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DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

RECORDS.

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REPORT OF MINOR INVESTIGATIONS CARRIED OUT BY THE PETROGRAPHIC AND MINERAGRAPHIC SECTIONS OF THE GEOLOGICAL LABORATORY FOR THE PERIOD - APRIL - JUNE, 1958.

Compiled by

G.J.G.Greaves.

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INTRODUCTION

This Record consists of a collection of reports completed in the petrological and mineragraphic sections of the Bureau Geological Laboratory during the period April to June 1958. The reports have been placed in chronological order and each has its date of completion and the relevant file number above its heading.

The officers responsible for these reports are - W.B. Dallwitz, W.M.B. Roberts and W.R. Morgan.

CONTENTS

Report No. 1

170 ACT/2
30th April, 1958.

ANALYSIS OF CLAY FRACTIONS IN BOREHOLE SECTIONS FROM THE UPPER COTTER DAM SITE

by

W.M.B. Roberts.

Two sections of core from hole No. 11, Upper Cotter dam site, taken at 13' and 18', were submitted for analysis of the clay fraction by L.C. Noakes.

The sections were ground and the clay fraction dispersed by treatment, with N sodium hydroxide. The resultant paste was made to 500 mls. with distilled water and placed in a measuring cylinder, shaken vigorously, and allowed to stand for six minutes.

Samples were drawn off at 10 cm. depth, evaporated, washed free of sodium hydroxide, and X-rayed.

Sample from hole 11 13'

Clay fraction - pure muscovite.

Sample from hole 11 18'

Clay fraction - quartz with approximately 10% kaolin.

Report No. 2

63/G/P
5th May, 1958.

EXAMINATION OF NICKEL ORE FROM THE SAVAGE RIVER, TASMANIA, HANDED IN BY MR. LUCK, M.H.R.

by

W.M.B. ROBERTS.

Interim Report

Six pieces of irregular size and shape were examined. They are of a serpentine rock heavily impregnated with sulphide, and containing veins and encrustations of a somewhat glassy green mineral. The identities of all minerals were confirmed by X-ray diffraction where possible.

In polished section the only opaque minerals were found to be a brassy yellow mineral, fairly soft, having a strong bireflection. An X-ray powder diffraction photo showed it to have a pattern identical with that of an artificially prepared nickel sulphide of the formula Ni_3S_2. The naturally-occurring substance having this formula has been named heazlewoodite, and it is probably a sulphur analogue of the nickel arsenide, maucherite (Ni_3As_2); the diffraction pattern shows no resemblance to that of millerite (NiS). Detailed X-ray crystallographic studies of this mineral are in progress.

The other opaque mineral is magnetite; this mineral has been named in the Tasmanian Government Laboratory Report of March, 1957, as the nickel-iron spinel, trevorite. The mineral is strongly magnetic and hard; microchemical tests gave only a very weak result for nickel. The magnetite-type spinels, having identical structures, and compositions based on exchange of geometrically similar atoms, as well as forming a continuous series, cannot be unambiguously differentiated by X-ray diffraction. The mineral in question gave a perfect magnetite-spinel pattern, and in view of the fact that it contains only a very small quantity of nickel, would be more justifiably labelled magnetite rather than trevorite. Published analyses show magnetites as containing up to 1.76% Ni, which would probably be higher than the nickel content of the mineral in question.

No pyrrhotite is present in the ore.

A section of the ore was ground to -200 mesh and examined in the X-ray spectrograph; the major metallic elements present were found to be nickel, iron, and cobalt, the last in much smaller quantity than the other two. Minor amounts of chromium and manganese, and traces of lead, arsenic and selenium were noted. No copper is present.

The rock itself is a serpentine consisting of the usual serpentine minerals. Examination of the thin sections shows that the major rock forming minerals are chrysotile and/or antigorite, which cannot be differentiated by X-ray diffraction. It is possible that both these minerals are present because between crossed nicols rather coarse intergrowths of two minerals, which have a markedly different birefringence and refringence, can be readily distinguished.

White uniform coatings on many of the specimens are hydromagnesite, a basic, hydrated magnesium carbonate.

The emerald green coatings on several of the specimens were X-rayed several times and gave no pattern - showing them to be amorphous.

The X-ray spectrograph gave the composition of the coating as nickel, iron and some cobalt, with traces of chromium and manganese; the mineral effervesced in dilute HCl, and in transmitted light, fragments have a distinct green colour. The refractive index (determined by W.B.Dall-witz) is 1.560-1.565.

These characteristics identify the mineral as the basic nickel carbonate, zaratite.

Another glassy green mineral occurring in irregular masses in the body of the rock, and also admixed with zaratite in coatings, was identified as antigorite/chrysotile. Mixtures of these minerals were found to effervesce in dilute HCl, and zaratite was found to be present on microscopic examination.

Also in the body of the rock are large irregular grains of a white mineral having a good cleavage, which proved to be carbonate-apatite, which has the formula $Ca_{10}(PO_4,CO_3OH)6(OH)_2$. A small quantity of quartz was observed in some sections. Irregular masses of an as yet unidentified greyish, isotropic mineral or substance were observed in some thin sections.

Report No. 3

8/G/1
6th May, 1958.

PETROGRAPHIC DESCRIPTION OF SPECIMENS N1, N2 AND N3 FROM THE TYPE SECTION OF THE CONDOR FORMATION, CONDOR CREEK, FIVE MILES SOUTH OF URIARRA

by

W.R. Morgan.

Summary

The positions of the specimens in the measured section southward from the Cotter Fault are as follows: N1, top of section; N2, 1200 ft. stratigraphically down the section; N3, 1500 ft. down the section.

1. N1 and N3 are silty or fine-grained quartz greywackes, with micaceous and chloritic matrices. N2 is a fine-grained quartz sandstone.

2. Specimens N1 and N2 contain up to 2-3% of feldspar, mostly plagioclase. None was observed in N3.

3. Specimens N1 and N2 contained accessory minerals:-

   (a) Zircon. In N1, this mineral is subhedral in shape, tending to be tabular, but with rounded edges, giving the grains a long oval shape. In N2 all the zircon observed consists of rounded grains giving a roughly circular shape. Specimen N3 contained no observed zircon.

   (b) Allanite and apatite, in exceedingly minor quantities, are present in N1. The apatite has a similar grain shape to that of zircon.

   (c) Pyrite, in N3, appears to be associated with the quartz vein.

4. Sericite and chlorite vary in amount from one specimen to another, i.e.
   N1 - 15%
   N2 - 5%
   N3 - 25%

   This variation in the quantity of matrix is the most important difference between the specimens.

5. The quartz in all three specimens is angular to subangular.

6. N3 shows a layering of greater and lesser amounts of sericite and chlorite mixed with quartz.

7. The presence of shearing in specimen N2 is not considered of importance in noting differences between the specimens, as this type of structure is probably not inherent in the rock's formation.

N1. Silty quartz greywacke or silty, sericitic quartz sandstone

Hand Specimen

Medium grained, slightly micaceous, light grey, quartz sandstone, with irregular areas showing slight ferric

oxide staining on fresh and weathered surfaces. Very slight corrugations are apparent in one place.

Thin Section

Mineralogy

Quartz	80%
Plagioclase	< 3%
Sericite	15%
Chlorite, Zircon, Leucoxene, Allanite, Tourmaline, Apatite, Hydrated iron oxide	< 3%

Texture. Fine to medium-grained, grains ranging between silt size (below 0.05 mm. diameter) and 0.3 mm. Very inequigranular. Quartz grains are angular to sub-angular. Flakes of muscovite and chlorite occur, again of varying size; little parallelism of the flakes is seen.

Both sericite and chlorite tend to hold an intergranular position, and show some slight "fretting" of the margins of quartz grains. A few muscovite flakes are present.

Hydrated iron oxide is intergranular.

Zircon and apatite occur as tabular grains with rounded edges. Allanite is rounded. Apatite, allanite and tourmaline are very rare in this rock.

N2. Fine-grained quartz sandstone

Hand specimen

Medium-grained, tough, greyish sandstone, with ferric oxide staining prominent on weathered surface, and much less obvious on fresh surfaces. Little mica to be seen in hand specimen. It is traversed by two milky quartz veins. Thin layering may be distinguished - alternate lighter and darker bands, each 1 to 3 mm. thick are present, but colour-differences are slight. They appear to be bands of weakness, a form of "cleavage", as on a transverse broken surface, the layers find physical expression in small "steps" up the side of the specimen.

Thin Section

Mineralogy

Quartz	90%
Plagioclase, Microcline, Perthite	< 2%
Sericite, Greenish chlorite	5%

Zircon, Leucoxene, Black iron ore	< 3%

Texture

Very fine to near medium grained (0.05 to 0.2 mm.), inequigranular. Angular to sub-angular grains, with a quite marked preferred orientation of the long axes of grains, due to shearing, in a direction close to that of bedding. One irregular band, 3-4 mm. thick, extends across the section and is composed of granulated, drawn out and stained quartz grains; it is obviously a shear plane and makes an angle of about 20° with the bedding. Throughout the rock, quartz shows undulose extinction, but especially in the shear zone, where it has completely recrystallized.

The feldspars also occur as angular grains; some of them show stained and bent twin planes.

Zircon and leucoxene show rounded grains. Sericite and chlorite occur as intergranular flakes, again tending to "fret" the quartz and feldspar grain edges.

N3. Fine-grained quartz greywacke or sericitic and chloritic quartz sandstone

Hand Specimen

Fine to medium-grained somewhat friable, slightly micaceous sandstone. On a fresh surface the rock is cream-grey coloured, with small flecks of red iron oxide. On a weathered surface the rock is stained orange with iron oxide. On a broken surface a form of "cleavage" is apparent.

Thin Section

Mineralogy

Quartz	70%
Sericite, Chlorite	25%
Hydrated iron oxide	4%
Pyrite	< 1%

Texture

Very fine-grained, rather inequigranular; quartz grains are angular to sub-angular, and show strained extinction, but their long axes do not show the parallelism noted in N2. Sericite and chlorite occur as small flakes holding an interstitial relationship with quartz: fretting of the quartz boundaries by these minerals was noted. Hydrated iron oxide occurs as small interstitial grains and dust. An apparent bedding is shown by greater and lesser amounts of chlorite and sericite being mixed with quartz in parallel bands.

A quartz vein 0.5 mm. thick cuts the rock, and for a distance of 0.5 to 1.0 mm. on either side of the vein the sericite and chlorite are stained by hydrated iron oxide.

Pyrite is also present either side of this vein, as euhedral grains.

The red flecks of iron oxide noted in hand specimen have probably been formed from pyrite.

Report No. 4

198F/3
15th May, 1958.

EXAMINATION OF SPECIMENS FROM HANESAVO ISLANDS, BRITISH SOLOMON ISLANDS

by

W.M.B. Roberts.

Several specimens of pyrite ore and a quantity of a deep blue mineral were submitted by the Geological Survey Department of the British Solomon Islands. All were from the same locality on Hanesavo Island.

The finely-divided blue mineral was identified by X-ray diffraction as covellite. Small sections from each of the pyrite ore specimens were ground to -200 mesh and examined in the X-ray spectrograph, and the major constituents found to be: iron, sulphur, and less than 1% copper. The same method was used for the examination for elements in trace amounts; these were found to be: arsenic, zinc, cadmium and chromium. The presence of gold could not be checked with the present instrumentation.

In thin section the specimen is shown to consist entirely of quartz and sulphide. The quartz has a wide range of grainsize - from 0.01mm to 0.15mm. - and the whole is marked by a mosaic texture. The rock is very porous in appearance, vesicles occupying 15-20% of the total volume, these vesicles range in size from 0.05 mm. to 1.0 cm., and vary in shape from rounded to extremely irregular.

The only sulphides present are pyrite and covellite, the latter mineral in very minor quantity, as small irregular areas enclosed in the quartz gangue, the largest grain measuring 0.06 mm.

Pyrite forms well developed crystals, the largest of which measures 0.5 mm., as well as large irregular masses, which at high magnification are seen to be composed of small well-developed crystals.

No indication of the field occurrence of the specimens was given in the accompanying letter. However, it appears the specimens came from a hydrothermal deposit, the gangue mineral of which is entirely quartz, the vesicles probably the result of release of volcanic gases. The occurrence of covellite - i.e. totally enclosed in the quartz gangue - strongly suggests that it has not been formed by the alteration of a pre-existing copper sulphide (chalco-pyrite or chalcocite) in the zone of secondary enrichment, but is actually a primary mineral. Such primary covellite has been reported from Vesuvius as a sublimation product. The finely crystalline nature of the mineral submitted for identification has the appearance of a sublimation product.

The only other possibility for the formation of the vesicles in the rock is that they are the result of leaching of chalcopyrite, this is unlikely in view of the fact that one would expect some traces of hydrated iron oxides in an environment where this mineral has been altered to covellite. In the specimens examined, no trace of any iron oxides was observed, especially in the vicinity of the vesicles, nor was there any evidence of the breakdown of pyrite, which was perfectly fresh in all of the specimens.

Report No. 5

97/NT/6
20th June, 1958.

EXAMINATION OF THREE SPECIMENS FROM THE ELDORADO MINE, TENNANT CREEK, N.T.

by

W.M.B. Roberts.

Three specimens were submitted by Mr. H. Field, of the Eldorado Mine for determination of the copper content. The specimens were not numbered so they were examined as two groups: (a) the apparently less oxidised, and (b) the apparently more oxidised.

Specimen (a)

Two of the specimens were examined in this group. A polished section was made of each piece of sample; subsequent examination in reflected light showed the specimens to consist of hematite and quartz. No copper sulphide mineral was observed. A thin section was made of each specimen and again no individual copper mineral could be observed.

Examination by X-ray spectrograph showed the metallic elements to be iron, bismuth, copper, chromium, manganese, and zinc, the last two in trace amounts. A concentrate of hematite separated in the isodynamic separator showed less copper present than in the non-magnetic fraction, which consisted principally of quartz and some free gold. It is assumed from this that the copper is mainly associated with the quartz fraction and not in solid solution in the hematite. An analysis by W.J. Thomas, gave the copper present as 0.06%.

Specimen (b)

This sample appeared to be much more oxidised than those examined as Specimen (a). A polished section showed no trace of any copper sulphide mineral, nor, as in the previous specimens, could any copper mineral be detected in thin section. X-ray spectrographic examination showed the metallic elements to be: iron, bismuth, copper, chromium, manganese, and zinc, the last element in trace amounts; the copper was approximately twice that in specimen (a), and an analysis by W.J. Thomas gave the copper present as 0.1%. This specimen contained approximately half the quantity of bismuth in specimen (a).

Regarding the query on cyanicides, any questions relating to the treatment of the ore should be sent to the Ore Dressing Laboratories, C.S.I.R.O., C/- University of Melbourne, Carlton, N.3, Victoria.

Report No. 6

198 PGN/1
20th June, 1958.

PETROGRAPHIC REPORT ON ROCKS COLLECTED FROM THE MAMBARE RIVER, NEW GUINEA.

by

W.B. Dallwitz and W.R.Morgan.

P30, Ivaro Creek, Mamba Estate

A partly serpentinized dunite whose average grain-size was originally between 2 and 3 mm. Abundant remnants of olivine are set in serpentine, and these remnants are optically continuous over areas measuring up to 3 mm. across. Probable chromite, which is dark red-brown in transmitted light, is the only accessory.

The olivine is biaxial positive, with estimated 2V about 85°; it, therefore, contains about 90% of the forsterite molecule ($Fo_{90}Fa_{10}$).

P52 Coarse-grained pyroxenite, Upper Orkawu, south Branch

This is an enstatite-pyroxenite containing a little (less than 1%) anthophyllite, a few minute specks of black iron ore, and some very thin veinlets of probable serpentinous material. The rock is virtually monomineralic. The optic axial angle of the enstatite was estimated as 85°, and its mean refractive index is about 1.67; these properties correspond to a composition of about $En_{85-90}Fs_{15-10}$.

P59, Upper Orkawu, east branch No. 1, Eastern limit of traverse

Enstatite-pyroxenite, medium to coarse-grained. Consists of enstatite containing lamellae of diopside. About 10% of the rock is labradorite. Texturally, the rock is allotriomorphic, inequigranular, tending to be slightly porphyritic. The grains are rounded, and extensively cracked. A little magnetite is present. The rock is unaltered.

P60, Medium-coarse grained pyroxenite, Upper Orkawu, east Branch No. 1.

This rock is very similar to specimen P52, except that the pyroxene, judging by its negative sign and optic axial angle estimated at about 85°, is slightly richer in the ferrosilite molecule, and has a composition of about $En_{80}Fs_{20}$; this places it on the border of enstatite and hypersthene. The rock is therefore an enstatite pyroxenite (enstatitite) or hypersthenite; however, as refractive index measurements place the pyroxene slightly on the enstatite side of the border, it may be more appropriate to refer to the rock as an enstatite pyroxenite. As with specimen P52, a little anthophyllite and black iron ore are present, and these minerals are noticeably more plentiful than in specimen P52.

P70 "Glittering black hypersthene (?) rock. From ¼ mile wide N-S belt: Lower Orkawu River.

Hypersthene-bearing hornblendite: The rock consists of pale brown hornblende, with about 5% of plagioclase and 10% of

hypersthene. The hornblende is pleochroic in brown; length slow, Z^C = 10°; birefringence = 0.025. Biaxial negative, 2V = C 70°. The felspar has R.I. greater than that of balsam, and has some pericline twinning: it is probably labradorite. Feldspar is slightly sericitized. Accessory black iron ore and a little quartz are present; texture hypidiomorphic, medium to coarse-grained, with subhedral prismatic crystals of hornblende interlocking with one another. Felspar and hypersthene occupy granular interstitial places. Hornblende crystals show a little straining and bending. Some preferred orientation of the hornblende prisms is present, though this is not too obvious; it seems that the prisms are orientated parallel to a plane, and are generally orientated within that plane. Hypersthene occurs in crystals sub-poikilitically surrounded by hornblende.

The prismatic structure of the hornblendes suggests that the rock is igneous; if it were metamorphic they could be rounded granoblastic crystals. Therefore the rock is a hornblendite.

P74, Volcanic (?), Oivi Hill.

Basalt. Contains augite and plagioclase, with black iron ore, sericite, chlorite, epidote, (?) zeolite or gypsum, and hydrated iron oxide. Texturally the rock is fine-grained, porphyritic, with variolitic arrangement of the sericitized felspars. The groundmass consists of partly chloritized augite and altered plagioclase; the arrangement of these minerals suggests a sub-ophitic texture. The phenocrysts consist of augite, with some of sericitized felspar.

Some chlorite occurs in veins, as does the epidote. The (?) zeolite occurs in very thin veins. The sequence of veins, from the first to the last is:

1. Epidote, 2. Chlorite, 3. (?)Zeolite or gypsum.

The last named mineral generally follows along the chlorite veins.

P87, Harzburgite (field name). Aguru Creek, lower. Wehrlite or augite picrite.

Diopside. Colourless. Forms anhedral grains. Birefringence 0.022. Length - slow Z∧C = 48°. Biaxial +, 2 V = C 55°. A diallage parting is present. Lamellae of orthopyroxene are present, parallel to the cleavage.

Olivine. Colourless anhedral. Biaxial negative, 2V = C 80° showing the mineral to have a composition between that of chrysolite and hyalosiderite, i.e. $Fo_{70}Fa_{30}$. Chrysotile occurs along the cracks in olivine and is fibrous, with a greenish-yellow colour.

Black iron ore is a byproduct of the serpentinization of olivine.

In texture the rock is coarse-grained (grains are about 2 mm. in size), xenomorphic-granular, the diopside and olivine grains being rounded to a certain extent.

Chrysotile mainly attacks olivine, but to a lesser extent attacks diopside. Sometimes a large amount of an olivine crystal may be attacked, but usually the alteration is small. Small grains of black iron ore occur along the alteration zones. Black iron ore also occurs as irregular grains.

Harzburgite is a name given to an ultrabasic rock containing olivine and orthopyroxene, according to Johannsen. The same authority uses the name wehrlite to cover the assemblage olivine (clinopyroxene).

P92 (i) "Fine-grained granular ultrabasic"
Granulitic bytownite norite

Augite. Colourless. Biaxial positive, 2 V = C.55. Length slow, C = 44°. Birefringence = 0.024.

Hypersthene. Lightly pleochroic, X = colourless; Y = Z = light bronze pink. Biaxial negative, large 2v parallel extinction.

Feldspar. R.I. C.B., Albite, pericline and carlsbad twinning present. Biaxial negative, bytownite (An_{85-90}), as determined in combined albite-carlsbad twins.

Black iron ore, speckled white in reflected light, suggesting ilmenite.

Accessory apatite. Some (?) talc, chlorite and kaolin are present.

Texture. Medium-grained, zenomorphic, inequigranular, and resembles that of a granulite or high-grade hornfels rather than an igneous rock. However, good twinning in plagioclase and lamellae of clinopyroxene in hypersthene preclude the possibility of a metamorphic origin. Some of the felspars show slight traces of zoning. Chlorite and (?) talc are alteration-products of pyroxene. Slight kaolinization of the felspars has taken place. The chlorite and talc have commonly been squeezed along cracks to form veinlets which traverse the whole rock.

P92 (ii), Gabbroic Rock, limit of traverse, Upper Aguru Creek.

Bytownite norite. This rock is mineralogically and texturally closely similar to P92 (i), except that it is scarcely altered at all, and that the plagioclase is much more severely cracked. Ilmenite, instead of forming grains, occurs in intergranular positions, and in crystal cracks.

P95 Serpentized Dunite - Upper Aguru Creek.

Mineralogy

Olivine. Colourless. Biaxial negative, 2 V = C 85. Birefringence 0.034. Crysolite.

Black iron ore. Form octahedral crystals, appear to be largely chromite, because most are translucent and dark brown.

Chrysotile. Fibrous serpentine occupying the cracks in the olivine. Has a greenish-yellow colour, and very low birefringence.

Antigorite. A little lamellar antigorite is present in the larger alteration zones. Length slow.

Texture. Coarse-grained (2.5 mm. to 5 mm. grain size), xenomorphic-granular olivine (chrysolite). The black iron ore forms euhedral grains up to 0.25 mm. size. The serpentine (antigorite and chrysotile) forms a meshwork along the cracks and crystal boundaries of the olivine, separating each grain into numerous smaller ones. The veins range between 0.025 and 0.15 mm. thickness.

The rock is, therefore, a serpentized dunite.

P100A "Fine-grained ultrabasic"
Uralitized quartz-dolerite.

Mineralogy. 50% basic andesine, slightly sericitized and kaolinized. 40% hornblende, actinolitic. Pleochroic in pale green. Somewhat fibrous. 8% quartz. Accessory black iron ore, apatite, sericite and kaolinite.

Texture Fine to medium grained, hypidiomorphic, subvariolitic. The feldspar occurs as rather long, thin tabular laths. The actinolite on its basal sections, pseudomorphs pyroxene. Quartz occurs as anhedral grains as does the black iron ore. Apatite occurs as minute circular crystals enclosed in feldspar.

The rock is apparently a uralitized quartz dolerite.

P100B. "Coarse-grained basic". Tributary of the Luwini River. North of Afa Village.

Mineralogy. Feldspar (Anorthite, An_{95-98}), Augite, Actinolite, Olivine. Accessory magnetite, pyrites, kaolin, chrysotile and chlorite.

Texture. Coarse-grained, xenomorphic, rather inequigranular.

Olivine occurs as crystals larger than the general groundmass. Usually it is partly surrounded by a rim of chrysotile; magnetite is present along the crystal cracks of the olivine, as a by-product of serpentinization.

Augite occurs as subhedral to anhedral grains.

Partial or complete uralitization of the pyroxene and clouding of the feldspar have taken place on either side of a crack or joint; the width of the zone of alteration is up to 2.5 mm.

The rock is an autometamorphosed, partly uralitized eucrite.

P103A. "Typical fine-grained basic rock, low spurs between Embeti Creek and Hungiri".
Partly Uralitized Quartz Dolerite

Mineralogy. Labradorite, augite, hornblende, quartz, accessory black iron ore, apatite.

Texture. Fine to medium grained hypidiomorphic, subophitic. Labradorite occurs as tabular laths. Augite is prismatic, and tends to be replaced by pale brownish green hornblende: the latter mineral also occurs interstitially, as a primary crystallized mineral. Quartz is interstitial and poikilitic, as is the black iron ore.

103B. "Coarse-grained pyroxene-brg. rock. Locality as 103A"
Olivine pyroxenite (picrite)

Mineralogy. Enstatite 30%, Olivine 25%, Augite 20%, Tremolite-Actinolite 15%, Accessory antigorite, partly saussuritized plagioclase, magnetite, chrysotile, zeolite.

Texture.

Coarse-grained xenomorphic inequigranular. Olivine occurs as rounded grains, with chrysotile and black iron ore are present in the crystal cracks, and antigorite around the margins. Pyroxene trends to be prismatic. The actinolite and tremolite occur interstitially, or replacing diopside. Zeolite occurs in thin veins cutting the other minerals.

The name "olivine pyroxenite" is given because of the presence of olivine in essential quantities: however, there is insufficient of that mineral to warrant the name "Lherzolite", which requires a ratio of olivine to pyroxene of at least 3:1.

P106 "Medium-grained basic rock". Limit of traverse up Iropa River.

Dunite. Forsterite. Biaxial positive, 2V = C.85°. Accessory antigorite, chrysotile and black iron ore, probably chromite. In texture the rock is xenomorphic granular and coarse-grained, the olivine forming somewhat rounded grains. The serpentine minerals form an irregular mesh work of veins of alteration along the cracks of olivine grains. The olivine shows pronounced undulose extinction. Black iron ore forms euhedral, squarish and six-sides grains; some grains are reddish black and translucent, and are, therefore, probably chromite.

P110B. "Medium-grained basic rock". Between Corta Creek and Hoija No. 1 Creek.
Partly Chloritized Dolerite.

Mineralogy. Feldspar, probably labradorite, augite, chlorite, accessory black iron ore, nontronite, prehnite.

Texture. Medium-grained amygdaloidal, sub ophitic hypidiomorphic, slightly porphyritic. The felspar forms tabular laths, in places intergrown with augite. Augite forms subhedral prisms. Chlorite replaces augite partially or wholly. Black iron ore forms squarish grains, except where associated with chloritized augite.

The amygdules are filled with nontronite, prehnite and some chlorite. The nontronite and chlorite are fibrous the former radially so; prehnite forms radial fibro-prismatic crystals.

P115. "Black doleritic rock", typical of Eastern flank Avaeti Dijari, Upper Hoija No. 1 Creek.
Quartz-dolerite.

Mineralogy. Feldspar, either andosine or labradorite. Augite, actinolite, chlorite, quartz, accessory black iron ore.

Texture. Medium-grained, hypidiomorphic. The feldspar occurs as tabular laths. Augite is prismatic, and largely altered to actinolite and chlorite. Quartz occurs as anhedral, sub-poikilitic grains. Black iron ore is more abundant than in most dolerites.

P118(i). "Medium grained basic rock". Bank of Mambare River, near change in topography.
Party uralitized eucrite.

Mineralogy. Olivine (Chrysolite) 35%; actinolite, colourless or very light green 10%, Augite 20%, feldspar, badly sericitized and kaolinized 25%. Accessory black iron ore, chlorite, antigorite, and chrysotile, 10%.

Texture. Coarse-grained, xenomorphic. The olivine forms ovoid, cracked crystals, with serpentine and black iron ore filling the cracks. Pyroxene tends to be poikilitic about olivine, and is anhedral to subhedral, prismatic in shape. Actinolite is poikilitic about olivine and pyroxene: it forms fairly large "plates" which may enclose two or three olivine crystals. Also actinolite forms a thin

alteration rim around both olivine and pyroxene. Feldspar is subhedral to anhedral, poikilitically enclosing olivine and pyroxene; it is badly altered to sericite and kaolin. Some grains of black iron ore occur.

P118 (ii) "Medium grained basic rock", as P118 (i).

Partly uralitized eucrite.

A similar mineralogy to P118(i) is present, except that the felspar is fresh; albite and pericline twinning are present, the optic sign is biaxial negative, and measurement of the angle between basal cleavage and the pericline twinning showed it to be Ab_{27}, sodic bytownite.

This specimen is texturally similar to P118(i) as well. Estimated mineral percentages are as follows:

Olivine 35; augite 35; actinolite 20; feldspar 25; alteration-products of olivine, etc. 5.

P119. "Lighter coloured basic rock". Mambare River, near change in topography.

Uralitized quartz dolerite (possibly the lamprophyre spessartite). Mineralogy: Feldspar, possibly andesine, hornblende, quartz. Accessory black iron ore, apatite, chlorite, prehnite, epidote, some sericite.

Texture. Medium-grained, hypidiomorphic, sub-ophitic. Feldspar is tabular, lath-like, texturally rather doleritic, and is partly kaolinized. Hornblende is prismatic, tending to be enclosed by felspar. Quartz occurs as interstitial, sub-poikilitic grains. Black iron ore is present as squarish to rounded grains. Hornblende may be chloritized, or very occasionally altered to a mixture of prehnite and epidote. Apatite occurs as very small, acicular euhedra.

P122. Specimen where fine-grained rock intrudes coarser gabbroic rock, Mambare River, west of P119 and of topographic change.

Coarser rock. Uralitized and serpentinized metagabbro.

Mineralogy. Bastite (probably derived from diallage) 55%; actinolite 15%; bytownite-anorthite (An_{90}) 15%; diallage 13%) accessory black iron oxide, hydrated iron oxide; sericite, apatite 2%.

Texture. Hypidiomorphic granular, medium-grained (0.5-1 mm.), showing a flow texture, with a little protoclastic straining of the crystals, shown more definitely by the slightly cronulate boundaries of the crystals. Bytownite is tabular and lineated parallel to flow texture. It is very slightly sericitized in patches. Diallage tends to be prismatic, and is largely replaced by bastite. The latter mineral is fibrous, and pseudomorphs diallage; often in these pseudomorphs, small irregular remnants of diallage occur. Bastite occurs as veinlets in plagioclase; it seems to have been squeezed along cracks in the felspars. A very narrow vein of actinolite derived from bastite occurs cutting through the slide parallel to the felspar lineation. A very few grains of black iron ore occur. Some irregular particles of hydrated iron oxide occur close to altered diallage in one or two places. Apatite occurs as minute acicular euhedra enclosed in felspar. Adjacent to the fine-grained intrusive bastite has been wholly converted to actinolite over a width of about 3.5 mm.

P122 Fine Rock. Uralitized basalt or fine-grained dolerite (or lamprophyre((?) spessartite).

Mineralogy. Labradorite-bytownite (An70), hornblende, accessory black iron ore, epidote, chlorite, carbonate, and quartz.

Texture. Fine-grained (0.1-0.2 mm. size) idiomorphic, porphyritic, sub-variolitic. Feldspar is tabular lath-shaped; hornblende is prismatic, tending to be acicular, it forms phenocrysts and present in the groundmass, though some apparent pseudomorphs of pyroxene are present. Small granules of epidote occur with the hornblende. Quartz occurs as a very narrow vein, cutting through the rock; these veins may contain epidote. Black iron ore occurs as small irregularly shaped granules throughout the rock. Chlorite occasionally replaces the hornblende.

The naming of this rock is uncertain; it probably has the composition of a basalt or dolerite, but has the texture of a lamprophyre. However, the plagioclase is too calcic for spessartite.

P122. The Junction

The fine-grained intrusive becomes exceedingly fine-grained, showing the presence of a chilled margin, and confirming that the basalt does intrude the gabbro. The chilled margin is porphyritic, showing phenocrysts that are clearly hornblende pseudomorphs of a pre-existing pyroxene. Tabular phenocrysts of feldspar are present, aligned in a flow texture parallel to the margin of the intrusion. The groundmass consists of a hypidiomorphic, flow-textured mass of tiny hornblende and feldspar crystals. Right at the border the texture is so fine-grained that the minerals present may hardly be seen by the microscope, though it is still porphyritic.

The coarse-grained rock maintains its textural characteristics, i.e. coarse-grained, with flow structure right up to the margin. The basalt cuts the gabbro at right angles to the latter rock's flow texture. For a distance of 3.5 mm. into the gabbro from the junction, the bastite in the gabbro has been converted to actinolite or light green hornblende. This denotes an increase in the tenor of iron, lime, and (?)alumina, possibly supplied from the basalt.

At the junction the two rocks are separated by vein 0.18 mm. thick. The vein is apparently intruded along the junction; a very thin layer of the chilled margin of the basalt is present in places on the gabbro side of the vein: also there are one or two small "islands" of chilled margin rock within the vein, usually closer to the gabbro side, as though a minor offshoot from the main vein had enclosed some of the thin layers mentioned above. The vein consists of quartz and prehnite, the latter mineral being in much greater quantity than the former.

Two very thin veins were noted, consisting mainly of quartz, but with a little prehnite present; these veins cut the previously mentioned vein.

P125(i) "Coarse grained grey pyroxene (?) with interstitial serpentine(?)". Mambare River, W. of P122.

Serpentinized harzburgite or enstatite picrite

Mineralogy. Enstatite, 2V near 90°. Parallel extinction.

Olivine, Chrysolite. 2V = C 85°, negative. Serpentine replacing olivine. (?)talc and tremolite replacing enstatite. Accessory black iron ore, partly original grains, partly by-product of alteration of olivine.

Texture. Very coarse-grained xenomorphic granular originally. Much of the olivine is replaced by serpentine, while the pyroxene is partly replaced by (?)talc and tremolite. Black iron ore occurs in subhedral grains.

The rock is therefore a harzburgite or enstatite-picrite in which a good deal of alteration to serpentine and talc has taken place.

P125(ii) "Coarse-grained grey pyroxene fine granular texture"

Enstatite pyroxenite. The rock is composed almost entirely of very coarse grains of enstatite, being 10 or 11 mm. across in the thin section. The enstatite has been slightly altered to (?)talc and tremolite, especially along the crystal boundaries; however, thin zones of alteration may be present along the cleavages and cracks within the crystal. A little black iron ore is present in the alteration zones.

P125 (iii) "Extra fine grained intrusive rock".

Uralitized quartz-dolerite. Mineralogy: quartz, labradorite (Ab_{40}), hornblende. Accessory black iron ore, epidote, very little kaolin, apatite, thomsonite.

Texture. Fine-grained, hypidiomorphic, variolitic, equigranular. The felspar occurs as lean tabular laths. Quartz is interstitial and sub-poikilitic. Hornblende is light green and somewhat fibrous: it appears to pseudomorph pyroxene. Black iron ore occurs as irregular grains. Epidote and kaolin slightly replace felspar. Thomsonite forms a vein intruding the rock.

P125 (iv) "Intrusive felspar-quartz-hornblende pegmatite"

Gabbro pegmatite. Mineralogy: actinolite, labradorite, tremolite.

Texture. Very coarse, inequigranular, xenomorphic. The felspar shows a tendency to be tabular; actinolite is anhedral, tending to be fibrous. Tremolite occurs as finely fibrous clots interstitial between plagioclase grains. Small amounts of the mineral are intergrown with the feldspar. Quartz was not noted in the section available.

129 (i) Mambare River, w. of P.125.

Uralitized bytownite gabbro.

Mineralogy. Bytownite An_{75}, slightly kaolinized, augite, actinolite, hornblende (olive-green), accessory apatite. Black iron ore, nontronite (?), and zeolite (natrolite(?)).

Texture. Coarse-medium grained, hypidiomorphic-xenomorphic, granular with occasional phenocrysts. Felspar is anhedral-subhedral, show some tendency to be tabular; some grains are zoned. Actinolite and green hornblende occur replacing augite; very often all that is seen of augite is a few grains within a hornblende crystal or enclosed in fibres of actinolite. Hornblende also occurs as a previously crystallized mineral, and is interstitial and poikilitic. Black iron ore occurs as irregular grains, often associated with hornblende.

Commonly actinolite is seen to be surrounded by a thick envelope of a large crystal of hornblende, i.e. a hornblende crystal has a core of fibrous actinolite, indicating that the fibrous material probably replaced augite, whereas the outer shell of hornblende crystallized directly from the magma.

Nontronite occurs as radial fibres, along with small, interlocking prismatic crystals of (?)natrolite in an interstitial position between plagioclase crystals.

P129 (ii) Mambare River, W. of P.125.

Eucrite or Olivine-anorthite gabbro.

Mineralogy. Augite, anorthite, An_{90-95}, olivine (chrysolite), enstatite, tremolite and actinolite, replacing augite. Accessory black iron ore occurring along the cracks in olivine, serpentine, altering from olivine; clinozoisite; kaolin; bowlingite.

Texture. Coarse-medium grained, hypidiomorphic, granular, with occasional phenocrysts. Feldspar is anhedral to subhedral, tending to be tabular. Augite shows rather similar characteristics. Olivine is anhedral, forming rather irregularly shaped grains, possibly due to resorption. Actinolite and tremolite replace augite, though in relatively minor quantities. Black iron ore is associated with olivine, as is serpentine. Clinozoisite and kaolin attach feldspar only slightly.

Enstatite occurs as the only phenocryst. It forms a very large, irregular crystal, enclosing small grains of augite, and is embayed by plagioclase. It is uralitized and serpentized along cracks. Bowlingite replaces olivine; sometimes whole crystals are replaced.

P130 (i) "Fine-grained basic intrusive" Mambare River, western limit of traverse.

Uralitized fine-grained dolerite.

Mineralogy. Labradorite (An_{58}), hornblende, accessory black iron ore.

Texture. Fine grained, slightly porphyritic, somewhat doleritic. Feldspar occurs as subhedral tabular laths, with rather crenulate margins. The laths show a tendency to criss-cross and radial arrangements. Hornblende tends to be acicular, though a few pseudomorphs after pyroxene are seen. The porphyrocrysts consist of acicular hornblende, and rare euhedra of feldspar.

Black iron ore forms irregular granules scattered throughout the rock. This rock is similar to P122 in having the mineral assemblage plagioclase-hornblende, but is coarser-grained. The hornblende in this specimen has a deeper green colour, and the feldspar is slightly more basic.

P130 (ii) Slightly coarser basic rock intruded by (i).

Altered granulitic norite.

Mineralogy. Labradorite (An_{55}), altered hypersthene (and hypersthene), augite and pigeonite, tremolite and actinolite, fibrous, replacing augite.

Accessory bastite black iron ore, hydrated iron oxide, chlorite.

Texture. Medium-grained granulitic pyroxenes, tending to be glomeroporphyritic, with a slight preferred orientation of the longer axes of the grains, and also of the albite twin lamellae of the labradorite. This mineral is anhedral forming rounded grains. Former grains of hypersthene have been replaced by fine-grained (?) talc and subordinate bastite; very little hypersthene remains. Augite and pigeonite are, in places, replaced by actinolite and tremolite. Black iron ore forms irregular grains in the groundmass, and is also associated with the ferro-magnesian minerals, as is hydrated iron oxide.

The hypersthene remains as relict grains within a mass of bastite and "talc". The latter minerals forms extremely fine flakes which are colourless, and which have high birefringence. They appear to be aligned parallel to the original cleavage of the hypersthene. The mineral has a slightly higher refractive index than bastite and chlorite. It may possibly be talc, which is a rare alteration produce of orthopyroxene. Chlorite occurs in very thin veins cutting across felspar at right angles to the preferred orientation.

The rock is obviously of a gabbroic type. The origin of its present form is open to a doubt. Actinolite rimming augite, and remnants of hypersthene and bastite remaining in an area of "talc", together with the prevalence of lamellar twinning in felspar, with a little zoning, all suggest a magmatic origin for the rock: if the preferred orientation is taken as magmatic, this suggests that the gabbro was intruded as a partially solidified mass. However, if this was so, then one might expect to see straining and granulation of crystals, especially the felspar , where the twin lamellae would be bent and fractured; in fact, this is absent. Hence the alternative presents itself, i.e. that it is a fairly high grade pyroxene granulite which has suffered some retrograde metamorphism, involving the introduction of hydroxyl minerals. The texture of the rock suggests that it is a pyroxene-plagioclase granulite derived from a basic igneous rock, but the presence of pigeonite and of good albite twinning in plagioclase preclude this possibility (cf. specimen P92(i).

P136 (i) "Fine-grained basic intrusive", Sisa Creek gorge, near Sisa-Diwor junction.

Chloritized and epidotized quartz dolerite.

Mineralogy. Intermediate - basic plagioclase, rather badly kaolinized; chlorite, pseudomorphing amphibole; epidote, pseudomorphing amphibole; quartz; black iron ore; calcite veinlet.

Texture. Fine-grained, hypidiomorphic, sparsely porphyritic. Felspar is in the form of lean laths; these are faintly radially arranged. Chlorite and epidote pseudomorph porbable amphibole as acicular crystals. The phenocrysts are now composed of epidote, but some of them show pyroxene-like basal section shapes. Quartz occurs as interstitial and poikilitic crystals. There is some doubt about the exact identity of this rock, but it appears to have been originally a fine-grained quartz dolerite.

P136(ii) "Coarse-grained basic rock". Sisa Creek Gorge, near Sisa-Diwor junction.

Granophyric Granodiorite, probably a differentiate from a basic rock.

Mineralogy. Quartz 15%; (?)andesine 35%(?); orthoclase 15%(?); actinolite 25%; accessory black iron

ore, kaolin, sericite, epidote, apatite.

Texture. Coarse-grained, hypidiomorphic, inequigranular, partly myrmekitic and suggestively doleritic in part. Pale green actinolite is prismatic, though interstitial to euhedral plagioclase. It tends to be rather fibrous, especially in the crystal centres. Plagioclase is euhedral, tabular; it is patchily kaolinized, with occasional flakes of sericite, and is, in places, surrounded by extensive growths of micropegmatite and/or myrmekite. Some crystals appear to have been altered wholly to epidote. Orthoclase is interstitial and poikilitic, anhedral in habit: only a small amount remains, as much appears to have been converted to a myrmekitic innergrowth of quartz and plagioclase. Where this has happened, and where the original orthoclase neighboured or surrounded plagioclase, the latter's margin has been corroded and fretted. Quartz occurs as interstitial, subpoikilitic grains.

The myrmekitization appears also to have affected one of the plagioclase crystals, as blobs and plumose structures of quartz appear in a belt across this grain.

The alteration processes appear in irregular area in this section: one area may be relatively unaltered, with fresh plagioclase, etc. In another area all the feldspars may be extensively kaolinized. Again, in yet another area, epidotization of feldspar has taken place. All these alterations, together with the myrmekitization of orthoclase, suggest extensive later stage alteration by magmatic fluids. The rock appears to be a granophyric "granodiorite", and is almost certainly an acid differentiate from a basic magma. The percentages of amphibole is too high for a granodiorite, and, in any case, it appears to have been formed by a process of uralitization. The distribution of the plagioclase is, in places, very suggestive of that seen in dolerite. The rock as a whole is reminiscent of granophyric differentiates from dolerite and/or gabbro which have been found in South Alligator and Davenport Range areas of the Northern Territory. These have been discussed with Professor F. Walker, late of Capetown, and he agrees that they are almost certainly derived from dolerite or gabbro.

P138 "Medium grained basic rock".
Uralitized dolerite.

Mineralogy. Andesine 45%, zoned with labradorite at the core and oligoclase at the edge, actinolite 40%, quartz 5-10%, augite 5%. Accessory black iron ore, kaolin and sericite.

Texture. Medium to coarse-grained, hypidiomorphic, equigranular doleritic. Plagioclase is subhedral-euhedral, forming tabular crystals. Actinolite is fibrous to prismatic, replacing augite, and filling interstitial positions: it sometimes occurs in veins cutting across felspar, and also as small fibres included in feldspar. Some plagioclase crystals which are partially enclosed in fibrous actinolite show corroded and fretted margins. Only a very small amount of augite remains, included as irregular grains within actinolite. Black iron ore, possibly ilmenite, is associated with the ferromagnesian minerals. Quartz is interstitial and, in places, poikilitic.

P139 Basic Rocks from Itau Creek

1. Partially serpentized anorthite-bearing dunite.

Mineralogy. Chrysolite. Biaxial, 2V = C.90°. Birefringence

= 0.036. The alteration products of olivine are, firstly, a mineral which is pleochroic in light green and light yellow, with a very low birefringence, and whose R.I. is slightly higher than that of Canada balsam. It occupies cracks cutting across the olivine and appears to be in minute fibres whose direction is at right angles to the vein. This is taken to be chrysotile. Secondly, there is a very light green fibrous, or chlorite-like mineral occupying the spaces between olivine crystals, and corroding their margins. It has a rather higher birefringence than chrysotile; this mineral is antigorite. Magnetite is a byproduct of the serpentinization of olivine. Thirdly, intergranular actinolite is present in small amounts, it is pleochroic in light green, and has a birefringence of 0.021. Its extinction angle is 18°. Its habit is fibrous, though the fibres are thicker than those of antigorite. Only small amounts are present, again around the margins of olivine crystals.

Minor amounts of feldspar are present. It has albite and pericline twinning. Extinction angles on the former show a composition of An_{95}, anorthite. It has a biaxial negative, interference figure. The anorthite has thin irregular cracks which are filled with an opaque mineral.

Accessory black iron ore is present as euhedral "square" crystals. A little hydrated iron oxide occurs in some of the serpentine "veins" in olivine, where weathering of byproduct magnetite has taken place.

Texture. Coarse-grained, xenomorphic granular. Chrysolite forms coarse, anhedral crystals. Anorthite is present in minor quantities, less than 5%, and occupies interstitial spaces between the chrysolite crystals.

Chrysotile occupies cracks in olivine crystals. The cracks form a general mesh work in the rock, with some dominant direction of parallelism. The cracks also occur in anorthite, but in this mineral they are filled with an opaque substance, and have not been widened by alteration as in olivine. The rock is a partially serpentized anorthite-bearing dunite.

ii. This specimen is practically the same as (i), except that a small amount of calcite occurs occasionally in the intergranular spaces.

ii. Troctolite or allivalite (if plagioclase is anorthite).

Mineralogy. 70% chrysolite. Biaxial, 2V=C90°. Birefringence = 0.034. The alteration products of olivine are:

1. A brown, minutely fibrous mineral occupying the cracks. This mineral's birefringence is rather strong. Possibly xylotile.

ii. Some chrysotile is also present in the cracks as minute fibres. It is pleochroic in a very light green and has low birefringence.
8% tremolite, colourless, with amphibole-type prismatic cleavage. Length slow along the cleavage, 2 C = 22°. Birefringence = 0.021.
20% feldspar. Biaxial negative, with a 2V = C80-85. Albite and pericline twinning are present, but in the section they are rather indistinct, making extinction methods difficult. Composition is bytownite or anorthite.

Accessory black iron occurs as euhedral "square-shaped" grains: it also occurs as minute grains along the alteration cracks of olivine.

Texture. Coarse-grained, xenomorphic. Olivine occurs as large, anhedral grains with a mesh work of cracks along which serpentinization has taken place. Tremolite is interstitial about olivine. Felspar is also interstitial to olivine. Numerous cracks appear in the felspar, radial to the grains of olivine: these were caused by the expansion of olivine on alteration (in part) to serpentine.

This rock is very similar to specimens (i) and (iii) of P[illegible]9, and it is suggested that all three are differentiates from the same magma.

Report No. 7

170ACT/2
24th June, 1958.

PETROGRAPHIC EXAMINATION OF PYRITIC CORE FROM THE UPPER COTTER DAMSITE C.

By

W.B.Dallwitz.

Following is a brief description of a slightly pyritic core from D.D.H. 14 at 68', Upper Cotter Damsite C, submitted by L.C. Noakes.

Macroscopically the rock appears to be a slightly pyritic quartzite. Small striated cubes of pyrite are unevenly scattered through the rock, and the specimen is ironstained for a maximum depth of about 4 mm. where weathering has taken place along a joint. The pyrite is noticeably more concentrated in some places, and it seems probable that mineralization has taken place along cracks and/or joints. The overall percentage of pyrite is difficult to estimate satisfactorily, but appears to be considerably less than 1 per cent.

In thin section the rock is found to be made up of quartz (92%), chlorite (6%), and accessory leucoxene, hydrated iron oxide, pyrite, and zircon. Most of the quartz has been recrystallized as a mosaic of irregular to sutured grains, but some perfectly rounded detrital grains remain. Both the detrital and recrystallized quartz commonly show undulose extinction. The chlorite occurs as small irregular clots, parts of which show a radiating structure; this mineral is probably an alteration-product of biotite formed during thermal metamorphism.

The rock as a whole is similar to several others described from the vicinity of Upper Cotter Damsite C, and is a chloritic quartzite.

Report No. 8. 84/G/1

MINERALOGICAL REPORT ON URANIUM SPECIMEN FROM BLACKSAND CREEK, BULLER GORGE, NEW ZEALAND

By

W.M. B. Roberts.

The rock consists essentially of quartz - strongly fractured and with a slight but distinct gneissic texture - in a matrix of brown chlorite.

Accessory minerals, in approximate order of abundance are: hydrated iron oxides, chromite, chlorite (penninite), a sulphur-yellow uranium mineral, possibly ferghanite, garnet, tourmaline, ?sphene, muscovite and torbernite. Quartz, the major constituent, forms a mass of irregular grains ranging in size from 0.05 to 1.0 mm., having a mosaic texture and a distinct gneissic structure. The grains are strongly fractured, and all have an undulose extinction, the larger grains showing a strong development of strain shadows. The fracturing is very strong in one direction only; roughly 25° to the gneissic banding, and persists across grain boundaries and intervening chlorite matrix. The chlorite matrix itself takes the form of a fine grained mass of fairly uniform grainsize, plumose aggregates occurring in places.

The hydrated iron oxides occur as interstitial granular masses in the quartz grains, in places filling fractures in this mineral.

Chromite, which was picked out by hand from the crushed rock under the microscope, was identified by X-ray diffraction; in thin section it is difficult to distinguish from the hydrated iron oxides, both minerals being opaque except on thin edges, where they are both reddish-brown. However, some angular fragments, somewhat larger than the other granular opaque material, are probably the chromite. A test fluoride bead gave a slight positive result for uranium with this mineral.

The penninite forms typical feathery aggregates moulding quartz grains, the largest of these masses measures 1.5 mm. in length, and shows the anomalous purple-blue interference colours associated with this mineral.

The sulphur-yellow uranium mineral could not be detected in thin section, its colour probably being masked by that of the brown chlorite matrix. A very small fragment of the mineral was obtained by heavy liquid separation, and was X-rayed. The resultant pattern coincided with none of the patterns listed for the uranium minerals. The mineral gave a strong positive test for uranium with a fluoride bead, and is of a flaky habit. The diffraction pattern indicates that it has a two-dimensional structure, i.e. that it is not completely ordered in its atomic arrangement in the direction probably normal to the platy cleavage. The mineral does not fluoresce in ultra-violet light and a microchemical test for copper was negative. An X-ray spectrographic analysis of the rock showed the metallic constituents to be Fe, Mn, Ca, U, V, Cr, Zn, Pb, Ti and As in that order of abundance. The absence of copper in the mineral and the presence of vanadium in the rock suggests that the mineral may possibly be a uranium vanadate; a test for vanadium was inconclusive due

to the extremely small quantity available for test. Of the vanadates of uranium only two - ferghanite and fritzscherite have no X-ray powder data available, and in view of the fact that the diffraction pattern fits none of the other minerals and that fritzscherite is reddish in colour, it is possible that the mineral is ferghanite.

Isolated grains of a colourless mineral with a high relief and weak anisotropism occur throughout the section, one of these grains was a perfect section through a rhombic dodecahedral plane. These gave a uniaxial negative interference figure, and are probably garnet. The largest grain measures 1.0 mm. across and all have the irregular fracturing typical of this mineral.

Irregular masses of tourmaline ranging up to 1.0 mm. across are present, these mould the quartz grains, replace the chlorite matrix, and appear to have been formed at the same time as the penninite. One small almost colourless grain of a mineral having a high relief and a waxy appearance in reflected light, was thought to be sphene, although this identification is not positive.

Muscovite is a very minor constituent, occurring as small flakes ranging up to .15 mm. across.

A greenish mineral forming a small surface encrustation was identified by X-ray diffraction as torbernite.

An X-ray spectrographic analysis gave the uranium content of the rock as 0.14% U.

The rock is a sediment which has first been regionally metamorphosed to a rock probably consisting essentially of quartz, biotite, and garnet. The chromite was probably carried over from the original sediment largely unaltered. Subsequent retrogressive metamorphism has converted the biotite to brown chlorite. Following this change, tourmaline and chlorite (penninite) have been formed, possibly as a result of an intrusion of an acid rock. The tourmaline appears to have locally pseudomorphed the chloritic matrix.

It is likely that the uranium was introduced at this (pneumatolytic) stage, possibly even in its present form as the vanadate. Gruner has demonstrated the possibility that some of the so-called "secondary" uranium minerals can be formed under hydrothermal conditions, which could have applied in this case.

Report No. 9

84Q/3
June, 1958.

EXAMINATION OF SPECIMENS FROM THE 90 MILE MINE, GREENVALE, NORTH QUEENSLAND DISTRICT

By
W.M.B. Roberts.

Seven specimens submitted by D.A. White were examined to identify the mineral assemblage and to obtain some idea of the geological history of the ore deposit.

They are all from the oxidised zone, but no locations for individual specimens were given.

Specimen No. 1.

A pinkish-red very friable material forms the bulk of this section, which contains small areas of native copper measuring up to 1.0 mm. across. The principal opaque mineral is hydrated iron-oxide which forms large irregular veins and lenses having a sub-parallel arrangement. In places well-developed cubic pseudomorphs consisting of this mineral are formed, but whether these were originally pyrite or magnetic could not be determined.

Specimen No. 2.

A compact reddish-brown rock containing a large quantity of sulphide. In thin section the rock is seen to be a strongly altered breccia, in which the angular fragments have been completely replaced by fine-grained calcite and blue chalcocite, the latter mineral forming rims around the calcite. The fragments are fairly uniform in size, the largest measuring 0.15 mm. across, and are set in a matrix of hydrated iron oxide.

Quartz forms large irregular masses measuring up to 2.0 mm. in length which are cut by numerous calcite veins; calcite also occurs as fairly large irregular areas throughout the section. Associated with the quartz are very minute masses of either talc or sericite.

The ore minerals are pyrite and blue chalcocite. Pyrite forms small rounded strongly fractured masses which have been recemented by blue chalcocite. These small masses are distributed fairly evenly throughout the section, which is also cut by veins of shattered pyrite, ranging up to 0.6 mm. in width, which have also been extensively fractured and replaced by the chalcocite. The calcite veins have, with the exception of a few interconnecting veinlets, a parallel disposition, imparting to the rock a schistose texture which is at right angles to the veins of sulphide.

Specimen No. 3.

The principal opaque mineral in this section is blue chalcocite; it forms irregular areas intimately associated with calcite and has altered extensively to covellite. The chalcocite masses contain small areas of chalcopyrite which are apparently unaltered residuals of what was once all chalcopyrite.

Pyrite, the next most abundant mineral, forms irregular masses and euhedral crystals measuring up to 0.5 mm. across; these have been extensively fractured and are partly altered to hydrated iron-oxide.

The principal gangue minerals, as far as could be determined from the polished section, are crushed quartz (recemented by blue chalcocite) and calcite which is associated with the chalcocite.

Specimen No. 4.

The specimen is a fairly hard earthy black rock containing some disseminated pyrite. Pyrite is the principal ore mineral, occurring mainly as veins measuring up to 1.5 mm. across, and having a roughly parallel arrangement, the veins have been strongly fractured. The pyrite has a strong anomalous anisotropism and contains large irregular grains of marcasite measuring up to 0.6 mm. across. A lesser quantity of pyrite is distributed throughout the section as irregular areas, associated with which is a mineral having a slightly lower relief and reflectivity and a somewhat greyish tinge as compared with pyrite. At extremely high magnificactions this was shown to be a very severely crushed mineral, the measured average grainsize of which is about 0.001 mm. These small grains are recemented by some other mineral into what appears as a solid mineral at lower magnifications. X-ray diffraction photos showed that the "mineral" is pyrite recemented with blue chalcocite. Covellite and some blue chalcocite are widely disseminated as small irregular blebs in calcite. Chalcocite also forms large veins ranging up to 1.0 mm. in width, parts of which are altered to covellite, and it recements the fractured pyrite - in fact the largest amount of mineral is associated with pyrite in this way. Chalcopyrite has a very sporadic occurrence as small irregular remnants in the blue chalcocite mass.

Specimen No. 5.

In hand specimen this rock is similar to Specimen No. 2. It is seen to consist of small areas of shattered pyrite recemented by blue chalcocite. The rock itself is an altered breccia, nothing remaining of the original constituents. Angular replacement bodies of fine-grained calcite with veins of chalcocite are the only evidence of its original cataclastic nature. These bodies measure up to 0.15 mm. across, and are set in a matrix of hydrated iron oxide which appears to have formed from the material in the fragments as veins which have coalesced into a semi-solid mass. The section is cut by calcite veins, some showing comb-structure, and contains irregular areas and subhedral crystals of quartz, this mineral having no signs of fracturing or any other evidence of stressing. It moulds the angular replacement calcite bodies and obviously has been introduced at the same or nearly the same time as the calcite.

Specimen No. 7.

A specimen of very oxidised ore containing large veins of cuprite altered extensively to malachite. Cuprite is the principal ore mineral in the specimen; it forms large veins consisting of coarsely granular aggregates which are bordered by colloform tenorite. Small veins of native copper are present in the cuprite veins.

Some hydrated iron oxide is present principally as irregular borders to the cuprite - tenorite masses, which have well developed colloform malachite formed along their boundaries.

Owing to the extensive oxidation the relationship of the gangue minerals was difficult to determine; however the principal minerals are colourless chlorite, a mineral resembling sericite, and quartz; the last-named mineral occurs both as

strongly fractured aggregates and as large fine-grained recrystallised masses.

Discussion

Very little of the history of the deposit can be gained from such oxidized specimens as were examined, but it is evident that pyrite is the earliest deposited of the sulphide minerals. Two generations could be observed, the first probably emplaced very early during, and before, the first period of deformation, and now represented by the extremely finely ground material identified by X-ray diffraction. The second generation is represented by the numerous veins having a parallel disposition, and the irregular areas cutting across this fine material. These veins have in turn been extensively fractured and subsequently recemented by copper sulphide.

The time relationships of these copper sulphides is rather obscure and examination of specimens from the primary zone would give a clearer picture. It appears that there is some relationship between blue chalcocite and the calcite gangue with which it is commonly associated. The residuals of chalcopyrite in the blue chalcocite recementing the shattered pyrite suggest that this was the original mineral, and that some of the blue chalcocite is its alteration product - this could be clarified by examination of specimens from the primary zone.

Quartz has been introduced during the period of copper sulphide mineralisation and some time before the introduction of calcite, as shown by the veining of quartz masses by calcite. A rough diagrammatic representation of the sequence of events would be -

Pyrite	shearing	PRIMARY
Pyrite	shearing	
Chalcopyrite Chalcocite ?		
Quartz		
Calcite & Chalcocite		
Alteration of Chalcopyrite to Chalcocite		SECONDARY
" " Chalcocite to Covellite		
" " Copper sulphides to Copper oxides		
" " Copper oxides to Carbonates		