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DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

RECORDS.

1961/139

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MISCELLANEOUS, PETROGRAPHIC AND MINERAGRAPHIC INVESTIGATIONS FOR THE PERIOD JANUARY-MARCH, 1958.

Compiled by

W.M.B. Roberts.

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 It may not be published in any form or used in a company prospectus without the permission in writing of the Director, Bureau of Mineral Resources, Geology and Geophysics.

MISCELLANEOUS PETROGRAPHIC AND MINERAGRAPHIC INVESTIGATIONS FOR THE PERIOD JANUARY-MARCH, 1958

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RECORDS 1961/139

INTRODUCTION

This record consists of a collection of reports completed by members of the petrographic and mineragraphic laboratory, Bureau of Mineral Resources, for the period January - March, 1958. The reports are in chronological sequence and each contains its date of completion and relevant file number in the upper right hand corner.

The officers responsible for these reports are W.B. Dallwitz (Senior Geologist), W.M.B. Roberts (Geologist Grade III), J.K. Lovering (Geologist Grade I) and M.B. Bayly (Geologist Grade I).

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CONTENTS (CONTD.)

Report No. 1

84Q/1
January 1958

MINERAGRAPHIC EXAMINATION OF A SPECIMEN FROM THE MARY KATHLEEN MINE, NORTH QUEENSLAND

by

W.M.B. Roberts

The specimen examined was submitted to the laboratory for the purpose of separating the contained pitchblende for age determination.

A section was polished and the following opaque minerals were identified; pitchblende, pyrite, chalcopyrite, and galena. Pitchblende is the most abundant of these, it forms irregular areas ranging up to 0.9 mm. across. Most of these areas are strongly fractured and have some signs of further oxidation developed along the fractures and grain boundaries. This oxidation shows up as a mineral of lower reflectivity and hardness than the original pitchblende. Many of the grains have a halo, of average width 0.015 mm, developed along their boundaries; these haloes range in colour from light yellow to deep orange. They are probably partly a secondary uranium mineral and partly the effect of radioactive bombardment of the surrounding gangue. Galena has its highest concentration in these areas immediately surrounding the pitchblende, where it forms a multitude of small cubes strung out along the haloes, and closely following the boundaries of the pitchblende; the individual cubes are small, ranging up to 0.0009 mm., but quantitatively they are an important part of the ore mineralisation. A minor quantity of galena occurs as cubes and irregular areas within the pitchblende, the largest grain measuring .01 mm.

Pyrite occurs in two forms in the specimen, one as extremely small cubes which have collected along the boundaries of some of the pitchblende grains, and the other as larger irregular areas measuring up to 0.3 mm. across which appear to be interstitial fillings between grains of the gangue. Small fracture zones cutting the section have pyrite deposited along the individual fractures, forming a system of reticulate veinlets.

Chalcopyrite is a very minor constituent, forming irregular areas in the gangue, in places associated with pyrite.

Conclusion

The specimen is worthless as a source of pitchblende for age determination, the reason being that almost all of this mineral has been extensively altered, probably by circulating hydro-thermal solutions, which may have added or removed uranium differentially to lead and hence upset the lead/uranium balance.

Report No. 2

1980/2
January 1958

PETROLOGICAL EXAMINATION OF SELECTED ROCKS FROM THE CAMOOWEAL AREA, N. W. QUEENSLAND

by

J.K. Lovering

The following is a report on rocks from the Camooweal area, Queensland, submitted by F. de Keyser:

Specimen No. 3236 - Camooweal Run 13/5509 pt. 87.

The rock is dark grey and fine-grained.

Rounded irregularly-shaped grains of quartz ranging in size from less than 0.1 mm. to 1 mm. constitute 40% of the rock; grains of anti-perthite (10%) are also seen. Fragments of green penninite (10%, fragments of feldspar (15%) altered to calcite and sericite, films and grains of limonite (10%) and hematite (5%) accessory zircon and apatite.

The rock is certainly sandstone but whether the rock is tuffaceous is difficult to state. The fragments are more rounded than one would expect in a tuffaceous rock.

Specimen No. 3237 - Camooweal Run 13/5509, pt. 87.

The rock is mottled reddish black and greenish grey. The rock is fine-grained.

The rock appears to consist of rock fragments. The rock fragments are pumiceous and consist of feldspar microlites and grains of iron ore. Some porphyritic grains of andesine feldspar and of quartz occur in the pumice. The vesicles are filled with green penninite and some calcite.

There is one rock fragment consisting of hematite and quartz.

The rock is a tuff.

Specimen No. 3243 - Camooweal Run 13/5509 pt. 89.

The handspecimen is a brownish rock containing numerous rounded vesicles filled with iron oxide. The weathering of the rock emphasises the vesicles which are blackish in the brown rock.

The rock mainly consists of interlocking laths of albitic plagioclase (60%), anhedral quartz (20%) and anhedral grains of limonite (10%). Specks of sericite (?) are also present. The vesicles (10%) are filled with quartz, and with quartz and hematite. Veins of hematite cut the rock.

The rock is an acid volcanic, and would be called a vesicular dacite.

Specimen No. 3245 - Camooweal Run 15/5444 pt. 57

The handspecimen is a reddish brown rock cut by small veins. The cut surface reveals a distinct lamination.

The rock consists of rounded grains about 0.5mm. in size of quartz (75%) and sodic andesine (7%) and finer grains of the same minerals plus hematite (10%), limonite films (5%) and a little chlorite and accessory apatite. These grains are definitely layered; bands rich in hematite grains appear to be periodic.

The rock is a hematitic sandstone. It appears to be neither tuffaceous nor contaminated.

Specimen No. 3253 - Mt. Isa Run 6/5075 $\begin{pmatrix} x = +2'' \\ y = +3'' \end{pmatrix}$

The fine-grained handspecimen is a grey massive rock.

The rock consists of rounded grains of quartz, about 0.5 mm. in size, the quartz makes up 75% of the rock. Between the grains is fine grained green chlorite and sericite. Accessory minerals include tourmaline, sphene, zircon and hematite and films of limonite.

Accumulations of the interstitial fine-grained material occur throughout the rock. They may represent shale fragments in the sandstone.

The rock is a fine-grained sandstone. It is doubtful whether it is tuffaceous. The rock may have been subjected to thermal metamorphism.

Specimen No. 3264 - Mt. Isa Run 6/5075 $\begin{pmatrix} x = 2\frac{1}{2}'' \\ y = 3\frac{1}{4}'' \end{pmatrix}$

The handspecimen is a dark grey, fine-grained rock containing small vughs partly filled with quartz, carbonate, and hydrated iron oxide.

The rock consists mainly of fine-grained quartz and sericite. Throughout the rock and making up about 20% of the rock are needles and euhedral grains of hematite.

The quartz is fine-grained and occurs in interstitial accumulations. It could have been subjected to metamorphism.

The sericite occurs mainly pseudomorphing laths of what might have been feldspar.

The rock could be a metamorphosed hematite-rich aplite, or a metamorphosed sedimentary rock with introduced or recrystallised iron oxide. This idea is not very probable. The rock could also be an acid sill or volcanic enriched in iron oxide. This seems to be the most probable explanation.

Specimen No. 4232 - Camooweal 111/5041, 2½m. N.E. of Crocodile W.H.

The rock is grey, very fine-grained and contains small vesicles.

The rock has a sub-ophitic, texture, in which laths of plagioclase andesine An 30 (50%) about 0.5m. in length surround irregular masses of penninite (25%) and calcite ($7\frac{1}{2}$%) and of fine-grained epidote (7%). Euhedral grains of magnetite make up about 7% of the rock.

Porphyritic grains of andesine An_{35} occur in the rock.

The rock is porphyritic basaltic andesite.

Report No. 3

120NT/5
January 1958

EXAMINATION OF A SECTION FROM NO. 3 D.D.H.
BROCKS CREEK AREA, N.T.

by

W.M.B. Roberts

The section, submitted by G. W. Patterson, of Enterprise Exploration Coy. Pty. Ltd., consists principally of sulphide minerals contained in a dark grey to black schistose rock.

The opaque minerals identified in the core are pyrrhotite, sphalerite, chalcopyrite, arsenopyrite and marcasite, in that order of abundance.

Pyrrhotite, occurring as large irregular areas, forms roughly 85% of the opaque mineral constituent of the core. It has a granular mosaic texture, the individual grains of which range from sub-microscopic to 1.5 mm. across.

Sphalerite is mainly present as intergrowths within the pyrrhotite, and forms approximately 5-10% of the opaque minerals present. These intergrowths form groups of sphalerite-rich areas throughout the pyrrhotite, only an occasional isolated grain appearing in the gangue. It is marked by a well-developed dodecahedral cleavage along which distinctive lamellae of chalcopyrite have resolved.

Chalcopyrite, as previously mentioned, forms resolution lamellae along the (110) planes of sphalerite, as well as irregular areas through the section, ranging up to 0.15 mm. across. It is a very minor component of the ore, forming approximately 1-2% of the total opaques.

Arsenopyrite occurs only as one isolated group of euhedral crystals located in the gangue, the largest crystal measuring 0.12 mm. Marcasite is also quantittatively unimportant, forming only as an isolated "myrmekitic" intergrowth with pyrrhotite, measuring 0.15 mm. across.

The principal gangue minerals are fine-grained sericite and quartz, with numerous, though small, euhedral crystals of tourmaline distributed throughout the sericite areas. The quartz has a mosaic texture and appears to have been recrystallised. A large amount of opaque material, which does not show up in polished section is interleaved with the sericite, and is probably carbonaceous material. The rock is a phyllite, and has certain similarities to some of the Rum Jungle ores.

From the examination of one sample it is difficult to form an opinion on the sequence of mineralisation; however, from the examination it is apparent that at least some of the chalcopyrite and the sphalerite were deposited contemporaneously and that the chalcopyrite has later exsolved. Sphalerite and some of the chalcopyrite form "mutual boundaries" with pyrrhotite, so their relative positions in the sequence cannot be determined.

The origin of the pyrrhotite cannot be determined without more knowledge of the field associations; mosaic texture is commonly associated with metamorphic re-crystallisation. Whether this is responsible can only be proved from further examination, and elimination of the possibility of an epigenetic origin. Some evidence of elevated temperatures (for the sulphides only) is contained in the sphalerite - chalcopyrite solid solution, although what are regarded as high temperatures in sulphide deposition need not necessarily be high temperatures related to metamorphism.

Report No. 4

198F/1
February 1958

MINERAGRAPHIC EXAMINATION OF SPECIMENS FROM ANTARCTICA

by

W.M.B. Roberts

The following are descriptions of eight specimens which were selected by P. W. Crohn for the identification of their opaque minerals:

Specimen G. Innerskjera Island

The specimen, described as a granular gneiss, contains pyrite, ilmenite and chalcopyrite.

Ilmenite is the most abundant of these, forming irregular grains varying up to 0.85 mm. across. Pyrite and chalcopyrite are present in roughly equal amounts, and occur as small irregular areas which measure up to 0.20 mm. across.

Specimen H. Vestskjera A.

A garnetiferous gneiss, contains only graphite which was identified by an X-ray diffraction photograph.

Specimen I. Kjolen Island.

A copper stained gneiss, contains only one opaque mineral - chalcopyrite, which forms small areas, measuring roughly 0.30 mm., mostly in the garnets.

Specimen J, Depot Island, King Edward VIII Gulf.

Described as a dyke rock, this specimen contains ilmenite, magnetite, pyrrhotite, chalcopyrite, and a mineral which could be marcasite.

Pyrrhotite is the most abundant of these, forming irregular masses ranging up to 2.0 mm. in size and containing as intimate intergrowths, a small quantity of chalcopyrite. Ilmenite is widely distributed in the section, but in very small grains, the largest measuring 0.25 mm. Magnetite is a very minor constituent only one grain being observed. The mineral tentatively named marcasite occurs as small irregular skeletal grains of fairly high reflectivity and hardness, and could be the result of breakdown of pyrrhotite to marcasite and pyrite, the skeletal form resultant upon removal of pyrite.

Specimen K. Island I in E of depot King Edward VIII Gulf.

A magnetite rich band in gneiss, this specimen contains only magnetite as the opaque mineral, which forms a matrix cementing the non-opaque constituents of the rock. The mineral is slightly anisotropic and at high magnifications exsolution lamellae of a non-opaque mineral can be seen along the (100) and (111) directions. The exsolving mineral is probably the iron spinel, hercynite.

Specimen L. Amundsen Bay Location B.

Described as a magnetite rich rock, the only opaque mineral in this specimen is magnetite, it is identical to the magnetite in specimen K, i.e. showing anomalous anisotropism and having ? hercynite exsolving along the (100) directions.

Specimen O. Location B. Amundsen Bay.

This specimen contains the following opaque minerals magnetite, pyrrhotite and chalcopyrite.

Magnetite is the most abundant of these, forming subhedral crystals ranging up to 1.6 mm. across and which contain exsolution lamellae of ? hercynite along the (100) direction and of ilmenite along the (111). Pyrrhotite is the next most abundant mineral, occurring as small irregular masses, most of which appear to be undergoing some degenerative process along the cleavage, this may be a breakdown to marcasite and pyrite as in section J. Chalcopyrite is intimately intergrown with pyrrhotite in which it forms small irregular areas ranging up to 0.06 mm. in size.

Specimen P. Masson Range Erratic.

The opaque minerals in the specimen, described as a pegmatite, are ilmenite and rutile. Of these, ilmenite is the more abundant, it forms subhedral crystals and irregular areas ranging up to 10.0 mm. across. The rutile is closely associated with the ilmenite as irregular grains ranging up to 1.0 mm. across.

Specimen Q. Peak Hill Mt. Bechervaise.

The specimen, a hybrid gneiss contains small crystals of graphite which were identified by X-ray diffraction.

Report No. 5

84NT/24
February 1958

IDENTIFICATION OF RADIOACTIVE MINERALS IN A SPECIMEN FROM THE HANDBOOK "PROSPECTING AND MINING FOR URANIUM IN AUSTRALIA"

by

W.M.B. Roberts

The following description was carried out at the request of Mr. P. J. Greening, Senior Geologist, United Uranium, N.L.

The rock containing the uranium minerals is probably a slightly to moderately ferruginous siltstone. The soddyite was originally identified by optical and spectrographic methods only, and there was some doubt about its identity. Uranium minerals in three different parts of the specimen have now been identified by X-ray powder photography.

The yellow substance occupying a large area in the top centre of the photograph is a soft, fine-grained somewhat earthy mixture of soddyite and phosphuranylite. The colour of the minerals as shown in the reproduction is slightly too green. The soddyite and phosphuranylite fill a pocket within the siltstone.

Below and to the right of the pocket of soddyite and phosphuranylite is a thin light green encrustation (the green is rendered too dark in the reproduction) of meta-autunite.

On the side of the opposite to that shown in the photograph are black, orange, orange-brown, orange-yellow, yellow, lemon-yellow, and canary-yellow encrustations or pockets of minerals. Some of the orange-yellow material, similar to that seen in the bottom right hand corner of the specimen figured in the reproduction, has been determined as soddyite. The black material is probably uraninite.

Report No. 6

94Q/1
February 1958

EXAMINATION OF A DRILL CORE SECTION FROM D.D.H. 42B, CONSTANCE RANGE, QUEENSLAND

by

W.M.B. Roberts

The section examined consisted of a portion of core approximately 1" in length; it is composed mainly of granular carbonate intersected by thin veins of sulphide. It has a uniform reddish-brown colour apparently due to iron oxide.

The rock is a siderite "marble" containing closely-packed oolites ranging up to 0.15 mm. across, and a very minor amount of quartz which forms irregular areas having an average cross section of 0.25 mm.

There is less than 1% of quartz in the section compared to 15-20% in the section previously examined from this locality, it is present as skeletal masses and sub-angular grains. The skeletal areas are optically continuous and where grains have been separated from the main body, the continuity is preserved, suggesting that they were originally part of larger grains which have been replaced by carbonate.

The composition of the oolites, which form roughly 30% of the section, differs from that of those previously described in that they contain more iron oxide and less chamosite. The iron oxide consists of a dense mass of very thin platelets of hematite, the largest of which measures 0.025 mm. across, as well as randomly oriented lamellar crystals of this mineral having an average length of 0.01 mm. These could be observed only at high magnification in the polished section and are densest along the edges of the oolites.

The carbonate matrix has a generally smaller grainsize than that noted in the previous section, although the mosaic texture is still very marked. Cutting across the section are several small fractures which have obviously been formed prior to the recrystallisation of the carbonate; their course can be traced through the oolites, where they have been filled with carbonate, but in the spaces between the oolites the recrystallised carbonate has removed all evidence of them.

Pyrite forms thin veins measuring 0.5 mm. in width, which in many places have been enlarged and completely cut by crystals of siderite. In other places between two ends of a vein, siderite has completely replaced the pyrite, still preserving the vein outlines. The oolites through which the pyrite passes, have, to a greater or lesser extent, been replaced by pyrite which has formed a fine grained spongy mass, in places replacing the whole oolite.

Apparently the pyrite was formed and deposited in the original sediment and has been very little affected by the succeeding metamorphism. It is probable that the sulphide is of sedimentary origin, being the typical product of the reaction between sulphur and iron in a reducing environment such as would be expected in a marine sediment of this nature.

Report No. 7

198PNG/1
February 1958

EXAMINATION OF A CORE SECTION FROM M49.A2 127' FROM THE AIFUNKA DRILLING PROJECT, N.G.

by

W.M.B. Roberts

The core submitted by J. E. Thompson, consists almost entirely of massive, granular sulphide containing small bands of medium grey schistose material.

The sulphides identified are pyrite, chalcopyrite, sphalerite, and pyrrhotite, in that order of abundance.

Pyrite forms approximately 95% of the total sulphide content of the core, it has a coarsely crystalline texture, the largest grains measuring 1.30 mm. across. Some stress has been operative after the pyrite deposition which has caused its recyrstallisation, and has, in places, caused the formation of small crush zones in which the mineral has been reduced to a finely divided state. Occasionally a crystal which still preserves its cubic habit can be observed in the main sulphide mass, although the cube and pyritohedral forms are common in small crystals isolated in the gangue.

Chalcopyrite forms roughly 4% of the sulphide mineral content, and occurs principally as an interstitial cement in the pyrite mass and occasionally as irregular areas in the gangue. It contains a very minor amount of sphalerite as small areas which were probably present originally as a solid solution.

Pyrrhotite has only an isolated occurrence as small areas of an average 0.024 mm. across, in both pyrite and chalcopyrite, together with sphalerite forming less than 1% of the total sulphide content of the core.

Only one fact can be stated with certainty in regard to the history of the ore, and that is that there has been a period of stress subsequent to the pyrite deposition, which gave this mineral its recyrstallised and shattered appearance. Whether the chalcopyrite has been deposited after this period of stress cannot be stated with certainty. It is possible that it could have been deposited before and has been reconstituted to form the interstitial cement; chalcopyrite being extremely mobile under these conditions, far more so than pyrite which tends to shatter rather than flow in the first instance. The sphalerite appears to be contemporaneous with chalcopyrite, as a solid solution, and the position of pyrrhotite is obscure.

Report No. 8

47NT/5
February 1958

DESCRIPTIONS OF ROCKS FROM HATCHES CREEK, NORTHERN TERRITORY

by

W.B. Dallwitz

Specimen 23A

The handspecimen is a dark grey medium-grained rock containing a small gabbroic pegmatite vein.

The gabbro pegmatite consists of grains of actinolite, saussuritized plagioclase, interstitial quartz and accessory iron oxide.

Remnants of plagioclase consist of andesine, but whether this represents the bulk of the altered plagioclase is indeterminable.

It is probable that the actinolite has replaced pyroxene. The rock enclosing the pegmatite is a uralitized gabbro, consisting almost entirely of actinolite and saussuritized plagioclase.

Specimen 23b

The handspecimen is a dark green, rather coarse-grained massive igneous rock.

In this section it is found to consist of a mass of interlocking grains of actinolite amphibole partly replaced by penninite, extensively-altered feldspar, irregularly distributed interstitial secondary quartz, and accessory iron oxide and apatite. The rock is a uralitized and saussuritized gabbro.

Specimen 24

The handspecimen is very coarse-grained, and consists of large greenish black, grey-green, and pink clots of minerals.

Quartz, commonly in graphic intergrowth with albite, is the dominant mineral. Next in order of abundance are penninite and epidote. Accessory minerals are sphene and iron oxide.

The rock is a probably a gabbro pegmatite, though it is an unusually acid type.

Specimen 27

The rock is pale pink and white, with small black patches. It appears to be medium-grained.

Grains of quartz and extensively saussuritized acid plagioclase make up most of the rock. A few eutectic intergrowths of quartz and plagioclase are scattered through the rock. Accessory minerals are accumulations of fibrous-radiating penninite, and grains of epidote, sphene, and iron oxide.

The rock is probably pegmatitic and as the field notes indicate that it is associated with No. 24, it is most probable that No. 27 represents the acidic differentiate of a gabbro pegmatite.

Specimen 28a

The handspecimen is a mottled brownish pink, grey, and black rock of medium to fine grainsize.

The rock consists mainly of eutectic, radiating intergrowths of albite and quartz, together with interstitial clots consisting of micropegmatite (orthoclase and quartz in eutectic intergrowth), quartz, and subhedral oligoclase. Some porphyritic grains of sericitized plagioclase are also present. (The grey areas noted in the handspecimen are those consisting of radiating intergrowths of albite and quartz).

Dark minerals comprise biotite, a little chlorite, and iron oxide.

The rock is a potash-soda granophyre or granophyric adamellite which is similar to others from the Hatches Creek area. These rocks are considered to be acid differentiates of a basic magma, and this impression was confirmed by Professor F. Walker, lately of Capetown, during a visit to Canberra last year. Similar rocks are associated with the Karroo dolerites in South Africa.

Specimen 28b

The handspecimen is a mottled greyish pink and grey rock of medium to fine grainsize.

In thin section this rock is seen to be mineralogically similar to specimen 28a, but the granophyric textures are scarcely developed at all. It is impossible to estimate the relative amounts of plagioclase and potash-feldspar, mainly because most of the plagioclase is untwinned, but, judging by the handspecimen, potash feldspar seems to be in excess of plagioclase. What appear in the handspecimen to be needles of ferro-magnesian mineral are found to be elongated accumulations of small, randomly oriented books of biotite. Porphyritic sericitized plagioclase grains containing abundant minute flakes of biotite are present throughout the rock.

The rock is a slightly granophyric adamellite, probably a differentiate of a basic magma.

Specimen 42

This is a fine-grained, massive, dark grey rock with a tendency to fracture conchoidally. Small crystals of probable feldspar, visible mainly by virtue of their good cleavage, are scattered through the rock; these crystals are about 0.25 mm. across.

In thin section the rock is seen to be a fine-grained version of specimens 28a and 28b. As far as can be ascertained, plagioclase is rather scarce, though the texture of the rock and abundant inclusions of biotite and chlorite in the feldspars make accurate identification difficult. Graphic intergrowth of quartz and orthoclase is on a very fine scale, so much so that, even under high magnifications, it is not everywhere possible to clearly resolve the granophyric texture. Flared or flamboyant shapes are fairly commonly seen in these intergrowths.

The principal minerals in this rock are orthoclase, quartz, biotite, and altered plagioclase. Most of the plagioclase occurs in the form of subhedral to euhedral porphyritic crystals, which are almost completely sericitized; these are the small crystals visible in the handspecimen. Biotite is generally very fine-grained and is fairly evenly distributed; it makes up about 20 per cent of the rock. Some of it is altered to chlorite. Small pockets of coarser-grained biotite are scattered through the slide; these are usually associated with interstitial granular quartz and orthoclase.

Magnetite and a little hematite or hydrated iron oxide are the only accessories.

The rock is a fine-grained, potassic, biotite granophyre, probably a differentiate from a basic magma.

Specimen 26a

Specimen 26a is a hard, light grey, quartzitic rock containing scattered greenish grey spots and several veinlets of probable epidote.

In thin section the rock is seen to be of medium grainsize and to consist mainly of severely cracked (not crushed) grains of quartz (60%) and dusty grains of albite (30%). In one small area the feldspar is more coarsely crystallised, is clear of inclusions, and has the composition of oligoclase. The mineral in the veinlets is epidote; this mineral is also irregularly distributed through the slide (the greenish grey spots noted in handspecimen).

Accessories are chlorite, sphene, black iron ore, leucoxene, rare apatite needles, and detrital zircon.

This rock is similar to several others previously examined from the area. It is an albitized and epidotized quartzite. The formation of chlorite, sphene, and apatite is probably due to the action of "emanations" from the basic rock on the original quartzite.

Specimen 26b

Specimen 26b is similar to specimen 26a, but differs in that the grey spots are larger and more prominent.

In thin section the rock is seen to be more heavily feldspathized than is specimen 26a. The feldspar is acid oligoclase, though some orthoclase may be present. Fine-grained myrmekitic texture is prominent in places, and the rock has assumed, in some parts, an igneous texture, similar to that of a granite aplite, though the shapes of most of the quartz grains are still unmistakably those characteristic of a quartzite. The dark clots noted in handspecimen are due to local enrichments in chlorite. Local sericitization of feldspar has given rise to less prominent clots.

The rock is a feldspathized (oligoclase) quartzite having some characteristics of an igneous rock, and may, with slight justification, be stated to be bordering on a hybrid type.

Specimen 29

Specimen 29 is a grey, massive rock of medium to fine grainsize. Mr. Ryan states that it is "part of the main intrusion close to quartzites".

Examination of the slide alone would not give a satisfactory clue as to the true nature of this rock. However, when considered in conjunction with other rocks studies, it is reasonably certain that specimen 29 represents a quartzite which has been severely metasomatized through contact with a basic intrusion.

The principal minerals are quartz (45%), sericite (30%) and biotite (20%). Chlorite and rare leucoxene and apatite needles are accessories.

It seems probable that feldspar and biotite have been formed in this rock by metasomatic processes, and that the feldspar has later (probably soon after formation, and as a continuation of the same process) been changed to sericite; local chloritization of the biotite probably took place at the same time.

However, the possibility that the rock is a straight-out biotite-sericite - quartz hornfels formed by contact metamorphism of a sediment, without any substantial addition of material, can not be dismissed. Even if the biotite and sericite have a metasomatic origin, the above name would still apply quite satisfactorily. It is mainly the fact that Mr. Ryan considered the rock to be part of the main intrusion that leads me to favour slightly the idea that the rock has the metasomatic origin first postulated.

Specimen 25

Specimen 25 is a massive medium-grained, grey igneous rock in which dark greenish grey actinolite can be macroscopically distinguished.

In thin section the rock is found to be made up almost entirely of actinolite, epidote, muscovite, and a little chlorite, in decreasing order of abundance. Black iron ore, sphene, and scapolite are rather uncommon accessories.

The rock is a uralitized and saussuritized gabbro in which the plagioclase is represented by epidote and muscovite, and the ferromagnesian by actinolite. The mica is unusually coarsely crystalline for a component of saussurite.

Specimen 32

Specimen 32 is a massive, fairly fine-grained, medium grey rock which appears to be a hornfels.

In thin section the rock is seen to be similar to specimen 29, but all minerals are of somewhat coarser grainsize. No chlorite is present. Thin films of possible hematite occur especially in cracks in quartz. Very thin apatite needles are prominent but rather scarce.

The rock is a biotite-sericite-quartz hornfels probably formed by metasomatic alteration of a quartzite (see previous descriptions).

Specimen 35

Specimen 35 is a dense, dark grey igneous rock containing what appear to be pink phenocrysts of feldspar measuring up to about 1 mm.

In thin section the rock is seen to be generally similar to specimens 28a, 28b, and 42. It consists of finely granophyric intergrowths of orthoclase and quartz in which are embedded abundant subhedral grains of andesine (J.K. Lovering) (the feldspar noted in handspecimen), scattered grains of quartz, and clots of fine-grained biotite. Accessories are pyrite, black iron ore, pyrrhotite, and epidote; the epidote forms a small pocket which contains pyrite, quartz and pyrrhotite. Some of the biotite clots are elongated; these may represent pre-existing hornblende or pyroxene. (cf. specimen 28b).

The rock is a potash-soda granophyre or a granophyric biotite adamellite, probably a differentiate of a basic igneous magma.

Specimen 36

Specimen 36 is a dense somewhat mottled, reddish brown, fine-grained rock, apparently a felsitic acid igneous type. Some small phenocrysts of possible feldspar can be distinguished.

In thin section the rock is seen to be very much altered and weathered, but its porphyritic character can still be made out. No feldspar remains in the rock. The groundmass consists of a mosaic of quartz grains containing abundant inclusions of sericite and smaller amounts of hydrated iron oxide and fine-grained chlorite. A few small porphyritic crystals of quartz are present; some of these are corroded, and some have had, at the time of alteration of the groundmass, quartz added to them as an outer zone which is optically continuous with the original grain. This quartz also contains abundant inclusions of sericite, like that in the groundmass and is virtually part of the groundmass. Pockets and veins of clear secondary quartz are common.

Clots and streaks of fine-grained, partly altered, iron-stained biotite apparently represent original ferromagnesian; sphene or leucoxene are generally associated with these. Heavily iron-stained pseudomorphs are abundant; judging by some of the least iron-stained of these, and considering their shapes, they appear to represent original feldspar.

The rock is a silicified sericitized, and iron-stained acid porphyry. There is no way of deciding whether it is extrusive or intrusive.

Specimen 38

Specimen 38 is a massive dark grey, felsitic rock in which elongated clots of a micaceous mineral and small, iron-stained phenocrysts can be distinguished. The rock is brown to red-brown on weathered surfaces.

In thin section the rock is seen to be essentially the same as specimen 36. The main differences are insignificant ones - the rock shows far less iron-staining, and all trace of feldspar phenocrysts has disappeared. The groundmass has been completely reconstituted, and consists of a mosaic of quartz grains (average diameter 0.4mm.) crowded with minute flakes of sericite; any feldspar phenocrysts that may have been present have been incorporated into this material.

Small phenocrysts of quartz, some of which have been embayed, are more plentiful than in specimen 36. A few bipyramidal crystals were noted. An outer zone of sericite-studded quartz has grown in optical continuity with some of the phenocrysts (cf. Specimen 36).

Small grains and octahedra and aggregates of grains of magnetite are plentiful throughout the rock. Some of the magnetite has been marginally altered to hematite.

Clots consisting of fine-grained biotite alone or of biotite and quartz, with or without sericite, probably represent original phenocrysts of ferromagnesian mineral.

The rock is a sericitized and silicified acid porphyry; field evidence alone can provide clues as to whether it is intrusive or extrusive.

Specimen 39

Specimen 39 is a massive, medium-grey, rather fine-grained or medium-grained rock, which, judging by more weathered parts, where the presence of mottling has revealed, to some extent, the grainsize and texture, appears to be of igneous origin. Clots of fine-grained micaceous material are distinguishable. Alteration in this rock is so intense that it has obliterated almost all clues as to its original nature. Taken in isolation it would be virtually impossible to give it a genetic name. However, studied in conjunction with specimens 36 and 38, to which it bears many close similarities, it is possible to state with reasonable confidence that specimen 39 is a silicified and sericitized acid porphyry.

Specimen 45

Specimen 45 is massive, greyish brown, fine-grained, and soft. It contains numerous light-brown specks.

In thin section the rock is found to have a hornfelsic texture. Biotite makes up about 70 percent of the rock; the rest is quartz, accessory sericite, and clots of limonitic material, which forms the specks noted in handspecimen.

The rock is a quartz-biotite hornfels probably derived from a sericitic and chloritic siltstone.

Specimen 34

Specimen 34 is a dark grey, massive apparently fine-grained rock, which, in thin section, is found to be very similar to specimens of granophyric rock (28a, 28b, 42, and 35) already described.

The main point of distinction from most of the other granophyrics described is that the subhedral plagioclase (oligoclase-andesine) crystals are smaller, and measure about 0.16 mm. by 0.05 mm. Plagioclase is also much less plentiful than usual.

The rock is a potassic biotite granophyre probably derived from a basic igneous magma.

Specimen 30

Specimen 30 is a weathered, felsitic, buff-coloured rock; along cracks and joints it is light red-brown.

The first impression, when this rock is examined under the microscope, is one of similarity to specimens of granophyric rock already examined. Eutectic intergrowths of quartz and orthoclase make up most of the slide, but weathering and alteration have obscured the original nature of the rock, which is very heavily impregnated with hydrated iron oxide, and contains irregular clots of "limonite"; some of these clots contain remnants of black iron oxide (hematite or magnetite). A few limonitic pseudomorphs after probable subhedral to euhedral porphyritic crystals of plagioclase are present; the suggestion that these pseudomorphs are after plagioclase is based entirely on analogy with the other granophyric rocks examined.

Clots consisting of "limonite" together with small to high percentages of sericite may represent clots of fine-grained biotite, such as were noted in less altered specimens already described.

Small (0.3 to 0.1 mm.) porphyritic grains and crystals (bipyramids) of quartz are conspicuous. Veins and pockets of secondary quartz are also present.

The rock is an altered limonitic potash granophyre.

Specimen 33

Specimen 33 is a hard dense pale buff rock which appears to be a quartzite.

In thin section the specimen is seen to consist of interlocking cracked (not shattered) quartz grains in which are set irregular scattered clots of sericite. Hematite is a sparse accessory. The size range of the quartz grains is 2 mm. to 0.1 mm.

It is likely that the sericite has been derived from acid plagioclase, as the distribution of the clots is similar to that of clots and grains of albite or oligoclase in feldspathized quartzites previously examined. Certainly the sericite is not of detrital origin, though it could have been formed through alteration of detrital feldspar; however, its distribution in detail is against such a mode of origin.

The rock is a quartzite containing clots of sericite.

Specimen 44

Specimen 44 is a pale buff to pinkish buff fine-grained, coarsely-bedded sandstone.

In thin section the rock is seen to consist mainly of angular quartz grains (diameter 0.1 mm or less), interstitial sericite, and grains of probable altered feldspar. Accessories are leucoxene, granules and dusty particles of "limonite", small detrital flakes of muscovite, zircon, and tourmaline.

The stratification noted in handspecimen is due to differences in the concentrations of interstitial sericite and limonite.

The rock is a very fine quartz greywacke or sericitic sandstone.

Specimen 43

Specimen 43 (listed as 45) is a very pale buff or off-white, fine-grained, rather massive sandstone.

In the slide the rock is seen to be similar to specimen 44. The only essential differences are that the distribution of interstitial sericite is constant throughout and that there is virtually no "limonite" present.

The rock is a very fine quartz-greywacke or sericitic sandstone.

Specimen 46

Specimen 46 is a massive, fine-grained weathered rock which is mostly brown and golden yellow, though some parts are red-brown. Thin veinlets of "limonite" fill cracks and closely-spaced joints. Small flakes of white mica can be seen in some parts of the rock.

In thin section the rock is found to be made up of sericite, irregular clots of "limonite", and accessory quartz. Scattered through the rock are small groups of sericite flakes which are several times coarser than is the bulk of the mica. Nearly all of the sericite is stained golden brown by hydrated iron oxide.

"Limonite" is so abundant in this rock that it seems probable that it has been derived from pyrite or other iron-rich sulphide.

The rock is a fine-grained "limonitic" sericite hornfels, probably derived from a sericitic claystone or siltstone.

97NT/3

Report No.9 5th March, 1958.

EXAMINATION OF DRILL CORES FROM THE COSMOPOLITAN HOWLEY MINE, BROCKS CREEK, N.T.

By

W.M.B. Roberts

D.D.H. I. 582'

This section of core consists mainly of a fine grained saccharoidal quartz and lenses of a greenish black fine grained material containing sulphide minerals and occasional veins of dolomite.

Quartz, chlorite and dolomite are the principal non-opaque constituents of the section. A mineral closely resembling chlorite having a high D.R., too high for chlorite, is probably bleached biotite.

The quartz has a uniform grain size, averaging 0.08 mm. across, and a mosaic texture. It forms large masses which in places have clearly defined edges and in others merges imperceptibly into the chlorite. This latter mineral forms a felted mass of bladed and sheaf-like aggregates intimately intergrown with a mineral having a very similar appearance but which has a very high D.R. This mineral could not be definitely identified, but is thought to be bleached biotite. The section is uniformly massive; no directional structure is evident.

Dolomite is present as irregular areas, ranging up to 0.75 mm. across, and as small veins, and is mainly confined to the quartz-rich parts of the core. The sulphide minerals are pyrite, chalcopyrite, arsenopyrite and pyrrhotite, in that order of abundance. Crystals of pyrite ranging up to 0.4 mm. across occur in the quartz areas, but the principal occurrence of this mineral is as irregular masses in the chlorite. Dolomite is closely associated with the quartz, although occasionally it appears with the chlorite. Chalcopyrite is very sporadic in occurrence, and forms irregular areas in dolomite, some of which are moulding pyrite.

Pyrrhotite is a very minor constituent, forming very small blebs in the pyrite, the largest of which measures 0.012 mm. across.

D.D.H. I. 557'

Texturally this section is identical with D.D.H. I 582'. The mineral assemblage is similar except that muscovite is present in place of bleached biotite. The muscovite occurs as lath-like crystals ranging up to 0.2 mm. in length which form felted aggregates, principally in the chlorite areas, associated with pyrite.

Pyrite and chalcopyrite are the principal opaque minerals, some graphite is present along small shears. The only difference between this section and D.D.H.I 582' is that the ratio chalcopyrite to pyrite has increased, although the former mineral still occurs as a very minor constituent.

D.D.H. I. 646'

The section is composed of a greenish-black fine-grained material containing lenses of saccharoidal quartz bands of coarsely-crystalline arsenopyrite, and bands of fine-grained pyrite. The mineral assemblage is quartz, chlorite, pyrite, arsenopyrite, chalcopyrite, dolomite and tourmaline.

The quartz has a mosaic texture with a grainsize ranging up to 0.5 mm. across, and although it is present chiefly in the form of lenses, a minor amount is distributed throughout the rock. Chlorite is uniformly fine grained, consisting of a dense mass of radial aggregates intergrown with fine grained quartz. Tourmaline is present principally as fine needles in the quartz, although an occasional crystal occurs in the chlorite. The largest crystal measures 0.3 mm. in length.

Aside from a small shear cutting the section there is no directional structure in the rock. Some carbonate (dolomite) was observed in the polished section, although none could be seen in the thin section examined.

Pyrite is fine grained and forms irregular borders to the quartz lenses. It is strung out as thin bands along thin but persistent shears which make an acute angle with the side of the core. It moulds euhedral arsenopyrite but does not appear to be replacing it. The arsenopyrite forming bands of euhedral crystals in the chlorite sections of the rock. The crystals themselves have a random arrangement and the largest measures 1.0 cm. across. They are strongly fractured and have a "parquet-like" twinning when viewed in polarised light. These facts suggest that arsenopyrite was present in the rock prior to the shearing, which has caused a strong fracturing and twinning in the mineral.

Wherever a quartz lens comes into contact with a band of arsenopyrite crystals, the outline of the lens is continuous and the crystals are truncated sharply against it. Small crystals of arsenopyrite in the thin shear fillings of pyrite are entirely preserved, and only show corrosion when in contact with quartz. Chalcopyrite is a very minor constituent, the largest irregular area measuring 0.01 mm. across.

Certain major facts are evident from the examination of these sections which give an indication of the history of the ore deposition; they are:

1. Bands of strongly fractured arsenopyrite crystals are truncated by quartz lenses.

2. Sulphide minerals (except arsenopyrite) form rims along the quartz lens boundaries, and bands in the rock parallel to the quartz lenses, chiefly associated with chlorite.

3. No texture of the original rock, and only traces of the original minerals remain, e.g. bleached biotite in sect. D.D.H. I. 582'.

4. The bulk of the tourmaline in the rock is present as small needles in the quartz.

These facts suggest that the deposit is of metasomatic origin, where a rock containing crystals of arsenopyrite, arranged either along a bedding or cleavage, has been sheared and a mineralising fluid introduced along the shear planes. The nature of the original rock cannot be determined with certainty, but the present high percentage of chlorite suggests it was probably an argillaceous rock containing a high percentage of biotite.

The introduced solutions contained mainly silica quartz, which has formed lenses along the shears, CO_2 and sulphide compounds which have reacted with the iron-bearing silicates to give the iron sulphides. The iron-rich silicate, probably biotite, was altered to chlorite during the process. Traces of copper in the solution would give the small quantity of chalcopyrite present. The reason for suggesting that the metasome contained sulphide compounds rather than the iron sulphides, is that the sulphide minerals have formed along the edges of the quartz lenses and along shears where solutions could move readily, and hence react with the iron bearing silicates. Very little sulphide is present in the actual quartz; the bulk of it is close to or intergrown with the chlorite mass.

Goldschmidt has suggested that such an association of sulphides in a magnesium-iron-silica assemblage is the result of high temperature metasomatism in which the association of graphite and sulphides is due to the reaction between ferriferous silicates and volatile compounds of carbon and sulphur, such as CS_2 and COS.

198NT/1
14th March, 1958.

Report No. 10

EXAMINATION OF ROCK SAMPLES FROM THE ALICE SPRINGS AREA, N.T.

by

J.K. Lovering.

The following is a report on rocks submitted from the C.S.I.R.O. Alice Springs Survey of 1957.

B4934 S.3258

The handspecimen is a grey medium-grained rock.

The rock consists of slightly distorted plates of microcline-perthite (49%), quartz (30%), interstitial fragments of biotite (5%) and muscovite (1%), andesine (10%) and accessory grains (5%) of epidote, zircon and ilmenite (?) surrounded by leucoxene, sphene and apatite.

The andesine grains are partly altered.

The rock is granite.

B 4935 S.3259

The handspecimen is a white coarse-grained pegmatitic rock.

The rock consists of large plates of quartz, microcline-perthite and accumulations of well-developed clay minerals. The rock is cut by veins of yellow chlorite. The microcline-perthite grains are also being replaced by clay minerals.

The rock is pegmatite.

B 4933 S.3257

The three handspecimens vary from light grey to white in colour and from fine to coarse in grainsize. The specimens are very similar as seen in thin section; the different colours are a reflection of grainsize.

The rock consists essentially of microcline-perthite and quartz. Fragments of brown biotite make up about 5% of the rock.

Accessory zircon, apatite, and iron oxide are present.

The rock is granite.

The specimens of Alcoota Granite are remarkably similar in thin section. The rocks consist mainly of microcline-perthite and quartz with up to 5% biotite. B 4935 was named a porphyritic granite in the field. It is probably an acidic differentiate of the magma.

B 4947 S.3260

The rock is white and coarse-grained with a graphic texture.

The rock consists of large anhedral grains of quartz and microcline interspersed with large accumulations of well-developed clay minerals. Some colourless mica has also developed.

The rock is pegmatite.

B 4949 S.3261

The rock is dark grey, medium-grained and gneissic in texture.

The minerals in thin section are strongly crushed. This is very noticeable in regard to the large plates of perthite (50%) in which oligoclase is the host feldspar, and of quartz (20%). Many grains of green-brown biotite (10%) are curved. Interstitial grains (10%) of bytownite An_{70} are also present. Iron oxide (5%) is an important accessory; other accessory minerals include apatite, sphene, zircon and green spinel. Some secondary green chlorite is also present.

The rock is gneiss.

B 4950 S.3262

The handpecimen is a coarse-grained gneissic rock in which are bands of light-coloured minerals and bands of black mica. This particular handspecimen is not a well developed augen gneiss although other parts of the outcrop may support this nomenclature.

The minerals are strongly crushed and margins have intergrown probably as a result of the metamorphism.

The rock consists of large plates of quartz intergrown with plates of microcline and including anhedral grains of andesine (An_{40}). Interstitially are smaller grains of quartz, microcline, andesine and green-brown biotite grains of which occasionally show pleochroic halos around accessory zircon.

Blebs of iron oxide (5%) are frequently surrounded by a thin layer of clay minerals and then by a zone of sericite. This is probably the result of metamorphism of a ferromagnesian mineral. Garnet is an accessory mineral and is veined and replaced by fine-grained green mica and by quartz. Apatite is also accessory. Secondary epidote replaces some biotite.

The rock is gneiss.

B 4951A S.3263

The handspecimen is motley grey, pink and white and has a distinctly gneissic texture.

The minerals seen in thin section have been evidently severely crushed.

Large plates of garnet (60%) are crushed and tend to become attenuated. Between these plates are zones of crushed grains of quartz (15%) and oligoclase feldspar (8%) and needles of sillimanite (7%), grains of brown biotite (5%) and iron oxide (3%). In places the garnet has altered to green biotite and clay minerals. Apatite grains and green spinel are accessory.

The rock is garnet-sillimanite gneiss.

B 4951B S.3264

The handspecimen is a pinkish-grey coarse grained rock.

The rock appears to have been extensively crushed. The rock is composed of quartz, garnet, biotite, sillimanite needles, accessory oligoclase, iron oxide, apatite and green spinel.

The rock is garnet-sillimanite gneiss.

B 4951C S.3265

The handspecimen is a deep grey coarse-grained rock.

The rock which is granitic in texture contains anhedral grains of bytownite feldspar (35%), amphibole (25%) pleochroic from brown to colourless and hypersthene (25%) and a pleochroic monoclinic pyroxene with a negative optic angle (5%) and accessory iron oxide (5%) and hematite 2% and apatite 3%.

The rock is norite.

B 4952A S.3266

The handspecimen is fine-grained and light brown in colour. It is cut by a small quartz vein.

Irregularly-shaped grains of quartz ranging in size from less than 0.1 mm to about 1.5 mm appear to be partly recrystallised around the edges. Between the quartz (85%) are grains of green-brown biotite (8%) and accumulations of limonite (7%). Accessory grains of tourmaline are present.

The rock is a thermally-metamorphosed sandstone.

B 4952B S.3267

The handspecimen is a grey, very fine-grained layered rock with a phyllitic sheen.

The rock consists almost entirely of recrystallized grains of quartz and light brown biotite and sericite. Iron oxide and tourmaline grains are accessory.

Several large grains of quartz are present; lenses rich in clay minerals can also be distinguished.

The rock is a pelitic phyllite.

B 4952C S.3268

The handspecimen is a dark grey fine-grained rock.

Euhedral needles of greeny-blue amphibole, sericitized interstitial grains of plagioclase and recrystallized quartz grains make up this rock. Iron oxide is an important accessory, in some grains it is surrounded and replaced by sphene.

The rock is amphibolite. The rock may have been a basic lava.

B 4953 S.3269

The handspecimen is a medium-grained grey rock.

Porphyritic anhedral grains, about 2 mm long, of microcline-perthite (25%) are in a groundmass about 0.5 mm in size. The groundmass consists of interlocking grains of quartz (15%), microcline (15%), green-brown biotite (10%), sericitised oligoclase (25%), epidote (5%), and accessory sphene (3%), apatite and zircon and some secondary green chlorite.

The rock is granite.

B 4954 S.3270

The handspecimen is a medium grey, coarse-grained rock.

In thin section the rock is found to be porphyritic in texture. Subhedral porphyroblasts about 2 to 3 mm in diameter of perthite, accumulations of quartz grains, and accumulations of green-brown biotite and quartz, are set in a fine-grained groundmass of quartz and feldspar which is mostly micro-perthite.

Relict porphyritic grains of zoned plagioclase are mainly replaced by sericite.

The rock has been partly recrystallised. It is a quartz-feldspar porphyry.

B 4955A S.3271

The handspecimen is portion of a quartz vein cutting a dark-grey, fine-grained rock. In the process the quartz vein appears to have brecciated the rock.

The thin section reveals that the rock has been extensively crushed. The quartz in the quartz vein extinguishes unevenly and is mylonitized in places. Portions of the rock are extensively brecciated. The rock is a tourmaline-quartz rock. The tourmaline is mostly green but is zoned blue at the brecciated edges.

B 4955B S.3272

The handspecimen is a coarse-grained brownish gneiss.

The rock is extensively crushed. Interstitial material is partly mylonitized. The rock consists of large plates of quartz, grains of microcline-perthite, curved grains of biotite and muscovite, interstitial sericite, clay minerals and epidote. Zircon is accessory.

The rock is gneiss.

B 4955C S.3273

The handspecimen is a light brown medium-grained gneiss.

The rock has been extensively crushed. It consists of quartz, microcline and microcline-perthite, brown biotite, phlogopite (?) interstitial sericite, clay minerals and epidote and accessory zircon.

The rock is gneiss.

Discussion

The rocks submitted from the Napperby complex can be divided into three groups.

One group (B 4951A, B: B 4950; B 4949; B 4955B, C.) consists of rocks which have suffered intense thermal metamorphism and deformation. The rocks are all gneiss. They include garnet sillimanite gneiss which contains a green spinel. Green spinel is also present in B 4949; garnet occurs in B 4950.

B 4954, a quartz-feldspar porphyry is probably of the same age as the group of gneisses. It seems to have suffered as much deformation.

A second group (B 4947; B 4953; B 4955A) consists of granite and derivatives of granite. This group would seem to be younger than the first group.

With this second group may be put the norite B 4951C. It does not seem to have suffered much deformation.

A third group includes the metamorphics, B 4952A, B, C. These appear to have been subjected to thermal metamorphism but have not been extensively deformed. It is probable that this group is younger than the first group and may be older than the second group of igneous rocks.

B 4966 S.3274

The handspecimen is a pinkish fine-grained granite.

The rock consists of interlocking grains of quartz (25%), microcline-perthite (48%), oligoclase (partly sericitized) (20%), brown biotite (5%), magnetite (1%) and accessory zircon and apatite.

The rock is granite.

B 4967 S.3275

The handspecimen is a medium-grained pinkish granitic rock.

The rock consists of interlocking grains of microcline-perthite and quartz. Fine laths of brown biotite are interstitial. Accessories include magnetite, zircon and apatite.

The rock is granite.

B 4990 S.3276

The handspecimen is a greyish porphyritic rock.

The rock consists of interlocking grains of quartz (40%), oligoclase (35%), brown biotite (15%), magnetite (5%), accessory zircon, tourmaline and pink garnet.

The rock is granodiorite.

B 4995 S.3277

The handspecimen is a very coarse-grained porphyritic grey rock.

The rock consists of large plates of oligoclase feldspar (50%), plates and grains of microcline-perthite (10%), grains of quartz (20%), biotite (5%), diopside (3%), green hornblende (5%), accessory iron oxide (5%), apatite (1%) and sphene (1%).

The rock is porphyritic granodiorite.

B 4979 S.3278

The handspecimen is a beautiful example of graphic intergrowth of quartz and pinkish feldspar.

The feldspar is microcline-perthite and occurs as one large plate. In places the microcline-perthite grows in crystals up to 2 inches long.

B 4971A S.3279

The handspecimen is a light-grey, fine-grained rock.

The rock consists of interlocking grains of microcline-perthite (75%), quartz (15%), brown-green biotite (5%), and accessory magnetite, apatite, zircon and metamict allanite.

The rock is granite.

B 4971 Dyke. S.3280

The rock is black speckled with white and fine-grained. There is a suggestion of lineation.

The rock consists mainly of amphibole grains pleochroic from bright green to olive green to pale yellow (75%), labradorite with margin of andesine (20%) and accessory magnetite, epidote which may be secondary, sphene and apatite.

The rock is amphibolite.

Most specimens of the Kulgera granite consist of microcline-perthite and quartz with oligoclase and minor biotite. Two specimens, however, B 4990 and B 4995 contain increased percentages of oligoclase and are termed granodiorites.

B 4965 S.3281

The handspecimen is a dark-grey, medium-grained rock.

The rock consists of laths of plagioclase which enclose ophitically, grains of pyroxene and of magnetite and accessory colourless, positive olivine. Some secondary yellow chlorite is present, replacing some olivine.

The pyroxene is pigeonite.

The rock is olivine dolerite and is similar to B 4991, B 4994 and B 4998 except that the olivine is colourless.

B 4991 S.3282

The handspecimen is a black, fine-grained rock.

Laths of plagioclase enclose, in an ophitic texture, grains of pyroxene including pigeonite and diopside with some brownish mauve pleochroic positive olivine (5%). Magnetite is accessory.

The feldspar is basic andesine.

The rock is olivine dolerite and is very similar to B 4965 and B 4998.

B 4994 S.3283

The handspecimen is a medium-grained dark grey rock.

Laths of labradorite with andesine margin enclose grains of pyroxene in an ophitic texture.

The pyroxene includes diopside and pigeonite. There are brownish mauve pleochroic olivine grains with a positive 2V, veined with magnetite; these make up about 5% of the rock. Euhedral magnetite comprises about 3%.

The rock is olivine dolerite and is similar to B 4991, B 4998 and B 4965.

B 4998 S.3284

The handspecimen is a black fine-grained rock.

Laths of plagioclase enclose, in an ophitic texture, grains of pyroxene, including diopside, pigeonite and some brownish mauve pleochroic olivine with a positive 2V and grains of magnetite.

The rock is olivine dolerite and is similar to B 4991 and B 4994 and B 4965.

B 4997 S.3285

The handspecimen is a dark grey rock in which medium-grained phenocrysts are in a fine-grained matrix.

Phenocrysts and accumulations of andesine An_{35} up to 10 mm in size often containing blebs of quartz and having altered margins about 0.5 mm thick are set in a fine groundmass in which limonite-stained laths of andesine and granules of pyroxene ($+2V=40°$) with altered margins are porphyritic in a mass of feldspar, iron oxide microlites and chlorite.

The rock is andesine porphyry.

B 4999 S.3286

The handspecimen is a coarse-grained fawn-coloured rock.

The rock consists of interlocking grains of oligoclase (45%), quartz (23%) and perthite (20%) and greenish-brown hornblende (7%), magnetite (5%) and accessory apatite.

The rock is granodiorite.

B 5000 S.3287

The handspecimen is a dark grey medium-grained rock.

The rock consists of perthite and quartz with interstitial brown biotite and accessory iron oxide and zircon.

The rock is granite.

C 177 S.3288

The handspecimen is a black rock containing white phenocrysts linearly oriented to give a gneissic texture to the rock.

The rock is slightly gneissic in thin section. It consists mainly of recrystallized grains of quartz (50%), laths of brown biotite (15%), euhedral epidote grains (15%), bright green amphibole laths (5%), anhedral orthoclase grains (10%) and accessory apatite.

The rock is quartz schist.

198 F/1
31st March, 1958.

Report No.11

PETROGRAPHIC REPORT

on

ROCKS FROM ANTARCTICA

(Part of B.H. Stinear's Collection)

by

M.B. Bayly

Specimens M.26, 29 Vesuvianite - phlogopite - DIOPSIDE HORNFELS from impure dolomite contact.

The handspecimens are a whitish rock with blue and brown mottling and an easily noticed white mica content.

In thin section, the texture is seen to be fairly uniform and composed of compacted equidimensional diopside grains (0.3 to 3 mm.). Among these, vesuvianite-grossularite aggregates are developed up to 5 mm. across. These now form 40% of rock M.29 though in M.26 the development is much less marked. The vesuvianite is a biaxial variety (2V = c.60°), generally mantling the garnet grains, the association being so close that the boundary is hardly visible in ordinary light. The mica content is phlogopite, occurring rather irregularly in sheaves or clusters but probably averaging 10% of the rocks. Scapolite and very rare calcite are accessory.

The rock is thus a calc-silicate product, by contact metamorphism of an impure dolomitic limestone. The absence of quartz, felspar and epidote minerals suggests that silica has been available in only limited amount.

(Alternative name: vesuvianite-phlogopite-diopside granulite-derived from impure dolomitic limestone by high-grade regional metamorphism. W.B.D.)

Specimen M.153 Scapolite-DIOPSIDE HORNFELS from impure dolomite contact

The hand specimen shows coarse irregular streaks of feldspar-scapolite, quartz and pyroxene. In thin section, the proportions are seen to be about 50%, 30% and 15% respectively. The association of scapolite and plagioclase is very close; at least some of the aggregate is formed by alteration and it seems permissable to suppose that the rock at one time carried no scapolite but only plagioclase (bytownite). The grain size is now 0.3-3 mm., both members mainly in independent grains; but less commonly, feathery development of scapolite in small flakes from the plagioclase can be seen. Twinning in the plagioclase is poorly developed and patchy, but on the other hand orientation of needle inclusions (potash felspar?) is often noticeably good. The quartz is, if anything, somewhat more coarse than the plagioclase-scapolite association and occurs mainly in separate clots, whereas the pyroxene is finer (0.1-1mm.) and widely distributed. It is a green variety, probably rich in the hedenbergite molecule, and is quite free from alteration. The only accessory, sphene, is commonly associated with the pyroxene but this is a physical rather than a chemical association.

The rock may have affinities with specimens M.26 and M.29, though the composition is less simple: silica is more abundant and iron and titanium apparent. However these differences may be attributed simply to a pelitic fraction in the original dolomite rock and the same metamorphism diagnosed for each.

(Alternative name: scapolite-diopside granulite derived from impure dolomitic limestone by high-grade regional metamorphism. W.B.D.)

<u>Specimen M.88</u> Wollastonite - DIOPSIDE HORNFELS from impure dolomite contact.

The medium-grey granular handspecimen is seen to be rather faintly banded (on the sawn surface this character is unmistakable). The weathered surface is possibly a clue to the rock's lime-rich character.

In thin section the equigranular mosaic is seen to consist of diopside (50%; 0.2 to 1.0 mm.) and plagioclase - scapolite (50%; interstitial in irregular areas up to 2mm. across). The diopside is very slightly coloured, with no alteration but some sphene in close association. The plagioclase by contrast is nearly half converted to scapolite, in some well formed crystals and many flaky aggregates. Its composition is in the bytownite range; twinning is frequent but of a very irregular kind, more in the nature of interfingering. In both felspar and scapolite, rectangular cleavage patterns are often well-developed. Not easily distinguished from these two are a few grains identified as wollastonite.

The rock is probably associated with specimens M.26, 29 and 153. Whereas M.153 is noticeably more siliceous, M.26 and 29 are of similar chemistry. In contrast with these it is seen that the grossular (and phlogopite) have been replaced by bytownite and wollastonite, a transformation characteristic of the sanidinite facies. The compatibility of this diagnosis with the field-evidence deserves close attention.

(Alternative name: wollastonite-diopside granulite derived from impure dolomitic limestone by high-grade regional metamorphism. W.B.D.)

<u>Specimen C.2</u> fine porphyritic ANDESITE with garnet.

The fine dark hand specimen shows very few textural signs, but in thin section the rock is seen to be faintly banded, with a few circular spots (1 mm.) and salic slivers. Beside these irregularities the general texture may be called porphyritic since plagioclase and augite grains range from 0.2 to 0.5 mm. whereas the matrix is mainly under 0.1 mm. The plagioclase (An 40-50; 30%) is dusted with iron ore and of corroded outline, but is otherwise unaltered and plainly twinned (similar to F4; contrast F3); but the augite (5-10%) is altering to finely granular hornblende as well as being dusted with iron ore. The macroscopic spots, which are under 1% in bulk, are in part garnet, though sieved with granules from the groundmass. It is thought more likely that they are incipient than that they are corroded relics of once better-formed individuals. On the other hand, the salic slivers are partly quartz, and are believed secondary.

The groundmass has roughly equal proportions of iron ore, plagioclase and hornblende (20% of each), among which a few small grains of pyroxene are identified. On the same grounds as are mentioned for F4, slight thermal metamorphism is postulated for this rock.

Specimen F3 Pyroxene ANDESITE

The handspecimen is bounded by two joint planes whose regularity is the first clue to the rock's texture - fine and very uniform, and dark grey in colour.

In thin section the rock is seen to be, though not exactly porphyritic, composed of idiomorphic crystals (about 0.2 mm.) in a finer groundmass. The larger crystals are plagioclase and augite in proportion 3:2. The same proportions are repeated in the finer fraction but here granular iron ore is also prominent. Overall proportions may thus be estimated -

plagioclase	45%
augite	35%
iron ore	15%.

The plagioclase (An 40-50) is lath-like, elongated 3:1 up to 10:1, but commonly of irregular outline. Strain is often apparent and a low degree of metamorphism may be postulated. The augite is more equidimensional but none is euhedral; outlines are generally corroded away to merge with the finegrained fraction. The granular character of the iron ore confirms to some extent the suspected metamorphism. Very small biotite flakes are also widespread.

Specimen F4 porphyritic pyroxene ANDESITE

The rock, which is superficially similar to specimen F3 (fine dark grey), is in fact much more clearly divisible into phenocrysts and finegrained matrix.

The phenocrysts (25% of the rock) are plagioclase (10%), augite (10%) and hypersthene (5%), the colour of the latter making it in this case readily distinguishable. While all may occur in individual grains from 0.2 to 2 mm. there are also 3 mm. clusters of small augite and plagioclase grains alone. All three minerals are heavily dusted with fine iron ore (only partly resolved at 360 magnifications). The plagioclase (An 45-50) is in well formed laths and apart from the iron dust mentioned is free of alteration. Both pyroxenes on the other hand are widely rimmed with finely-granular hornblende-iron ore and biotite-iron ore aggregates.

The matrix is of very even grain (about 0.01 mm.). Pyroxene, plagioclase and iron ore are about equally abundant, but augite and hypersthene cannot be distinguished. The plagioclase seems to match that of the phenocrysts in composition.

The granularity of the matrix, the clean condition of all the minerals, and the dusting in the phenocrysts all point to slight thermal metamorphism. The straining of specimen F3 is absent; it may be supposed that whereas F4 has been altered purely thermally, slight effects both thermal and dynamic show in specimen F3.

Specimen M.38 Altered ANDESITE (or MYLONITE)

This finegrained dark rock shows no textures in handspecimen except a few pale flecks; but in thin section it is seen to contain many pale areas of comparatively coarse grain, in a matrix of grains around .01 mm., in which iron ore is very prominent. For the rest, nothing can be said but that the ferromagnesian and salic fractions seem to be about equal and that grains less refringent than the mounting medium are rare. The matrix might thus be supposed andesitic.

The pale areas on the other hand are iron-free, being mosaics of clear equidimensional grains (.01 to .05 mm.) in form somewhat elongated, ovoid, irregular, or rarely rectilinear. Some appear to be feldspar alone, some are of quartz and feldspar mixed, and some, as far as can be determined, comprise patches which are feldspar-rich and patches nearly all quartz. Beside these, a very few corroded pyroxene individuals are present.

The genesis of this rock is open to question. It is closely allied to part of M.174 (see p.37) and in both, the granulation, especially of the iron-ore of the matrix, suggests a degree of thermal metamorphism. It is impossible to say whether the patches now clear were ever single phenocrysts, whether they were flow inhomogeneities or whether the fine grain is wholly a mylonitisation effect in which the clear areas are simply relics of the once coarse-grained texture. For both this rock and M.174, no hypothesis is preferred until the field relations are known.

Specimen F.2 Gneissic biotite-hornblende MONZONITE

The handspecimen is dark where fresh but on weathering, the feldspar content shows up pale. Mica orientation gives a rough foliation.

In thin section the texture is seen to be uniform, with hornblende grains up to 1 mm. and biotite, generally smaller and showing the rough orientation mentioned, in a granular mosaic of salic minerals, from 0.1 to 1 mm. The rock is rather highly fractured, with the cracks tending to run perpendicular to the biotite foliation.

Mineral proportions are visually estimated at orthoclase 20%, plagioclase (c. An_{30}) 35%, hornblende 15% and biotite 15%, with accessory iron ore and apatite. The quartz content is uncertain but apparently small. In the plagioclase, twinning is only poorly developed and inclusions are rare; in contrast, much of the orthoclase is rich in perthitic inclusions, mainly rounded but occasionally angular. Infrequently, large areas (3 mm.) of vermicular intergrowth develop, in which the two felspars occur in subequal proportions. Both hornblende and biotite are irregular in shape with normal pleochroism (viz. green in one and straw to purplish-brown in the other). The hornblende contains widespread granular iron ore internally and more rarely in rims, whereas the biotite, though closely associated with iron ore grains, shows no alteration. The minor constituents are apatite, black iron ore, chloritic veins and rare anhedral fragments of a dirty pale green clinopyroxene.

Specimens F.5: M.1; 10, 16, 25, 37, 39, 42, 55, 79, 80, 82, 83, 86, 100, 134, 137, 146, 170 HYPERSTHENE ADAMELLITE

It is supposed from information of P.W. Crohn (verbal) and B.H. Stinear (Prelim. Rep. Geology of MacRobertson Land) that these specimens are all varieties of the normal rock around Mawson base against which local modifications are contrasted (e.g. specimens M.2, 22, 101, 103, 122, F.1)

The rock body is reported to be variable in grain-size, particularly in the phenocryst fraction, and to carry pegmatite and aplite members in which the same mineralogy is repeated but the textures are different. Among the specimens present, some carry phenocrysts up to 2 cms. and some are phenocryst-free (e.g. F.5) but no genuine vein textures (pegmatite or aplite) are seen.

The components which are common to all the specimens, will be described first, and their proportions and other properties which vary from rock to rock will be detailed subsequently.

The phenocrysts are perthitic orthoclase, anhedral but usually Carlsbad-twinned. Alteration is very slight, but a variety of inclusions occur. These are:

1. quartz grains and aggregates, with rounded outlines up to 1 mm.

2. grains of calcic plagioclase, less frequent but some up to 2 mm. long, which themselves carry inclusions identified as scapolite - probably alteration flakes.

3. shreds of sodic plagioclase; compared with (2). these are smaller, (less than 0.2 mm.) tending to rhombic outlines, much less marked in relief. These are in fact taken to be genuine perthitic exsolution products whereas the grains noted in paragraph 2 are early crystals subsequently enclosed.

4. swarms of rod-like specks from 0.1 mm. down to vanishing size. These are indeterminable but are likely to be albitic also, simply a finer development than those described under 3.

Beside the Carlsbad twinning, occasional areas of multiple twins are seen; these, though not showing proper development in a rectangular grid, are still taken to be a microcline structure. Beside the phenocryst fraction, orthoclase in smaller grains shows exactly the same characteristics.

The plagioclase of the group only infrequently reaches phenocryst dimensions - 1 or 2 mm. maximum dimension is common. The composition seems to be uniform throughout, An_{50-60} labradorite. Twinning though general tends to be distorted; lamellae taper away or fade out and sets of twins are often bent. Apart from this widespread physical deformation, alteration is very slight: antiperthitic orthoclase is the only natural impurity, though other minerals are occasionally enclosed by plagioclase grains.

The quartz content is fine grained in comparison with the felspars but often clotted into aggregates of comparable size.

Beside the original content, myrmekitic quartz is seen developed in many sections as a product of lime enrichment from the orthoclase. At orthoclase-plagioclase contacts the development is fine, but along joints of orthoclase and other minerals the development is more coarse and lumpy. In either case the stimulus is supposed to be migrant calcium.

Another feature of the quartz content which is possibly relevant to the stability relations of the salic minerals is the rounding of the quartz inclusions in the orthoclase. Even aggregates in which the grains have angular outlines against each other are smoothly ovoid in outline against the orthoclase; yet there are no signs of the embayment which often accompanies rounding by solution/corrosion.

In sum, it may be said that redistribution of the salic components since solidification has been slight but not extensive.

Turning to the ferromagnesian components of the rock body, we find hypersthene conspicuous and only iron ore and a little biotite and hornblende beside. In the hypersthene, pleochroism is in the standard colours but variable in intensity (cf. M.100 and M.134). Birefringence is commonly high (.018) indicating an iron-rich variety. Alteration is usually restricted to the development of iron ore in some of the cleavage cracks, but shattering of the crystals and granulation round the edges is a widespread effect; and in the few biotite and hornblende-bearing specimens (e.g. M.25, M.!?7) these minerals have some appearance of alteration products.

The proportions of the minerals mentioned in any one section are rather controlled by the presence or absence of orthoclase phenocrysts. The size and irregular distribution of these crystals in the handspecimens, and presumably in the parent rocks, shows that sound sampling can only be done on a very large rock area. (A large-area estimate of the phenocryst fraction on sawn surfaces, coupled with an estimate of the groundmass by analysis of the phenocryst-free parts of thin sections, seems a feasible attack.) The nineteen specimens are considered as members of a single body not because of positive demonstration, but because the nineteen slides are insufficient to show up internal variations even if they are present.

Within this limitation the rocks are named adamellites. Slides with granitic proportions and slides with granodiorite proportions occur frequently but their equal abundance points to the intermediate average composition quoted. Two quartz-poor slides similarly are included in the adamellite body in spite of their locally monzonitic or syenitic proportions. The existence of a series of separate intrusions remains a possibility but, field data being absent, a division is not justified by petrography alone.

The virtual absence of chemical alteration has been shown. Among physical considerations the bending of the plagioclase twin-planes has been mentioned, and the development of a prominent cleavage in the hypersthene. Beside these, strained extinction and various kinds of cracks characterise the salic minerals, and areas and veins are general where they have been reduced to a granular mosaic (mean diameter 0.1 mm.). These may be results of regional stress, but in view of the connection postulated between charnockite-type rocks and high-pressure environment, it is thought that they may alternatively be simply accommodations in the early-solidified parts of the rock-body during the final stages of the consolidation.

Individual names for the nineteen specimens grouped in the adamellite body:

F.5	hypersthene adamellite body,	calcic variant
M.1	" " "	potassic variant
10	" " "	calcic variant

16	hypersthene	adamellite	body, potassic variant
25	"	"	.
37	"	"	body, potassic variant
39	"	"	" quartz-poor variant
42	"	"	potassic variant
55	"	"	"
79	"	"	"
80	"	"	calcic variant
82	"	"	" "
83	"	"	" "
86	"	"	" "
100	"	"	body, syenitic variant
134	"	"	.
137	"	"	body, calcic variant
146	"	"	" , potassic variant
170	"	"	" " "

Specimens M.2, 22 HYPERSTHENE DIORITE, associate of the adamellite body.

The handspecimens are both medium-grained rocks with even pepper-and-salt appearance, in which only M.2 shows a degree of mineral banding. The difference re-appears in thin section, for the grains in M.22 appear quite randomly orientated whereas both biotite and pyroxene show a preferred orientation in M.2.

The mineral components are principally pyroxene (30-40%) and plagioclase (50-60%). In M.22, these are accompanied only by iron-ore grains (1%) and very sparsely distributed tattered red-brown biotite fragments. In M.2, biotite is better developed, up to 1 mm. plates and 10% in amount over the bands (c. 1 cm. wide) where it is concentrated. Another difference is accessory perthite in M.22; apart from this, M.22 and the biotite-poor layers of M.2 may be matched very closely.

The plagioclase (c. An_{50}) shows poorly-developed twinning; lamellae are strained and the grains widely fractured, but chemical alteration is only slight. Both augite and hypersthene are represented in the pyroxene fraction but hypersthene is by far the more abundant (11 negative figures to 1 positive). Its birefringence is high but its pleochroism low, so that the two pyroxenes are only distinguishable optically; both are highly fractured and cleaved but incipient biotite is the only alteration product.

If the biotite content can be accepted as entirely due to retrograde change, these rocks may be classed as comagmatic with the adamellite group described. If the biotite content is held to be in part original, it must be proposed that these basic variants are marginal, for hydrous minerals are not primary constituents of the main body. (See also subsequent discussion, p. 44 and 45). At present the second view is preferred.

Specimen M.174 ?ANDESITE VEIN in HYPERSTHENE GRANODIORITE

The hand specimen shows a coarse grained rock cut by a fine black vein. The coarse grained part is directly comparable with the hypersthene diorite M.22. It contains more significant proportions of quartz and orthoclase; estimates are:

andesine-labradorite	50%	(c. An_{50})
quartz	10%	
orthoclase	10%	
hypersthene	25%	
iron ore	5%,	

but it is thus seen to be only a short distance along the transition to the orthoclase-rich members of the adamellite body. The only unusual feature is textural and related to the fine dark vein.

The vein resembles in many features the andesitic specimen M.38, p.33. The degree of metamorphism is in this case less however; the pale areas are less completely granulated and individuals of orthoclase and plagioclase can be seen accompanying the quartz. The areas can sometimes be seen to comprise mainly quite large crystals (0.5 mm.) with granular replacement only partly advanced. The outlines of both aggregate and individual crystals are quite irregular however so that neither the nocrysts nor streamlined flow pockets can be easily imagined as the original textural units. In isolation the texture could be compared to a mylonite; but the sharp contacts against the granodiorite are difficult to explain on this hypothesis.

There are clear signs that the granodiorite has suffered crushing to some degree: cracks along which the adjacent minerals have been granulated affect even the hypersthene in this rock. It must be noted that along some of these cracks material identical (as far as can be seen) with the groundmass of the vein occurs, but until field notes are available the question of its origin remains open.

<u>Specimen F.1</u> HYPERSTHENE TONALITE or contaminated diorite.

The handspecimen is a pale banded or bedded rock whose connection with the hypersthene granite is not at once apparent. Coarse and fine bands from $\frac{1}{4}$" to 2" in width can be seen, the fine ones having the higher ferromagnesian content. In thin section, however, this is seen to be hypersthene-biotite so the rock must be regarded as a contamination gneiss or simply a flow-banded marginal development of the hypersthene adamellite.

The coarse leucocratic bands are quartz and plagioclase (An_{40-50}) alone. In the remainder of the rock these are accom-panied by biotite and hypersthene but potash felspar is virtually absent - it occurs only as antiperthite in the plagioclase. The proportions are approximately

andesine	50%
hypersthene	20%
biotite	10%
quartz	15%

The plagioclase is distinguished from that of the hypersthene-adamellite by a slight development of sericite. The hypersthene has a greater tendency to blue in its pleochroism, and small chips are rather common (c.0.05mm.). A serpentine-type alteration occurs as in M.101, but the fracture and the association with iron ore and biotite are similar to those in the main rock body.

Beside the quartz content, distinction from specimens M.2 and 22 may be drawn on grounds of pleochroism of the hypersthene and on the less crushed texture of the rock. However, if contamination by a siliceous sediment is maintained, the other component may well have been similar to M.2 and 22, viz., an early basic associate of the main hypersthene adamellite. The poverty in potash felspar prevents this rock from being regarded as a linear intermediary between M.2, 22 and the main adamellite body. (Contrast M.174.)

Specimen M.103 HYPERSTHENE TONALITE or contaminated diorite

Though microscopically similar in many respects, this specimen and F.1 differ widely in handspecimen. Whereas F.1 looks pale and porous, M.103 is a compact rock in which even the salic bands look dark on the weathered surface.

In spite of this difference, which may be due simply to the weathering environment of the two handspecimens, the banding from ferromagnesian-free to ferromagnesian-rich and the near-absence of orthoclase are significant properties common to both. The aggregation of quartz into coarse-grained lenticles, which in F.1 opposes to some extent any theory of direct magmatic crystallisation, is absent from this specimen; but this is in accord with the generally more deformed condition of the rock-granulation, shadowy extinction and bent twin-planes all recur. It is consequently regarded as another example in which probably a dioritic original has suffered secondary quartz enrichment.

The crushing effects constitute, in fact, the only significant difference between this rock and specimen F.1. Besides the effects mentioned, the shredding of biotite plates as in M.122 is seen again and this time the occurrence of garnet is definitely associated with the crush-zone. Myrmekite is also occasional but it is doubted whether any strict connection between this development and the mechanical effects can be demonstrated. Apatite and black iron are accessories.

The approximate mineral proportions are:

labradorite-bytownite (An_{70})	50%
quartz	20%
biotite	20%
hypersthene	10%

Specimen M.101 BIOTITE SYENITE associated with the adamellite body

This rock, while undoubtedly related to the main hypersthene adamellite body, differs from it by showing well-developed clots of biotite in the hand specimen. In thin section, these appear almost hypersthene-free. Whereas in the main body and in the mica-poor parts of this specimen, the biotite that does appear is associated with hypersthene, there here appear high independent concentrations.

The section is unusual again in that the salic fraction is more than 80% perthite with only a few grains of plagioclase to be seen. It must, therefore, in any case be regarded as a local concentrate but the question whether it is purely magmatic or a contamination product cannot be answered without field information.

The biotite is in rather irregularly-shaped plates 0.2 to 2 mm. across, with the same pleochroism as in the main body (straw, brown and a deep, slightly purplish brown). The hypersthene is similar in size, not well shaped, and in this rock conspicuously thick with iron-ore grains, generally as well as in cleavage cracks. Some grains in fact approach being pseudomorphs in iron ore after hypersthene. Another unusual occurrence in this rock is a very slight development of ?antigorite from the pyroxene also. In other respects, the mineral properties shown are similar to the main body; in particular, the same clouds of rod-shaped perthitic inclusions are prominent in the orthoclase. It is the mineral proportions which give the rock its individuality: though it is clear that a single slide is not a representative sample, the proportions seen may be estimated:

felspar	75%
biotite	15%
hypersthene/iron ore	5%
quartz	5%

Specimen M.122 BIOTITE HYPERSTHENE GRANITE associated with the adamellite body.

The rock appears to be intermediate between the main body and the unusual variant M.101. The biotite content is more prominent than is customary but the salic constituents are not so far removed from normal magmatic proportions as in M.101. Quantities are estimated thus

orthoclase (perthite)	50+%
quartz, plagioclase and myrmekitic inter-growth	35%
hypersthene	5%
biotite	5%
iron ore, etc.	1%.

The quartz and plagioclase both occur as independent grains, but the spreads of myrmekite are better developed in this section than any other (10 mm. across). Quartz also develops into large grains (7 mm.), (somewhat contrasted with its size in the main body) whereas plagioclase (labradorite) rarely exceeds 2 mm. Twinning is rarely straightforward - shadowy and discontinuous patterns are the rule. The strain effects and inclusions in the salic components are as described for the main rockbody.

The hypersthene in this rock, as in M.101, shows a variety of alterations. The prominent cracks are filled with iron ore and biotite and a more greenish mineral (chlorite-serpentine) occurs again. An associate not seen elsewhere is a finegrained granular development taken to be garnet.

The biotite is as M.101 except that this section shows well the effect of the mechanical disruption discussed in the main rockbody; the same zones of granulation in the salic minerals can be seen and where biotite plates interrupt the zones, they are seen to be crushed to a fine felt of needles. Though the connection is not apparent here, in specimen M.103 the generation of garnet seems to be definitely associated with crushing of this sort.

(Beside M.103, other garnetiferous rocks possibly associated with this specimen are M.115, M.128, M.129, M.161.)

Specimen M.115 GARNET-ORTHOCLASE GRANULITE

This handspecimen is the nearest approach in the whole set to an aplitic texture, with uniform grain size between 0.2 and 1 mm. The section examined has parallel joints but these may as easily be an exfoliation development as a textural property. The micro-appearance gives no clue because there are no laths or platy minerals in which foliation could be shown. All that is seen is a high degree of cracking and good, sometimes striking, development of felspar cleavage.

The composition is estimated:

orthoclase	65%
quartz	15%
garnet	15%

Plagioclase (andesine) is very rare, simply accompanying biotite and iron ore in the remaining 5% of volume.

The garnet is pink as in specimens M.128 and 129 (contrast specimens M.103 and 122), in small solid rounded grains, showing no signs of degeneration.

The association garnet-orthoclase is characteristic of the granulite metamorphic facies, and so may be expected adjacent to charnockitic rocks. The bulk composition leading to the mineral proportions here quoted cannot be common however: the rock seems to be more or less time-free and in spite of the perthitic inclusions, potash seems to be in unusual excess over soda. Its genesis may be linked with the other orthoclase-rich rocks M.101 and 122, but in these, conditions have been less severe (or retrograde effects more extensive), since biotite has been able to develop.

Specimen M.128 GARNET NODULE in hypersthene adamellite.

Although one of the rocks carrying this number appears to be typical hypersthene adamellite, the thin section is from another which has a nodular structure. The nodule, about two inches across, has a black rim, pale body and pink centre. It is supposed that outside the rim, the rock is adamellite as usual, but neither this nor the black rim are shown in the thin section.

The pink component is garnet. It constitutes 80% of the area studied and appears to be a more or less single crystal growth one inch across. Filling the cracks in the garnet and scattered in the surrounding quartz and felspar are bright redbrown flakes of biotite. The salic surroundings are andesine (An_{40-50}) and quartz with a very small interstitial orthoclase content. Secondary developments are confined to very sparse calcite in the garnet cleavage.

The nodular character at present isolates this specimen from discussion with the other garnetiferous rocks. Though clearly some kind of associate of the granitic body, its exact relation cannot be determined in the laboratory.

Specimen M.129 GARNETIFEROUS ADAMELLITE GNEISS

The inhomogeneity in this rock is more widespread and less regular than in its analogue M.128. An approximation to banding recalls F.1 but contamination as a cause of the inhomogeneities is again only hypothetical.

The components are	quartz	30%
	orthoclase	30%
	labradorite An_{60-70}	30%
	biotite, etc.	10%

In spite of the variable handspecimen, the thin section shows a typical coarse granitic texture, with the salic components ranging from 0.2 to 5 mm. The clarity of the twinning and the freshness of both felspars is unusual for this group of specimens; and the perthitic inclusions in some grains reach a high degree of uniformity and alignment. Similarly the biotite is in fresh idiomorphic plates, clustered with a little iron ore. The only poor development is the garnet, which shows little sign of euhedral shape. (The garnet in the section seems to be a poor representation of that in the handspecimen: in the latter the garnet content is conspicuous, probably equal to biotite, and well developed grains may possibly be present.)

Specimen M.98 QUARTZITE

The handspecimen is a highly compacted pure quartz sandstone, on which weathering has very little effect. In thin section the grains are seen to be welded rather than cemented, but are not visibly strained. Grainsize is variable from 0.2 to 2 mm. Plagioclase (labradorite) up to a few per cent is distributed in the rock, grains being smaller and smoothly rounded in contrast to the subangular quartz - i.e., the plagioclase retains its sedimentary form whereas the quartz has been modified on compaction. The feldspar seems to retain even a surface coating and is perfectly fresh. The only coloured component in the rock is a lime-poor diopside in scattered subhedral grains (small 2V, + ve; pleochroic, pale greens; extinction angle 20°); associated with it but even sparser in occurrence is a little carbonate mineral.

Specimen M.147 QUARTZITE or VEIN QUARTZ

The handspecimen is a mass of blue-grey quartz carrying scattered brown stained impurities: if it is in fact a metamorphosed sandstone then recrystallisation is complete, but no directional texture is seen.

In thin section, the impurities are seen to be principally plagioclase feldspar (c. An 50) with a little accompanying orthoclase. Both occasionally carry tiny seedlike perthitic inclusions. There are also rare crack-fillings of carbonate. 90% of the rock however is quartz, in grains up to 8 mm. across, strained and riddled with finely granulated streams.

The rock may be a precise equivalent of M.98 which has suffered a higher degree of dynamic metamorphism; equally probable is that it is a totally unrelated occurrence of vein quartz.

Specimen M.104 GARNET QUARTZITE or QUARTZ VEIN

The two handspecimens carrying this number seem to differ only in coarseness. The sliced specimen has grains up to 1 cm. (similar to M.147) whereas the unsliced specimen is of finer grain (1 or 2 mm.).

The thin section shows a two-component rock, 70% quartz and 30% garnet (brown in bulk, colourless in thin section). Other components are strictly accessory - three grains of sphene, one of a clinozoisite-type mineral and crack fillings of biotite and ?rotted feldspar are the only impurities seen.

Two origins are possible for this rock, as for M.147, i.e. the quartz may be venous or sedimentary. In either case the generation of the garnet may be linked to its occurrence in rocks M.115, 128, and 129. In particular, contamination of the adamellite body by quartzite such as M.98 is thought capable of generating M.129, the present rock, and M.161 as different degrees of the same process.

Specimen M.161 GARNET GRANITE

The handspecimen is inhomogeneous in blue and brown portions. Both are leucocratic, the only ferromagnesian visible being a coarse development of red garnet particularly in the brown portions.

From both this thin section and that of M.147, it appears that the brown colour is attributable to iron staining of orthoclase and that the blue parts are quartzose, and orthoclase-free. The section available from rock M.161 shows only the brown variety, whose components are estimated:

orthoclase	60%
quartz	20%
plagioclase	5%
garnet	15%

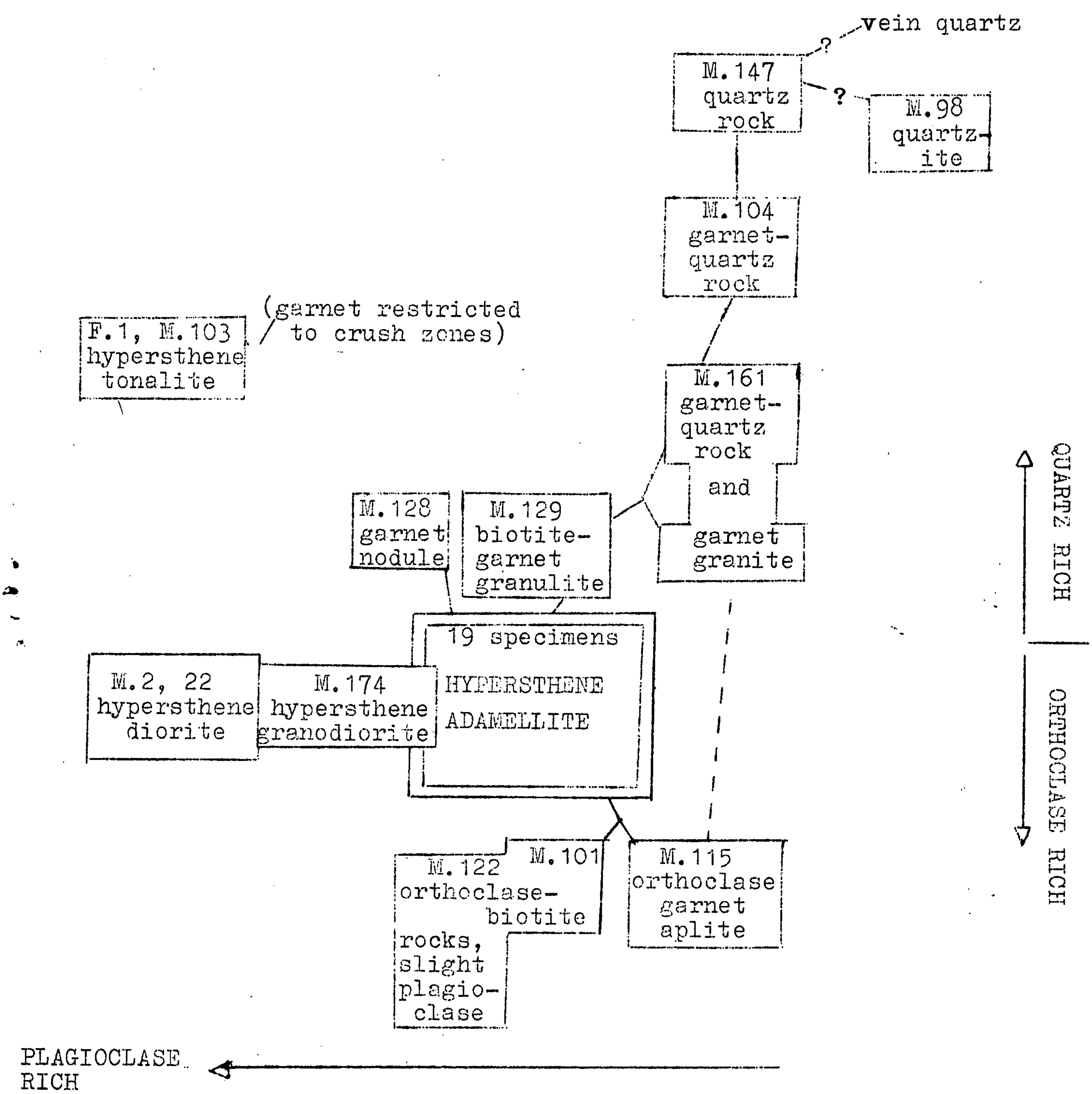
The same clotted lenticular texture recurs as is seen in M.129, with grains of both principle components varying from 0.5 to 3 mm. Pressure effects on the texture are prominent, even the quartz in this rock being full of cracks; and local reduction of grain size below that quoted is notable along granulation zones.

The orthoclase carries the commonly-noted swarms of perthitic inclusions. In this slice there is also development of a very fine close cleavage distinct from the usual widely-spaced ones, which seems to be the seat of some of the iron-staining. The biotite differs from that commonly seen in preservation and in pleochroism - X and Z show a deeper yellow and a brighter brown than in other specimens of this group. One crystal of the more common pleochroism is identified however, and points to the possibility of here identifying two generations, of which one may be a retrograde development. (Otherwise throughout the series of specimens, mineral instability is very rarely shown.)

The occurrence of inhomogeneity and quartz-rich layers, as is supposed from the colour banding in this specimen, has already been discussed under M.104.

B.H. Stinear's collection: general note on the rocks with charnockitic affinities.

Although subject to modification in the light of field information, the following scheme of connections between the specimens seen may be drawn up on petrographic grounds:-



The rocks clearly have similarities with other charnockitic suites on the one hand and with rocks of the granulite facies on the other. It remains in doubt whether these two are inseparable. The chemical peculiarities of charnockites are only partly attributable to their conditions of formation; the absence of hydrous minerals may be a consequence of depth but the low Ca:Al ratio which persists through the suite from basic to acid and prevents the generation of lime-bearing pyroxene, is not so obviously susceptible to physical control. However this may be, the present group is undoubtedly another instance of the association of granulite facies and charnockitic composition.

biotite & retrograde effects

The only deviations from a straight charnockitic suite are the biotite-bearing rocks on the one hand and the garnetiferous ones on the other. The occurrence of biotite must be regarded either as a retrograde development or else as evidence that the fringe of the granulite facies is approached, where less severe conditions permit a hydrous mineral. As a retrograde effect it is supported by the frequent adjacence of biotite and hypersthene but made unlikely by the rarity of overgrowth structure and by the absence of any of the other retrograde effects listed by Turner (p. 103). This absence is in fact a striking feature of the entire rock group.

garnet

The occurrence of garnet is not in itself discordant with the known character of charnockites, but it appears - for instance in the scheme above - that in this particular group it is strictly associated with boundary effects, or at least with differentiates. In M.103 it appears only in a crush-zone and is easily interpreted as stress-controlled; in the other rocks M.115, 129, 161 and 122, it may be simply a chemical phenomenon but, since the locations for boundary differentiates and contaminates are also locations where shear is probable (on account of rock inhomogeneity), it may be suggested that its generation has been encouraged by the physical environment.

The hypotheses here glanced at demand re-assessment on field information, but in the interim, M.101, 115 and 122 are interpreted as differentiates, and M.129, 161, 104 and 147 as a contamination series.

Reference

Turner F.J., 1948 : Geol. Soc. Amer. Mem. 30, 'Mineralogical and Structural Evolution of the Metamorphic Rocks'.