of epidote between (001) cleavage planes.

Silica cements the sediment as secondary overgrowths on quartz grains and fillings between grains. Some newly formed epidote crystals and sphene also fill intergranular spaces.

Opaques, zircon, and apatite are rare accessory minerals.

9533 Ivanoff Peninsula

The rock is a quartzite composed of quartz (about 85 percent) and feldspar (about 15 percent). It shows poor sorting (grains range in diameter from 0.5 mm to 0.07 mm and have an average diameter of 0.13 mm). Grains are sub-angular to very rounded; the largest grains are the only ones which are well-rounded. Overgrowths of quartz and recrystallised argillaceous matrix (now sericite) cement the grains. Feldspar has altered to aggregates of sericite and kaolinite. Minerals present in accessory amounts are opaques, zircon, tourmaline, biotite and muscovite; all are inherited from the sediment. Many of the quartz and feldspar grains have a coating of hydrated iron oxide (goethite perhaps).

Rock 9530 shows similarities to this specimen. Notable are the ironstained grains of both samples and the similar composition and rounding of the coarse grains of 9533 to the general composition and rounding of the grains of 9530.

PART II

7289

This is most likely a metamorphosed sediment. Broken and rounded zircon crystals within the rock give additional evidence of a sedimentary origin.

It is possible that the rock has been emplaced by the method suggested - of mobilized material (in a semi-solid crystal mush state) - but again it is necessary to emphasize that a microscopic examination of the host and dyke-like body contact would provide generic evidence of a more exact nature.

5568

The mineral assemblage (epidote-clinozoisite), rounded and broken zircon crystals, texture, and the poorly defined foliation all attest to a sedimentary origin for this rock. In fact, further examination reveals that there is a fair case for two periods of metamorphism; a portion of the biotite appears to be of a later generation; some partially cuts across plagioclase grains and another portion has formed retrogressively from hornblende. The epidote and clinozoisite would then also be a product of the second metamorphism.

5574

Here the case for metamorphism is not supported by as much evidence as for 5568, but texture - typically metamorphic - and the megascopically visible lineation make an igneous genesis unlikely. Evidence for a second, retrogressive, period of metamorphism is evident; during this period biotite altered to chlorite, plagioclase was sericitized, and epidote crystallized.

APPENDIX II

Chemical composition of rock specimens.

(Analyses by Australian Mineral Development Laboratories.)

	1.	2.	3.
SiO_2	68.8 percent.	72.5 percent.	76.8 percent.
Al_2O_3	13.5	13.7	10.8
Fe_2O_3	1.01	0.43	0.59
FeO	3.65	1.62	2.72
MgO	0.82	0.52	1.20
CaO	2.90	1.25	1.73
Na_2O	2.55	2.20	1.94
K_2O	4.70	6.25	2.70
H_2O-	0.02	0.04	0.09
H_2O+	0.63	0.65	0.72
CO_2	0.04	0.03	0.13
TiO_2	0.76	0.35	0.46
P_2O_5	0.21	0.20	0.14
MnO	0.08	0.02	0.03
Total	99.7	99.8	100.1

1. Sample number SQ48-49/11/1. Thin section 5565. Biotite adamellite from Hudson Island, Davis Islands, Vincennes Bay.

2. Sample number SR56-57/7/1. Thin section 7221. Garnet-sillimanite-quartz-feldspar gneiss from easternmost of Aviation Islands, Oates Land.

3. Sample number SR56-57/8/1. Thin section 7220. Banded feldspar-biotite gneiss from Parkinson Peak, Wilson Hills, Oates Land.

PART OF ANTARCTICA

SCALE 1:20,000,000