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RECORD OF MINERALS OF KING GEORGE LAND, ADELIE LAND AND QUEEN MARY LAND

BY
DOUGLAS MAWSON

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PART 12.

RECORD OF MINERALS

OF

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BY

DOUGLAS MAWSON.

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THE MINERALS

OF

KING GEORGE LAND, ADELIE LAND AND QUEEN MARY LAND.

BY

DOUGLAS MAWSON, D.Sc., F.R.S.

SECTION I.—THE MINERAL RECORD OF KING GEORGE LAND AND ADELIE LAND.

THIS section of the geological publications is a record of the minerals observed and collected in King George Land and Adelie Land by members of the Expedition. In it copious references are made to minerals identified and recorded by the various collaborators who have undertaken petrological reports upon portions of the Expedition rock collections.

Many specimens, however, were collected on account of their interest in illustrating some special mineral occurrence. Such are dealt with in these pages. The list, therefore, is a comprehensive one, including all observed mineral formations, excepting the ubiquitous ice and the contents of the Adelie Land meteorite, which, of course, is extra-terrestrial. The minerals are dealt with in the order of Dana's chemico-mineralogical classification, and therefore do not need any further indexing than the general list of divisions hereunder outlined.

1. Precious Metals, etc.
2. Sulphides, Arsenides, etc.
3. Sulpho-salts.
4. Haloids.
5. Oxides.
6. Oxygen Salts—
   a. Carbonates.
   b. Silicates, Titanates.
   c. Phosphates.
   d. Sulphates.
   e. Molybdates.

1. PRECIOUS METALS, ETC.

Gold.—On return of the Expedition a number of siliceous veins carrying small quantities of iron pyrites from the neighbourhood of Cape Denison were submitted to J. C. H. Mingaye of the Mines Department, Sydney, for gold assay. The results were, however, negative.

More recently other material from *in situ* vein formations crossing the gneisses near Winter Quarters, Cape Denison, was submitted for examination to T. W. Dalwood, F.I.C., of the School of Mines, Adelaide. The sample assayed was a composite of two specimens; one collected as an example of the vein formation containing zinc blende, the other containing arsenical pyrites and a little copper. Mr. Dalwood reported that the sample was very carefully assayed and that he found "that it contains gold at the rate of 0·1 dwt. per ton and silver 0·7 dwt. per ton. Very special precautions were taken to ensure that the sample could not become contaminated and you can place every reliance upon the results stated."

Though this is an exceedingly small content of gold, it is an important determination as constituting the first record of gold in the Antarctic.

Silver in very small quantities is evidently a regular constituent of the pyritic pegmatite and adamellite gneisses near Cape Denison.

A recent assay kindly made by T. W. Dalwood of the School of Mines, Adelaide, on a sample (spec. 999) containing pyrites and zinc blende obtained from one of these veins returned a value of 2 dwt. of silver to the ton of rock.

Other assays made by J. C. H. Mingaye of the Mines Department, Sydney, in the year 1914 all showed silver to be present, as detailed below.

1. A pyritic stringer at the lower junction of the granodiorite gneiss and a black schist band traversing it at 300 yds. W.N.W. of the Hut, Commonwealth Bay. "Fine silver at the rate of 2 dwt. 8 gr. per ton of stone. A trace of copper detected, but no other metals of commercial value present."

2. Pyritic quartz from Cape Denison. "Fine silver at the rate of 1 dwt. 6 gr. per ton of stone. No other metals of commercial value present."

3. Chips broken from a pyritous quartz vein 2 inches thick crossing the gneiss a few hundred yards from the eastern extremity of the rocky outcrop in the neighbourhood of Winter Quarters, Cape Denison. "Traces of copper and silver detected but no other metals of commercial value present."

4. A pyritic stringer in a black schist band traversing the gneiss ½ mile due east of the Winter Quarters Hut, Cape Denison. "Copper, a minute trace; silver, a trace. No other metals of any commercial value detected."

5. A pyritic vein in the gneiss at 200 yards east of the Anemometer, Cape Denison. "Copper, a minute trace; silver, a trace. No other metals of any commercial value."

6. Pyrites-bearing gneiss from a belt located ½ mile east of Winter Quarters Hut, Cape Denison. "Contains traces of copper, arsenic and silver. No other metals of any commercial value detected."

Amongst the moraines at Cape Denison, many erratic blocks were found containing iron pyrites and copper sulphides. None of these have been examined for precious metals except a pyritic garnet gneiss. In this Mingaye found "a trace of copper detected; silver, a trace; gold, nil. Manganese present. No other metals of any commercial value detected."

Graphite has been recorded by Glastonbury occurring in minute particles in some of the silicated marbles of the Cape Denison moraines.

Carbonaceous matter, some of it of the nature of earthy graphite, is met with in the coal-bearing sedimentary series at the Horn Bluff, occurring both as coal seams and as an amorphous, carbonaceous powder as an ingredient of the associated sandstones and shales.

2. Sulphides, Arsenides, Etc.

Stibnite has been noted in vein quartz at Cape Denison.

Molybdenite occurs in small quantity distributed irregularly through a narrow quartz vein crossing the adamellite gneiss at a point just east of the anemometer site at Cape Denison; that is some 200 yards E.S.E. of the Main Hut. The largest piece exhibited in the specimen examined is 4 cms. long. Some iron pyrites and a little mispickel are also contained in the quartz vein. In the vicinity of the pyrites the quartz is stained brown owing to partial oxidation of the iron sulphide. Around the embedded fragments of molybdenite there is usually a canary-yellow stain of molybdic ochre (No. 26).

Galena.—Several small crystals of galena (No. 1280) were found in a drusy vein in quartz of an erratic in the moraine at Cape Denison. Embedded in the quartz is an angular fragment of dolomite, partly altered. This suggests that the erratic was derived from a fissure filling in a dolomitic limestone formation.

Sphalerite in yellowish brown crystals up to 1 cm. diameter have been observed in quartz vein material crossing the gneisses in the Cape Denison area. Specimen No. 999 which exhibits iron pyrites and sphalerite in reef quartz is an example of such.

Pyrrhotite is recorded in a hornblende-plagioclase-pyroxene-gneiss of Stillwell Island, and has been observed in amphibolite at Cape Denison.

Copper Pyrites occurs *in situ* in veins traversing the gneisses in the Cape Denison area. It is usually in very small quantity associated with more abundant iron pyrites. Attention is drawn to its presence by the green colour of oxidised compounds staining the surrounding rock.

An example No. 23A of this nature is seen in a quartz vein 7·5 cms. thick traversing the gneiss where it is unusually rich in biotite near the anemometer at Cape Denison. The quartz contains bunches of copper pyrites and some iron pyrites. These minerals are also regularly distributed along the junction of the vein and the gneiss and as impregnations within the gneiss itself for a distance of 2·5 cms. from the vein. The gneiss along the course of the vein is locally epidotised and pinitised.

Pyrite is quite frequently met with in isolated crystals or small pockets in the siliceous pegmatitic veins traversing the adamellite and granodiorite gneisses of the Cape Denison area. Perfectly developed pyritohedral forms have been noted, but it appears usually as aggregates. Examples of such occurrence are specimens Nos. 607, 1264, 41, 42, etc. The pegmatitic matrix may be quartz and felspar, or what is more usual the pyrite is embedded in quartz vein rock. As would be expected in a recently glaciated region the pyrite remains quite unaltered except for a surface skin of limonite on fully exposed outcropping faces. On the outcrop, the quartz is coloured by limonitic stains where pyrite is exposed to weathering.

Larger pockets of iron pyrites have been met in association with the amphibolitic masses traversing and embedded in the adamellite and granodiorite gneisses in the neighbourhood of Cape Denison. Such occurrences are usually at the contact of the acid gneiss with the amphibolite (No. 40) or in saussuritic, epidotic and calcitic veins in the amphibolite itself. An example of such is seen in specimen No. 1262.

Some quite nice patches of iron pyrites have been met with embedded directly in the adamellite gneiss. Such an occurrence about 7·5 cms. in diameter was noted *in situ* (No. 73) in the gneisses near the Magnetic Hut (250 yards N.E. of the Living Hut at Cape Denison). In these cases a local enrichment of biotite mica is usually to be observed in the gneiss around the pyrite; also in such locations magnetite is usually distinctly more abundant (Nos. 2B and 1263).

Pyrite is also recorded in many of the garnetiferous schists and gneisses from the moraines.

Arsenopyrite occurs in the siliceous pegmatitic veins traversing the gneisses at Cape Denison. In these it is not so abundant as pyrite. It is oxidised only where actually exposed to the weather, and in such situations appears to be slightly more affected than pyrite. It has been observed in quite small quartzose pegmatitic schliers in the gneisses, as in the case of specimen No. 124.

3. Sulpho-salts.

Tetrahedrite has been found in several erratics from the moraine at Cape Denison. One example (No. 831) superficially stained green was found to be quite rich in this mineral in crystal nodules up to 2 cms. in length. The tetrahedrite occurs embedded in areas rich in biotite in a pegmatitic quartz felspar rock with abundant biotite and a little secondary garnet.

Another example is in specimen No. 694. This is a coarse garnet, felspar, biotite rock in which iron pyrites, copper pyrites and tetrahedrite occur, the latter mineral in individuals as much as 1·25 cms. diameter. The garnets in this rock reach 2·5 cms. diameter (see also No. 512).

Copper sulphides and sulpho-salts were found to be frequently associated with garnetiferous gneisses of the moraines.

Tetrahedrite from No. 831, carefully selected and cleaned, was submitted to J. C. H. Mingaye, who reported that it contains 48·76 per cent. of copper and 0·25 per cent. of zinc. There was found, also, a little iron; but lead, cobalt and nickel were tested for and found absent.

4. Haloids.

Fluorite has been recorded by Kleeman as a primary constituent of certain acid igneous rocks including the following: in pink adamellite (No. 690) present to the extent of 0·1 per cent.; in aplite (No. 472) present to the extent of 0·1 per cent.; to the extent of 0·3 per cent. in an aplite (No. 221) traversing a fluorite-bearing adamellite.

Pale purple globular fluorspar is recorded (Glastonbury) in a diopside-actinolite gneiss (No. 958). Fluorspar occurs in veins crossing the foliation of the phyllites at Cape Hunter. Also patches of nice blue fluorspar are associated with epidote along fracture planes and contacts in the gneissic series *in situ* at Cape Denison; examples of such are Nos. 43 and 5 (see under epidote).

Atacamite as vivid green stains is met with on some of the outcropping rock surfaces at Cape Denison and on some of the boulders in the moraines. In all cases it is derived from the weathering of primary copper minerals locally occurring in the rocks so stained. Specimen No. 1191, which is an amphibole erratic, illustrates such occurrence of atacamite.

5. Oxides.

Quartz is of course widely and abundantly distributed as a constituent of the igneous, sedimentary and metamorphic rocks. It is also common enough as vein fillings traversing the igneous and metamorphic rocks.

A fine saccharoidal milky quartz (No. 736) was collected from the moraine at Cape Denison. Much of the quartz reef material collected from the moraines and *in situ* is associated with metallic sulphides. Vein quartz and faceted crystals of vughs are met with both *in situ* and as erratics.

One specimen (No. 330) from the moraine, Cape Denison, represents a vein breccia with cavities filled by quartz crystals in comb arrangement. Some of these quartz crystals exhibit a faint amethystine tint.

Stillwell notes that the quartz of a hypersthene-alkali-felspar-gneiss (No. 797) of Madigan Nunatak has a bluish tint. So also are the quartz phenocrysts in one of the somewhat metamorphosed quartz-porphyry erratics from Cape Denison.

Quartzites and sandstones are quite common as erratics in the moraines. At the Horn Bluff a thick sandstone formation has been recorded *in situ*.

Corundum is recorded by Stillwell as small crystals studded through a garnet-felspar-gneiss (No. 777) located *in situ* at Garnet Point; also as small crystals in a gneiss on Stillwell Island. Tilley (*ante*, page 227) records squat rhombohedra of corundum in sillimanite gneiss from the moraine at Cape Denison.

Haematite is not widely represented amongst the Expedition's collections. Odd flakes and films of haematite do appear amongst the general rock collections; such, for instance, as a film of haematite (specimen No. 180) along shear planes of a crush zone in original granodioritic rock, now highly epidotised and invaded by vein quartz.

Micaceous haematite is, however, in notable amount in some of the iron-rich magnetite schists and gneisses from the moraines at Cape Denison.

Haematite is recorded (Glastonbury) in a jaspilite (No. 360).

Ilmenite is a frequent constituent of the metamorphic and igneous rocks examined. It is recorded in small quantity in gneisses from Stillwell Island and from Madigan Nunatak.

The best examples have been observed in rocks from the moraines. A remarkable occurrence of skeleton crystals was noted (Glastonbury) in a plagioclase amphibolite (No. 977).

Ilmenite appears in some of the schists. In these it is often difficult to distinguish between ilmenite and titaniferous magnetite, so that these are apt to be confused in cursory rock descriptions. For instance, what has the general appearance of ilmenite in specimen No. 971 was found by Mingaye to contain only 7·28 per cent. of TiO_2. In this specimen, which is a quartzose schlier in a muscovite gneiss from the moraines, it occurs in flattened, streaked and bent plates up to 5 cms. in length and 1 cm. in thickness. In another black ilmenitic mineral occurring in a pegmatitic intrusion in schist (No. 104) Mingaye found 13·01 per cent. TiO_2. Coarse ilmenite occurs in No. 714, which is an ilmenite-sillimanite-sericite-schist.

Ilmenite is a constituent of a sandstone band containing heavy minerals associated with the coal-bearing series at the Horn Bluff.

Spinel is recorded by Tilley in the metamorphosed marbles (Vol. III, Part 2). He states that the type represented is usually the colourless magnesian variety, and that it appears in rounded grains or octahedral form.

Pleonaste is mentioned by Tilley as a constituent of one of the calc-silicate rocks.

Magnetite appears in such quantities in local belts of the acid gneisses of the Cape Denison area that it is worthy of special mention. A locality from which many specimens were collected was that of an outcrop near the Magnetograph House (No. 31). There, in several bands, the usual ferromagnesian minerals of the gneiss are reduced to a minimum, at the same time magnetite in black specks and spots strongly contrasting with the quartzo-felspathic base increases to notable proportions. The magnetite blebs reach 0·6 to 0·8 cms. diameter. In the midst of these magnetite rich patches of the gneiss one may see scattered grains of pyrites.

Specimen No. 414 illustrates a case of special note. This occurs as a leucocratic vein, several inches wide, intersecting the granodiorite gneisses just north of the anemometer site, Cape Denison. The intersected gneisses are richer than usual in biotite. The vein which is subsequent to and intersects the gneiss is composed of quartz and felspar in which are studded large black octahedral crystals of magnetite up to 2·5 cms. in length.

Some striking magnetite-bearing schists in which the magnetite is frequently associated with garnet are a feature of the moraines at Cape Denison. These have been described by Coulson. Kleeman records it to the extent of 20 per cent. in a magnetite-quartz-chlorite schist (No. 458). Glastonbury found it to the extent of 7·3 per cent. in a biotite-plagioclase-hornblende schist (No. 115). It is of course notable in the basic igneous rocks. Glastonbury records 5·5 per cent. in a dolerite (No. 906); 9·8 per cent. in another dolerite (No. 438); also 3·3 per cent. for a gabbro.

A good example of magnetite in platy form in a quartzose schlier out of the gneisses is represented in specimen No. 1281 from the moraine, Cape Denison. Here the magnetite is seen to be flattened and drawn out by shearing.

Chromite (or possibly picotite) is recorded by Glastonbury in No. 462, an ultra-basic metamorphic rock from the moraines.

Cassiterite has been detected in microscope slides of coarse grits associated with the late Palaeozoic coal measures discovered in King George Land in the neighbourhood of the Horn Bluff. It is present as small water-worn grains associated with other heavy minerals such as garnet, cyanite, zircon, tourmaline and ilmenite. As seen in the thin sections, it is in the form of rounded yellow-brown grains. Its occurrence in this specimen of grit (No. 1175) collected *in situ* by C. T. Madigan's sledge party, suggests that it is quite likely to be present in Antarctica in useful quantities.

Rutile has not been met with in any quantity but is recorded as an accessory constituent of a number of gneisses and schists. For example, in gneisses from Aurora Peak and the Madigan Nunatak (Stillwell) and in a mica garnet schist (Coulson). Rutile needles are noted (Glastonbury) in a banded injection gneiss (No. 50).

Brookite (biaxial) occurs (Glastonbury) as abundant deep red-brown crystals in a coarse charnockitic gneiss (No. 878).

Limonite.—On account of profound glacial erosion in recent times affecting the whole of Antarctica, oxidisable iron minerals remain fresh and unaltered practically to the surface of the outcropping rocks. In such places, however, where exposure to the weather has been maintained for some time past, limonitic stains are to be observed on the rock surrounding particles of pyrite and arsenopyrite (No. 274). In rare cases outcropping crystals of pyrite are partly oxidised to limonite pseudomorphs.

6. Oxygen Salts.

(*a*) *CARBONATES.*

Calcite is an abundant constituent of the marbles and certain calc-silicate rocks gathered from the moraines at Commonwealth Bay.

In very small quantities it is met with occasionally as a secondary mineral in other rocks, for example, in the gneisses of Cape Denison. A notable occurrence of the latter type (No. 723) is as a white to flesh-coloured filling in epidotic vughs along fracture planes in the granodioritic gneiss; one crystallised calcite individual shot through by crystals of epidote measuring 7 cms. by 4 cms.

Calcite forms a vein (No. 734) in a shear zone of the dolerite formation at the Horn Bluff, King George Land.

An unusual occurrence of calcite is recorded by Glastonbury (No. 468) in a chlorite-felspar-hornblende schist. This is an optically biaxial form, with optic-axial angle about 10 degrees.

Dolomite is a constituent of many of the silicated marbles. It is principally met with (Tilley) in the forsterite and the tremolite marbles.

Malachite.—Green stains and encrustations of copper bearing minerals were noted both in vein formations of the granodiorite complex at Cape Denison and as a feature of erratics in the moraines. Some of these when examined were found to effervesce with acid and are evidently malachite. Others gave a reaction for chlorine showing that atacamite is present.

Green copper stains on reef quartz (No. 173) of a vein *in situ* at Cape Denison is chiefly malachite. Microscopic particles of bornite seen on the face of the quartz are observed to be giving rise to the green stains.

A large granite erratic (No. 897) weighing about 2 tons exhibits green malachite stains between the laminae of the biotite and along cracks in the quartz and felspar. A tourmaline-bearing pegmatite (No. 489A) of the moraine also exhibits malachite stains.

Azurite was located in one example only. This is as a secondary accretion with malachite on a garnet-felspar-gneiss (No. 1147) from the moraine at Cape Denison.

(b) SILICATES, TITANATES, ETC.

The Felspars.

Felspar in one form or another is, of course, the chief constituent of the rock formations met with.

Orthoclase is developed to a moderate degree in the Cape Denison granodiorites (Stillwell); porphyroblasts as much as 5 cms. diameter being recorded. It is also a feature of the granites of the moraines.

A red even-grained aplitic rock (No. 1278) from the moraines contains felspar of a striking red colour. The rock is chiefly constituted of quartz and felspar. The latter is mostly acid plagioclase but is associated with some orthoclase. Viewed in microscope section the red colour is seen to be fine dusty inclusions, possibly haematite, distributed throughout the felspars along definite tracts. The orthoclase is chiefly affected and to a less extent the plagioclase. Another rather similar aplitic red felspar granite from the moraines is N0. 1279.

An outstanding example of bright red orthoclastic felspar is contained in rock No. 1138. This specimen shows the red aplitic granite passing into a pegmatitic schlier of coarse quartz and red felspar. The felspar exhibits two good rectangular cleavages and has a mean R.I of about 1·521. This red felspar carefully selected and cleaned of mechanical impurities has been analysed by J. C. H. Mingaye of the Mines Department, Sydney, with the following result :—

	Per cent.
Silica (SiO_2)	65·02
Alumina (Al_2O_3)	18·88
Ferric Oxide (Fe_2O_3)	0·60
Ferrous Oxide (FeO)	0·54
Manganous Oxide (MnO)	0·01
Lime (CaO)	0·01
Barium Oxide (BaO)	0·13
Strontium Oxide (SrO)	Present.*
Magnesia (MgO)	0·10
Soda (Na_2O)	2·47
Potash (K_2O)	11·08
Lithia (Li_2O)	Absent.
Titanium Dioxide (TiO_2)	Absent.
Water (H_2O)	0·88
Total ...	99·72

* Slight spectroscopic reaction only. The analysis is that of an orthoclase in which soda takes the place of some of the potash.

Red orthoclastic felspar has also been observed *in situ* as thin sheet veins (filling old cracks) in adamellite gneiss towards the eastern extremity of the rock area at Winter Quarters, Cape Denison (No. 988). Another example of red felspar sheet vein in schist is illustrated in No. 944 from the moraine, Cape Denison.

Adularia with the pearly opalescence typifying moonstone is a constituent of a coarse pegmatitic band (No. 1276) in a coarse biotite-sillimanite schist obtained from the moraine at Cape Denison. The pegmatite is constituted of large individuals of glass-clear adularia (one piece measuring 5 cms. in length) together with more-opaque, crushed adularia and some quartz, with a very little mica. The mica is in the nature of odd bits of muscovite and a little chloritised biotite which latter is possibly an inclusion from the intruded bounding rock.

Several grammes of the clean adularia was separated from this rock and submitted to J. C. H. Mingaye of the Mines Department, Sydney, for analysis. The percentage chemical composition recorded is as follows :—

	Per cent.
Silica (SiO_2)	64·92
Alumina (Al_2O_3)	19·36
Ferric Oxide (Fe_2O_3)	Absent.
Ferrous Oxide (FeO)	Minute trace.*
Manganous Oxide (MnO)	Minute trace.*
Lime (CaO)	Absent.
Barium Oxide (BaO)	0·39
Strontium Oxide (SrO)	Present.†
Magnesia (MgO)	0·05
Soda (Na_2O)	1·59
Potash (K_2O)	13·63
Lithia (Li_2O)	Absent.
Titania (TiO_2)	Absent.
Water (H_2O)	0·24
Total	100·18

Noteworthy, in review of the chemical analysis, is the content, though small, of barium.

In another coarse garnetiferous gneiss, original adularia is seen to be crumbling at its boundaries due to pressure and reforming as microcline.

Microcline is very widely developed in these Antarctic rocks. It is an abundant constituent of the Cape Denison adamellite and granodiorite gneisses. It is also a regular constituent of the abundant red granites of the moraines.

* Less than 0·01 per cent. † Spectroscopic reaction only.

An interesting occurrence is that recorded by Kleeman in rock No. 279 which is a garnetiferous, microcline gneiss containing much microcline which is perfectly fresh and translucent in pieces 5 mm. in thickness, but which exhibits a purple fluorescence when exposed to ultra-violet light.

Detrital microcline occurs in some of the metamorphosed limestones and has in part been rebuilt into the resulting calc-silicate rock.

A creamy white to flesh-coloured microcline is met with in some of the veins traversing the gneisses of the Cape Denison area. This is exemplified in No. 420 which is from an 18-inch wide vein extending W.S.W. and E.N.E. at a spot lying S.E. from the Magnetic Hut. The felspar is graphically intergrown with quartz. A measurement of this graphic intergrowth showed that in it the quartz is present to the extent of only 15 per cent.

Coarse microcline felspar is a feature of abundant acid pegmatites traversing the gneisses in the Cape Denison area. The coarser-grained examples are very irregular in the distribution of their mineral content. A typical example of this kind is met with *in situ* at Beryl Peak. It is 18 inches wide and trends east and west across the grain of the gneisses (Nos. 69 and 422). This formation is chiefly microcline felspar and quartz. Accessories in these pegmatites are biotite, muscovite and apatite. The biotite is very coarse and situated in the main as a marginal feature. Muscovite is developed only in occasional flakes in special situations. Coarse apatite prisms are well distributed in this pegmatite. A feature of these formations is that they have been subjected to considerable stress subsequent to their formation. In microscope slides the quartz usually shows crushing and streaming gneissic flow. Apatite crystals associated therewith are seen to be cracked; granular quartz and microcline are seen to have entered along the cracks. The felspars show cataclastic features and in places mineral changes; for example, the development of sericite on crush zones and changes *en masse* towards pinite. The latter change is accompanied by a discolouration of the felspar. This change in the felspar is to be noted also in the case of several specimens collected from the moraines at Cape Denison, e.g., No. 554. The outward sign of the change is usually first expressed by the felspar acquiring opacity and whiteness, if clear to begin with; then a brownish or greyish colour pervades it with increasing appearance of oiliness and loss of brilliance on cleavages. During this process the hardness is reduced until it can be quite easily scratched.

Anorthoclase is reported in a hornblende granodiorite.

Perthite has been frequently observed on the examination of these Antarctic rocks. It is a feature of the Cape Denison acid gneisses.

Antiperthite with a sodic phase, albite and a potassic phase, microcline is recorded by Kleeman in a tourmaline-bearing, garnetiferous, granite gneiss (No. 15).

Analbite (?).—An unusual felspar (No. 1273) was obtained from a pegmatite vein *in situ* near the eastern extremity of the rocky area at Cape Denison. It is white, clear and quite translucent. The felspar of the specimen is embedded in vein quartz. A basal section cut perpendicular to the 010 plane exhibits checker-like lamellar twinning. It is biaxial negative. The R.I. is a little below 1·528. Its properties appear to relate it to analbite or hyalophane.

Albite in a nearly pure state is a constituent of a wide range of the metamorphic rocks examined. For example, in hypersthene-alkali-felspar gneiss from Madigan Nunatak and in certain epidotic rocks from the moraines. It is a frequent constituent of the schists as for example in albite-epidote-chlorite schist (No. 574).

Plagioclase in all intermediate forms is met with in one group of rocks or another. Some notable occurrences are *oligoclase* in an oligoclase basalt (No. 875) and in the hypersthene-alkali-felspar gneiss of Madigan Nunatak. The latter rock also contains *andesine*. Andesine occurs in the gneiss of Stillwell Island. *Labradorite* is recorded in some of the basic dyke rocks and lavas of the moraine.

The most basic of the plagioclases is recorded by Stillwell who found in a pyroxene amphibolite (No. 212) porphyroblasts of a basic *bytownite*.

About half a mile east of the Hut at Cape Denison there is a patch of coarse pegmatitic quartz and felspar rock which is peculiar in that the felspar is strikingly cellular. Associated with it is some development of fine secondary muscovite (specimen No. 56). The optical characters of the felspar show it to be an acid oligoclase (Ab 85 An 15). The explanation of the honeycomb structure of the felspar appears to be that it was originally an intergrowth with other felspar or other mineral but at a late stage of formation subjected to hot gases or solutions which removed the other intergrown constituent, at the same time depositing muscovite—in fact, a partial greisenisation.

A curious feature met with in the case of some of the acid plagioclase felspar in an east-and-west-trending pegmatitic quartz "blow" located 200 yards east of the anemometer site, Cape Denison, is illustrated in No. 1275. In this the felspar in parts exhibits patches of a peach-blossom-pink colour. Microscopic examination reveals that this colouration follows recrystallisation, there being a development of exceedingly fine flakes of a platy-mineral apparently sericite or paragonite ranged along the crystallographic directions of the felspar. These felspar crystals which are as much as 2·5 cms. across are embedded in a matrix of quartz which when examined microscopically is seen to have been completely crushed and to have flowed under stress. There is just a little biotite and muscovite associated with it.

This felspar has been analysed by H. P. White of the Mines Department, Sydney, with the following result :—

	Per cent.
Silica (SiO_2)	62·72
Alumina (Al_2O_3)	23·66
Ferrous Oxide (FeO)	0·03
Ferric Oxide (Fe_2O_3)	.....
Manganous Oxide (MnO)	Absent.
Lime (CaO)	2·44
Barium Oxide (BaO)	Trace.
Strontium Oxide (SrO)	Present.*
Magnesia (MgO)	Absent.
Soda (Na_2O)	8·76
Potash (K_2O)	1·57
Lithia Oxide (Li_2O)	Present.*
Titanium Dioxide (TiO_2)	Absent.
Phosphoric Anhydride (P_2O_5)	.....
Water (H_2O)	1·04
	100·22

This felspar is for the most part in the nature of a highly sodic plagioclase. On account of the secondary change that has taken place it is not obvious in what form the potash originally entered the mineral constitution.

The Pyroxenes.

Enstatite.—Stillwell found colourless enstatite present with the hypersthene in hornblende-hypersthene-alkali-felspar-gneiss of Stillwell Island.

Hypersthene is a notable constituent of a number of gneissic rocks extending from Stillwell Island towards the Madigan Nunatak. As examples may be mentioned the hypersthene-alkali-felspar-gneisses.

Clino-enstatite.—This mineral is abundantly developed in No. 188 which is a recrystallised gneissic rock of acid character. It contains inclusions or segregations of a grey colour, which are rich in clino-enstatite embedded in a white quartzo-felspathic base. Rock No. 119 which also contains clino-enstatite is rather similar to No. 188 and both are from the moraine at Cape Denison. Taken together these specimens suggest that the original was a shattered igneous rock subsequently recrystallised and traversed by schlieric veins of a pegmatitic facies. In general appearance and in many of its optical characters this clino-enstatite closely resembles some forms of diopside and zoisite. The matrix of these rocks is composed principally of granular quartz and orthoclase. Other minerals present in small quantity are red-brown mica, zircon and leucoxenised ilmenite. Clino-enstatite has been recorded (Glastonbury) in a pegmatitic gneiss (No. 878).

* Spectroscopic reaction only; less than 0·01 per cent.

Diopside is an important constituent in a wide range of calc-silicate rocks collected from the moraines at Cape Denison. In these rocks Dr. Tilley found that the diopside is usually of a pale grey-green colour. However, it varies in character considerably in conformity with changes in the chemical character of the matrix. Thus a very light grey coloured diopside is abundant in some cases whilst a green variety may be met with in others. This latter contains enough of the hedenbergite molecule to impart to the mineral a dark green colour when viewed in the hand specimen.

Crystals of the darker coloured variety occurring with epidote and garnet in a handsome calc-silicate marble (No. 830) containing pink calcite were extracted and submitted to the Mines Department, Sydney, for analysis. The chemical composition was determined by H. P. White to be as stated in Column I below.

	I. *Green Diopside.* Per cent.	II. *Grey-green Diopside.* Per cent.
Silica (SiO_2)	51·36	53·66
Titanium Dioxide (TiO_2)	0·08	0·04
Alumina (Al_2O_3)	2·57	0·79
Ferric Oxide (Fe_2O_3)	Nil.	Nil.
Ferrous Oxide (FeO)	4·32	2·70
Manganous Oxide (MnO)	0·43	0·38
Lime (CaO)	24·44	24·26
Barium Oxide (BaO)	Nil.	Nil.
Strontium Oxide (SrO)	Nil.	Nil.
Magnesia (MgO)	15·98	17·14
Soda (Na_2O)	0·40	0·10
Potash (K_2O)	0·05	0·25
Lithia (Li_2O)	Present.*	Present.*
Phosphoric Anhydride (P_2O_5)	Nil.	Nil.
Carbon Dioxide (CO_2)	Nil.	Nil.
Water...	0·72	0·92
	100·35	100·24

This pyroxene appears almost black in the hand specimen. In section it is of a blue-green colour. The extinction angle on the prism zone is between 35° and 40°. It is biaxial +ve.

Tilley records that in the pyroxene-garnet marbles the hedenbergite molecule is dominant.

* Spectroscopic reaction only.

As an example of the paler coloured diopsides of the calc-silicate marbles and gneisses may be taken the coarse greenish-grey variety beautifully developed in rock No. 958. This specimen, which is also from the moraines at Cape Denison, is completely silicated. It contains in addition to the diopside some darker coloured fibrous actinolite, a little quartz in irregular tracts and a small amount of fluorite.

Some carefully selected crystal fragments of the diopside were separated and submitted to J. C. H. Mingaye (Mines Department, Sydney) for analysis with the result shown in Column II above. This analysis indicates that this grey variety is composed of the pure diopside molecule to the extent of about 95 per cent. The extinction angle $Z \wedge c$ in the case of this diopside is 38°; $n\beta$ is about 1·680; D.R., about 0·030; biaxial +ve. It will be noted that this lighter coloured diopside contains less iron and more magnesia than the darker coloured type.

Salite is reported by Glastonbury as present in a dolerite (No. 906) and a gabbro (No. 647).

In an acid quartz-felspar-pyroxene-gneiss (No. 764) which exhibits well-marked foliation, there occurs a rather light coloured, greenish-grey pyroxene, which appears to be intermediate between augite and diopside. It is typified by high extinction angles (about 40°) and a D.R. of 0·030.

Augite in large black crystals is recorded by Stillwell as occurring in a hornblende-plagioclase-pyroxene-gneiss of Stillwell Island. It is recorded in the dolerites; but Browne found that the bulk of the augite of the Horn Bluff locality is the variety styled enstatite-augite (Nos. 732 and 733).

Dr. Browne found a violet pyroxene as a constituent of an essexitic dolerite (No. 208).

Pale brown augite is recorded by Glastonbury in a basalt (No. 909) to the extent of 43 per cent. In a dolerite (No. 938) he found 36 per cent. of a pale purple-brown augite. In another dolerite (No. 1225) the purple-brown augite was estimated at 35·7 per cent. Glastonbury found a beautiful mauve titan-augite in a gabbro (No. 423) to the extent of 8·9 per cent.

Diallage in a fibrous form is recorded by Stillwell in gneiss from Stillwell Island.

The Amphiboles.

Amphibole is present in the rocks of Adelie Land and of King George Land in a wide range of forms.

Anthophyllite was found by Stillwell to be an important ingredient of some magnesium-silicate gneisses as Nos. 513 and 109 which are both anthophyllite schists. The anthophyllite in these is usually colourless to very faint brown when seen in section. Glastonbury refers to a pale green variety in an epidotic rock No. 257 from the moraines. He found this mineral also in an ultra-basic schist (No. 462).

Tremolite is of course an important constituent of some of the metamorphosed limestones. Tilley mentions that gradations between tremolite and actinolite are represented; the mineral becoming greener as it is enriched in the actinolite molecule. Kleeman found 16 per cent. of this mineral in a tremolite granulite (No. 287).

Actinolite in abundance is recorded by Stillwell in actinolite schists. A pale blue-green actinolite is reported (Glastonbury) in certain metamorphic dyke rocks. In certain of the metamorphosed limestones much actinolite of a pale green colour has been developed. Uralitic actinolite has been frequently noted in some of the basic igneous rocks and metamorphosed equivalents.

Hornblende of a yellow-green normal variety is recorded (Summers and Edwards) to the extent of nearly 5 per cent. in a granodiorite (No. 200). In another granodiorite (No. 859) Kleeman has recorded over 6 per cent. Hornblende of yellowish-green and bluish-green colour (in thin section) is met with in more basic rocks including some of the amphibolites. Green compact hornblende occurs in some of the gneisses and amphibolites of Stillwell Island.

The hornblende in a gneissic granite (No. 352) from the moraines contains good haloes (Kleeman). Hornblende schists examined by Glastonbury were found to contain hornblende to a maximum amount of 77 per cent. A hornblende more markedly blue than usual, present (Glastonbury) to the extent of 47 per cent. in a biotite-hornblende-plagioclase schist (No. 115), is suggestive of high concentration of the glaucophane molecule. Specimen No. 78, an erratic from Cape Denison, affords a good example of coarse hornblende in association with vein quartz.

Edenite is recorded by Dr. Tilley in some of the forsterite marbles.

Glaucophane is mentioned (Stillwell) as a fringe around green hornblende of an amphibolite (No. 799).

The Micas.

Mica in one form or another is one of the most widely distributed minerals in Antarctic rocks.

Muscovite, though not at all uncommon, does not appear in the rocks of King George Land and Adelie Land to anything like the extent of biotite. It is met with in small amounts in the granitic rocks, but as a constituent of some of the gneisses and schists it is important. It has been found in crystal books up to 10 cms. diameter and 2·5 cms. in thickness, in pegmatite reefs intersecting the granodiorite gneisses at Cape Denison.

The variety *sericite* is a notable constituent of many of the schists. For instance it is present to the extent of 25 per cent. in a garnet-chlorite-sericite-schist (No. 552), and in a garnet-sericite-schist (No. 1260) it constitutes 35 per cent. of the rock (Kleeman).

Biotite has a very wide range in both the igneous and the metamorphic rocks. Fine showy examples have been collected from some of the acid pegmatite veins crossing the granodiorite gneisses of the Cape Denison outcrop. Thus coarse biotite occurs in a biotite-quartz-felspar pegmatite west of Lake III. There the biotite is in patches usually located along the margin of the vein. The plates reach 15 cms. across. It is pseudo-uniaxial, or with small optic axial angle, about 5°. Haloes are only poorly or rarely developed in it (Nos. 66 and 419).

A similar occurrence of biotite is located near Lake II. There the cleavage flakes are pitch black in colour and up to 30 cms. long. Some of the mica at this occurrence has been deformed, being sharply folded.

Biotite appearing brown to greenish yellow in thin sections is a notable feature of the granitic rocks. It appears in some of the charnockitic types where it is usually a paler variety. Both the brown and green varieties have been recorded in silicated marbles. Coulson mentions certain biotites occurring in the magnetite and magnetite-garnet schists which exhibit remarkable haloes around embedded zircons. Stillwell records that the biotite in the gneiss at Garnet Point has fine haloes surrounding included monazite. Kleeman found the biotite in a sillimanite-bearing garnet-biotite gneiss (No. 441A) to amount to 30 per cent. of the rock and records therein splendid haloes. Glastonbury gives the biotite content of a biotite-plagioclase-hornblende schist (No. 115) at 14 per cent.

Phlogopite is recorded by Tilley to occur in some of the metamorphosed marbles. He found it colourless to pale yellow-green (in section) in tremolite marble. Glastonbury records an almost colourless phlogopite, in an ultrabasic schist (No. 462).

Pinite.—Specimen No. 334 apparently represents sheared and altered quartz-microcline pegmatite. Some of the microcline 5 cms. in length has been altered to a steartite-like mass as seen in the hand specimen. This, however, is apparently an aggregate of pinite.

The Chlorites.

Chlorite is of common occurrence, but is abundant only in the schists. To a very limited extent it exists *in situ* in patches and selvages amongst the gneissic series at Cape Denison. Stillwell has recorded its presence more abundantly in some of the amphibolites—for example, a chlorite amphibolite.

Amongst the morainic material it is frequently met with in small quantity as an alteration product of ferromagnesian minerals in a variety of rocks. Compact patches of dark yellowish green chlorite are contained in No. 882, which is an altered igneous rock.

It occurs (Coulson) importantly in a chlorite-magnetite gneiss. Its importance in some of the schist has been demonstrated (Kleeman): For example, in a garnet-chlorite-sericite schist (No. 552) it is represented to the extent of 10 per cent. In a chlorite-felspar-hornblende schist (No. 468) it is reported (Glastonbury) to the extent of 25 per cent. of the rock. Plumose chlorite is present (Glastonbury) in a banded injection gneiss (No. 50).

Pennine is noted (Glastonbury) in a calc-albite-zoisite-hornblende schist (No. 965).

Prochlorite is reported (Glastonbury) in several rocks, including (No. 32) a pegmatite gneiss containing 8 per cent. and in a hornblende-plagioclase schist (No. 193) containing 1·9 per cent.

Delessite is recorded in several rocks. In a delessite-hornblende gneiss (No. 517), Glastonbury found 5·4 per cent. of this mineral.

Other Silicates, Titanates, Etc.

Cordierite has been met with in a wide range of metamorphic rocks from the moraines at Cape Denison. In colour and other chemical and physical characters it varies with the composition of the enclosing rock. The most striking variety, which at the same time is fairly commonly met with in the morainic debris, is of a blue colour, in some cases a real cobalt blue.

A small quantity of this rich blue variety was separated from the enclosing schist (No. 1270) and submitted to Mr. J. C. H. Mingaye for analysis with the following result:—

	Per cent.
Silica (SiO_2)	47·96
Alumina (Al_2O_3)	31·52
Ferrous Oxide (FeO)	3·24
Ferric Oxide (Fe_2O_3)	1·03
Manganous Oxide (MnO)	1·09
Lime (CaO)	Absent.
Barium Oxide (BaO)	Trace.
Strontium Oxide (SrO)	Present.*
Magnesia (MgO)	12·16
Soda (Na_2O)	0·33
Potash (K_2O)	Trace.
Lithia Oxide (Li_2O)	Present.*
Titanium Dioxide (TiO_2)	Absent.
Phosphoric Anhydride (P_2O_5)	Trace.
Water	2·80
	100·13

* Spectroscopic reaction only; less than 0·01 per cent.

Its specific gravity determined on a crystal fragment is 2·60. Professor Tilley describes this particular cordierite as an optically positive variety (*vide* his account in Part 10).

This type of cordierite is notably associated with iron-rich schists. In these Coulson has described blue cordierite in a magnetite-garnet gneiss; also in a garnet-free, tourmaline-bearing magnetite gneiss. Other occurrences have been dealt with by Tilley, who has examined about twenty-nine cordierite-bearing rocks from the Expedition collection. Tilley finds that more than half the cordierite-bearing rocks he examined have igneous affinities and the majority might well be designated as cordierite pegmatites.

Cordierite is recorded *in situ* on Stillwell Island in a cordierite-garnet-plagioclase-biotite-gneiss. Also it is *in situ* at Cape Gray in a garnet-cordierite-sillimanite-gneiss.

An unusual form of cordierite occurs in a richly micaceous and highly foliated schist (No. 100A) with large kernels which are chiefly constituted of colourless to grey cordierite. In it inclusions of zircon surrounded by haloes are abundant.

Garnet is widely distributed, occurring both in siliceous and in basic rocks. Stillwell has described belts of garnetiferous gneisses *in situ* in the Garnet Point—Stillwell Island region. He mentions particularly, as occurring at Garnet Point, striking aggregates of mica and pale pink garnet up to 10 cms. broad, imparting to the rock (No. 777) a mottled appearance. Some of the garnetiferous rocks in this region are granitic, some charnockitic and some are metamorphosed basic dykes which are full of fine garnets.

Amongst the rocks of the moraines, garnetiferous gneisses and schists are quite common. Coulson records examples of garnetiferous magnetite schist. He records manganiferous garnet in a mica-garnet schist (No. 348). Tilley found garnet importantly developed in certain metamorphosed marbles, a clove-brown garnet being important, particularly in the pyroxene-garnet marbles.

Kleeman notes the presence of pink almandine garnet in a number of gneisses, for example in a granite gneiss (No. 234). In a sillimanite-bearing garnet-biotite gneiss (No. 441A) he records as much as 57 per cent. of almandine.

In No. 289, a gneissic garnet-pegmatite, large garnets appearing black in the hand specimen stand out against a white felspathic background. In section these are seen to be of a light colour, apparently almandine, but wrapped around by dark green chloritic mica which has arisen as an alteration product.

Garnets as much as 4 cms. in diameter occur in No. 88, which is a garnet-felspar-gneiss from the moraine. A coarse garnet-free pegmatite (No. 512) from the moraine, contains bornite in crystals ranging up to 1·25 cms. diameter. In this the garnets reach 3·75 cms. diameter. Coarse biotite associated in this formation is partly chloritised. This garnetiferous pegmatite is seen to be an intrusion into a coarse, granular, grey schist which appears to represent a recrystallised fine-grained sediment.

A fine example of coarse garnet poikilitically intergrown with quartz is represented in a specimen (No. 67) which was collected from a highly quartzose pegmatite formation 8 feet wide, trending north and south in the gneissic area at Cape Denison. In some portions of this pegmatite formation microcline felspar was observed to be abundant, but in the actual specimen collected only garnet, quartz and a little muscovite are represented. The optically continuous garnet which includes the quartz is a mass 10 cms. across.

Forsterite is characteristically developed in the group of forsterite marbles described by Dr. Tilley. In these rocks it is usually colourless and with D.R. about 0·034. It is biaxial —ve. It readily alters to pale yellow serpentine.

Olivine has been found only in rocks from the moraines, namely gabbro and basalt. Glastonbury records olivine to the extent of 10 per cent. in gabbro (No. 423).

Scapolite is noted by Tilley to exist in some of the calc-silicate rocks, especially in the pyroxene epidote marbles. Stillwell records it in amphibolite from Garnet Point. A notable occurrence is in a scapolite microcline gneiss (No. 725) reported by Kleeman.

Zircon has a very wide range through the rocks of Adelie and King George Lands, but is scarcely ever more than a quite minor accessory constituent of the rocks. It has been recorded both by Tilley and by Glastonbury in diopside-tremolite rocks and in pyroxene epidote marble. It features in all the granitic rocks, including the granodiorites of Cape Denison, and in some of the charnockites. It is recorded in most gneisses and many schists. In No. 711A it is reported (Kleeman) to be abundant and in No. 81 notable in amount.

Sillimanite is recorded by Stillwell in garnet-cordierite gneisses *in situ* in the neighbourhood of Cape Gray. In small quantities it is very frequently met in schists and gneisses from the moraines, but occasionally it is very abundant in such. Kleeman specially records its presence in specimens Nos. 270 and 709.

Detrital sillimanite has been noted in No. 1175, a sandstone band containing heavy minerals at the Horn Bluff.

Cyanite is reported by Stillwell as colourless coarse crystals in a cyanite-biotite-gneiss (No. 772) from Garnet Point.

Detrital cyanite appears in No. 1175, which is a heavy sand band in the sandstones of the coal-bearing beds at the Horn Bluff.

Zoisite is widely recorded as a change mineral in older igneous rocks that have suffered some degree of alteration. It is also recorded by Glastonbury in tremolite-epidote marbles, in metamorphic dyke rocks and in epidotic rocks of the moraines. Kleeman has recorded it in quite large amounts in certain schists, e.g. 10 per cent. in a zoisite-biotite schist (No. 930) and 17 per cent. in a zoisite-biotite amphibolite schist (No. 1211).

Clinozoisite is reported by Tilley in a carbonate-free calc-silicate rock. Stillwell records it in the metamorphosed xenoliths in amphibolite *in situ* at Cape Denison and he remarks upon its characters (*ibid.*, p. 50). Glastonbury has found it in metamorphic dyke rocks and in felsite from the moraines.

Epidote is rather abundantly represented amongst the erratic material of the moraines and good examples are to be met with *in situ* amongst the gneisses of Cape Denison. The development of epidote in the metamorphic recrystallisation of the older rocks of that region post-dates the intrusion of the acid granodiorites and porphyries. It may represent a late stage or aftermath of that revolutionary period.

Stillwell has referred to the occurrence of epidote along the joint planes of the granodiorite gneiss *in situ* at Cape Denison (Nos. 68, 722). A good example of this (No. 43) is from a shatter zone in the gneiss at 50 yards south of the Magnetograph Hut. In this blue fluorite, yellow-green epidote and iron pyrites occur in patches sometimes several inches in length; the main vein filling is of quartz and the walls are of chloritised biotite.

Another notable occurrence of epidote *in situ* is that along the junction of amphibolite and gneiss at a point just south of the anemometer site at Cape Denison (No. 410). Here the epidote crystals are as much as 7·5 cms. long and 1·25 cms. diameter. It is grey-green in colour, in well-formed crystals associated with a little white calcite, all embedded in a highly micaceous schist. The large individuals of epidote are all arranged along a main fracture line. Another specimen from an extension of the same belt exhibits a central, cavity filling of quartz into which the epidote extends from the wall. In this is located also a cube of iron pyrites 1·25 cms. diameter. Specimen No. 5, also *in situ* on the Anemometer Ridge at Cape Denison, illustrates epidote from amphibolite lenses in the gneiss. It is loaded with tiny epidote and pyrite particles; in shear zones through it, blue fluorspar appears.

Epidote has been noted in the fracture planes of the phyllites located *in situ* at Cape Hunter.

Specimen No. 44 is an unfoliated granitic rock traversed by hair cracks c[redacted] by epidote and blue fluorspar.

Specimen No. 701 from the moraine, Cape Denison, illustrates epidote along fracture planes of a siliceous pegmatite.

Epidote is a common and abundant constituent of many of the calc-silicate rocks from the moraines described by Tilley and by Glastonbury. Tilley states that the yellow-green epidote of the epidote marbles is always rich in ferric-oxide,

It is of course very prominent in the group of epidotic rocks from the moraines described by Glastonbury. It is in large proportion in specimen 578, an epidote-andesine-hornblende schist. In the gneisses and schists from the moraines it is often a very prominent constituent. Coulson found such to be the case in some garnet-magnetite schists, whilst Kleeman reports as much as 20 per cent. of epidote in rock No. 1257, an epidote-biotite schist. Even in the granites where it is developed as a secondary mineral it has been recorded (No. 44) to the extent of 4·6 per cent. of the rock.

Allanite has a remarkably wide distribution in the ancient igneous and metamorphic rocks of West Antarctica.

A notable occurrence is in the granodiorite gneisses of Cape Denison in which it is particularly abundant in some of the bands most free from ferro-magnesian minerals and richest in apatite. In some places, as in the vicinity of the Magnetograph House (Nos. 31 and 60), it is clearly visible in black vitreous prisms on the outcropping face of the rock. Examples over 2 cms. in length have been observed there. The prisms are sometimes bordered by a reddish-brown zone surrounding the black central area. It has good cleavages. In thin section the crystals appear reddish brown and pleochroic. This mineral also occurs in the more orthoclastic related gneisses of the Mackellar Islets.

Stillwell finds it in plagioclase gneisses and mentions that large crystals of allanite are contained in a chlorite amphibolite. Glastonbury records it in felsitic and in epidotic rocks from the moraines. Summers found it in granite (No. 833). Kleeman records it in many gneisses and some schists; he found 0·3 per cent. in a felspar-biotite gneiss (No. 543).

Prehnite has been noted (Kleeman) in a thin vein in a granitoid gneiss (No. 39).

Chondrodite as small orange-yellow crystals is recorded (Tilley) in forsterite marbles (Nos. 135 and 137).

Lawsonite was first identified in these Antarctic rocks by Stillwell. He has described it in several lawsonite amphibolite schists (e.g., Nos. 634A and 635) occurring *in situ* at Cape Denison and in plagioclase gneisses. In his report Stillwell observed that "Lawsonite being a saussuritised product, it obtains its best development in rocks [redacted] abundant saussuritised felspar, though it may also form from hornblende partly by intergrowth with biotite." He also describes veins with epidote walls and lawsonite fillings; further remarking that calcite may form vein fillings with lawsonite walls and calcite centres.

Occupied

Glastonbury has observed the presence of lawsonite in many rocks from the moraines. He has noted much in banded injection gneisses; in garnet amphibolite (No. 1259); in a coarse granite (No. 833A); and to the extent of 7·5 per cent. in a hornblende-plagioclase schist. Kleeman records it in a bytownite-biotite gneiss (No. 112).

An unusual occurrence is that in a vein crossing an almost white, very fine-grained matrix (No. 896) which may have originally been a silicated marble. The vein varies from 1·25 to 3·75 cms. wide. On one side of the vein and partly on the other is a marginal zone of light coloured mica 0·3 to 1·25 cms. wide, arranged in comb formation. Against the mica and at other times directly against the vein wall is a belt of greenish-grey diopside of which some individuals are large, one measuring 1·8 cms. in length. This diopside is also in comb arrangement. The centre of the vein is occupied by granular crystalline lawsonite. In the hand specimen the lawsonite appears slightly mauve-blue; in thin section it is clear and colourless. It shows poor cleavage traces; is biaxial positive; negative elongation; straight extinction and a double refraction between 0·018 and 0·020.

Another unusual occurrence of lawsonite is a fine grained porcelain-white rock (No. 433) with irregular puce to mauve coloured splotches distributed through it. Microscopic investigation indicates that originally this was, in the main, a granular mass of labradorite felspar. Crushing and saussuritization has reduced it to an opaque and dusty nature. The areas which, in thin section, appear dusty under the microscope correspond with areas that are puce coloured in the hand specimen. Throughout these puce areas, veins of lawsonite, often shot through with elongated zoisite individuals, can be observed. Small particles either albite or quartz are also present.

Tourmaline is not a feature of the adamellite-granodiorite following of the Cape Denison area, but it is frequently met with in erratics from the moraines. Though rare in such rocks, it has been observed (Tilley) in pyroxene-epidote-marble. It is common in the schists and gneisses and quite abundant in pegmatitic gneisses. In the case of No. 708 the rock is principally tourmaline—a luxullianite (Kleeman).

Tourmaline is very abundant in long needles in a tourmaline-bearing magnetite gneiss; this rock is free of garnet but contains blue cordierite and sillimanite. The coarse tourmaline of the moraine specimens is always black. In the case of some specimens from the moraines copper stains discolour the rock indicating that traces of copper sulphides were not infrequently deposited with the tourmaline.

An unusual occurrence met with amongst the moraine specimens (No. 925) is that of large crystals of tourmaline set in a granular, white base composed mainly of quartz, the whole presenting a striking black and white appearance. The tourmaline is in idiomorphic crystals often 2 cms. diameter and up to 5 cms. in length. Examined in microscopic section this rock is seen to be chiefly composed of quartz grains averaging about 0·2 mm. diameter and containing innumerable liquid inclusions and moving bubbles. There is just a very little felspar, part albitic, part microcline. A very little mica; part biotite converted to chlorite and part muscovite which appears to be original and not sericitic. The tourmaline viewed in thin section is green with a pleochroism somewhat less marked than usual. It is uniaxial negative; D.R., 0·023. There are several cracks extending across the specimen which are occupied by orthoclase.

Another erratic (No. 585) is remarkable for great development of black tourmaline needles about 0·8 mm. diameter which penetrate all the other minerals of the rock. The rock is very rich in felspar which is predominantly microcline but with some andesine; the felspar is generally cloudy and somewhat altered. The larger individuals of quartz show shadowy extinction indicating that the rock has suffered stress. A moderate quantity of muscovite is also present.

Dumortierite has been observed in several specimens of rock from the moraines at Cape Denison. In each case they are fragments of pegmatitic formations invading metamorphic rocks.

It occurs in rock No. 674. This is a siliceous pegmatite vein traversing a coarse muscovite schist of a character suggesting that the latter was derived from a situation close to the contact of a large acid intrusion: Microscopically examined the pegmatitic vein material is seen to be composed of coarse microcline (up to 5 cms. in length) and much quartz; embedded in the quartz at isolated centres is some dumortierite of a sapphire-blue colour. A little sillimanite is present. There is also some clear albite-oligoclase felspar, which is in all probability secondary. The pegmatite itself has been subjected to considerable crushing stress which has crushed the quartz and developed mortar structure around residual kernels of microcline.

The dumortierite is strongly pleochroic: X = blue, Y = Z = colourless. In form it is completely fibrous with straight extinction. It is biaxial positive. D.R. is about 0·018. Its refractive index is rather low for normal dumortierite.

Dumortierite also occurs in a white saccharoidal quartz boulder from the moraine at Cape Denison. Embedded in the quartz are small hexagonal crystals of a grey-green apatite as much as 1·25 cms. in length and 0·3 cms. in diameter. A few blue tinged areas of what is apparently dumortierite show up against the dead white of the rock.

Dumortierite also is recorded from a vein formation occurring in a large erratic on the moraine (see description of No. 104, under apatite).

Kornuperine.—In rock No. 100A, which is a richly micaceous foliated schist constituted principally of cordierite, biotite and sillimanite, there is a little colourless to grey mineral which, in its optical characters, agrees closely with those of kornuperine. It is distributed in small amount only. The grains as seen in the slide are roughly rhombic in section. It shows straight extinction and is biaxial negative, with a small optic axial angle. The R.I. is greater than cordierite and the D.R. closely similar to sillimanite. The elongation is positive.

Stilbite is mentioned by Stillwell as occurring in some of the metamorphosed dyke rocks, and with epidote and fluorspar filling cracks in gneisses (No. 5) of Cape Denison.

Serpentine appears in grains and patches as a constituent of some of the silicated marbles from the moraines, as described by Tilley and Glastonbury. In these it is mainly derived from the alteration of forsterite (No. 316). In some of these marbles the serpentine appears in the fibrous variety filling narrow veins (No. 316).

In small quantities it occurs widely distributed in a variety of rocks. Thus in a basalt (No. 909) Glastonbury found it present to the extent of 4·6 per cent. He also records the form bastite in a gabbro gneiss (No. 1220).

Talc has rarely come under notice, but is in notable quantity (Glastonbury) in an anthophyllite-talc schist (No. 462) from the moraine.

Iddingsite derived from the alteration of olivine is described by Dr. Browne in Nos. 837 and 838.

Sphene is a minor accessory constituent of a wide variety of rocks both *in situ* and from the moraines. There is a little sphene in the granitic gneisses of Cape Denison.

It appears in some of the calc-silicate rocks, Tilley recording that it is " a constant member of the garnet pyroxene marbles." Stillwell records it frequently in his amphibolitic rocks and so does Glastonbury in his account of the epidotic rocks. It appears in the granites (Summers and Edwards) to the extent of 0·1 per cent. in an adamellite (No. 469) and 0·5 per cent. in a coarse granite (No. 833A). Kleeman mentions it frequently in the schists and gneisses; he records brown sphene as usually abundant in a granite gneiss (No. 822).

Perhaps the best example of sphene encountered was found as a constituent of a siliceous pegmatitic schlier in a very large block of gneiss (No. 1277) on the moraine, Cape Denison. The pegmatitic matrix rock is dominantly composed of white to clear vein quartz, white felspar, black amphibolite and a little biotite. The pegmatite has not been greatly affected by pressure but some of the quartz is undulose. The abundant felspar is chiefly plagioclase, in composition about $Ab_{62}An_{38}$. There is just a little microcline and a small amount of orthoclase present. The amphibolite is a soda hornblende strongly pleochroic in greens and yellows: X = blue-green, Y = Z = yellowish green; the extinction angle is 14° and elongation positive. The biotite is fresh, pleochroic in green and yellow, and with haloes. Crystals of clove-brown sphene up to $\frac{3}{4}$ inch in length, though mostly small, are distributed through the above matrix. Other accessories include a little zoisitic epidote, abundance of apatite and not infrequent magnetite.

Leucoxene has been noted (Summers) in a granite (No. 833); in (No. 934) andesite basalt (Glastonbury); and in a mica-magnetite schist (Coulson); and in other rocks in inconspicuous amount.

(c) *PHOSPHATES.*

Xenotime has been noted to occur in a pink adamellite (No. 960). Kleeman records it in a plagioclase-biotite gneiss (No. 702); in a sillimanite-bearing garnet-biotite gneiss (No. 441A); and notably in a garnet-apatite-bearing pegmatite (No. 81).

Monazite recorded by Stillwell in (No. 772) a cyanite-biotite-gneiss from Garnet Point.

Apatite.—A notable feature of the more prominent pegmatite veins intersecting the Cape Denison gneisses is the prevalence in them of well crystallised apatite. The crystals are usually perfect hexagonal prisms of a light bluish- to grey-green colour. The resemblance to beryl is so close that, when first discovered, we assumed the mineral to be beryl. Crystals of iron pyrites are not uncommon in the same formations. Some of these pegmatites have already been referred to under the record for felspar.

A perfect crystal of a grey-green colour got out of a pyritic quartz vein situated to the east of the Cape Denison rock area was found to have a specific gravity of 2·18.

Specimen No. 549 is a pegmatitic vein formation from near the Magnetograph Hut, chiefly quartz, but with a small percentage of white to faintly flesh-coloured microcline and a little chlorite and sericite along cracks and shears. It contains bluish-green hexagonal prisms of apatite up to 2·5 cms. long and 8 mm. across. Specimen No. 28 is another example of this gneissic pegmatite of the adamellite-granodiorite series. In some schliers in this specimen the apatite constitutes about 5 per cent. of the rock. Biotite is also present in this rock.

A number of apatite-rich examples related to the *in situ* pegmatites of Cape Denison and doubtless of similar age and origin were also found in the moraines (see Nos. 47, 501, 480, 444 and 323). In some of these biotite is rather abundant. In certain cases these have suffered cataclasis, fracturing and distorting the apatite (No. 97).

Another noteworthy occurrence of apatite is in a vein formation of unusual interest which occurs in a massive block in the moraine at Cape Denison (No. 104). This rock is a fine, even-grained, quartz-felspar-biotite-garnet schist and probably represents a recrystallised sediment. The vein crossing this rock is probably mainly constituted of the rock matter recrystallised with the addition of some introduced constituents. At the junction of the vein and the intersected rock there is, in places, a marked development of coarse black mica with which are associated plates, usually bent, of magnetite. The vein contains a number of minerals which as seen under the microscope are as follows : Quartz is very abundant as granular, graphic and myrmekitic forms. Felspar is present in several varieties including orthoclase, microcline, perthite and oligoclase. Mica is present both as muscovite, in very small amount which in any case is partly secondary, and as biotite which is fairly abundant in localised areas. The latter is a deep brownish green variety and in part shows some bleaching and incipient change. Apatite is abundant in large crystals up to 2·5 cms. in length. In hand specimens these crystals are of a light olive-yellow appearance but some are browner. They thus resemble very much in shape and colour some forms of beryl. Zircon in tiny needles is to be seen chiefly in association with the micas. Magnetite in black square sections is to be seen in some of the slides inspected. Dumortierite appears to be present also. It is in a form resembling sillimanite but as some of the fibres show definite pleochroism there appears to be no doubt as to the presence of

dumortierite. A macroscopic examination of this vein material reveals occasional faintly-blue patches in the clear quartzo-felspathic base. This colouration is due to the presence of matted dumortierite fibres.

Apatite is present to the extent of 0·1 per cent. in a pink adamellite (No. 960), also in a coarse granite (No. 833A). Summers and Edwards found it to be present in a hornblende granodiorite (No. 200) to the extent of 0·34 per cent.; and in the granodiorite (No. 747) of Penguin Point they found 0·9 per cent. In a gabbro (No. 423) apatite was found (Glastonbury) to amount to 0·9 per cent.

In certain gneisses Kleeman found apatite in notable amount: For example in a felspar biotite gneiss (No. 543) he records 0·8 per cent.; it is abundant in a garnet-felspar gneiss (No. 711A). In a garnet apatite-bearing pegmatite (No. 81) Kleeman records abundant apatite which is, however, abnormal in that it exhibits a biaxial interference figure.

Specimen No. 422 illustrates a notable occurrence of apatite in a siliceous pegmatitic vein formation trending east and west intersecting the gneisses at Beryl Peak, Cape Denison area.

In an erratic specimen (No. 691) of pegmatite, probably of the granodiorite following, excellent examples of blue-green apatite crystals are embedded.

Phosphatic Mineral Deposit in Penguin Rookeries.—In several low-lying portions of the penguin rookery on the west side of the Boat Harbour at Cape Denison, rookery liquors, with a strong odour, accumulate to a very limited extent in the late summer. The rocks in such locations become encrusted with a white mineral deposit, which on fractured faces is dense and exhibits no obvious crystalline structure.

A chemical analysis of this white encrustation undertaken by J. C. H. Mingaye of the Mines Department, Sydney, resulted as follows:—

	Per cent.
Moisture and Water above 100° C.	36·24
Lime (CaO)	3·74
Magnesia (MgO)	14·13
Soda (Na_2O)	0·78
Potash (K_2O)	0·29
Chlorine (Cl)	0·33
Sulphur Trioxide (SO_3)	0·12
Phosphoric Anhydride (P_2O_5)	26·49
Organic Matter	14·68*
Insoluble Matter (Sand, etc.)	3·48
Nitrates	Trace.
	100·28
Less Oxygen equivalent to Chlorine	0·07
	100·21

* Containing nitrogen 0·513 per cent; 3·85 per cent. of the P_2O_5 found was soluble in distilled water

Obviously this is not one single mineral but in all probability a mixture of at least two mineral compounds with some organic matter and sand.

The composition recorded suggests that the chief component is likely to be newberryite, $HMgPO_4.3H_2O$, with which is associated a hydrous calcium phosphate, probably brushite $HCaPO_4.2H_2O$. Some of the soluble phosphate, alkali and nitrogen may be combined as stercorite.

(*d*) *SULPHATES.*

Mirabilite in white salty surface encrustations (No. 894) from the Mackellar Islets.

This has the appearance of snow. Attention is drawn to it in midsummer when all snow has melted from large areas on the main islets. It is a saline residue derived from the showers of frozen sea spray blown across the islets by the prevailing hurricane winds.

A sample submitted for qualitative chemical examination recorded good reactions for chlorine, sulphate and sodium; also a small amount of calcium and magnesium. A trace of ammonium as chloride or sulphate was detected. Tests for bromine, iodine, nitrate, phosphoric acid and potassium gave negative results. In fact the sample was found to consist chiefly of sodium sulphate with some admixture of sodium chloride.

On these islets scattered penguin rookeries occupy a good deal of the surface which fact accounts for the trace of ammonium in the sample. For the rest the substances present are obviously derivatives from sea salts. These mixed sea salts when distributed over the islets by the wind are slowly affected by forces operating with the result that the sodium sulphate tends to be retained whilst all the other salts are eliminated. This elimination is obviously brought about by the liquidation from the frozen mass in winter of substances like sodium chloride which have low cryohydric temperatures; leaving behind those substances with higher cryohydric temperatures such as sodium sulphate. In the low temperatures prevailing in Antarctica this sodium sulphate is in stable combination with 10 molecules of water and crystallised as mirabilite ($Na_2SO_4 + 10H_2O$). At higher temperatures this mirabilite breaks down to a dead-white powdery substance exanthalose ($Na_2SO_4 + 2H_2O$). Apparently it is in this manner that the mirabilite deposits in the neighbourhood of McMurdo Sound (Ross Sea area) have been formed.

(*e*) *MOLYBDATES.*

Molybdic ochre (ferrimolybdite) has been noted on outcropping surfaces as an oxidation product of molybdenite (*vide* Molybdenite).

SECTION II.—MINERALS RECORDED FROM QUEEN MARY LAND AND KAISER WILHELM LAND.

(Abstracted from Dr. Nockold's report (*Antea* Part 2).

NON-SILICATES.

Pyrites appears in a biotite-garnet-gneiss (No. 1188).

Fluorite is recorded in a number of the rocks. In the form of colourless grains it appears in biotite-granite erratics from Gaussberg. Purple fluorite occurs in a granitic aplite collected *in situ* from a vein at Haswell Island. Purple fluorite is recorded in a granite erratic from Depot Bay and in a hornblende-granite erratic from Haswell Island.

Quartz in larger or smaller proportions is a constant ingredient of a large section of the rocks collected, more especially, of course, the granites. Some examples of vein quartz were collected. A striking example of smoky quartz occurs in a granitic erratic collected from an iceberg in Depot Bay.

Ilmenite in small grains is also distributed widely as a very minor ingredient of many rocks. It is perhaps most commonly recorded in the case of acid igneous rocks including granodiorites.

Magnetite as an accessory constituent is widely distributed in a variety of igneous and metamorphic rocks.

Rutile occurs in small quantity in a meta-dolerite.

Calcite has been noted in very minor quantity in several rocks. Most notable is a pink variety from a silicated marble collected as an erratic at Gaussberg.

SILICATES.

The Felspars.

Felspar is recorded in a wide range of varieties. Orthoclase and microcline are abundant in the granitic rocks. In the case of the plagioclases, the more acid varieties are most common, especially in the charnockites and schists.

Leucite appears in the Gaussberg basalts.

The Pyroxenes.

Enstatite occurs in the charnockitic rock of Haswell Island and in certain metamorphosed calcitic sediments found as erratics (Nos. 1088 and 1050B).

Hypersthene appears in basic charnockitic rocks (No. 1075) of Haswell Island and of Eastern Queen Mary Land; also in some granites of Eastern Queen Mary Land.

Diopsidic pyroxene has been noted in a charnockite (No. 1095) of Haswell Island, and in a garnet amphibolite (No. 1324) from Eastern Queen Mary Land.

Augite is a constituent of the basalt of Gaussberg.

Diallage, somewhat altered, occurs in a crushed gabbro found as an erratic at Haswell Island.

The Amphiboles.

Cummingtonite of a dark greyish colour is recorded in a semi-argillaceous schist (No. 1052) collected as an erratic at Gaussberg.

Actinolite is reported as a constituent of certain altered gabbroic rocks and in metamorphosed calcitic sediments met with as erratics.

Hornblende is met with in several varieties. A brown form appears in the charnockites of Haswell Island, whilst in granite erratics from the same locality a green form is recorded. A greenish-blue variety occurs in one of the gneissic erratics.

Cordierite appears in a garnet-sillimanite-cordierite-biotite-muscovite-gneiss found as an erratic embedded in an iceberg in Depot Bay.

Garnet appears in a number of erratics, mostly schists and gneisses. The variety almandine is recorded in certain amphibolites.

Olivine is an ingredient of a basic charnockite erratic from Haswell Island.

Scapolite replaces plagioclase in several gneisses found as erratics (e.g., Nos. 1053 and 1088).

Zircon is widely distributed as an accessory mineral in granites, tonalites, charnockites and a variety of gneisses.

Sillimanite is one of the constituents of a gneissic erratic (No. 1114) from Depot Bay.

The Epidotes.

Clinozoisite appears in metamorphosed calcareous sediments (Nos. 1050B and 1088) found as erratics respectively at Gaussberg and at Haswell Island.

Epidote occurs widely in gneisses and schists and in granite erratics both from Gaussberg and Haswell Island.

Allanite has been recorded in various granites found as erratics. Orthite is recorded in a granite erratic from Gaussberg; in a hornblendic granite erratic from Haswell Island; in an erratic of micaceous gneiss; and in a charnockite *in situ* at Haswell Island.

Tourmaline of a black colour occurs in several pegmatitic erratics of Eastern Queen Mary Land.

The Micas.

Both *biotite* and *muscovite* are widely distributed as a constituent of granites, gneisses and schists. A brown biotite occurs in the leucite basalts of Gaussberg. A deep-fox-red biotite is recorded in the more basic, hypersthenic charnockite of Haswell Island.

Sericite appears in several schists.

The Chlorites.

Chlorite occurs in certain chloritic schists and, associated with epidote, it is recorded in veins crossing hornblende gneiss (No. 1122) found as an erratic at Depot Bay.

Penninite occurs in a granite erratic from Gaussberg.

Prochlorite is recorded in an erratic (No. 1041) from Gaussberg.

Delessite resulting from the alteration of enstatite appears in a charnockite of Haswell Island. In certain granites of Eastern Queen Mary Land, delessite is an alteration product of hypersthene.

Sphene is rather abundant in a hornblende granite (No. 1082) found as an erratic at Haswell Island. It is met with in some of the granodiorites and in a bi-mica gneiss and in certain schists. In a tonalite erratic (No. 1079B) from Haswell Island there is a pale-brown sphene.

Apatite is widely distributed as an accessory mineral in granite, granodiorite and gneisses. The tonalite (No. 1305) is rich in apatite.

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