COMMONWEALTH OF AUSTRALIA.

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QUARTERLY REPORT OF PETROGRAPHIC AND MINERAGRAPHIC WORK FOR THE PERIOD JULY - SEPTEMBER, 1958.

Compiled by

W.R. Morgan.

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INTRODUCTION

This Record consists of a collection of reports completed by the petrographic and mineragraphic personnel of the Bureau Laboratory during the period July to September, 1958. The reports have been placed in chronological order, and each one has its date of completion, and the relevant file number above its heading.

The Geological Officers responsible for these reports are: W.B. Dallwitz (Senior Geologist), W.M.B. Roberts (Geologist, Grade 3), and W.R. Morgan (Geologist, Grade 1). Mr. Roberts is in charge of X-ray and mineragraphic work; Messrs Dallwitz and Morgan deal with general petrographic problems; Morgan is also responsible for beach sand analyses.

The majority of the reports need no elaboration. Those such as Nos.1 and 5, which were written in the form of letters have been slightly altered and given a title. It is worth noting that Report 6 on rocks collected during the Mambare River Survey, T.P.N.G., is additional to a larger report on specimens from the same area written by Dallwitz and Morgan, which will be included in the Record for the period immediately preceding this one (Records 1959 in.prep.) Report 8 is intended by Mr.Dallwitz as a guide to those interested in granite sampling for age-determination purposes.

84G/7. 17th July, 1958.

1. ANALYSIS OF BEACH SAND, RESIDUE DUMP MATERIAL, AND ELECTOSTATIC TAILINGS, RECEIVED FROM CABLE (1956), LTD., W.A.

by

W.R. Morgan

Three sand samples were received from Cable (1956), Ltd., Perth, W.A., for analysis. Table I shows the results of combined heavy liquid - magnetic separation and grain count analyses of these samples. The results are expressed as weight percentage of minerals present in the heavy fraction of the liquid separation.

TABLE I

Sample	Composition of heavy mineral concentrates.					
	Ilmenite	Zircon	Monazite.	Rutile	Other Minerals	Weight % heavy minerals.
Original Sand	85.0	4.1	1.0	0.7	9.2	67.9
Residue dump	51.8	17.0	2.2	2.4	26.6	25.1
Electrostatic tailings.	77.6	0.4	1.0	0.2	20.8	99.0

Percentages of individual "other minerals" were determined only for the sample from the residue dump, and they are: garnet 6.9; hornblende 6.6; magnetite 4.0; epidote 3.1; leucoxene 2.3; staurolite 0.8; kyanite 0.7; pyroxene 0.5; calcite 0.4; clinozoisite 0.4; tourmaline 0.3; spinel 0.2; quartz 0.2; biotite 0.1; glass 0.1.

Grains of "other minerals" were individually counted for the other two samples, but percentages were not worked out; presumably the proportions of the individual minerals would be similar to those determined for the residue dump.

A monazite concentrate was obtained, having the following composition: monazite 90.8; zircon 4.6; ilmenite 2.2; rutile 0.4; and "other minerals 2.0. This sample was given to the Senior Chemist for determination of the Rare Earth and Thorium content of the monazite.

63PNG/1 7th July, 1958.

2. SPECIMENS OF NICKELIFEROUS ROCKS FROM NORMANBY ISLAND, T.P.N.G.

by

W.M.B. Roberts and W.B. Dallwitz.

Following is a report on specimens P190 and P191 from Normanby Island.

Specimen P190 (Slide Number 3690) resembles closely a dark grey volcanic glass (pitchstone), and has a conchoidal fracture. It contains a spongy meshwork of fine-grained sulphide.

In thin section the rock is found to consist mainly of opal and sulphide. Structures remaining in the opal clearly show that the rock was formerly a serpentine, and that this serpentine was probably derived from olivine. In other words, the rock can be genetically referred to as an opalized, sulphide-bearing serpentinized dunite.

Books of talc and a few grains of red-brown chromite are scattered through the slide. Fine-grained doubly-refracting material, possibly talc, forms abundant inclusions in the opal in places. The structures referred to in the previous paragraph pseudomorph a serpentine which consisted of antigorite veined by chrysotile. The veinlets of chrysotile have been replaced by more or less clear opal, whereas the antigorite has been made over to murky brownish opal. Black iron ore, probably magnetite (which is a common by-product of serpentinization), is associated with the clear opal replacing former chrysotile veins.

The polished section showed the following opaque minerals to be present: marcasite, pyrite and chromite; magnetite is also present, but cannot be detected under the microscope because of its extremely fine grainsize.

Chromite forms euhedral and subhedral crystals ranging up to 2 mm. in length which have been fractured and later recemented by marcasite. The crystals are almost always surrounded by a "halo" of marcasite, which, although obviously later in origin, is not replacing the earlier chromite.

The marcasite itself is present mainly as spongy masses through which irregular veins of coarser grained marcasite are emplaced. These veins are clearly controlled by a well developed jointing in the rock which has two directi roughly at 60° to each other. The spongy masses themselves represent a diffusion outwards from these mineralising channels.

Pyrite occurs in the same manner as marcasite although much less abundantly, forming spongy masses as well as diffusion textures resembling liesegang rings. This mineral appears to be moulding irregular granular areas of marcasite, but the evidence is not sufficient to state that it is of later origin.

Specimen P191 (slide number 3689) is a dark grey, chalcedonic rock containing sulphide. Marginally the rock has been stained brown and red through weathering of iron sulphide.

In thin section the rock is found to consist of chalcedony, sulphide, and fine-grained black, opaque material (magnetite - see below). Veinlets of coarser chalcedony traverse the slide; these may contain brown chalcedony showing distinct spherulitic structure. Brown chalcedony in small clots is also scattered through the main body of the rock.

This specimen is more thoroughly altered than is No.P190; none of the talc remains, and all reliable signs of former serpentinous structure have been obliterated; nevertheless, there can be little doubt that the rock is simply more highly altered and silicified material than that represented by specimen P190. The likelihood of its derivation from dunite and serpentine is strengthened by the presence of chromite, which was noted in polished section.

The opaque minerals, determined in polished section are the same as for specimen P190, although far less sulphide is present.

Marcasite is the principal sulphide, forming irregular thread-like veinlets having a random arrangement and distribution; sponge-like areas, as are common in specimen 190, are not present in this specimen.

Pyrite forms irregular masses composed of euhedral crystals .001 mm. across which are only visible at extreme magnification. Chromite occurs as in specimen P190, but to a slightly lesser extent, the largest crystal measuring 0.15 mm. across.

Magnetite, although quite abundant, could not be identified microscopically because of its extremely finely divided state.

The source of nickel.

The sulphides of both rocks were tested microchemically for nickel, and all gave a negative result.

The polished sections were analysed in the X-ray fluorescence spectrograph and the presence of nickel was verified.

The finely-divided magnetite was not apparent as such under the microscope, and was only identified by its behaviour when the finely crushed rock from specimen P191 was probed with a magnet. Sufficient magnetite was separated to test microchemically with dimethyl glyoxime; a strong positive result for nickel was obtained.

These rocks have been formed by serpentinisation and subsequent silicification of dunite, and it is fairly certain that the dusty magnetite is a by-product of the serpentinisation (see above). The magnetite has picked up nickel present in the original olivine during its alteration to serpentine.

Nickelian magnetite has been recorded in the literature.

66PNG/1 29th July, 1958

3. AN EXAMINATION OF BEACH SAND SAMPLES P192, P193, AND P194, T.P.N.G.

by

W.R. Morgan

Samples P192 (Mouth of the Gira River), P193, (Mouth of the Mambare River), and P194 (Douglas Harbour), all from the Northern Districts of Papua, were received for examination in a search for chromite. A rough estimate only of the mineral content was made, after separation by electromagnet and heavy liquids, as little of economic interest was seen in the samples. Specimens P192, and P193 were found to be largely similar, hence estimates for P193 only were made. The results are shown in Table II.

TABLE II

The mineralogical compositions of specimens P193 and P194.

P.193.		P.194.	
Rutile	0.3	Ilmenite	0.5
Zircon	0.1	Zircon	0.1
Monazite	Trace	Chromite	0.1
Ilmenite	Not detected	Monazite	Trace
Chromite	Not detected	Rutile	Trace
Quartz	43.6	Pyroxene (very dark green to pale green).	92.1
Chlorite	26.9		
Muscovite	21.7	Calcite	2.9
Felspar	1.9	Magnetite	1.3
Limonite	1.9	Leucoxene	1.3
Leucoxene	1.1	Hornblende	0.8
Hornblende	0.9	Quartz	0.4
Epidote	0.6	Haematite	0.2
Soda Tremolite	0.5	Pyrite	0.1
Magnetite	0.3	Epidote	0.1
Garnet	0.2	Unknown	0.1
Staurolite	Trace	Chlorite	Trace
	100.0		100.0

The magnetite of specimens P192 and P193 occurs in composite grains, with, usually, quartz, but sometimes with hornblende or chlorite.

139G/1 29th July, 1958

4. THE PETROGRAPHY OF SIX SPECIMENS FROM COPPER HILL, MOLONG, N.S.W.

by

W.R. Morgan

Six specimens were collected by Mr.J.W.Horsfield from outcrops on his property - "Tyneham", Copper Hill - and were sent to the Bureau laboratory for petrographical description. The hand specimens and thin sections were returned to Mr.Horsfield. The following is the result of the investigation.

I. Hand Specimen

This rock is dark grey, speckled with white. It contains dark angular fragments up to 5 mm. in length cemented by a lighter grey-green groundmass. Smaller fragments of angular grains of felspar are present, and a few even smaller reddish grains may occasionally be seen. It has the appearance of being an agglomerate.

Thin Section

The dark fragments of the hand specimen are seen in section to consist of fine-grained porphyritic andesite; the minerals of this rock, in the groundmass are microlites of felspar (andesine), and interstitial green chlorite; occasional phenocrysts of felspar, again andesine, occur; phenocrysts of augite are also present. Some accessory iron ore, in minor quantities only, may be seen. In texture the andesite fragments show that the andesine microlites have a lean, tabular shape, and collectively have a flow texture, i.e., all the little tabular crystals are arranged so that their longer axes are roughly parallel to each other; since this is believed to be a result of the flow of lava, it is termed flow texture. The presence of phenocrysts tells us that the rock is "porphyritic", i.e., a fine-grained groundmass is present, studded with much larger crystals - in this case, of andesine (felspar) and augite.

Other fragments in the rock consist of single crystals of augite, and andesine or oligoclase (both the latter are plagioclase felspars). These single crystals are often fractured showing broken, angular edges. The felspar is often partly altered to kaolin, and slightly to sericite, both of which are hydrous (or water-bearing) alumino-silicates to which felspar alters by the chemical action of alkali or acidic water - this may be groundwater, or hot solutions produced at the end of the crystallization of a magma. Some epidote, formed in a similar way, may also be found altering from felspar.

Other evidence of the existence of these hot solutions may be seen in the section. A few of the lava (andesite) fragments contain rounded cavities (amygdales), filled, however, with green chlorite towards their centre, and with a shell of colourless prehnite surrounding the chlorite. These amygdales are formed in lava by hot solutions becoming gaseous when lava is erupted: the pressure of the gas is sufficient to form a rounded cavity - an extreme of this kind of thing is

pumice stone, which is merely an amygdaloidal lava without any minerals filling the cavities. Prehnite and chlorite are hydrous silicate minerals which are deposited from these solutionsl Prehnite also occasionally occupies other less regular cavities.

Augite is very often altered to chlorite, again by these solutions, and in this rock a few grains of augite have been altered in this way, forming prismatic crystals consisting of masses of little green chlorite crystals, "pseudomorphing" the older mineral.

Very thin veins of prehnite occur in cracks in the rock, showing that even after the rock was formed, hot solutions were still circulating in it, depositing this mineral. This mineral has grey to yellow interference colour.

It is possible that the fragments of lava contained in the rock were not quite solidified on deposition, since some of them show signs of being indented by surrounding fragments.

Calcite (Calcium Carbonate), which is colourless and has cleavage in three directions, occurs in irregular grains, and occasionally in veins, in the rock. This mineral may have been deposited by the hot solutions, or may have been formed from circulating groundwater in the rocks; this very often happens, especially in places which have rocks containing a fai amount of lime, as there may well be in this area.

In conclusion, then, it may be said that this specimen is an agglomerate, composed of fragments of lava, and of single, fractured crystals.

II. Hand Specimen

The rock is fairly fine-grained, and has a dark mottled green and pink appearance. The whole is traversed by irregular veins of faintly pink calcite, the veins ranging in thickness between 1 and 3 millimetres.

Thin Section

The section may be described in two parts: firstly, the greenish, chloritic material which is present; and secondly, the light coloured, calcite areas.

Firstly, the chloritic areas. On close examination, with a higher-powered objective lens, this material shows itself to be an extremely fine-grained, porphyritic lava. Within this lava, small phenocrysts of kaolinized felspar occur showing good crystal shape, though they are now so strongly altered that they defy identification by optical methods. Also occurring as phenocrysts are small, prismatic areas of green chlorite, possibly pseudomorphing augite. The fine-grained groundmass consists of tiny microlites of tabular felspar, with some interstitially placed chlorite and black iron ore. Small amygdales are also filled with calcite - this mineral occurs as a single crystal in any one amygdale, not as an aggregate: however, reddish dust of hydrated iron oxide occurs throughout the calcite, but is concentrated in patches, and towards the borders of the amygdales.

Secondly, is the area of calcite. This mineral is predominant in these areas and occurs mostly as small, granular crystals except in a zone 1.2 to 1.5 mm. thick, around the areas of lava, where large crystals, up to a millimetre in size occur. In the fine-grained calcite, small irregular masses of hydrated iron oxide occur, with no special relationships to the calcite or lava. But in the coarse-grained calcite the reddish to black hydrated iron oxide shows a "botriyoidal" structure, i.e., concentric layering with the convex surfaces pointing away from the lava. The impression is given of a series of segments of concentric circles along the edge of the lava. In some cases the circle segments appear to be centred on a small area of chlorite, or iron oxide. This suggests diffusion of iron oxide from the lava into the calcite, spreading outwards from the centre of the circles (i.e. if the circles were full, instead of being segments), in the manner of ink spreading from a central spot on a blotting paper.

Therefore we have a lava, traversed by veins of calcite, with diffusion of iron oxide from the lava into the calcite. Whether or not the lava was fragmented, i.e. an agglomerate, before the emplacing of the veins, cannot be told from this section.

III Hand specimen

A green-coloured, fine-grained rock consisting mostly of epidote (the green mineral), with some milky quqrtz occurring usually as very thin veins. At one part of the specimen is a rather more thick quartz vein (up to 10 mm. thick) opening out into the remains of a vug in which some fairly well formed prismatic crystals of quartz, with pyramidal terminations directed towards the interior of the cavity.

Thin Section:

Under the microscope the rock is seen to consist mostly of an aggregate of fine-grained, granular crystals of yellow epidote, the crystals being 0.03 mm. in size. The interference colours of epidote range from grey, through blue and green, to bright orange. They became rather more coarse at one end of the section. Veins of more coarse epidote occur, as sub-tabular crystals of up to 0.1 mm. in size. These veins may be seen to be displaced by a millimetre or two by micro-faults.

Veins of colourless quartz are present in two forms:- Firstly as rather irregular "schlieren", i.e., elongated clots. The epidote grains become more coarse near these clots. Secondly as more straight veins, often rather more thin than the finest type. Sometimes they appear to have replaced, or crystallized with, vein epidote (described above). The quartz in both types of veins is only slightly cracked, shows no strained extinction, and is mostly clear of inclusions, though some very fine opaque dust does occur in places. Near an edge of the section, the epidote grades quite suddenly into a material consisting of about 40% epidote and 60% felspar and quartz. The epidote forms rather irregular grains, and is faint yellow, having high relief. Felspar occurs as rather tabular crystals, with irregular margins, and shows twinning. Quartz occurs as very small, highly irregular crystals. It is possible that this material is the remains of a lava, with some of its mineral altered to epidote.

Thus, this rock is, in the main, an epidote quartz rock, with a small patch of lava. Epidote and quartz often occur as veins in or near rocks of volcanic or platonic origin, and are the result of crystallization of the late liquids of magmas.

IV. Hand Specimen.

The rock is dark, basic, medium-grained and igneous, It contains pyroxene (i.e. augite, the dark mineral) with some biotite, and white felspar. It is fairly equigranular, the pyroxene tending to be prismatic in form, and the felspar is tabular.

Thin Section.

The rock is medium-grained and idiomorphic (i.e., all the minerals showing fairly good crystal shape). The felspar is mostly labradorite, this mineral forming colourless subhedral, tabular crystals, which sometimes interfere with one another's growth. Albite and Carlsbad twinning is present in the labradorite, and its refractive index is greater than that of Canada Balsam (i.e., the material used to stick the rockslice to the slide); measurement of extinction angles on carlsbad twinning shows a composition of An 61 (61% of the anorthite molecule). Its interference colours are shades of grey. Augite is colourless, and forms subhedral, prismatic crystals. It may be identified by its higher relief than that of felspar, and by the good cleavage, shown in one direction on vertical sections, and in two directions, at right angles to one another, on basal sections. Length slow, the inclination of optic axis Z to the crystallographic axis C is 46°. Birefringence is 0.024, i.e., interference colours range from grey to green. It is biaxial positive, $ZV=c50^{\circ}$. Augite often shows slight alteration to green hornblende on its margins, a thin film of this mineral being present. It, however, seems more often to have altered to biotite, a dark mica which is pleochroic from nearly black to light fawn. As well as altering from augite, the biotite crystals have also extended themselves, and formed new crystals by straight out crystallization from the magma. It is very often to be seen interstitial to, or enclosing, labradorite crystals. Another type of pyroxene is present - hypersthene. This one may appear to be similar to augite, but in fact the optic axis Z is parallel to the crystallographic axis C, i.e. there is parallel extinction. The birefringence is also lower, i.e. 0.011, i.e., interference colours are grey to yellow. This mineral is, in this section, largely altered to bastite, a type of serpentine, However, where it is not altered, a very faint pleochroism from colourless to faint pink may be seen.

Another kind of felspar also occurs - orthoclase. This is characterized by a lower refractive index than that of canada balsam, and a biaxial negative figure with $2V=c.80^{\circ}$. Orthoclase forms anhedral crystals which are interstitial to, and very often totally enclose all, the other minerals. Where orthoclase borders plagioclase, an intergrowth called 'myrmekite' structure may sometimes be seen.

A little quartz is also present, interstitially.

Black iron ore forms subhedral, opaque, "squarish" grains in the groundmass. It sometimes has a reaction rim of biotite. Other black iron ore may be found as granules associated with augite, hypersthene, and biotite.

Accessory apatite occurs as minute acicular (needle-like)prisms enclosed within felspar. Some kaolin dust occurs in patches in labradorite, as a result of slight alteration of that mineral.

The rock, from all its characters listed above, is a dolerite, a type very similar to basalt, only of rather larger grain size. Dolerites (and basalts) are widely occurring rocks, examples of the type occurring in almost all the countries of the world.

V. Hand Specimen.

A white-coloured rock of fine to medium grain size, composed in the main of felspar and quartz, with some small aggregates of green epidote, and very thin veins of that mineral cutting the specimen. One side of the specimen has a thin layer of epidote: this is, in fact, a vein along which the specimen has been broken. A few, widely separated, crystals of a brown mineral also occur.

Thin Section:

The rock is fine-grained, and wholly crystalline, with a slight porphyritic texture, the groundmass crystals being about 0.06 mm. in size, and the phenocrysts are 0.18 mm. in size.

The groundmass is allotriomorphic (i.e., the grains have no crystal shape). It consists mostly of quartz and albite slightly altered to kaolin. The albite's refractive index is slightly lower than that of canada balsam, while it is biaxial positive, with a $2V=c,75^{0}$. Albite twinning is present. Albite forms anhedral to subhedral grains showing a rather irregular tabular shape, with crenulate margins. Quartz, which is present in rather less quantity than albite, is present as very irregular grains with crenulate margins.

The phenocrysts consist of albite and quartz. Albite forms euhedral, tabular crystals. Quartz forms somewhat rounded and cracked grains.

Epidote, with high relief, and a pale yellow colour, is present in the groundmass as irregular granules occurring as clots. In one or two small openings, possibly amygdales, zeolite occurs, a mineral with low relief and whose refractive index is less than that of Canada balsam. Zeolites are alumino-silicates which crystallize at a late stage from a magma; they are commonly formed by alteration of felspar.

Kaolin forms a thin dusty appearance on the albite crystals, and is also the opaque mineral which traces the borders, and sometimes the cleavage planes, of that mineral. A few wisps of yellowish nontronite occur in the groundmass, it has a low relief than epidote, and appears to be more dusty. This mineral is normally an alteration product of biotite.

Some rather irregular quartz veins are present: they are extremely thin, and appear to connect quartz-rich zones in the rock. The quartz in these zones has similar textural characteristics to the quartz elsewhere in the slides: however, in the centres of the zones are holes in the slide, which, in places, contain the remains of zeolite, which have been all but pulled out during the manufacture of the slide. It is suggested that the quartz crystallized rather later than albite, and, in fact concentrated in areas around incipient amygdales, where the zeolite later crystallized.

The rock is a porphyritic rhyolite. Rhyolites are the fine-grained lava equivalent of granites, both being mineralogically, and chemically similar. The difference between the two lies in their respective cooling histories, reflected in the widely differing textures of the two types.

VI. Hand Specimen

A coarse-grained, very inequigranular rock, composed mainly of greenish coarse crystals (0.1-2mm.) of epidote. Some crystals of white and colourless quartz are present. This quartz-epidote mass encloses several large angular fragments 6 mm. x 15 mm. of a very fine-grained, pink quartz material. Numerous cavities are present in the specimen, occasionally giving it the appearance of a pumaceous lava, although this is not what it is. Some of these cavities show well formed prisms of colourless quartz, with pyramidal terminations directed towards the interior of the cavities.

Thin Section:

In section, the quartz-epidote mass is coarse-grained and fairly inequigranular, and is hypidiomorphic (the grains on masse showing partial crystal shape). Epidote, the yellow mineral in ordinary light, forms subhedral, vaguely tabular crystals, showing, in places, a fairly good cleavage. Quartz forms crystals which are anhedral, and interstitial to epidotes: it is colourless, with low relief. The angular fragments consist of exceeding fine-grained, anhedral quartz, with clots of some opaque dusty material, and some small crystals of epidote.

It seems possible that this work is the result of crystallization of later magmatic liquids, veining its local country rock. White being intruded into, the country rock, fragments of the latter were broken off.

139G/1 29th August, 1958.

5. THE IDENTIFICATION OF CHLORITE IN A SILICIFIED SERPENTINE FROM NORTH QUEENSLAND.

by

W.B. Dallwitz.

A sample was received from New Consolidated Gold Fields (A/sia) Pty. Ltd., containing an unknown green mineral which was to be identified. The specimen was collected from the Company's prospect on the Burdekin River, North Queensland. The following is the report:-

In thin section the rock is found to consist essentially of quartz, hydrated iron oxide, and subordinate chalcedony. Structure preserved in the rock (they are pseudomorphed in quartz, "limonite", and chalcedony) strongly suggest that the specimen is an altered and silicified serpentine which was veined by chrysotile.

The green mineral is a type of chlorite. Microchemical tests on separated material gave a negative test for nickel. To ensure solution of the mineral it was treated with fusion mixture.

Semi-quantitative X-Ray fluorescent spectrometric analysis showed that nickel and chromium are present. As the instrument has not yet been calibrated for nickel, it is not possible to say how much of that metal is present. However, it may be of the order of 0.5 to 1 per cent. The quantity of chromium is less than that of nickel. A few grains of chromite were noted in thin section.

As the green mineral does not contain nickel, the only other likely host of this element is the hydrated iron oxide. It may not be possible to determine nickel in this rock by simply digesting it in acid because it is almost certain that the hydrated iron oxide is impregnated with silica, and would, therefore, be partly shielded from attack by acid. Attack by fusion would probably be necessary to ensure that all the nickel will be available for determination.

198PNG/1 4th September, 1958.

6. THE PETROGRAPHY OF SIX SPECIMENS COLLECTED DURING THE MAMBARE RIVER SURVEY. T.P.N.G.

by

W.R. Morgan

P.80. Oivi Hill. (Slide No.3794).

Hand Specimen:

A medium to fine-grained, basic, porphyritic and amygdaloidal rock is seen to be in sharp contact with a very fine-grained, porphyritic rock. The junction appears to be fiarly straight, though slightly irregular - the hand specimen is too small to show if either of the rocks has a chilled phase.

Thin Section:

1. Medium-grained rock: In texture, this specimen is medium to fine-grained and holocrystalline. It is hypidiomorphic sub-ophitic, variolitic and glomeroporphyritic. Some amygdules are present.

In the groundmass, labradorite forms numerous lean, lath-like crystals, with rough margins and ragged terminations. It is in sub-ophitic intergrowth with augite. Symmetrical extinction angles measured on albite twinning show an approximate composition of An61. Its refractive index is greater than Canada balsam. Augite forms coloulress or very faintly green anhedral crystals, commonly enclosing labradorite. It is biaxially positive with $2V \simeq 55^{\circ}$. The birefringence = 0.019, while $Z \wedge C = 41^{\circ}$. Some alteration to chlorite may be seen, partiaularly in certain sphemlite-like masses, which consist of radially arranged laths of labradorite, some fibrous chlorite, and anhedral augite.

The phenocrysts consist of labradorite and augite. The former occur as large tabular crystals, of about a millimeter size in the section, often in the clusters. They are commonly strongly kaolinized and sericitized. Albite and carlsbad twinning are present. The feldspar is biaxial positive, with $2V \simeq 85^{\circ}$. An extinction angle measured from the (001) cleavage on a section normal to the X-bisectrix showed a composition of An70. The crystals are zoned to more acid labradorite at the margins. Sometimes a labradorite phenocryst appears to partly enclose part of the groundmass, i.e. as if it has grown around an ophitic mixture of augite and labradorite laths. Augite phenocrysts measure up to 0.75 mm., and are subhedral prismatic, sometimes ophitically enclosing groundmass feldspar at their margins. Augite crystals are often clustered. Black iron ore is restricted to the groundmass, and forms "cubic" subhedral grains.

The amygdules have a circular to irregular shape, the mineral infilling quite often partly enclosing groundmass feldspar. The greater part of the infilling is a green, rather fibrous chlorite. Small amounts of radially arranged fibres of a zeolite, possibly thomsonite, are present. This latter mineral has a refractive index less than that of labradorite, and greater than that of Canada balsam. Its birefringence = 0.005, and the fibres are length fast.

The rock is cut by very thin veins containing a mixture of green chlorite and dusty opaque material. Thin veins of chlorite cut feldspar along cleavage planes.

An estimation of the mineralogical composition is: - labradorite, 40%; augite, 35%; chlorite, 20%; black iron ore, 5%: The rock is an amygdaloidal dolerite.

2. Fine-grained rock. In texture it is holocrystalline and very fine-grained, and is hypidiomorphic, porphyritic and sub-variolitic. The groundmass appears to consist of laths of feldspar, and prismatic pyroxene, with some chlorite. The phenocrysts consist of felspar, and prismatic pyroxene, with some chlorite. The phenocrysts consist of feldspar and pyroxene. The feldspar has a refractive index greater than that of Canada balsam, while extinction angles on combined carlsbadalbite twins give a composition of An54 (labradorite). It occurs as rather lean, tabular crystals, or as rhomb-shaped grains, and as larger rather broken, kaolinized and sericitized crystals. Augite phenocrysts occur as euhedral, prismatic crystals, or as apparently broken up crystals. The broken crystals of augite and feldspar occur close to the junction with the dolerite, all within two to three minutes, as seen in the section. The rock becomes exceedingly fine-grained against the dolerite.

Thin veins of chlorite cut the fine-grained rock at right angles to the junction. The rock contains very fine-grained and granular black iron ore.

The fine-grained rock is a basalt. The broken crystals of feldspar and pyroxene mentioned above appear to be xenocrysts from the neighbouring medium-grained dolerite. Again, it was mentioned above that the basalt becomes even more fine-grained at the junction. Hence it is suggested that the basalt intrudes the dolerite.

P.104. Hegahorte Hill. (Slide No.3795).

Hand Specimen.

Two rocks in contact may be seen. The apparently older rock is medium to coarse-grained, and contains quartz, white feldspar and hornblende, and has the appearance of an igneous rock. The younger is fine-grained and porphyritic and contains white feldspar and a ferromagnesian mineral, with the possibility of quartz. The feldspar has the form of laths, which have a rough flow texture. A fragment of the older rock is enclosed in the younger, the fragment's margins being gradational to the younger. The actual contact, excluding the fragment, is sharp, and a white mineral occurs in a vein between the two.

Thin Section.

1. The older rock and fragment. In texture the rock is medium-grained, hypidiomorphic, and very inequigranular; porphyritic quartz forms anhedral, interstitial and poikilitic grains, partly enclosing feldspar. Bytownite occurs as euhedral laths, enclosed by both quartz and actinolite. Albite, carlsbad and pericline twinning is present. It is biaxial negative, with $2V \triangleq 85^{\circ}$; several extinction angles measured on a combined albite-carlsbad twin showed a composition of approximately An70(?). Orthopyroxene has now been replaced by both bastite and a pale green actinolite. The former mineral sometimes occurs on its own, pseudomorphing prismatic crystals, but more commonly it is surrounded by a vein of, or entirely replaced by,

fibrous actinolite. Black iron ore occurs as irregular grains. Some hydrated iron oxide occurs in thin veins associated with actinolite. Small amounts of an apparent clino-pyroxene are present as anhedral crystals, mantled by actinolite.

An estimation of the mineralogical composition is: quartz 25%, bytownite 35%, actinolite and bastite 30%, black iron ore 5%, the rock is an uralitized quartz-bytownite (?) microdiorite.

2. The younger rock. Texturally, the specimen is fine to medium-grained, hypidiomorphic and inequigranular. It is sparsely porphyritic, and the sub-parallel laths of labradorite suggest a flow texture. Quartz occurs as anhedral, interstitial and poikilitic crystals. Labradorite is present as tabular laths, partly enclosed by quartz and actinolite. It has a refractive index greater than that of Canada balsam, and albite and carlsbad twinning were observed. Symmetrical extinction angles on albite twin planes, and on a combined carlsbad - albite twinned crystal both show a composition of An59. Pale green actinolite forms anhedral, interstitial crystals: it is partly interstitial to quartz. Black iron ore occurs as subhedral to anhedral crystals.

The phenocrysts are composed of strongly kaolinized feldspar, and are tabular to rhomb-shaped. They appear to be of a similar composition to that in the groundmass.

A thin vein of chlorite cuts the rock, the mineral spreading out for a short distance either side of the vein, becoming interstitial to the rock minerals.

An estimation of the rock's composition:- quartz 15%, labradorite 45%, hornblende and actinolite 35%, black iron ore 5%.

The rock is an uralitized quartz (?) microdiorite.

P.105. Hegahort Hill. (Slide No.3796)

Hand Specimen

The rock is fine-grained, and porphyritic, and is composed mostly of ferromagnesian material, with some phenocrysts of a white mineral.

Thin Section.

In texture the specimen is medium-grained, hypidiomorphic, and very porphyritic.

In the groundmass, tremolite occurs as an accumulation of sub-radiating acicular crystals; or, more rarely, as subprismatic crystals with fibrous terminations. Occasionally quartz may be seen in the groundmass, as anhedral crystals enclosing tremolite: sometimes it occurs as a concentration of granular crystals in one or two small areas. Small amounts of plagioclase are also present in the groundmass. Its refractive index is greater than that of Canada balsam. It has a biaxial positive figure with a large 2V; some indistinct (?) albite twinning is present, and some symmetrical extinction on this suggested a composition of An40.

The phenocrysts consist of pyroxene, tremolite and (?) talc. The pyroxene forms euhedral, prismatic crystals: it is biaxial positive, with a 2V, very approximately, of 50^{o}-60^{o}, Z∧C " $40^{o}45^{o}$. Its birefringence is moderate. Very often it is rimmed by tremolite. The latter mineral very often forms euhedral pseudomorph phenocrysts after pyroxene; sometimes small, irregular patches of the pyroxene may be seen enclosed in tremolite. The latter is biaxial negative, with 2V≏ 85^{o}, and has a moderate birefringence, with a low extinction angle. Its refractive index is less than that of the pyroxene: tremolite is colourless. Fine-grained aggregates of talc and tremolite have pseudomorphed phenocrysts of pyroxene; talc occurs as fine-grained, irregularly-shaped flakes, which may at first be taken for sericite. Elsewhere (?) talc encloses irregular patches of tremolite, which are in optical onntinuity, and so the mineral is inferred to be an alteration product of amphibole. Winchell (1951) states that talc is one of the results of alteration of amphibole. Another phenocryst in this specimen shows long, acicular crystals of tremolite, separated by thin "layers" of (?) talc.

Black iron ore occurs as granules, and "cubic" shaped crystals enclosed in tremolite.

The rock is a quartz-bearing uralitized (?) pyroxenite. From its texture it appears to be a minor intrusive.

P.110B (ii). Between Corta Creek and Hoija No.1 Creek. (Slide No. 3791).

Hand Specimen.

The rock is very fine-grained, basic and amygdaloidal. It is composed of tabular feldspar and a ferromagnesian mineral. A white mineral occupies the amygdules.

Thin Section.

In texture, the specimen is holocrystalline, variolitic fine-grained, hypidiomorphic, with a sub-variolitic and pilotaxitic fabric. It is amygdaloidal. Albite occurs as rather ragged, lath-like, crystals. Its refractive index is less than that of Canada balsam, while some albite twinning is present. Some symmetrical extinction angles on the twin planes suggest a composition of An2. Chlorite occurs interstitially as anhedral flakes. It is faintly pleochroic in pale green, and the birefringence = 0.0085. It is length slow, showing it to be optically negative, while its refraxtive index is rather less than that of neighbouring prehnite. Granular epidote, faintly pleochroic in yellow, occurs inthe groundmass. Black iron ore and hydrated iron oxide form anhedral grains. Albite is lightly kaolinized in the section.

The amygdules range between 0.2 and 2.1 mm. in size, and contain quartz, prehnite, chlorite and epidote, though not all these minerals may be present in any one. Green chlorite, rather similar to that in the groundmass, occurs as a fringe on the edges of the larger amygdules and completely fills the smaller ones: sometimes granular, yellowish epidote occurs with chlorite in the latter case. Quartz and prehnite occur as larger, equidimensional grains inside the chlorite rims in the large amygdules, sometimes with epidote. Commonly a fibrous or acicular chlorite is included in prehnite and epidote: it has a higher refractive index than the groundmass chlorite.

A thin vein of epidote cuts the rock, but its relationship to the amygdules is not seen in the section. A very thin vein of hydrated iron oxide is present, its course skirts around the amygdules.

The mineralogical comppsition of the rock, excluding the amygdules, is: albite 50%, chlorite 35%, epidote 5%, black iron ore and hydrated iron oxide 5%. The rock is an albitized and chloritized amygdaloidal basalt.

Comment:

The present section was compared with P.110B of the original report. (Dallwitz and Morgan, 1959). The following differences may be noticed:-

1. In texture (a) the present section is fine-grained, whereas the original is medium-grained.
   (b) a slight flow texture is seen in the present section.
   (c) The present section is non-porphyritic.
2. Mineralogy: (a) This section has albite, while the original has (?) labradorite.
   (b) Augite is entirely altered to chlorite in the present section.

P.111. Hoija Creek. (Slide No.3792).

Hand Specimen:

The rock is a very fine-grained, apparently basic, igneous rock, which is slightly porphyritic. It has numerous large amygdules, often up to 2.5 mm. across, which are sometimes joined by veins.

Thin section:

In texture the specimen is found to be holocrystalline fine-grained and porphyritic: its fabric is hypidiomorphic, sub-variolitic and interstitial. Numerous amygdules are present in the section.

The phenocrysts consist of euhedral, tabular crystals of albite, and are occasionally clustered. They have a refractive index less than that of Canada balsam, while they are biaxially positive, with $2V \simeq 85^{\circ}$. An extinction angle measured on a section normal to the X-bisectrix gave a composition of An5. Some of the phenocrysts have irregular areas of prehnite occupying their centres.

The groundmass feldspar appears to be of an approximately similar composition. It occurs as a mass of subhedral to euhedral laths, often showing albite and carlsbad twinning. A very slight amount of kaolinization has taken place. Some prismatic crystals of very pale green to colourless augite occur, with $Z \wedge C = 42^{\circ}$, and a birefringence of 0.021. More often a pale green chlorite occurs, holding a position interstitial to albite.

The amygdules are rather similar to those of P.110B(ii) in that they have an outer rim of chlorite, surrounding quartz and prehnite. Either mineral may be dominant, and commonly occurs as large, roughly equidimensional crystals. In one or two amygdules, prehnite may occur as a mass of very small, irregular grains.

Black iron ore occurs as minute granules in the groundmass. Hydrated iron oxide has a similar occurrence, and is present also as thin veins cutting both amygdules and groundmass. Green chlorite occurs in irregular veins, joining amygdules.

An estimation of the mineralogical composition excluding the amygdules, is: albite 50%, augite and chlorite 45%, black iron ore and hydrated iron oxide 3%.

The rock is an albitized and partly chloritized amygdaloidal basalt.

P.117. Avalti Dijari (Slide No.3793)

Hand Specimen:

The rock is fine-medium-grained, and is light grey and marginally stained with hydrated iron oxide. The cut surfaces show several, larger, spherical mineral accumulations, reminiscent of amygdules.

Thin section:

The major constituent of this specimen is quartz, which is present, commonly, as a fine-grained, granular mosaic of crystals, showing sutured margins to one another. Occasionally rounded aggregates of much coarser quartz grains occur, having rather a similar relationship to one another as in the groundmass, except that the grains tend to be elongated, nearly parallel to the C-axis. These aggregates are the "amygdules" of the hand specimen.

Occurring in lesser quantities are other minerals. Separating quartz areas are regions composed of a mixture of fibrous chlorite, pleochroic in pale green, and granular epidote, faintly pleochroic in yellow. Some hydrated iron oxide is present in clots, staining chlorite. In the quartz-rich areas, chlorite and (?) nontronite are present as fibrous material, holding an intergranular position. Both these minerals are often stained by hydrated iron oxide. Granular epidote is also present, enclosed by chlorite and quartz. Some rather prismatic, iron stained actinolite may also be seen.

The coarse-grained quartz aggregates are mostly free from the chloritic and (?) nontronitic matter, and instead have associated with them rather coarse-grained, sometimes roughly tabular, crystals of epidote. Enclosed in the quartz are very long, acicular needles of actinolite, or ferrotremolite, slightly pleochroic in very pale green: the needles have no general orientation. Very thin veins of hydrated iron oxide cut the rock.

If, for the moment, the quartz is ignored, the texture of the remaining minerals is basaltic. Again, the quartz aggregates are suggestive of amygdules. Hence, on these slender grounds, it is very tentatively suggested that the rock is a silicified basalt.

DISCUSSION

In the letter that came with the specimens, it was stated that often the quartz-dolerites, etc., are observed to be intrusive, but that the amygdaloidal nature of some of them argues for an extrusive origin.

Williams, Turner & Gilbert (1954) state that vesicles, or amygdules, may be found in lavas and shallow intrusions. The writer has observed amygdules in a suite of spilitic dykes in Alderney, in the British Islands of the English Channel. Likewise, Walker (1930), during a description of the Shiant Islands, describes amygdaloidal structures in a dolerite sill of that locality. From the above, there is no reason why the dolerites etc. should not be intrusive. The fact that some of these rocks have been called basalt is not necessarily meant to imply that they are extrusive. Shallow and/or narrow basic dykes commonly have a basaltic texture and certain of the rocks here described have been called basalt on the basis of grain-size and texture.

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1060/7 September, 1958

7. EXAMINATION OF A GROUP OF SPECIMENS FROM THE BOULIA AREA, NORTH-WEST QUEENSLAND.

by

W.M.B. Roberts

The ten specimens examined were submitted by J.N. Casey. The following will list the specimen number, the reason for examination of that specimen, and the result of the examination.

SPECIMEN W268.

An arkosic rock required examination for trace lead.
Result - no trace of lead.

SPECIMEN W200.

A manganese-bearing rock, an iron to manganese ratio was required. What appeared to be a solid manganese mineral was examined by X-Ray spectrograph and gave a ratio Mn/Fe = 1/1.

The rock itself with replacing metallic mineral was examined and gave a ratio Mn/Fe = 1.8/1.

SPECIMEN G18.

A similar requirement to specimen W200. In this case the specimen was practically homogenous, and gave a ratio Mn/Fe = 11/1.

SPECIMEN W274

A carbonate rock containing small areas of a green mineral. Result - The green mineral is calcite containing traces of Fe and Mn.

SPECIMEN S25b .

Chert bands containing masses of a green mineral.
Result - The green mineral was identified by X-Ray diffraction as a mixture of quartz and sericite

SPECIMEN W49.

A carbonate rock for trace lead analysis.
Result - No trace of lead.

SPECIMEN W263.

An arkose for trace lead and copper.
Result - Trace elements in order of abundance.
Fe, Cu, Pb, perhaps Ni.

SPECIMEN S23a.

A spring deposit from Springvale H/S for trace analysis.
Result - Trace elements in order of abundance,
Fe, Sr and Mn. No Ba.

SPECIMENS G403C, G439a, G440c.

Gneissic rocks for determination of opaque mineral.
Result - polished section identification as Hematite.

SPECIMEN G18.

A carbonate rock for identification.
Result - Identified by X-Ray diffraction as Magnesite.

226/1 23rd September, 1958

8. THE SAMPLING OF GRANITE TO BE USED FOR RADIOACTIVE AGE - DETERMINATION.

by

W.B. Dallwitz.

There are enough difficulties in the business of age determination without adding any that could be avoided. So far we are relying, as far as I know, on K/A determinations only, and for this reason what I am about to say is probably of more significance than it would be if the Rb/Sr method and/or determination of Pb isotopic abundance in zircon were being used.

I have recently examined 23 samples of igneous rocks collected in South Australia for age determination. I do not regard any of them as satisfactory, though three might pass with a bit of a push. All of them show signs of weathering, as can be clearly seen even without comparing them with a really fresh sample, and even more so when compared with such a sample. This, of course, raises a strong suspicion of argon loss, and we cannot afford to have any doubt on this matter right at the start. There may well be loss of K also, and differential loss of Rb and/or Sr, so one could not feel particularly happy even if the Rh/Sr method were being used.

Following are notes on the condition of the samples, which were collected by Messrs Arkin and Crawford:

H/54/9/1(K12). Broken weathered surface visible. Staining by limonite along cracks and joints.

I/53/4/1(K17). Does not appear fresh. (?) Clay and limonite encrustations along cracks. Calcite also along cracks, but this may not be significant, as it may be late-magmatic (hydrothermal).

H/54/9/2(K13). Does not appear fresh. Limonite stains visible in places. Percentage of mica low.

I/53/8/2(K20). Limonite staining along cracks. (?)Clay films along cracks. Doubtful whether any biotite present; if there is, it is probably too fine to separate.

H/54/6/2(K9). Not fresh. Limonite staining throughout.

H/54/6/1(K8). As for previous sample.

G/53/9/3(K27). Not fresh. (?)Clay films, limonite staining.

I/53/6/1(K23). Not fresh. (?)Clay films along cracks. Traces of limonite staining.

H/54/9/3(K15). Weathered, limonite-stained. Hematite along joints may be hydrothermal, and therefore not significant.

I/53/8/1(K19). Best so far. Possibly satisfactory, but some limonite staining.

H/53/3/1(K29). Not fresh. (?)Clay films. Some limonite staining.

G/53/9/4(K28). Not fresh. "Soft" appearance - surface powdered by abrasion.

I/53/16/1(SA/5). Little mica, fine-grained. Not fresh.

I/54/2/1(SA/1). Not fresh. Weathered, limonite-stained surface exposed. Limonite staining throughout.

I/54/13/1(SA/4). Reasonably fresh, possibly O.K. Appears to have been collected from breakwater or other quarried material, biotite has been dislodged, leaving pores on the surfaces.

H/54/6/3(K10). Not fresh. Limonite-stained.

I/53/7/1(K22). As for previous specimen.

I/53/8/3(K21). Probably O.K. Only very slightly weathered.

G/53/9/2(K26). Weathered, heavily limonite-stained, very little mica. Hopeless.

G/53/9/1(K25). Not fresh. Limonite-stained.

I/54/2/2(SA/2). Not fresh. (?)Clay films. Limonite-stained.

I/54/2/3(SA/3). As for previous specimen.

H/53/10/1(K24). Not absolutely fresh. Probably satisfactory.

It seems possible that the granite-samplers were not sufficiently well briefed for this job. It is not good enough for them to be told to collect rock which is "as fresh as possible". It must be absolutely fresh, in my opinion: "as fresh as possible" lets them out too easily, as there will be a tendency to collect second best material where a great deal of work would be necessary to collect absolutely fresh rock. It may be asked: "How do you know when a rock is "absolutely fresh". I can only reply in terms of a parallel. It is said that, if there is any doubt as to whether a mineral suspected of being gold is actually gold, then that mineral is <u>not</u> gold. In other words, one recognizes gold as such without any doubt whatever. It is virtually the same with a fresh rock. The feldspar in a really fresh rock has a degree of brilliance and sparkle which is visibly greater than that of feldspar in a rock that is not quite up to the mark. The samplers should have been shown the difference between fresh, doubtful, and poor material. Incidentally, even poor material, in terms of requirements for age determination, may be excellent for ordinary petrographic and chemical study.

It is far better, I think, to collect ten reliable samples in a given time than one hundred that are even slightly suspect. If a perfectly satisfactory sample cannot be obtained, it would be better not to collect at all. This, at any rate, is the attitude that must be adopted until it is proved unnecessarily stringent.

Early in August (file 226/1) I prepared a memorandum to you concerning this subject of freshness of samples. In this memorandum I suggested that we should take a set of three test samples from each of three granitic masses to find out what is the influence of weathering on age. One of Mr.O'Driscoll's comments on this suggestion was: "Is there any purpose in measuring the error since it is quite impossible to get standards of "freshness" for future comparisons". This comment is quite valid. But the proposed testing would, at least, give some indication as to whether even slightly suspect samples can be used. It may be that the samples which I have condemmed are satisfactory, but we could not possibly risk using them until we have some guide in the form of concrete results.

One or two of the S.A. samples appear to contain no mica at all. In others, the mica is scarce and/or very fine grained. The samplers should surely use some initiative in such matters. Instead of blindly collecting a sample from a designated rock body they should simply not collect the rock if no mica is visible, and record this fact. Fine-grained mica will probably be difficult to purify because of more than usual difficulty with composite grains. I suggest that, if mica is scarce and/or fine-grained, it would be well for the samplers to look for places where mica is coarser and/or more plentiful, as the case may require. Xenoliths enclosed in granite, or hornfels, gneiss, or schist into which granite has been intruded may provide material suitable for dating the granite itself, provided that the mica recrystallized at the time of intrusion. Variations in grainsize and mica content may also be found within the granite.

Our efforts in the sphere of age determination will not be judged by the number of igneous bodies samples, but by the reliability of the results, I think that an effort should be made to have K/A determinations checked by the Rb/Sr method and any other that might be applicable. It is only when we get some concordance of results that a rock can be said to be satisfactorily dated.

198NT/1 29th September, 1958.

9. THE PETROGRAPHY OF SPECIMENS COLLECTED DURING THE 1957 FIELD SEASON IN THE JERVOIS RANGE. N.T.

by

W.R. Morgan

HA.2. pt.1054. Huckitta, Run 10, photo 5009. (Slide No.3797).

Hand specimen. A fresh surface shows that the rock is pale grey, with darker bands, and is coarse grained. It appears to be composed mostly of xenoblastic calcite, with a little garnet and quartz. Flecks of yellow pyrites may be seen. On a weathered surface, the rock is stained a dark brown colour.

Thin section: In texture the specimen is coarse-grained, inequigranular and xenoblastic. Calcite is the dominant mineral, forming coarse, interlocking xenoblastic crystals. Grossularite is commonly xenoblastic though it tends to show idioblastic outlines against calcite and quartz. The edges of the grains are often altered to a green, micaceous-looking mineral with a high birefringence; cracks within the garnet are also enlarged by this alteration. Quartz forms xenoblastic grains with sutured margins. It may occur with, or away from grossularite. Pyrites and magnetite are present in small amounts. The latter is xenoblastic, the former often occurs as cube-like crystals. Some flecks of hydrated iron oxide occur.

The rock is formed of over 90% calcite. It is a grossularite-bearing marble.

HA.8. pt.1139. Huckitta, 12/5161. (Slide No.3798).

Hand specimen: On a fresh surface the rock is seen to be very fine-grained, having a grey colour, and being of a "flinty" appearance. It breaks with a conchoidal fracture, and seems highly siliceous. A weathered surface is brightly stained by hydrated iron oxide.

Thin section: In texture the specimen is very fine-grained, but inequigranular, with occasional larger grains of felspar and quartz. The grains are angular, and often have sutured margins.

Quartz is anhedral, often angular, with sutured margins; some grains have a triangular, shard-like shape. Some irregular pockets of brownish, isotropic opal occur. Felspar is anhedral, though it sometimes has a tabular shape. Its refractive index is less than that of Canada balsam; in some of the grains, albite multiple twinning is present, while in others, multiple twinning on both the albite and pericline laws may be seen. Hence, it is thought that both albite and microcline occur. Biotite and chlorite occur as thin tabular flakes, some bent between grains of quartz and felspar. Rare muscovite is present as individual flakes.

Small areas of the slide, usually about the size of the coarser quartz and felspar grains, consist of quartzo-felspathic material even finer-grained than the groundmass. These areas are irregular in shape.

The rock is cut by thin quartz veins.

An estimation of the amounts of minerals present is: quartz, 75%; felspar, 20%; the remainder 5%. The rock is a silicified tuff, or a chert.

HA.9. pt.1185, Huckitta, 13/5115. (Slide No.3799).

Hand specimen: On a fresh surface the rock has a silvery-cream appearance due to the presence of felspar and muscovite. Substantial quantities of quartz are also present. The specimen is coarse-grained and granitic. On one side a vein of quartz is present. On a weathered surface the rock is stained with hydrated iron oxide.

Thin section: In texture, the rock is coarse-grained, allotriomorphic and inequigranular, with some granulation. Quartz forms anhedral grains with crenulate margins; some cracking, with a little granulation is present; it shows slight strained extinction. The size of quartz crystals ranges between 0.25 and 1.75 mm. Albite occurs in a rather smaller quantity in the rock as anhedral crystals, commonly partly altered to muscovite. Its refractive index is less than that of Canada balsam, while an extinction angle in a section normal to the X-bisectrix showed a composition of Ang. Multiple albite twinning is present. Muscovite occurs as colourless, anhedral to subhedral crystals, as clusters of small crystals, or as single large crystals. It is biaxial negative, with $2V=45^{0}-55^{0}$. Its birefringence = 0.035. Often, it may be seen to be altered from albite, the cleavage planes of the muscovite appear to be parallel to the longer axis of a tabular felspar - in one case, parallel to the albite twin planes. Some muscovite crystals leave small "islands" of felspar remaining in them. The clusters of small muscovite are strong out between quartz grains; muscovite has a slight tendancy to occur in layers.

A little accessory zircon and allanite are present, together black iron ore dust, and hydrated iron oxide, associated with muscovite.

The rock is a gneisenized granite.

HA.13. pt.1290. Huckitta. 8/5087) (Slide No.3800.)

Hand specimen: On a freshly exposed surface, the rock is dark, and fine-grained, laminated into dark, and lighter grey bands. The darker layers, 2 - 10 mm.thick, alternate with the lighter layers, which are 1 - 3 mm. thick. The specimen reacts on the application of dilute hydrochloric acid, showing it to contain a considerable amount of calcite.

Thin section: In texture the rock is very fine-grained and granular. Calcite is by far the most dominant mineral present, the remaining minerals being scattered in the groundmass. It forms a granular mosaic of anhedral crystals, of 0.016 - 0.032mm. in size. A little quartz is present as similar sized, rather angular fragments, with some strained extinction; the fragments have crenulate margins. Colourless sericite and brown biotite occur as flakes with their cleavages tending to be parallel with one another, and to the rock banding. Hydrated iron oxide dust occurs as very thin bands, parallel to the strike of the mica flakes.

A vein of calcite cuts the rock at right angles to the lamination.

The rock is a calcilutite.

HA.18. pt.1318, Huckitta 11/5211. (Slide No.3801.)

Hand specimen: The rock is greyish, medium-grained, foliated, and has a schistosity. It contains white mica, tourmaline, and quartz. Its weathered surfaces are stained and coated with hydrated iron oxide.

Thin section: In texture the rock is medium-grained and inequigranular, tending to be porphyroblastic. It is granoblastic-lepidoblastic, with occasional nematoblastic tourmaline layers. Quartz is xenoblastic, and has sutured margins. Some strained extinction, and cracking of crystals may be seen. Some bands containing rather larger crystals than the normal grain size occur. Muscovite forms small flakes running parallel to one another, though tending to wrap around quartz grains. The mineral is concentrated more in the areas of finer quartz grains. Tourmaline occurs as large prismatic porphyroblasts: these crystals are elongated parallel to the schistosity. It is uniaxial negative, with a birefringence of 0.024. Its pleochroism is : o = dark blue-grey; e = very light grey. Tourmaline is slightly poikiloblastic, enclosing black iron ore and some quartz. Black iron ore occurs as "cubic" crystals, and is red in reflected light: it thus appears to be hydrated iron oxide, altered from pyrites.

An estimation of the composition is: quartz = 50%; muscovite: - 30%; tourmaline - 20%.

The rock is a tourmaline-muscovite-quartz schist.

HA.27. pt.2575, Huckitta 10/5007. (Slide No.3802).

Hand specimen: On a fresh surface, the rock is seen to be dark grey, and is a coarse-grained, basic, igneous rock. It contains tabular white felspar, with some pyroxene and amphibole. The weathered surfaces have a coating of hydrated iron oxide, and weathering has caused differential solution of the plagioclase, leaving the ferromagnesians standing out in relief.

Thin section: In texture, the rock is coarse-grained, hypidiomorphic, rather inequigranular, and subophitic. Bytownite occurs as subhedral, tabular crystals, sometimes being slightly intergrown. It has albite and carlsbad twinning, and its refractive index is greater than that of Canada balsam. It is biaxial negative, with $2V \simeq 85^{\circ}$. Extinction angles in carlsbad twins give a composition of An_{72}. It is slightly altered to kaolin and sericite. Augite occurs as subhedral, rather prismatic grains, and is colourless, length slow, and has $Z \wedge c = 46^{\circ}$. It is biaxial positive $2V \simeq 40^{\circ}$; its birefringence is 0.022. Augite is sometimes seen to be intergrown with hypersthene, the latter mineral forming rounded blebs in the former, or else forming lamellae parallel to (100) in augite. (Poldervaart and Hess, 1951, and Walker and Poldevaart, 1949). Hypersthene is practically colourless, and may occur as subhedral, prismatic crystals, as well as inclusions in augite. It has parallel extinction, with low polarization colours, and is biaxial negative, with a large 2V. Tremolite and actinolite occur as large masses of fibres, surrounding pyroxene crystals, and altering from them. The actinolite is pleochroic in pale green. The outer edges of actinolite crystals are often of a darker green, while a similarly coloured hornblende occurs in small amounts as interstitial crystals.

Black iron ore occurs as highly irregular masses within actinolite, or as blebs enclosed in pyroxene; in augite it sometimes occurs as parallel rows of concentrated dust, lying obliquely to the (010) cleavage. Black iron ore also occurs as irregular grains in the groundmass. A little ilmenite, with leucoxene, is associated with hornblende. Epidote occurs in minor quantities as granules enclosed in felspar. Apatite is present as euhedral prisms in felspar. Sericite occurs rarely as quite large flakes, altering from felspar. Some hydrated iron oxide occurs as large irregular masses enclosed in actinolite.

The estimated composition of the rock is: bytownite - 60%; augite - 13%; actinolite - 13%; hypersthene - 6%; hornblende - 3%; the remainder - 5%.

The rock is an uralitized hypersthene-bytownite gabbro

HA.28. pt.2578. Huckitta. 10/5007. (Slide No.3803).

Hand specimen: A fresh surface is seen to be dark grey, speckled with white. The rock is coarse-grained, and equigranular, containing quartz, white tabular felspar, and biotite. A vague lineation of felspar crystals is apparent. The weathered surfaces are coated with dark hydrated iron oxide, and quartz and felspar tend to stand out in relief.

Thin section: In texture the rock is coarse-grained, rather equigranular, and hypidiomorphic: it contains rare phenocrysts of felspar. Some granulation of crystals may be seen. Quartz forms anhedral, granulated crystals, and tends to accumulate in crystal clusters, each grain with sutured margins. It has a foliated strained extinction. Quartz is interstitial to the remaining minerals. Andesine occurs as subhedral tabular crystals, with irregular margins, sometimes slightly intergrown with quartz. Its refractive index is greater than that of Canada balsam, while it is biaxial negative, with $2V = 85^{\circ}$. It has albite, carlsbad and pericline twinning, and the crystals are zoned. An extinction angle measured on a section normal to the X-bisectrix gave a composition of An_{30}; measurements of extinction angles on twin planes of zoned crystals showed that their cores are composed of An_{40}, their edges are An_{28}. Some irregular alteration to kaolin and sericite has taken place. A little microcline is enclosed in andesine phenocrysts.

Biotite forms subhedral to anhedral flakes, and is commonly interstitial to, and slightly poikolitic about, andesin Muscovite occurs as minor flakes associated with biotite. Some biotite is chloritized to peninite.

Black iron ore forms subhedral grains, having crystal faces against quartz and felspar. Apatite occurs as acicular prisms enclosed in felspar. Zircon is present as small prismatic crystals, while sphene forms anhedral grains, often associated with biotite. Allanite occurs with epidote, and has become metamict, forming expansion cracks in the epidote and quartz around the crystal.

The estimated composition of the rock is: Andesine - 55%; quartz - 25%; mica - 15%; the remainder - 5%.

The rock is a tronhjemite or biotite-andesine granodiorite.

HA. 30. pt.2602. Huckitta 11/5211 (Slide No.3804).

Hand specimen: The rock as, on a fresh surface , a dark, faintly green colour. It is a basic, medium-grained, slightly porphyritic rock, and contains a dark amphibole, apparently enclosing randomly oriented white laths of felspar. The occasional phenocrysts consist of felspar. The weathered surfaces are stained with hydrated iron oxide.

Thin section: The texture of the rock is medium-grained, hypidiomorphic, and ophitic. Felspar occurs as subhedral, doleritic laths, and shows albite lamellar twinning. The refractive index is greater than that of Canada balsam. Extinction angles on the twin planes give a composition of An_{51} - labradorite. Labradorite is now largely altered to kaolin and sericite. Actinolite has an ophitic relationship to labradorite.

. It may occur as large, single crystals, or in masses of fibres. It is pleochroic in pale green, though the centres of larger crystals are almost colourless. The birefringence ranges between 0.025 at the crystal centres to 0.023 at their edges. Some chloritization has taken place. Biotite occurs in small quantities as flakes, usually enclosed in actinolite. Black iron ore is present as irregular masses associated with actinolite. Apatite forms small prisms enclosed in felspar.

The rock appears to be a saussuritized and uralitized dolerite.

HA.34. pt.579. Huckitta 12/5163. (Slide number 3805).

Hand specimen: The rock is very inequigranular, grain size ranging from coarse to fine. It consists mostly of quartz and felspar. The specimen has a mylonitic structure, with a pronounced rodding of the felspar. Felspar augen are also present.

Thin section: In texture, the rock is allotriomorphic and mylonitic being badly crushed. It is very inequigranular. Microcline- perthite occurs as large grains 1.5 to 2.5 mm. in size; it is also present in the fine groundmass. The larger grains have a generally rounded shape, though the detail of their margins is rough and angular. Some of the felspar crystals have granulated zones with them. Partly sericitized acid plagioclase has a similar mode of occurrence to that of microcline-perthite, twinning is absent in this mineral.

Quartz occurs in the groundmass as fine granules; it also occurs as large, irregular, fine-grained masses, which appear to be drawn out in a fairly well-defined direction, though they wrap around the larger grains of microcline-perthite. Each quartz mass is composed of small (0.05 mm. to 0.06 mm.) grains with sutured margins. Close examination shows that several neighbouring grains may be in actual or close optical continuity, while individual grains often show strained extinction. It is apparent that these grains comprise parts of original larger quartz crystals which have been granulated and drawn out to their present shape. The individual grains also show an elongation in a common direction, at 20° - 30° to the direction of the elongation of the large masses.

Muscovite and biotite form very small, flaky crystals, which have been drawn out into narrow, sometimes diffuse zones parallel to the direction of the quartz mass elongation. These minerals are accompanied by a little hydrated iron oxide.

The rock is obviously dynamically metamorphosed from an original quqrtz-felspar rock. The original rock is thought to have been granite, because several of the felspar grains contain some individual crystals within them, having an igneous relationship to one another, and not sedimentary. One such grain consists of seven individual crystals showing crystal boundaries to each other, including "re-entrant" faces. Thus, although the rock is coarsely granular, it gives the impression of having been an aplo-granite rather than an arkose.

The estimated composition of the rock is: quartz - 40%; microcline - perthite - 45%; plagioclase - 10%; mica and others - 5%. The rock is a flaser aplo-granite.

HA. 38. pt.594. Huckitta 12/5163 (Slide No.3806).

Hand specimen: The rock is pink-coloured, coarse-grained and inequigranular: at first sight it could be taken for a coarse arkose. However, close examination shows that the milky quartz grains are interstitial to, and partly poikilitically enclose the pink felspar. Quartz crystals are gathered into clusters. Very little ferro-magnesian mineral seems to be contained in the rock.

Thin section: In texture, the rock is coarse-grained, inequigranular and allotriomorphic, with a little granulation. Quartz is anhedral, and has a foliated strained extinction, with the development of cracks. It has sutured margins with other quartz crystals, and with felspar. Felspar is partly poikilitically enclosed by quartz. Microcline-perthite consists of about 50% potash felspar, and 50% plagioclase; the exsolution lamellae are close together and anastomozing, giving a fingerprint effect. W.B. Dallwitz has seen similar effects in some Antarctic Archeozoic granites. Microcline perthite, in this section, has a refractive index less than Canada balsam, and has a biaxial negative figure, with $2V \simeq 80^{\circ}$. Indistinct cross-hatch multiple twinning is present.

Minor quantities of muscovite (or sericite) occur intergrown with felspar. The felspar has been kaolinized, the plagioclase to a greater extent than microcline perthite.

The rock is a leucocratic granite.

HA.39. pt.598, Huckitta 12/5165 (Slide No.3807).

Hand specimen: The rock is basic, and coarse to medium-grained, containing white tabular felspar, shining black hornblende, with the possibility of some dark greenish pyroxene. A definite lineation of felspars is present. The section is cut normal to the plane of lineation, at right angles to the longer axes of the felspar tabulae. Weathered surfaces are stained with hydrated iron oxide.

Thin section: In texture the rock is coarse-grained, equigranular, hypidiomorphic and cataclastic. Bytownite occurs as subhedral, rather tabular crystals, with crenulate margins. Its refractive index is greater than that of Canada balsam and albite and pericline twinning is present. It is biaxial negative, with $2V \simeq 85^{\circ}$. The angle between (001) cleavage and the pericline twinning showed a composition of approximately An_{72}. Hornblende is subhedral to anhedral, vaguely prismatic, though the crystals tend to be rounded. Occasionally, clusters of fine, granular crystals also occur. It is pleochroic: - X = olive green; Y = almost colourless; Z = light olive. Augite occurs in small quantities partly or totally enclosed by hornblende. The latter mineral is apparently replacing the former. Scapolite forms fine granular to tabular grains occurring at the edges of felspar crystals, possibly replacing it. Its refractive index is about equal to that of labradorite. The birefringence = 0.026. It has straight extinction, and it is uniaxial negative. Its composition is approximately Ma_{35}/Ma_{65}. Black iron ore is present as irregular grains, and as diffuse dust enclosed in hornblende. Apatite occurs as small prisms enclosed in felspar.

A slight lineation is present in the section: parallel to this is a band, 3-5 mm. broad, composed of mylonitized hornblende and scapolite, with a little felspar. Away from this band are other, thinner "veins" of mylonitized material wind their way between the grains. Anhedral scapolite crystals occur all along these bands, suggesting metasomatism during the cataclastic action.

The rock is a uralitized bytownite gabbro which has had scapolite introduced, possibly during the time of mylonitization.

HA.42. pt.610. Huckitta 12/5165. (Slide No.3808).

Hand specimen: On a fresh surface, the rock is seen to be medium to coarse-grained, and basic. It contains tabular white felspar, and amphibole. A faint lineation of the hornblende may be seen. Weathered surfaces are stained with hydrated iron oxide.

Thin section: In texture, the rock is medium to coarse-grained, hypidiomorphic and sub-ophitic. Bytownite is subhedral to anhedral, forming vague tabular shapes. Its refractive index is greater than that of Canada balsam; albite and carlsbad twinning is present, and it is biaxial negative, with $2V \angle 85^{\circ}$. Measurement of extinction angles in carlsbad twins shows a composition of An_{72}. Hornblende occurs as subhedral, prismatic crystals, and occasionally as small euhedral enclosed in felspar. Length show $Z \wedge c = 24^{\circ}$. It is biaxial negative, with a $2V \angle 80^{\circ}$. Black iron ore forms small, irregular, grains associated with hornblende. Zircon is present as tiny euhedral prisms, while apatite is enclosed in felspar.

The rock is a hornblende gabbro, or bojite.

HA.55. pt.2147. Huckitta 11/5207. (Slide No.3809).

Hand specimen: A fresh surface shows that this rock is a fine to medium-grained, banded metamorphic rock, consisting of quartz and tourmaline. The weathered surfaces are stained with hydrated iron oxide.

Thin section: Texturally, the rock is fine-grained, nematoblastic-granoblastic. Quartz is granular, xenoblastic, forming equidimensional grains, a little strained extinction may be seen. Tourmaline occurs as fine-grained, tabular prismatic crystals whose elongation is roughly parallel. It is pleochroic: o = dark green, e = very light grey. Allanite occurs as very occasional, yellowish grains. Some hydrated iron oxide is present as diffuse dust occurring around an opaque grain.

A layering is present, due to the concentration of tourmaline in certain bands: the direction of these layers is inclined at 70° to the direction of tourmaline elongation. This may be a relict texture. However, small clusters of quartz and tourmaline are elongated parallel to the tourmaline elongation.

The rock is a tourmaline-quartz hornfels, which may be the result of contact metamorphism or metasomatism.

HA.67. pt.2212. Huckitta. 12/5151 (Slide No.3810).

Hand specimen: The rock apparently consists of large, white, felspar crystals enclosed in a finer-grained, greenish groundmass. Some quartz and epidote veins cut the specimen.

Thin section: In texture the rock is inequigranular, and hypidiomorphic, with large, subhedral felspars being enclosed by a groundmass composed of numerous, small intergrown crystals of anhedral to subhedral hornblende. The felspar is badly kaolinized and sericitized, and includes a few grains of epidote. One section gave a biaxial positive figure: its refractive index is greater than Canada balsam: these facts suggest labradorite. Hornblende is pleochroic; X = olive green; Y and Z = light olive: length slow, Z$\wedge$C = 15°. Very small, irregular crystals of quartz may sometimes be found enclosed in hornblende.

Veins composed of quartz and felspar, up to 0.75 mm. thick cut across hornblende, but not labradorite. The veins approach labradorite crystals, stop, and are continued on the other side. It is possible that the veins continue around, but not through, the crystal. In the veins, quartz forms equidimensional grains with slightly sutured margins. Epidote forms subhedral, rather tabular crystals which commonly have the crystals larger axes at right-angles to the direction of the vein. The veins, in the section, are mostly parallel to one another, but one younger vein cuts across the others at right angles to their direction.

The rock is a saussuritized hornblende gabbro or bojite.

HA.69. pt.2239. Huckitta, 12/5151. (Slide No.3811).

Hand specimen: On a fresh surface, the rock is seen to be fine to medium-grained, and has alternating, sub-parallel wavy light and dark layers, each 3 to 20 mm. thick. Some of the layers are lenticular. The light layers consist of calcite, the darker ones of ferro-magnesian minerals and epidote. Occasionally, acicular crystals of hornblende occur, with no general orientation at all. Weathered surfaces are stained with hydrated iron oxide, while the calcite layers tend to be leached out, leaving the remaining material standing as a series of ridges.

Thin section: In textures, the rock is exceedingly inequigranular, xenoblastic, and porphyroblastic. There is a foliation of the rock's minerals into calcite-rich layers, and quartzo-felspathic layers. The ferro-magnesian may occur in either type of layer.

Calcite is xenoblastic, with sutured margins: it commonly has some quartz and felspar occurring with it, in minor quantities in the calcite-rich layers. Oligoclase occurs as xenoblastic granular crystals. Its refractive index is less than that of Canada balsam, while it is biaxial negative, with 2V $\leq$ 80°. Microcline, with its characteristic cross-hatch twinning, occurs as granoblastic grains, normally restricted to the quartz-felspathic bands. Quartz forms fine xenoblastic grains, and is subordinate to felspar in quantity, in the quartzo-felspathic layers.

Diopside occurs as tabular, poikiloblastic crystals in the calcite and quartzo-felspathic layers. It may also occur as fine, granoblastic crystals in the general groundmass. Length slow, Z c = 41°. Its birefringence = 0.025. Hornblende occurs

as prismatic, often poikiloblastic crystals; it is commonly confined to the quartzo-felspathic layers. Length slow, Z/\C = 20°. It is pleochroic: X = olive green; Y and Z = light olive. Biaxially negative, 2V = c.60°. The birefringence = 0.024. Epidote occurs as xenoblastic, granular crystals, in minor quantities.

The rock is a calc-silicate gneiss.

Although, in the field, the calcium-carbonate poor rocks on either side of this specimen have a pronounced schistosity, this rock has only a foliation parallel to this. There is no mineral orientation at all. Harker (1939, pp.187 and 255) suggests that the presence of large quantities of calcite and dolomite act as a cushion during metamorphism, so reducing, locally, the regional stress. This gives an explanation of the lack of mineral orientation found here.

HA.71. pt.2241. Huckitta 11/5195. (Slide No.3812).

Hand specimen: The rock is a pegmatite showing coarse graphic intergrowth of pink felspar and quartz, the latter minerals being enclosed within the former. On the weathered surface, felspar has been corroded along its cleavage planes, giving a very rough surface, much like solution-enlarged joints on a bare limestone outcrop, only on a far smaller scale.

Thin section: Quartz and felspar are intergrown, with quartz enclosed by the felspar. The masses of quartz are rod-like, and somewhat curved in shape: neighbouring "rods" of quartz are not in optical continuity; neither is the quartz in any one "rod" composed of one whole crystal. Instead it is divided up into a number of grains showing some development of sutured margins.

The microcline-perthite has numerous exsolution lamellae of plagioclase, which are more kaolinized than the microcline. The amount of plagioclase present seems to vary between 25 - 35% of the whole felspar. Some patch replacement of potassic by sodic felspar is seen. The development of exsolution lamellae is not so great as in HA.38.

Narrow veins of granulated quartz and felspar extend across the microcline-perthite crystals, between the quartz zones.

No ferro-magnesian minerals are present.

The rock is pegmatite.

HA.76. pt.2294. Huckitta. 12/5153 (Slide No.3813).

Hand specimen: On a fresh surface the rock is seen to be medium-to coarse-grained and basic. It contains laths of white felspar and black hornblende. The latter mineral, in bands measuring up to a centimetre thick, occurs as coarse crystals measuring 2mm. across, and elongated parallel to the banding. Felspar, in these bands, is variously oriented. Other bands contain hornblende crystals under a millimetre in size - these layers are 1.5 cm. across: here, the felspar laths are elongated parallel to the layering. Some small phenocrysts of felspar are present in the medium-grained layers. The weathered surface of the rock is stained with hydrated iron oxide, and has a rough surface due to the weathering out of the more soluble minerals.

Thin section: In texture, the specimen is hollocrystalline, medium to coarse grained, inequigranular and hypidiomorphic. The thin section is cut at right angles to the lineation, which is probably a flow texture: most of the hornblende crystals show basal sections.

Anorthite forms subhedral, rather rounded stubby-tabular crystals. Its refractive index is greater than that of Canada balsam, while it is biaxially negative, with $2V = 85^{0}$. Symmetrical extinction angles on albite twinning gave a composition of An_{95}. Anorthite is patchily sericitized, some crystals being wholly altered, while others are practically untouched. A zone approximately 4mm. wide crosses the section in which felspar is quite badly sericitized. Some kaolinizattion has also taken place. Very occasional phenocrysts of anorthite occur; in these, the albite twinning is badly strained.

Hornblence forms euhedral crystals. It is pleochroic: X = olive; Y = Z = light olive. Length slow, $Z \wedge C = 19^{0}$. The birefringence = 0.023. Black iron ore occurs as occasional, rounded, grains. Apatite forms minute euhedra enclosed in felspar. Zircon is occasionally present as small, prismatic crystals.

Thin veins, 0.03 mm. thick, of prehnite cut the rock, across the lineation. They cut across felspar and hornblende, and tend to bleach the nearest portion of the latter mineral. Cleavage fragments of hornblende are also broken off by the vein.

An estimation of the mineralogical composition is: anorthite = 55%; hornblende = 43%; the remainder = 2%.

The rock is a saussuritized hornblende gabbro or bojite.

HA.79. pt.2358. Huckitta 12/5151 (Slide No.3814).

Hand specimen: The rock is dark grey, speckled with white, and is medium-grained and granular. It consists of quartz, with smaller grains of tourmaline. A slight foliation is present. Weathered surfaces are stained with hydrated iron oxide.

Thin section: Texturally, the specimen is xenoblastic, and rather inequigranular. A slight foliation can be seen, shown by some concentration of tourmaline into bands.

Quartz occurs as xenoblastic, amoeboid grains with sub-sutured margins. Slight cracking and lamellated strained extinction may be seen. There is a slight elongation of quartz grains in one direction. Quartz sometimes poikiloblastically enclosed tourmaline. The grain size is 0.5 - 0.8 mm.

Tourmaline occurs as rather smaller grains, 0.15 - 0.25 mm. in size. The crystals are prismatic with rounded edges: a slight elongation is present, parallel to the quartz elongation.

A very small amount of black iron ore is present as granular grains.

An estimation of the rock's composition is: quartz = 70%; tourmaline = 30%. The rock is a tourmaline-quartz hornfels.

HA.80. pt.2366. Huckitta 11/5205. (Slide No. 3815).

Hand specimen: The rock is medium-grained, with a well-developed schistosity; it consists of quartz, and parallel flakes of white mica. Rather larger, grey porphyroblasts are present, shown in section to be probable pseudomorphs after cordierite. The rock is stained with hydrated iron oxide throughout, this giving it a dull red colour.

Thin section: In texture, the rock is medium to coarse-grained, porphyroblastic and xenoblastic, with lepidoblastic muscovite and granoblastic quartz. Quartz forms rather granulated crystals, and shows strained extinction. Muscovite occurs as colourless flakes nearly parallel to one another, in bands; the flakes in each band having a "feather"-arrangement. Tourmaline is present as small, prismatic crystals, with a pleochroism: o = green, e = nearly colourless. A few minor flakes of biotite are present, pleochroic in brown. Large hexagonal shaped grains, 0.05 - 1.3 mm. in size occur, having a pronounced sieve structure, enclosing quartz. Muscovite flakes are wrapped around them. These porphyroblasts are probably cordierite, now largely altered to sericite and muscovite. Hydrated iron oxide and black iron ore are disseminated throughout the crystals.

Black iron ore, now partly altered to hydrated iron oxide, forms irregular grains. Accessory zircon and sphene are present,

An estimation of the mineralogical composition of the specimen is: quqrtz = 38%; muscovite = 33%; (?) cordierite = 15%; black iron ore = 10%; tourmaline = 2%; the remainder = 2%.

The rock is a muscovite-quartz schist.

The occurrence of (?)cordierite suggests that the rock has suffered polymetamorphism, i.e. regional, followed by thermal. The decomposition of this mineral to muscovite is probably retrograde. Compare this specimen with HA.117. This specimen may be compared with others having a similar character, described by Morgan (1959), from the Jervois Range Mining area.

HA87. pt.315 . Huckitta 13/5117. (Slide No.3816).

Hand specimen: On a fresh surface, the rock is seen to be dark, medium to coarse-grained, and basic igneous. It is composed of black hornblende, and white, tabular felspar. Weathered surfaces are stained with hydrated iron oxide.

Thin section: Texturally, the specimen is hollocrystalline, medium-grained, and inequigranular. The fabric is xenomorphic-granular, with hornblende crystals showing some lineation. Bytownite forms anhedral, rounded crystals, and is little altered. Some albite and pericline twinning may be seen. Its refractive index is greater than that of Canada balsam, while it is biaxially negative, with $2V \triangle 80^{\circ}$. Extinction angles in a section normal to the Z - bisectrix show a composition of An_{82}. Hornblende occurs as anhedral crystals, often enclosing blebs of quartz and felspar, sometimes giving the effect of a metamorphic sieve-structure. Hornblende is pleochroic: X = dark apple green; Y = very light olive; Z = light olive. The birefringence is 0.019; length slow, $Z \wedge C = 24^{\circ}$. It is biaxial negative, with $2V \triangle 80^{\circ}$. Quartz occurs in minor quantities, as anhedral grains.

Black iron ore forms euhedral to subhedral grains. Accessory apatite, zircon and sphene are present.

An estimation of the mineralogical composition is: bytownite = 50%; hornblende = 43%; quartz = 3%; black iron ore = 3%; the remainder = 1%.

The rock is a hornblende-gabbro or bojite.

HA91. pt.403. Huckitta 13/5117 (Slide No. 3817).

Hand specimen: The specimen is light grey, and fine to medium-grained, porphyritic. The groundmass is composed of lath-like white felspar, minute flakes of white mica, and some darker ferro-magnesian mineral. The groundmass reacts strongly on application of hydro-chloric acid, suggesting the presence of calcite - this is confirmed in the section. The phenocrysts are tabular and white in colour; the largest measures about 1 cm. The weathered surfaces are stained with hydrated iron oxide. The rock has a very rough cleavage.

Thin section: In texture, the specimen is allotriomorphic, inequigranular, the individual grains often being highly irregular. The rock is medium to coarse-grained and is porphyritic, it consists mainly of chlorite, sericite, and calcite.

Sericite forms roughly tabular flakes probably pseudomorphing subhedral feldspar. It is sometimes intergrown with calcite, this mineral forming "layers" running parallel to the sericite's cleavage . The sericite is biaxially negative, with $2V_{\alpha} = 15^{\circ}$. Aggregates of fine-grained, very pale greenish buff to colourless chlorite are present, often intergrown with highly irregular masses of calcite - though the latter mineral may sometimes be arranged along chlorite's cleavage planes. The chlorite has a very low birefringence, i.e. 0.003. Its refractive index is approximately 1.58. Quartz is present in minor quantities, as irregularly shaped grains, in some places intergrown with sericite. It has undulose extinction, and some cracking. Small clots of limonite are evenly distributed through the rock. Sphene is uncommon, enclosed in sericite. Apatite is fairly common as euhedral, acicular crystals enclosed in sericite.

When the slide is examined in ordinary light, with a low power objective lens, it gives the textural impression of being a medium-grained-porphyritic igneous rock, with the sericite taking the place of felspar, and chlorite for the ferromagnesian content. The ratio of sericite to chlorite is 1:1, hence it is suggested, tentatively, that the rock was a fine-grained and porphyritic gabbro. Hence, the rock is called a carbonated, sericitized and chloritized, fine-grained porphyritic gabbro.

HA.98. pt.3126. Huckitta. HA.98. (Slide No.3818).

Hand specimen: The rock is fine to medium-grained, and dark-coloured with parallel pink bands 2-5mm.thick, and 5-15 mm. apart. The pink bands appear to be composed of felspar, with some quartz; the remainder is quartzo-felspathic, with some ferro-magnesian content. The weathered surface is stained with hydrated iron oxide.

Thin section: In texture, the rock is fine-grained, with clots, and layers, of medium-grained material, and is xenomorphic-granular. In the fine-grained areas quartz forms granular crystals. commonly with sutured margins. The felspars have similar textural features, and are composed of microcline-perthite and andesine. The former has a refractive index less than that of Canada balsam, and it has multiple, cross-hatch twinning on albite and pericline laws. It is biaxial negative. The latter felspar has a refractive index above that of Canada balsam, and it is biaxially positive, with $2V_{\alpha} = 80^{\circ}$. An extinction angle in a section normal to the X-bisectrix showed a composition of An_{40}. Symmetrical extinction angles on albite twinning confirmed this.

Colourless muscovite and brown biotite occur as anhedral flakes, occupying an interstitial position, or being streaked out between quartz and felspar grains. Occasionally long streaks of chloritized biotite occur, connected by thin veins of chlorite, and associated with irregular grains of epidote. The direction of streaking is parallel to the banding.

In the medium-grained bands, rather tabular crystals of andesine occur, with some microcline-perthite. Anhedral grains of quartz are present, often granulated into veins lying between the felspar crystals. Irregular grains of muscovite and epidote may be seen.

Black iron ore forms irregular grains in the groundmass. Apatite occurs acicular euhedra enclosed within felspar, while zircon is present as euhedral, prismatic crystals.

An estimation of the mineralogical composition of the specimen is: andesine = 45%; quartz = 20%; microcline-perthite = 15%; biotite = 10%; muscovite = 10%.

The rock appears to be a mylonitized granodiorite, the fine-grained areas representing the granulated material, while the coarser material represents remnants of the rock as it was originally.

HA. 100. pt.3133. Huckitta 10/5013. (Slide No.3819).

Hand specimen: A fresh surface shows the rock to be medium-grained, with a pink colour, mottled with dark green. It is composed of pink granular felspar, quartz and a dark mica, the latter as parallel flakes. The specimen's weathered surface shows the granular-schistoze texture with effect. It is stained with hydrated iron oxide.

Thin section: Texturally, the rock is medium-grained, equigranular, and granoblastic-lepidoblastic. Quartz occurs as angular grains, rather smaller than the general groundmass. They have sutured margins, and show cracking and strained extinction. Albite is subidioblastic, occurring as roughly tabular crystals, but with slightly crenulate boundaries. It is badly kaolinized and sericitized. Albite multiple twinning is present, and is strained. Albite has a refractive index less than that of Canada balsam, and it is biaxial positive. Hydrated iron oxide dust sometimes occurs along the twin planes in some crystals. Biotite forms anhedral flakes with strained cleavage. It is slightly poikilitic about quartz and felspar. The flakes show a rough lineation. Biotite is pleochroic: X = olive brown; X = Z = very light brown, tending to be colourless towards the crystal edges. Black iron ore and prehnite occur in lenses along biotite cleavage planes. Apatite is also included in

biotite. A little chloritization of the biotite has taken place. Black iron ore also occurs as octahedra in the groundmass. Very thin veins of chlorite appear to cut the slide, often utilizing the felspar cleavage.

An estimation of the composition of the rock is: albite = 45%; biotite = 20%; quartz = 30%; the remainder = 5%. The rock is a biotite-quartz-albite schist.

HA.101. pt.3134, Huckitta. 10/5013. (Slide No. 3820).

Hand specimen: On a fresh surface the rock is seen to be coarse-grained, basic, hypidiomorphic and igneous. It consists of stubby tabular crystals of feldspar, often slightly stained with ferruginous matter, and black crystals of hornblende. A few flakes of mica were noted. The weathered surfaces are stained with hydrated iron oxide.

Thin section: In texture the rock is coarse-grained, inequigranular and hypidiomorphic. Bytownite is subhedral, and roughly tabular in shape, showing sub-crenulate margins, but without granulation. Some intergrowth of crystals was noticed. Albite, carlsbad and pericline twinning are present. Its refractive index is greater than that of Canada balsam. and it is biaxial negative, with $2V \angle = 80^{\circ}$. The angle of the rhombic section showed a composition of An_{86}. Bytownite is slightly sericitized and kaolinized. Hornblende is subhedral, prismatic: it forms large prismatic crystals, or clusters of smaller prisms. None of the more euhedral basal sections present appear to pseudomorph pyroxene - in fact, small euhedra of hornblende sometimes occur near the centres of felspar crystals. Hornblende is pleochroic: X = light green; Y = Z = very light olive. Length slow, $Z \wedge c = 19^{\circ}$. Some flakes of biotite are present, they are subhedral and tabular, with prehnite occurring along the cleavage traces. It is pleochroic from light foxy brown to almost colourless. Some hornblende, of irregular shape, is enclosed within some of the biotite, showing probable alteration of the former to the latter.

Black iron ore occurs as small, irregular masses where biotite has formed from hornblende.

An estimation of the mineralogical composition of the rock is: bytownite = 50%; hornblende = 47%; biotite = 3%. The rock is a hornblende gabbro, or bojite.

HA. 107.i. Locality ? (Slide No. 3821).

Hand specimen: Missing.

Thin section: Texturally, the rock is medium-grained, inequigranular, and xenoblastic. A diminution of grain size from medium to fine may be noticed across the section. Quartz occurs as xenoblastic grains with crenulate margins, the grains showing a slight preferred orientation. It has a badly strained extinction, and a slightly biaxial interference figure; the crystals are well cracked. Tourmaline forms xenoblastic, rounded grains, rather smaller than those of quartz, and often included in that mineral. A slight preferred orientation may again be noticed, in the same direction as that of quartz. Tourmaline occurs in aggregates which are elongated in the same direction. Pleochroic o = green-grey; e = very light grey. Its birefringence = 0.023, while it is uniaxial negative. A very small amount of black iron ore is present.

It is estimated that 70% of quartz, and 30% of tourmaline are present. The rock is a tourmaline-quartz hornfels.

HA. 107.ii. pt.3188. Huckitta 10/5013. (Slide No.3822).

Hand specimen: The rock is medium to coarse-grained and rather equigranular, and contains roughly parallel, flat, lenticular inclusions of rather finer material. The specimen consists of quartz, felspar and a ferromagnesian mineral. The weathered surfaces are stained with hydrated iron oxide.

Thin section: In texture, the specimen is medium to coarse-grained, aphyric, hypidiomorphic and equigranular. Quartz forms rounded, anhedral grains with slightly strained extinction. Some quartz is, however, intergrown with sericite, suggesting that in this case it is secondary. The felspar is entirely sericitized, and highly kaolinized. The sericitized masses form poikilitic grains enclosing quartz, and partly enclosing hornblende. Hornblende forms subhedral crystals, often interstitial to quartz, and enclosing the smaller quqrtz grains. It is pleochroic: X = olive green; Y = brunswick green; Z = deep green. Length slow, $Z \wedge C = 22^{\circ}$. Birefringence = 0.021. It is biaxial negative, with $2V = -30^{\circ}$. Included allanite gives pleochroic haloes. Black iron ore forms rounded, anhedral grains. Hydrated iron oxide forms tabular crystals. Apatite occurs as minute, acicular euhedra enclosed in quartz, while allanite forms rounded grains, enclosed in quartz and hornblende.

An estimation of the mineralogical composition is: sericitized felspar = 45%; hornblende = 25%; quartz = 25%; the remainder = 5%. The rock appears to be a saussuritized acid igneous rock, possibly (?) granodiorite. The inclusions seen in the hand specimen are probably flattened xenoliths.

HA. 109. pt.3211. Huckitta 10/5011. (Slide No.3823)

Hand specimen: The rock is fine to medium-grained, and greyish, and is porphyroblastic. It contains quartz, epidote, amphibole, and a pinkish garnet, all in the granular groundmass. The porphyroblasts consist of rows of large crystals of magnetite, up to 5 mm. in size. The weathered surfaces are brightly stained with hydrated iron oxide.

Thin section: The groundmass is fine-grained, though inequigranular, and granoblastic. Quartz forms granular crystals with sutured margins: it is cracked and shows strained extinction. Actinolite occurs as xenoblastic crystals which have a vague prismatic shape: it commonly poikiloblastically encloses garnet. It is pleochroic: X = almost colourless; Y = very light green; Z = light apple green. Birefringence = 0.027. Length slow, $Z \wedge C = 22^{\circ}$. Epidote is present as tabular crystals, or as grains intergrown with actinolite. Sometimes it occurs partly around the borders of the magnetite crystals. Garnet forms very small granular crystals occurring in clusters. Magnetite occurs as idioblastic porphyroblasts, up to 5 mm. in size, as compared with 0.3 mm. average size of the groundmass. They often enclose a few grains of quartz.

The specimen is a garnet-epidote-actinolite-magnetite-quartz skarn.

HA.115. pt.38, Huckitta. 11/5206. (Slide No. 3824).

Hand specimen: A fresh surface shows the rock to be fine-grained and porphyritic, and basic. White tabular crystals of felspar occur with a dark ferromagnesian mineral in the groundmass, while the phenocrysts are square-tabular shaped, and composed of white felspar. Weathered surfaces are stained with hydrated iron oxide.

Thin section: The specimen is, in texture, medium to fine-grained, idiomorphic and glomeroporphyritic. A flow texture is present. Oligoclase, in the groundmass, occurs as laths with irregular, somewhat crenulate margins. The phenocrysts are square-shaped to tabular, with slightly irregular margins; they occur in clusters. Groundmass and phenocryst felspar appear to be similar in composition, . The refractive index is greater than that of Canada balsam, and the edges of the phenocrysts gave a biaxial negative figure: a figure at the centre of one phenocryst was positive, suggesting that the core is of andesine.

An extinction angle on a section normal to the X-bisectrix showed a composition of An_{25}. Hornblende is euhedral, and confined to the groundmass. It is pleochroic: X = light green; Y = dark olive green; Z = dark green. Length slow, $Z \wedge C = 17^{o}$. Its birefringence = 0.021. Biotite occurs in minor quantity, and is confined to the groundmass. Epidote is present as granules associated with hornblende. Tourmaline is seen to be enclosed in felspar. Black iron ore and hydrated iron oxide occur in small amounts, generally associated with hornblende.

Aggregates of equidimensional, sub-angular grains of quartz are present, the aggregates measuring 0.5 to 1.0 mm. Very often they are adjacent to felspar phenocrysts. They are possibly xenoliths, as may be numerous, angular grains of quartz scattered in the groundmass.

An estimation of the rock's composition is: oligoclase = 50%; hornblende, 45%; quartz xenolith matter = 3%; the remainder = 2%. The rock is a metamorphosed andesite.

HA.117. Reward Copper Mine, Huckitta 10/5009. (Slide No.3825).

Hand specimen: The rock is medium-grained, and has a pronounced schistosity imparted to it by parallel flakes of mica. Other constituents appear to be quartz, with some garnet. Large, grey, porphyroblasts occur, around which the mica flakes are wrapped. The rock is stained with hydrated iron oxide.

Thin section: The texture is medium-grained, lepidoblastic and porphyroblastic: some slip-strain cleavage affects the mica in the quartz-rich bands. The specimen is foliated into quartz - and mica-rich layers. Quartz is xenoblastic and granular, with a tendancy for the longer axes of the crystals to be elongated parallel to the schistosity. Muscovite forms slender, colourless flakes, with a general preferred orientation. Biotite has a habit similar to that of muscovite, except that the flakes are more stumpy in shape. Garnet forms idioblastic crystals, and has a slightly pink colour. The porphyroblasts appear to be composed of cordierite, and enclose numerous rounded grains of quartz, and some black iron ore. Mica flakes are wrapped around them. Tourmaline forms small idioblastic crystals. Small amounts of zircon are present. Black iron ore occurs as square-shaped crystals. A little chlorite is present.

An estimation of the amounts of minerals present is: quartz = 40%; muscovite = 35%; (?) cordierite = 10%; biotite = 5%; garnet = 5%; black iron ore = 3%; the remainder = 2%. The rock is a garnet-biotite-muscovite-quartz schist.

This specimen may be compared with HA.80, in that it contains (?) cordierite, suggesting that the rock has suffered polymetamorphism.

HA.118. pt.3183. Huckitta 10/5013. (Slide No.3826)

Hand specimen: The rock is micaceous and pink-cream coloured, with alternating bands in which mica is more coarse, and more fine. The mica is lineated, giving the rock a schistosity. This lineation is inclined at 15° to the banding. The specimen consists of mica, felspar and quartz. Weathered surfaces are stained with hydrated iron oxide.

Thin section: In texture, the rock is medium grained and granoblastic-lepidoblastic. Quartz occurs as rounded, granular crystals with sutured margins, and appears to be interstitial to oligoclase. The latter mineral is sub-idioblastic, with a granular-tabular shape. Its refractive index is greater than that of Canada balsam: it is biaxial negative, with $2V \simeq 80°$. Some albite twinning is present. Extinction angles measured on a section normal to the X-bisectrix gave a composition of An_{25}. Biotite occurs as sub-xenoblastic flakes, which are roughly parallel to each other. In certain layers they are of a similar size to the surrounding minerals (i.e., 0.5 mm. long), but in other layers they are larger (1 mm. long) and fewer in number. Some granular epidote is associated with biotite. A little muscovite occurs as xenoblastic flakes. Sericite and kaolin are present as alteration products of oligoclase; they have been formed from the felspar, particularly around its margins, and along cleavage planes, more usually the (010) plane. Apatite and zircon occur as prismatic crystals. A very few irregular grains of black iron ore are present. An estimation of the specimen's composition is: oligoclase = 40%; quartz = 35%; biotite = 20%; the remainder = 5%.

Although terminology of metamorphism has been used in the description of this specimen, it is by no means certain that it is of metamorphic origin. The angle between the layering and the lineation of the mica flakes suggests metamorphism. But sericitization of the felspars has taken place, sometimes badly altering whole crystals. Again, the felspar is well twinned. These latter points are rather against a metamorphic origin for the rock. More facts from field work will no doubt throw some light on the problem.

The rock is a somewhat schistose biotite-oligoclase-quartz granulite, probably derived from a medium to fine-grained, banded biotite granodiorite.

SUMMARY.

The specimens in this suite may be grouped:-

Regionally metamorphosed:

HA2.	Grossularite marble.
HA.18	Tourmaline-Muscovite-quartz schist.
HA.69.	Calc-silicate gneiss.
HA.100	Biotite-quartz-albite schist.
HA.118	Biotite-oligoclase-quartz granulite.

Specimens showing signs of contact metamorphism:

HA.55.	Tourmaline-quartz hornfels
HA.79	Tourmaline-quartz hornfels.
HA.80	A mica schist, bearing cordierite
HA.107(i)	Tourmaline-quartz hornfels.
HA.109	Garnet-epidote-actinolite-magnetite-quartz skarn.
HA.117	A mica schist, bearing cordierite.

Dynamically metamorphosed:

HA.34	Flasser aplo-granite
HA.98	Granodiorite.

Acid igneous:

HA.9	Gneisenized granite.
HA.28	Trondjemite
HA.38	Leucocratic granite
HA.107(ii)	(?) granodiorite

Basic igneous:

HA.27	Hypersthene-bytownite gabbro
HA.39	Uralitized bytownite gabbro (scapolitized)
HA.42)	
HA.67)	
HA.76)	Hornblende gabbro, or bojite.
HA.87)	
HA.101)	

Minor intrusive:

HA.30	Saussuritized and uralitized dolerite.
HA.91	Sericitized and chloritized fine-grained gabbro.
HA.115	Metamorphosed andesite.

Sedimentary:

HA.8	Chert, or silicified tuff.
HA.13	Calcilutite

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