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THE CARBONIFEROUS AND PERMO-TRIASSIC IGNEOUS ROCKS OF THE MOSSMAN FOUR-MILE SHEET AREA, NORTH QUEENSLAND.

by

W.R. Morgan

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SUMMARY

The main intrusions in the Mossman 4-mile Sheet area are the Mareeba and Cannibal Creek Granites (probably Carboniferous) and the Almaden and Elizabeth Creek Granites (Permo-Triassic). The Mareeba Granite, a grey, coarse-grained and porphyritic two-mica granite, occurs in the east of the area and is responsible for wolfram and tin mineralization. The Cannibal Creek Granite, located in the north central part of the area, is cream, medium-to coarse-grained and less porphyritic than the Mareeba Granite, and is responsible for tin mineralization. The Almaden Granodiorite variant of the Herbert River Granite found farther south, is a grey, porphyritic biotite-hornblende granite responsible for gold-bismuth mineralization at the Beaverbrook mine. The Elizabeth Creek Granite is found, with the Almaden Granodiorite in the south-west corner of the sheet, and is a pink, markedly porphyritic, leucocratic granite that probably caused the tin mineralization at the Pandora mine.

The granites are all "high level": they are intruded into regionally unmetamorphosed folded lower Palaeozoic sediments and have narrow contact-metamorphic aureoles. Dykes are associated with the Mareeba Granite; and the Nychum and Featherbed Volcanics are associated (and probably co-magmatic) with the Almaden and Elizabeth Creek Granites, respectively.

Other intrusive rocks in the area include north to north-westerly trending acid dykes in the Palmer River area, and a small stock of granodiorite near the Mitchell River and McLeod River junction.

There are two series of volcanic rocks. The Nychum Volcanics consist of acid lavas, tuffs, and ignimbrites, subordinate andesites and basalts, and rare sediments. Sediments associated with the Nychum Volcanics at Jug Water Hole on the Mitchell River, and at Mt. Mulligan, contain coal and fossil plants of Upper Permian or possibly lower Triassic age. The younger Featherbed Volcanics consist of ignimbrites and acid lavas.

A summary of the igneous activity is :-

4.	a. Elizabeth Creek Granite b. Featherbed Volcanics	Triassic
3.	Almaden Granodiorite	to
2.	Nychum Volcanics	Upper Permian
1.	Cannibal Creek Granite Mareeba Granite	Carboniferous

GENERAL INTRODUCTION

This report summarizes field observations of the Carboniferous and Permo-Triassic rocks in the Mossman 4-mile Sheet area during the 1960 field season. Also included in the main text is the more important petrographic information gained from microscopic study of the specimens collected. The detailed petrography is given in Chapter VII. The report is interim as the preparation of thin sections is not complete.

The maps shown in Plates 1, 2, and 3 are based, topographically, on the 1943 edition of the Mossman Military four-mile sheet and on uncontrolled mosaics of photo overlays, and are therefore not accurate. They will be redrawn later when controlled planimetrics become available.

The rocks described in this report comprise the Mareeba, Cannibal Creek, Almaden, and Elizabeth Creek Granites, the Nychum and Featherbed Volcanics, and some minor intrusives. These rocks are the northerly extension of a large upper Palaeozoic acid igneous complex cropping out to the south of the area (fig. 1); they intrude the Palaeozoic sediments of the Tasman Geosynclinal Zone, which in this part of North Queensland is faulted on its western edge against the Precambrian Shield. In the Mossman sheet area the intrusion of batholyths of the Mareeba and Cannibal Creek Granites, probably in the Carboniferous, was followed by two cycles of acid igneous activity in Permo-Triassic times. After the extrusion of dominantly acid volcanics in each cycle, granitic rocks were intruded.

The Cannibal Creek Granite is restricted to the area of the Mossman Sheet, and the Mareeba Granite does not extend much farther south than the township of Mareeba (fig. 1, and Plate 1).

The pattern of events of the Permo-Triassic igneous activity in this area was similar to that which occurred in the area immediately south of the Mossman Sheet. Thus, the Upper Permian Nychum Volcanics have as their equivalents in the igneous cycle (though not in age) the Carboniferous Nanyetta Volcanics and lower Permian Agate Creek Volcanics (Branch 1960b). The Almaden Granodiorite, which intrudes the Nychum Volcanics, is a part of the probably composite batholyth of Herbert River Granite. It is thought by others, e.g., Branch and White (pers. comm.), that this batholyth ranges in age from (?)Carboniferous in the south to Permo-Triassic in the north.

The younger volcanics in the area of the Mossman sheet are the Featherbed volcanics. Elsewhere these overlie and intrude the Herbert River and Almaden Granodiorite. These volcanics are Permo-Triassic, and extend southwards from the Mossman Sheet area. Their equivalents in North Queensland are, for example, the Croydon Felsite and the Scardons Volcanics. These are intruded by the youngest rocks in the cycle: the Elizabeth Creek and Esmeralda Granites. A few stocks of the Elizabeth Creek Granite occur in the Mossman Sheet area.

THE MAJOR INTRUSIVE ROCKS

General

The intrusive rocks described here comprise the Mareeba, Cannibal Creek, Almaden, and Elizabeth Creek Granites. Some notes on dyke rocks associated with the Mareeba Granite are given; the dyke swarm associated with the Nychum Volcanics is described with the volcanics.

The Mareeba Granite crops out in the east of the area, and the Cannibal Creek Granite in the central north. The Almaden and Elizabeth Creek Granites are restricted to the south-western portion of the sheet. In this report the major intrusive rocks are called "granite" in their formational names, in spite of the fact that granites (sensu stricto) have been rarely observed. Because each variety of acid types (e.g., adamellite, granodiorite) may occur in any one intrusive type, I have used granite (sensu lato) as a general rock name.

The Mareeba Granite

Introduction. The name "Mareeba granite" was first used by Jensen (1923) when he referred to the granite outcrop on Hann's Tableland, north-west of Mareeba. In a recent submission to the Stratigraphical Nomenclature Sub-Committee I used the name "Mareeba Granite" to describe a series of lithologically similar intrusions extending north from Hann's Tableland to near the Daintree and Palmer Rivers. Intrusives are known to crop out north of these rivers, extending north to the adjacent Cooktown four-mile area, and may have a similar lithology. This matter will be investigated in the 1961 field season, and will not be discussed here.

The Mareeba Granite, as at present known, comprises four large intrusions and a number of smaller stocks, and crops out over a total area of about 700 square miles (Plate 1). The intrusions are aligned and elongated in a north-north-westerly direction, coinciding roughly with the regional strike of the folded sediments which they intrude.

Except in the coastal rain forest areas, the granite forms bold grey hills and high, dissected tablelands on which the granite stands out as rounded crags and tors, in contrast to the surrounding country rock which forms hilly but more subdued country with reddish-brown soil. On aerial photographs it is usually very easy to outline the granite contacts, but in the coastal rain forest areas the boundaries are much more difficult to follow because of the forest cover.

My account of the Mareeba Granite is divided into sections dealing with the main granite, its marginal variations, its contacts, the country rocks, associated dyke rocks, economic geology, and short sections on the control of intrusion, its age, and brief petrological notes.

The Granite. In the larger intrusives that form, for example, Hann's Tableland and Mt. Carbine Tableland, the granite outcrops as a coarse-grained and very prophyritic rock, that is generally weathered brownish-grey, and which tends to shatter when struck by a hammer. A fresh specimen obtained from a cutting on the Mt. Lewis forestry road, about two miles west of Rumula, is pale blue-grey and has a coarse groundmass of feldspar, quartz and biotite, enclosing large feldspar phenocrysts that range up to an inch across.

Several thin sections cut from specimens collected at Gorge Creek (near Mareeba: E55/1/2), the Mt. Windsor Tableland (M1127), and from the intrusion that crops out between Kelly's and Maitland Downs Homesteads (M1107, M1114, M1120) show the rocks to be microcline adamellites and granodiorites. They contain sodic plagioclase, quartz, microcline, biotite, and muscovite. In all the sections the texture is xenomorphic and inequigranular, and appears to be protoclastic.

The rocks in the smaller stocks show slight differences in outcrop and in hand specimen from those in the larger intrusions. The group of three stocks surrounding Font Hills Homestead (ten miles west of Mt. Molloy) and most of the group of stocks south of Mt. Carbine are coarse-grained and aphyric. A thin section cut from a specimen (E55/1/1) obtained from this group is a muscovite adamellite, and contains quartz, albite, and perthite. The stock four miles west of the junction of the McLeod River and Spencer Creek, and the stock a mile east of the Mulligan Highway-McLeod River crossing, are lithologically similar to the larger intrusions described above, except that the second one appears to be garnetiferous. The intrusion four miles north-east of the Mulligan Highway-McLeod River crossing is a "microgranite porphyry" in hand specimen, and consists of coarse phenocrysts of feldspar and quartz enclosed in a fine-grained groundmass.

Marginal Variations. Several varieties of marginal granite were observed during traverses across the granite/sedimentary rock boundary. The following descriptions are based on field and hand-specimen determinations only, as the thin sections are not yet available.

In many places the marginal granite is coarse-grained and either aphyric or porphyritic; it shows no decrease of grain-size towards the contact. The phenocrysts, where present, are usually aligned vertically or at a high angle, presumably parallel to the contact; similarly, the aphyric granite and the groundmass of the porphyritic varieties commonly show foliation, which regionally is parallel to the contact, although this is not everywhere so in detail. R.M. Rucker (Queensland Geological Survey, pers. comm.) did not observe foliation in the granite cropping out between Kelly's and Maitland Downs Homesteads. Examples of aligned phenocrysts may be seen in the stock a mile east of the Mulligan Highway/McLeod River crossing, and in the foliated granite at the Cumble Cumble mine.

Chilled margins and other marginal variations are commonly absent; however, some variations do occur. Several of the varieties of the granite (described below) crop out close to, or at, places where mining has taken place, but it must be emphasized that the more unusual marginal variations are not all associated with economic minerals and neither are all the mines situated where these unusual varieties crop out. Nevertheless there may be some significance in the association of some of the mine locations with some of the more unusual marginal varieties.

At the south of Mt. Alto, near the abandoned wolfram crusher on the bank of the Mitchell River, a chilled margin of white fine to medium-grained tourmaline-bearing aplogranite increases in grain-size within twenty to thirty feet of the contact to form a coarse-grained muscovite granite. A mile to the north-west of this locality a chilled margin is formed of a creamish-white feldspar-phyric microgranite. Tin has been worked a short distance into the granite from its chilled margin at this locality.

In the vicinity of the Pom Pom and Sweet William mines the marginal rock is a medium to coarse-grained aphyric dioritic type which encloses small schlieren of pegmatite, and grades within about fifty feet into normal granite. The lode of the Pom Pom mine (wolfram) is about six feet wide, and was emplaced along the contact between the granite and its country. The dominant mineral in the lode is quartz, with some greisenized feldspar, and rare wolfram and chalcopyrite. A quartz-greisen lode containing chalcopyrite was worked at the Sweet William mine; the lode intruded the dioritic marginal types of the granite. Samples of diorite on the mine dump are stained by malachite.

Scheelite workings are located near a wedge-shaped apophysis of biotite microgranite porphyry that extends a short distance south-east from the granite, 2 miles east-north-east of Mt. Carbine. Near the Vera mine, about two miles north of Mt. Carbine, the marginal rock is composed of a pink aplitic type containing phenocrysts of partly greisenized feldspar; this grades away from the contact through a granular granite to normal granite.

One small stock in a group south of Mt. Carbine consists of a fine- to medium-grained tourmaline-bearing aplogranite. It crops out on the east side of a hill about a mile west of "Brooklyn" Homestead. (fig. ii). The grain-size of the aplo-granite decreases from the bottom of the hill to a small bench, about ten to twenty feet wide, at about a hundred feet above the valley floor. On the inner side of the bench, rubble of the sedimentary country rock rests on the aplo-granite, and forms the hillside that continues above the bench; no granite rubble was noted above the bench. It seems likely, therefore, that the bench represents a plane at, or close to, the junction of the aplogranite with its country rock. The aplo-granite on the bench contains several discontinuous patches in which are enclosed large euhedral crystals of feldspar that are one to two inches long, and which are arranged perpendicularly to the supposed contact. Interspersed amongst these crystals are long acicular crystals of tourmaline with a similar orientation. This is possibly a metasomatic effect developed along the contact at this place, but the matter cannot be decided until thin sections are examined.

Contacts

Actual contacts of the Mareeba Granite with its country rock are generally hidden by soil and vegetation. Where they are exposed, in creek sections, they are sharp and somewhat irregular. In a creek immediately west of the Sweet William mine, the granite cuts across the cleavage of the country rocks. An exposure close to where the track to the Mt. Spurgeon tin workings crosses the contact, thin veins of granite, only a few feet from the main intrusion, form tongues along the cleavage of slate country rock (fig.iii).; a similar feature was noted by R.M. Tucker at the contact on the southern end of the Mt. Windsor Tableland. A contact was observed by F. de Keyser in the Mossman River. Here thin apophyses of granite cut the country rock within about a hundred yards of the main granite body, and metasomatically formed feldspar porphyroblasts occur in the country rock.

Xenoliths are rare in the Mareeba Granite, even at its contacts. Some xenoliths were observed on the side of the forestry track from Mareeba onto Hann's Tableland; these consisted of a probable acid porphyry that may represent cognate inclusions.

Country Rocks

The sediments which the granite intrudes are composed mostly of highly cleaved and sheared slates. In some places, as at Reedy Creek, thin arenaceous beds have been sheared to form small elongated spheroidal pellets measuring about half an inch. An exposure across a part of the highly cleaved zone is shown fairly well in Reedy Creek. This zone is bordered to the west, and possibly to the east, by a relatively uncleaved, steeply dipping and dominantly arenaceous series. At Reedy Creek the slates grade into the sandstones in a thin zone of tightly folded, thin-bedded slates and sandstone.

The slates are contact metamorphosed by the granite in many places. At the Cumble Cumble mine, and on the Mt. Spurgeon track the slate has been metamorphosed to a micaceous "schist" in a zone about a hundred yards wide, and, in this zone, crystals of andalusite have developed that have since been sericitized. A thin section of a specimen (m1112) collected from the metamorphic aureole at the north-east corner of the intrusive cropping out between Kelly's and Maitland Downs Homesteads contains tabular crystals of partly sericitized andalusite (pleochroic from pink to colourless) enclosed in a microfolded groundmass of quartz and sericite layers.

At several places, e.g., at Bakers Blue Mountain and at the scheelite workings east of Mt. Carbine, the slaty cleavage is tightly folded close to the granite margin; this was probably caused by the force of intrusion of the granite.

Dykes

Aplite. Dykes of aplite, up to two feet thick, intrude granite near the Vera mine; they have a northerly trend. At the scheelite workings east of Mt. Carbine thin dykes of tourmaline-bearing aplite intrude the sedimentary country rocks.

Acid porphyry dykes intrude granite at Bakers Blue Mountain and Lighthouse Mountain. At Lighthouse Mountain lines of rubble overlie the granite; these are composed of fine, acid porphyry, and trend east-west, at right-angles to the nearest granite contact with the sedimentary rocks; however, no actual outcrop of porphyry was observed. It seems likely, that the rubble represents dyke material cutting the granite. Similar rubble was noted on Baker's Blue Mountain, immediately west of Font Hills Homestead.

Acid porphyry dykes intrude the slates, parallel to the cleavage, north of Bakers Blue Mountain, on the McLeod River, and in Spencer Creek. According to Ball (1912) similarly trending dykes intrude granite and ore veins at Mt. Holmes.

Strongly weathered aphyric and medium-grained granular acid dyke rocks containing muscovite cut the granite in an east-west direction in the massif that crops out between Kelly's and Maitland Downs Homesteads.

Economic Geology. Wolfram, scheelite, cassiterite and chalcopyrite are associated with the Mareeba Granite, all occurring in quartz and rare pegmatite reefs; cassiterite also occurs in alluvial deposits.

The granite and its country rocks are cut, in many places, by quartz reefs, some of which contain ore minerals. The reefs trend in directions ranging from easterly to south-south-easterly, and consist mostly of quartz, with minor quantities of muscovite, chlorite, and feldspar, and rare tourmaline. The more common minerals are wolfram, e.g., at the Mt. Carbine, Cumble Cumble, and Pom Pom mines; and casserite, e.g., at the Mt. Holmes Mine. Scheelite is at present being worked from thin pegmatitic veins near Mt. Carbine, and chalcopyrite was mined at the Sweet William.

Alluvial cassiterite was worked at Mt. Spurgeon for a few months in 1960 and has been worked intermittently in most of the creeks running off the Mareeba Granite.

Control of the Intrusion. B.J. Amos has concluded (pers. comm.), from his studies of the structures of the Mossman Sheet area, that the zone of intense cleavage in the sedimentary rocks along which the granite has been intruded is part of the regional structure of the area, and is not caused by the intrusion of the granite. However, it is very likely that this highly cleaved argillaceous rock was a zone of weakness along which the granite was intruded.

The age of the Granite. The granite is post-kinematic. The earth-movements responsible for the folding and cleavage of the country rocks are believed to be late Devonian or early Carboniferous because, in the area of the Atherton sheet, strongly folded Devonian Hodgkinson sediments are unconformably overlain by the Ringrose Formation, and this, in turn, is unconformably overlain by the Silver Valley Conglomerate, which contains (?)middle Carboniferous fossils, viz., Rhacopteris inequilatera. Hence, as field evidence shows that the granite post-dates the folding, it is younger than early Carboniferous, although its relationship to the Silver Valley conglomerate is not known. However, Marmo (1958), from a study of the literature, considered that microcline-bearing granites are mainly synkinematic, and that orthoclase granites are mainly post-kinematic. The Mareeba Granite generally has microcline as its potash feldspar, which suggests that the granite's intrusion may well be closely associated with the period of folding of the Hodgkinson sediments; hence the granite is probably immediately post-kinematic. Thus, it is tentatively concluded that the Mareeba Granite is Carboniferous in age.

Brief Petrological Notes

In most places the stocks and batholyths are elongated parallel to the regional strike of the lower Palaeozoic sedimentary rocks, although in detail, as seen in outcrop, the contacts trend somewhat irregularly across the cleavage and bedding. This regional parallelism came about because the granites intruded a zone of dominantly argillaceous rocks. One or two stocks, for example the one four miles west of the McLeod River/Spencer Creek junction, are, in outcrop, notably discordant; these intrude dominantly arenaceous rocks.

The intrusions have only a thin contact metamorphic aureole, and the sedimentary country rocks have not been highly regionally metamorphosed. Close to the contacts the cleavage of the country rock is tightly folded in some places, suggesting that some pushing aside of the country rocks occurred during the intrusion of the granite.

These observed characteristics indicate that the granite is "high level" (Read, 1957), or, according to a classification of Buddington (1959), it was intruded in an epi-mesozonal environment.

Chilled margins in some parts of the intrusions show that the granite magma was probably in a fairly liquid condition when it was first intruded. The aligned phenocrysts and the foliation found in some places, thought to be platy flow structures, are (flow) structures impressed upon the granite magma later when it was composed mostly of a crystal mush: thin sections show that the granite has a faint protoclastic texture which supports this idea.

The cause of this flow texture is in doubt. One explanation could be that it was caused by the force of intrusion late in the cooling history of the batholyth. Another explanation is that it was caused by convection currents in the batholyths; Lacy (1960) considers that even in a highly viscous magma, convection currents can be important. However, if convection currents were the cause of this textural phenomenon then the foliation and alignment of phenocrysts should be all through the intrusions, but this has not been observed, for this texture is only marginal. Hence, from present evidence, the idea that the texture is caused by the force of intrusion appears to be the correct one.

In a reconnaissance study of these intrusions there are two main problems: first, to account for the space taken by the granite; secondly, to deduce the source of the magma. A third problem, the mechanism of intrusion, depends upon the other two. Little can be written about these problems without further work in the area.

The Cannibal Creek Granite

Introduction. The name "Cannibal Creek Granite" is derived from a small tin-mining field close to Cannibal Creek, five miles west of the north-west corner of the granite outcrop. The location of the granite is shown in Plate 1. The granite outcrop is oval and is elongated in a north-west direction. A small, dome-shaped intrusion some eight miles to the east is lithologically similar to the main Cannibal Creek Granite.

Like the larger of the Mareeba Granite intrusions, the Cannibal Creek Granite mostly forms a partly dissected tableland that protrudes above the surrounding sedimentary rocks. The granite in outcrop forms large rounded crags.

The Granite. In outcrop the granite is weathered to a creamish-brown rock that is medium- to coarse-grained, somewhat foliated, and sparsely porphyritic. A fresh specimen obtained from the northern end of the mass (M1693) is creamish-grey, and the mica has a preferred orientation.

A thin section of this specimen shows the rock to be a biotite-muscovite-microcline adamellite; the specimen is hypidiomorphic and porphyritic, one or two of the microcline phenocrysts showing a rapakivi structure, i.e., having a thin shell of oligoclase.

In places where the contact with the sedimentary rocks was observed, the granite has a chilled margin showing a pronounced flow structure that is roughly parallel to the contact. A thin section of a specimen (m1687) of chilled rock shows that it is a biotite-muscovite micro-adamellite porphyry, which has a xenomorphic-granular, protoclastic texture.

As mentioned before, the granite mostly protrudes above the surrounding country rock. However, its north-east margin is difficult to trace on aerial photographs because here the granite topography is not very different from that of the country rock. The dips of the granite foliation in this area are low, and, in fact, some dips are towards the main part of the intrusion. This suggests that the roof of the intrusion has not long been exposed by erosion, and that the roof roughly coincides with the present land surface at this place.

The junction of the granite with the sedimentary country rocks is sharp, and the granite cuts across both bedding and cleavage. Xenoliths of the country rock are, near the contact, only baked and slightly recrystallized, but farther into the granite from the margine they are recrystallized, more coarse-grained, and porphyroblastic.

The small stock cropping out eight miles east of the main granite may be a small dome of Cannibal Creek Granite. It is strongly foliated near, and parallel to, its margins; some xenoliths are drawn out parallel to the margins. In hand specimen the rock is very similar to the Cannibal Creek Granite.

Hornfels. The steeply dipping sedimentary rocks (dark sandstones and cleaved siltstones) forming the country rock to the granite form a landscape of low but sharp relief. Few continuous ridges are exposed; in fact, on aerial photographs the structure is shown by strings of small rounded hills divided by innumerable small but deep creeks. Aerial photograph interpretation shows that around the granite margin there is a zone about a mile wide in which the topography of the country is subdued. It seems likely that this zone represents an aureole of rock affected by the granite intrusion. Observations on the ground show that recrystallization due to contact metamorphism occurs only up to a few hundred yards from the contact. A thin section of a specimen (M1689) of hornfels shows large tabular porphyroblasts of andalusite, now replaced by sericite, enclosed in a fine groundmass composed of alternating quartz-rich and mica-rich layers. The micas are biotite and sericite, and the texture is crystalloblastic, although a relict fracture cleavage has been accentuated by the growth of mica flakes.

Economic Geology. Cassiterite was mined from quartz reefs at the Cannibal Creek tinfield. These reefs have a westerly to north-westerly trend. Numerous reefs cut the northern part of the granite and the country rocks. Alluvial cassiterite is worked in creeks on the north-east edge of the granite, and, at one time, was worked within the granite itself, and in Granite Creek, on the western margin of the granite. In an attempt to trace the source of this alluvial cassiterite two specimens of quartz reefs from the granite, and two of the granite itself, were crushed, and the heavy separates were examined; no cassiterite was found.

Age. The granite is post-kinematic, and is microcline-bearing; hence the same argument can be used for dating it as was used for the Mareeba Granite. Thus, a Carboniferous age is tentatively suggested. Specimens of the granite will be collected in 1961 for dating by radio-active means.

Petrological Notes. Only two thin sections have been prepared, one from the granite, and the other from its chilled margin; hence any conclusions made here can only be tentative.

Firstly, the granite, from its environment of intrusion is "high level". Secondly, the texture is hypidiomorphic and foliated; the granite also has a chilled margin. Thus, like the Mareeba Granite, the magma must have been fairly fluid during intrusion. The foliation suggests that the magma was still moving after much of the crystallization had taken place.

The Almaden Granodiorite.

Introduction. In the area of the Mossman Sheet the Almaden Granite forms four small stocks and several minor intrusions, the distribution of which is shown on plates 1 and 2. Also, the northern end of an intrusion of Herbert River Granite is exposed on the boundary of the sheet south-south-east of Mt. Mulligan.

The Herbert River and Almaden Granites, south of the Mossman sheet, form a large composite batholyth of 5,000 square miles (White, 1961) that has a north-westerly trend; the Almaden Granite occurs at the north-western end of this batholyth, extending from Almaden, north to the Featherbed Range north of Chillagoe. The relationship between the two granites is not clear, but C.D. Branch (1960 a.) suggested that the Almaden Granite is formed by contamination of Herbert River Granite magma by assimilation of limestone of the Chillagoe Formation, which the Almaden Granite intrudes. Recent petrographic studies by W.B. Dallwitz (1961) seem to confirm this idea. Dallwitz has found that the Almaden Granite in the Almaden-Chillagoe area contains calcic plagioclase, and the Herbert River Granite contains sodic plagioclase. Using this evidence the occurrences in the area of the Mossman four-mile area will now be described.

The stocks in the Mossman Sheet area appear to represent isolated "pinnacles" at the north-western prolongation of the Herbert River Batholyth.

The Almaden Granite crops out differently from the Mareeba and Cannibal Creek Granites in that it does not form areas of high land protruding above the surrounding country rock. In fact it forms low, craggy country that tends to be more heavily wooded than that of the neighbouring rocks; it is, therefore, usually more difficult to photointerpret its boundaries. "Metal hills," which characterize the Almaden Granite near Chillagoe (Dallwitz, 1961) also occur in outcrops on the Mossman sheet, e.g., at Nolan's Creek, and in the intrusion five miles north of the point where the Mungana/Mitchell Bridge road crosses the Walsh River.

The Granite. In outcrop the granite is hard, greyish-green, and porphyritic. Fresh specimens are pale grey, speckled with black, and have a fine- to medium-grained groundmass enclosing the phenocrysts. In the minor intrusions, such as the very small stock immediately south of Nolan's Creek, and east of the large stock bisected by the creek, the euhedral phenocrysts are enclosed by a dark grey to black, almost aphanitic groundmass.

A thin section of a specimen (m1653A) collected in the larger stock at Nolan's Creek shows the rock to be a biotite-hornblende quartz diorite (tonalite) with phenocrysts of plagioclase enclosed in a hypidiomorphic-granular groundmass composed of plagioclase, quartz, hornblende, biotite, minor orthoclase, and accessory zircon, apatite, black iron ore, and tourmaline. A specimen (M579A) collected by F. de Keyser from the stock some four miles south-east of the Nightflower Mine is an actinolite-biotite adamellite, and differs from the previous specimen chiefly in the much greater amount of orthoclase present, and in the development of a granophyric texture in the groundmass.

A specimen (M1651) collected from the small stock south of Nolan's Creek, mentioned above, has a fine hypidiomorhpic-granular groundmass enclosing phenocrysts of plagioclase, hornblende, biotite, and quartz.

Contacts. The only place where contacts were not entirely obscured by soil was in Nolan's Creek. On the east side of the larger intrusion that crops out west of the Wrotham Park road (Plate 2) granite intrudes sandstones of the Mt. Garnet Formation. At this contact the granite includes zones containing angular to sub-rounded xenoliths of the sandstones, many of them having perfectly preserved sedimentary structures. Farther from the contact xenoliths are represented by patches of ferro-magnesian material.

On the western side of the intrusion, in a small valley just to the north of Nolan's Creek, is a contact between the granite and the Nychum Volcanics. Here the granite has a chilled margin that encloses rounded xenoliths of the volcanics. A specimen that shows a contact between the chilled margin of the granite and a xenolith of volcanic rock was collected from this exposure, and is described in Chapter VII, section C (M1656).

No effects of contact metamorphism were observed around the Almaden Granite intrusions, except in a roof pendant of Chillagoe limestone exposed in Nolan's Creek. The limestone has been recrystallized to a very coarse-grained marble.

Economic Geology. The only evidence for mineralization by the Almaden Granodiorite in the area of the Mossman sheet is at the Beaverbrook Mine (south of the point where the Wrotham Park/Mungana road crosses Nolan's Creek). Here a contact lode was mined for gold (Morton, 1939).

Age. The Almaden Granodiorite was, prior to this year's work, thought to be Carboniferous. However, it has been shown to intrude the Nychum Volcanics. Fossil plants obtained from coal-bearing sediments associated with these volcanics are Upper Permian in age. Hence the granite is younger than this, possibly Triassic.

Brief Petrological Notes. Thin sections of specimens of the granite from localities other than those described above have not yet been described. However, from the field data and from the specimens already examined, it is evident that the granite magma was in a liquid condition when it was intruded. Evidence in favour of this is the lack of flow foliation, the lack of protoclastic texture, and the presence of chilled margins.

The thickest succession of Nychum Volcanics so far measured does not exceed five hundred feet, although at one time they were probably thicker, because the top of the section is eroded. However, the volcanics, as will be shown later, are terrestrial deposits, and probably attained no great thickness. They are intruded by the Almaden Granodiorite this suggests that the granite was intruded to a fairly high level, possibly within five hundred feet of the land surface as it was in Upper Permian or Lower Triassic times. There is no real evidence at the moment for the close association of the granite and the acid volcanics, as has been found for the Elizabeth Creek Granite and the Featherbed Volcanics (C.D. Branch, pers. comm.), but the factors just mentioned, considered with the probability of a highly liquid granite magma, suggest that the volcanics and the granite are comagmatic.

The Elizabeth Creek Granite

Introduction. Elizabeth Creek Granite which has been shown by Branch (1960) to be younger than the Almaden Granodiorite from a small stock about five miles east of the Nightflower mine; some may be associated with the stock of Almaden Granodiorite about seven miles north of the point where the Wrotham Park/Mungana road crosses the Walsh River. Another small stock of possible Elizabeth Creek Granite is exposed on the southern boundary of the Mossman Sheet immediately south of the Featherbed Range (Plate 2).

The Granite. In outcrop the Elizabeth Creek Granite tends to stand out from the surrounding country rock, much in the same way as the Mareeba and Cannibal Creek Granites.

In hand specimen the granite is mottled pink, and is crowded with coarse phenocrysts of pink feldspar that are enclosed in a medium-grained groundmass. A thin section cut from a specimen (M579B) collected from the occurrence east of the Nightflower Mine is a leucocratic biotite adamellite, and has phenocrysts of (?)anorthoclase and sodic plagioclase enclosed in a xenomorphic groundmass composed of these minerals, as well as quartz, and rare biotite.

In the occurrence associated with the stock of Almaden Granodiorite, the Elizabeth Creek Granite has a chilled margin composed of a fine- to medium-grained pink aplo-granite; a thin section of this rock has yet to be made.

Contacts and Hornfels. Only poor exposures of contacts of the granite with its country rock were seen. Where the granite is associated with the Almaden Granodiorite stock, the contact appears to be sharp. The country rock of the Elizabeth Creek Granite is baked, but no recrystallization was observed in hand specimen.

Mineralization. The cassiterite of the Pandora Mine may have been emplaced along a fault which was intruded by the Elizabeth Creek Granite (F. de Keyser, pers. comm.).

Other Intrusive Rocks.

Two thick dykes crop out in almost inaccessible country close to Mt. Mulligan; these were examined by F. de Keyser. One, to the south of Mt. Mulligan, strikes north-north-west, and is faulted against the Triassic sediments of Mt. Mulligan; its relationship to the Featherbed Volcanics is not known. North-west of Mt. Mulligan is another dyke that strikes east-north-east, and which is faulted against both the Featherbed and the Nychum Volcanics. A thin section of the dyke-rock has not yet been examined. Both dykes contain rock which, in hand-specimens, appears to be a mottled black-and-white, medium-grained hornblende-biotite granodiorite that, in places, grades into a fine-grained "rhyolite."

The dykes contain inclusions of other rock types, including specimens of leucocratic granophyric aplites and granites (M752A and B and M753B). These may be similar to a granophyric granite that occurs in the Boxwood Complex in the Atherton four-mile area.

About five miles west of the confluence of the Mitchell River and the McLeod River is a small intrusion of what seems to be a medium-grained biotite grandodiorite. In contrast to the nearby Mareeba Granite intrusions, its outcrop is low and smooth, forming a small topographic basin within the surrounding lower Palaeozoic rocks. Its contact aureole forms a low ridge around the intrusion and cuts across the bedding.

The hand specimen of the rock is medium-grained, and contains small phenocrysts of feldspar measuring up to 3 mm. across. The groundmass consists of white feldspar, quartz, and much biotite. The hand specimen differs from both the Mareeba and Cannibal Creek Granites, and is quite unlike those of the Almaden and Elizabeth Creek Granites.

According to K.G. Lucas the intrusion is cut by dyke-rocks similar to those that are associated with the Mareeba Granite on the McLeod River and Spencer Creek (M1624); hence this granodioritic rock is probably about the same age as the Mareeba Granite, and may be related to it.

In the north-east portion of the four-mile area, between Maytown and the Mitchell River, a number of acid to intermediate dykes crop out, mainly in the Maytown area. Their strikes are generally north or north-west, and their thicknesses range from one to twenty feet. The dykes post-date the folding of the lower Palaeozoic rocks, but otherwise their age is not known.

Dolerite dykes (M628) were found by F. de Keyser to intrude the Dargalong Metamorphics parallel to, and immediately west of their boundary fault; de Keyser considers that they may be associated with the fault.

THE VOLCANIC ROCKS.

Introduction. The units described here are the Nychum and Featherbed Volcanics and also a swarm of dykes associated with the Nychum Volcanics. These formations are restricted to the south-western portion of the area, extending from Mt. Mulligan in the east to Mt. Mulgrave on the Mitchell River in the west (plates 1, 2 and 3).

With the Almaden and Elizabeth Creek Granites, the volcanics form the northerly extension of an Upper Palaeozoic-Triassic acid igneous intrusive and extrusive complex. To the south of the Mossman 4-mile area, these rocks have been studied by C.D. Branch. The Featherbed Volcanics, and to a lesser extent, the Nychum Volcanics, form areas of fairly bold highland which are less wooded than the surrounding areas of Lower Palaeozoic rocks. The Nychum Volcanics usually weather to small blocky fragments, whereas the surface of Featherbed Volcanics is covered with large, rounded boulders.

The Nychum Volcanics.

Introduction. The name is derived from Nychum Homestead, which is situated about thirty miles north-north-west of Chillagoe. The location of the Volcanics is shown on plate 1, and more detailed sketch maps of their occurrence are shown in plates 2 and 3.

The Nychum Volcanics unconformably overlie the Precambrian Dargalong Metamorphics, and also the Chillagoe, Mt. Garnet, and Hodgkinson Formations, and are overlain unconformably by Cretaceous sediments. As described in a previous section, they are intruded by the Almaden Granodiorite

Generally, the formation is composed mostly of acid lavas and pyroclastics, with subordinate intermediate and basic lavas; some sedimentary rocks, including coal seams, are inter-bedded with the volcanics.

In my account of the Nychum Volcanics I will write some notes on their structure, describe in some detail the representative areas, draw some conclusions as to their environment of deposition, and summarize their petrography. Detailed petrographic descriptions can be found in Chapter VII.

Structure. The volcanics and their associated sediments are faulted and gently folded. Plate 2 shows that the faults trend in two main directions, north-easterly and north-westerly. The volcanics are folded about north-westerly trending axes, as observed on aerial photographs. On the ground it is nowhere certain whether the dip is structural or depositional. For example, in a creek west of the Kum Kum Range there is an unconformable relationship between two rhyolite flows; the lower one dips fifty degrees to the north-west, and the upper flow dips at ten degrees to the south.

Description of Areas. The rock types of the Nychum Volcanics vary laterally, so that a description of a "type area" would not give a complete picture of the formation. Hence, the Nychum Volcanics will be described from different areas in order to show something of the environment of their formation. Specimen numbers quoted in the descriptions refer to petrographic descriptions in the appendix.

a. The region north and north-west of Nychum Homestead is generally flat, except for a small area, south-east of the Nychum/Coldwater yard track, which is formed of volcanic breccia and which is hilly. About six miles north of Nychum is the south-east facing scarp of the Kum Kum Range.

   At Nychum, and about a mile and a half northeast of the homestead, fine-grained andesite (similar to M1530D) overlies a coarse micaceous sandstone, which, in turn, unconformably overlies isoclinally folded sediments of the Mt. Garnet Formation. Farther to the north-east, the andesite is replaced by a coarse volcanic breccia, and in a creek bed close to the Nychum/Coldwater yard track this was seen to overlie Permian feldspathic sandstone and quartz conglomerate. Close to the Coldwater yard, andesite overlies, and may be, in part, a lateral equivalent of the volcanic breccia.

   North-westward from a point some three miles north-east of Nychum, some acid lavas and tuffs overlie the Permian sediments in place of the volcanic breccia, and these are overlain by the fine-grained andesite. The scarp of the Kum Kum Range is formed of acid lavas and tuffs which overlie the andesite. Figure i7 illustrates these relationships.

b. West of Nychum, in an area extending some three miles west-south-west to the water tank near Bessie Creek, a change in the lithology of the volcanics may be observed. West of Ticklehim Creek, volcanic breccia and fine-grained andesite unconformably rest on sediments of Mt. Garnet Formation. Farther west, at the headwaters of Bessie Creek and immediately north of the water tank a more coarse-grained andesite of a different type (M1617L, and figs xii and xiii) forms a thick flow directly overlying Mt. Garnet Formation. Three-quarters of a mile north-west of this occurrence on the headwaters of Bowler Creek a section is exposed in which no intermediate lavas are present:-

		Thickness in feet
	Coarse sandstone (Cretaceous).	
	Unconformity.	
Permian	10. Purplish-cream acid lavas and tuffs	50
	9. Black, porphyritic ignimbrite (M1617B and fig. xi)	50
	8. Pale-green agglomeratic crystal tuff, possibly water-worn grains	30
	7. Cream vesicular acid lava	30
	6. Green weathered and friable tuff	20
	5. Coarse agglomerate, overlain by thin-bedded water-sorted tuffs	30
	4. Cream vesicular acid lava) 3. Pink crystal tuff)	10
	2. Interbedded conglomerate and tuffaceous sandstone; the pebbles consist of flow-banded rhyolite	10
	1. Cream vesicular acid lava	15
	Unconformity	
Siluro-Devonian - Mt. Garnet Formation		245

All thicknesses are approximate.

c. About a mile south-west of the water tank near Bessie Creek is a succession of interbedded acid lavas and volcanic breccias that is repeated several times by a series of north-easterly trending faults. Traced eastwards towards Ticklehim Creek, the succession changes to one of volcanic breccia and fine-grained andesite; the nature of the change is obscured by the faulting. The flows of acid lava are interesting in that they show some columnar jointing.

d. In the section exposed by Flaggy and Bowler Creeks, immediately west of the Mungana/Mitchell Bridge road, the succession of Permian volcanics observed was :-

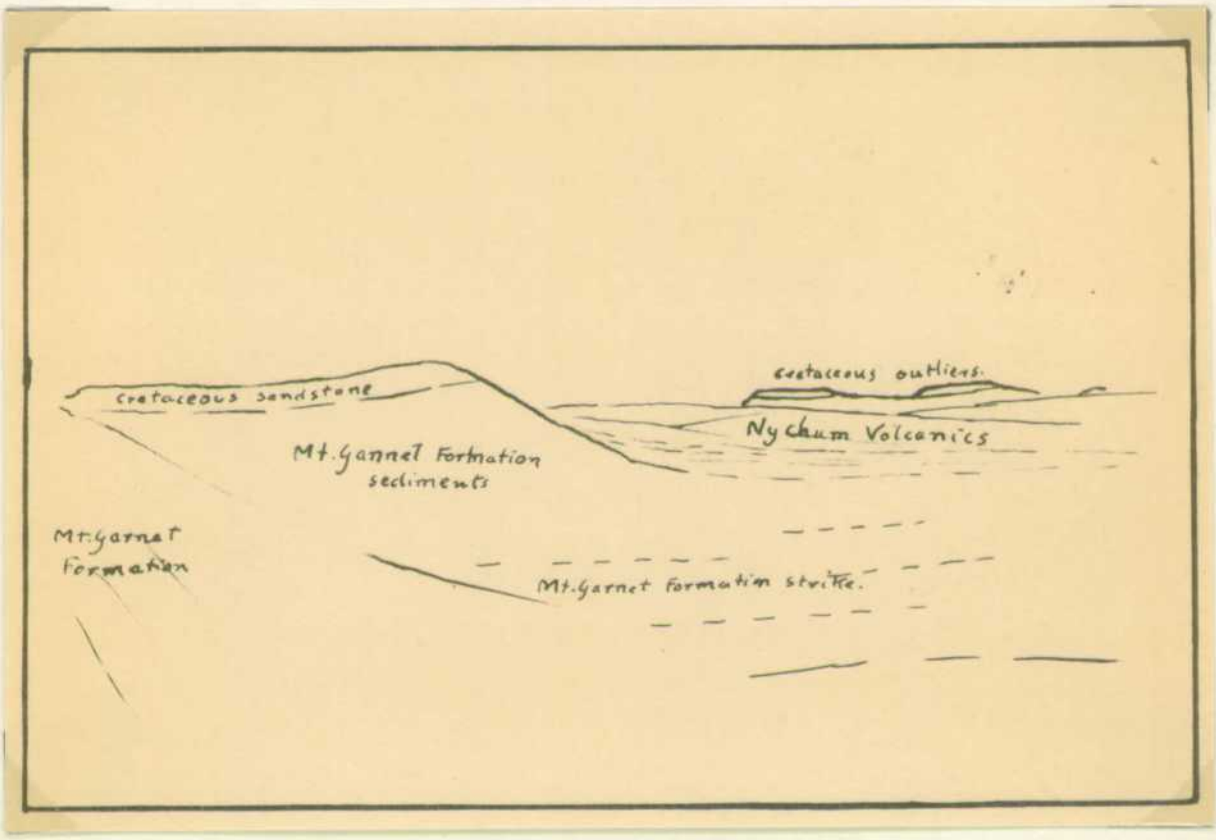


Fig. vi. Nychum Volcanics in the area north of Elizabeth Creek flanking the side of a pre-Nychum Volcanics hill. B.M.R. Negative G/3410. The sketch shows the geological relationships.

Recent Erosional Surface	Thickness in feet
6. Fine hypersthene - augite andesite, forming flows one to three feet thick (M1530D and fig. x)	up to 100
5. Grey altered trachyte (M1589A)	4
4. White, bedded volcanic breccia	10
3. White, thin-bedded, sorted tuff and micro-breccia	30
2. Basalt (M1591 and fig. x)	10
1. White, bedded volcanic breccia	0 to 15

The white, bedded volcanic breccia is, in hand specimen, similar to M1556, which is described in Chapter VII, section E 2.

e. Immediately south of the water mill (see plate 2) on the Mungana/Mitchell Bridge road is a flow of fine- to medium-grained basalt (M1664B). This flow is interesting as it envelopes the base of a ridge formed of chert of the Mt. Garnet Formation; evidently this ridge is a relic of the pre-Nychum Volcanics landscape.

f. The volcanics south of Elizabeth Creek and west of the Mungana/Mitchell Bridge road consist of bedded, probably water-sorted, white tuffs and volcanic micro-breccias (M1556).

g. North of Elizabeth Creek and about a mile west of the Mungana/Mitchell Bridge road the succession is :

		feet	inches
Cretaceous	9. Coarse, current-bedded sandstone	20	
	8. Conglomerate		6
	7. Red shale		3
	6. Current-bedded sandstone		0 to 18
	Unconformity		
Permian	5. Flow-banded and auto-brecciated acid lava	100	
	4. Volcanic breccia, with angular fragments of flow-banded acid lava	110	
	3. Bedded agglomerate with tuffaceous sandstone beds.	40	
	2. Flow-banded rhyolite	40	
	Unconformity		
	1. Isoclinally folded Mt. Garnet Formation.		

About a hundred yards east of this measured section an acid lava flow about twenty-five feet thick is intercalated between the bedded agglomerate (3) and the lowest rhyolite (2).

Half a mile west of this locality is a vent with an oval-shaped outcrop measuring two hundred yards from east to west, and fifty yards from north to south. It is composed of a dull red, fine-grained felsite (M1627) that has vertical flow-banding oriented parallel to the sides of the vent. The vent is situated on the flanks of a small pre-Permian hill composed of Mt. Garnet Formation. The top of this hill is about four hundred feet above the base of the section described above, and the hill is capped by an outlier of Cretaceous sandstone. Fig. vi. shows the hill, with the volcanics overlapping one another on its flanks.

h. The volcanics north of the hill described in g. above were examined by B.J. Amos, and consist of Permian sediments overlain by acid lavas and tuffs.

The sediments are well bedded, the thicknesses of individual beds ranging between two and thirty-six inches. Sedimentary structures are not common, but current-bedding, washouts, and possible slumping were observed. Amos describes one locality where, on one horizon, extensive channels, measuring up to fifteen feet wide and several feet deep, are present; they extend across the whole width of the outcrop - two hundred yards - and over twenty channels were seen.

The weathered surfaces of the sediments are grey and granular; fresh surfaces are white to pale cream, and speckled with the grey, green, pink, and brown grains. The sediments include sandstones and microbreccias, and the grains are angular to sub-angular. Individual beds are fairly well sorted although average grain-sizes vary from bed to bed, and range from the limits of visibility to one inch diameter. The fragments consist of shale, quartz, quartzite, quartz siltstone, chert, jasper, pink feldspar, (?)plutonic rocks, and quartz greywackes.

i. The area west of the Wrotham Park/Mungana road consists almost entirely of acid tuffs and ignimbrites (M1643A, M1643B, M1644, M1646A, M646B, M1648, and M1649); a flow of devitrified obsidian (M1660) was observed near the base at one place; and at Bowler Creek, close to where it enters the Walsh River, the volcanics have basal beds of volcanic breccia which lie unconformably upon nearly vertical beds of the Chillagoe Formation.

The thickness of the succession is difficult to measure here, because the attitudes of the beds are uncertain; however, it is unlikely that the total thickness is more than a hundred and fifty feet.

The volcanics in this area are intruded by two volcanic necks which may be seen easily on the aerial photographs as two small circular, steep-sided hills. One that was investigated on the ground proved to consist of a coarse and inequigranular volcanic breccia surrounding a plug formed of fine-grained andesite (M1642) that has a vertical flow-banding.

j. On the <u>Mitchell River</u>, south-east of Mt. Mulgrave Homestead (plate 3), coal-bearing sediments are associated with the Nychum Volcanics. The sediments were observed by F. de Keyser at Jug Water Hole, and at Packhorse Creek about a mile south-west of Jug Water Hole. The sediments may be at or near the base of the volcanics; the lowest beds in the succession are covered by alluvium. The sediments consist of coarse, current-bedded arkose or tuffaceous sandstone, grey siltstones, and a seam of coal five feet thick. The coal is very impure, soft, black, and smudgy, and has shale partings. Plant fossils were found in the sediments, and M.E. White (1960) considers that they represent the Uppermost Permian or a passage into the Lower Triassic. Balme (in Dickson, 1957) examined microflora obtained from the coal seam and considered that it was Upper Permian.

The sediments are overlain to the east by cream amygdaloidal and porphyritic acid lavas, basalt (621a), dacite (621 c/4 and 621 c/5), ignimbritic micro-breccias (621 c/2 and 621 c/3 - fig. vii), and andesite (621 c/1). The section shown in fig. v. illustrates these relations.

About three miles south-east of Jug Water Hole, and three-quarters of a mile east of Jimmy's Lookout, the Nychum Volcanics were observed to overlie Dargalong Metamorphics. Here the sediments are absent, the succession consisting of acid lavas and rare basalts. The acid lavas are flow banded, and joints, cavities, and amygdales are filled with agate.

k. To the north west of Mt. Mulligan, probable Nychum Volcanics underlie Permian coal measures. According to M.E. White (1961) fossil plants collected from the measures at the north of Mt. Mulligan, and at the King Cole Mine (to the south of Mt. Mulligan township), show an Upper Permian or Lower Triassic age, i.e., roughly equivalent to the coal-bearing sediments at Jug Water Hole.

North west of Mt. Mulligan the volcanics consist of flow-banded rhyolite (M662), amygdaloidal lavas, and volcanic breccias. At Mt. Mulligan and the King Cole Mines, the volcanics are represented by a thin bed of volcanic breccia, and are overlain by a conglomerate containing pebbles of acid lavas.

l. Apart from those mentioned in the foregoing text, three other volcanic necks were located. Two of them consist of fine-grained andesite (similar to M1642); of these, one is located on the west side of the Mungana/Wrotham Park road, about three miles north-west of the Bowler Creek crossing, and the other, half a mile east of this road, three miles south-east of the Nolan's Creek crossing. The third volcanic neck is on the south-west side of Nolan's Creek, two miles west of the water mill on the Mungana/Mitchell Bridge road, and consists of a fine-grained rhyolite that has steeply inclined flow-layering (M1583, fig. ix).

Two probable centres of vulcanicity, one west, and the other east of Nychum Homestead are inferred to have been present in early Nychum Volcanic times because of the large deposits of volcanic breccia that are exposed there.

Environment. From the foregoing I can make only a general picture of the environment in which the volcanics and their accompanying sediments were deposited.

It is evident that the sedimentary deposits are terrestrial and possibly lacustrine. The coal seams found interbedded with the sediments at Jug Water Hole and Mt. Mulligan are evidence of this. The washouts noted by Amos are suggestive of a braided river channel.

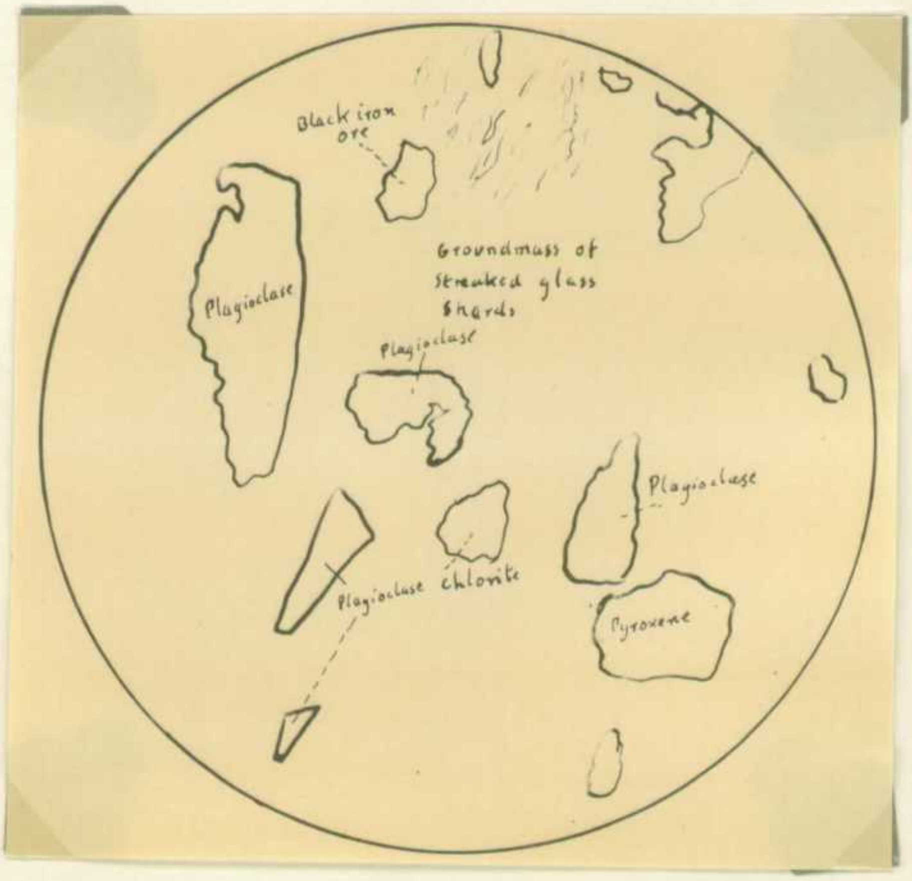


Fig. vii. Specimen M1617B. Ignimbrite, Nychum Volcanics. X35, ordinary light. B.M.R. Negative G/3379.

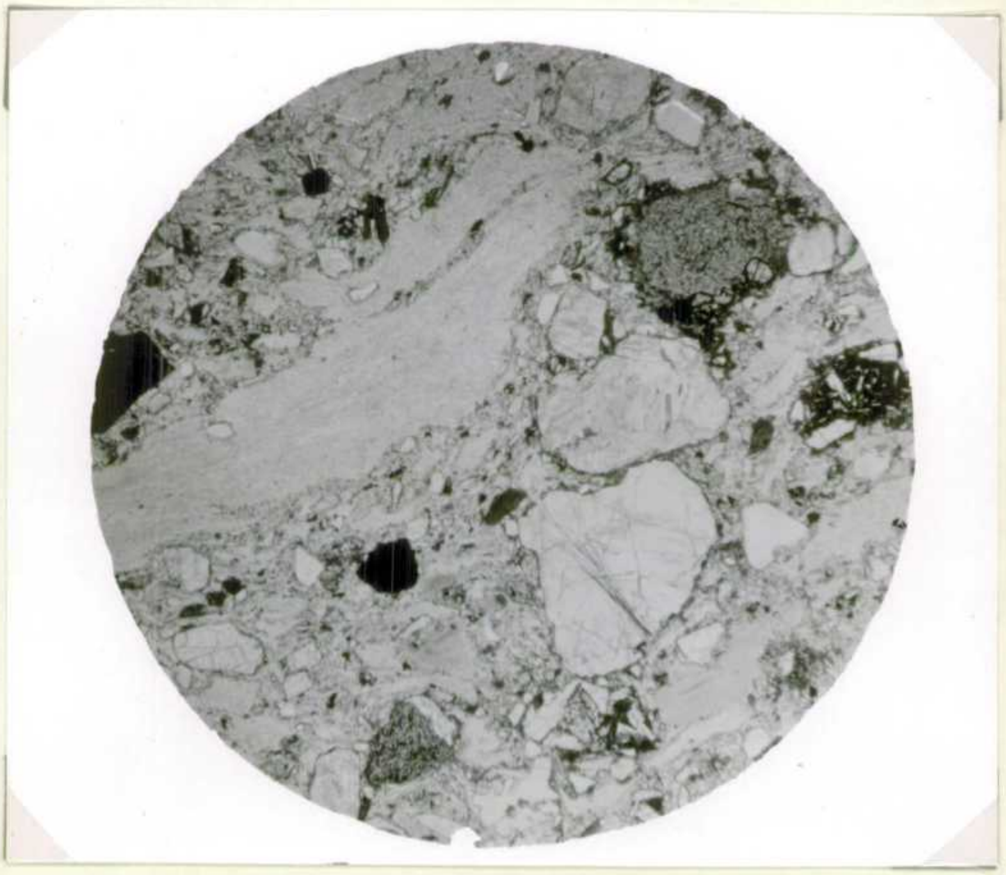


Fig. viii. Specimen M621C/3. Ignimbritic microbreccia, Nychum Volcanics. Fragments of glass (e.g., the elongated fragment extending from the top to the right centre of the picture), quartz (lower left centre), metamorphic rock (lower centre), and basalt (bottom) may be seen. X18, ordinary light. B.M.R. Negative G/3381.

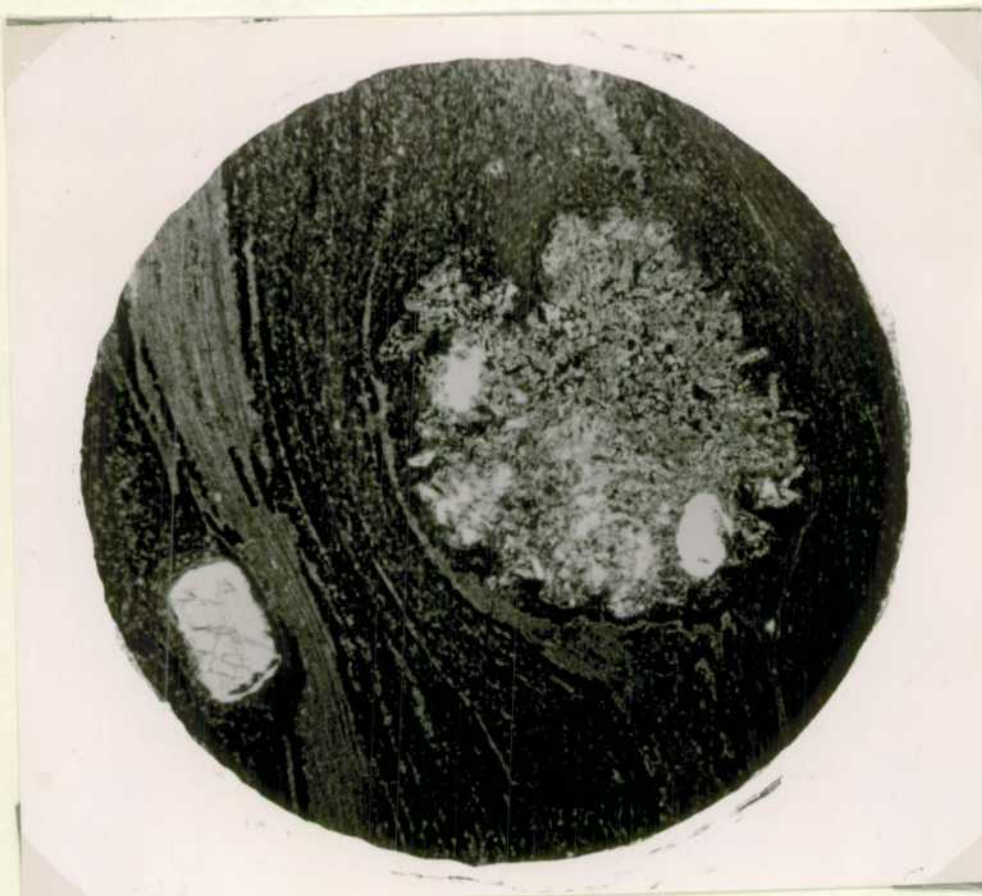


Fig. ix. Specimen M1583. Flow-banded dacite (Nychum Volcanics) with a plagioclase phenocryst (lower left) and a basalt inclusion. X18, ordinary light. B.M.R. Negative G/3377.

The pre-Nychum Volcanics surface appears to have had some relief, as shown by the chert ridge enclosed by basalt at the water mill, and by the hill of Mt. Garnet Formation sediments flanked by volcanics north of Elizabeth Creek.

The vulcanicity was at first intermittent, and, in many places, may have been explosive. Andesites and basalts were probably extruded early in the succession, but at Mt. Mulligan they are absent; in the area west of the Mungana/Wrotham Park road, andesite occurs in volcanic necks intruding the volcanics. The later volcanics consist almost entirely of acid lavas and tuffs, and form a blanket covering the older volcanics, overlapping these on to the lower Palaeozoic sediments.

The Permian sediments, although fairly widespread in early Nychum rocks, decrease, and become absent higher in the succession.

Thus in early Nychum times the landscape had some relief, and contained broad river valleys; in some of these valleys dense forest flourished. Here and there were volcanoes, some of which erupted fairly quietly producing basalt and andesite flows; others were violently explosive, and were responsible for the volcanic breccias. Later, the vulcanicity became much more intensive: the valleys were filled and the forests were buried by lava, tuffs and ignimbrites, producing the later Nychum volcanic rocks.

The Dyke Swarms. A dyke swarm, with a north-north-westerly trend, may be seen clearly, on aerial photographs, intruding Mt. Garnet Formation and the Nychum Volcanics between the Mungana/Mitchell Bridge road and Nychum Homestead. The dykes are mostly acid porphyritic rocks (e.g., M1602), although dolerites (M1624) and probable intermediate rocks are present. They are displaced by the fault separating the Nychum Volcanics from the Featherbed Volcanics. Another swarm, with a similar trend, occurs in the north-east portion of the Kum Kum Range, and extends down to the Nychum Homestead/Coldwater yard track.

Their dominant trend agrees roughly with that of the strike of the Lower Palaeozoic rocks. At Coldwater yard the strike of these rocks changes from the north-north-west to a north-easterly direction (plate 2). It is interesting to note that dykes that are part of the swarm intruding the Nychum Volcanics immediately to the west also change their trend in a similar way.

Summary of Petrography and Petrological Notes

Petrography. The detailed petrographic descriptions of Nychum Volcanics rock types can be found in Chapter 2, section E. Thin sections of representative specimens of the sediments have yet to be made.

Pyroclastic rocks. The ignimbrites and crystal tuffs consist of subhedral to anhedral crystals of plagioclase, potash feldspar, quartz, and ferro-magnesian minerals enclosed in a glassy groundmass that, in all but one specimen, is devitrified to a fine felsite. In those specimens that I have termed "ignimbrite" a eutaxitic texture may be seen reasonably clearly (fig. vii). In the crystal tuffs this texture is absent. In the one specimen whose glass is not devitrified (fig. vii) the ferromagnesian minerals consist of green clinopyroxene and probable iron-rich olivine. Such

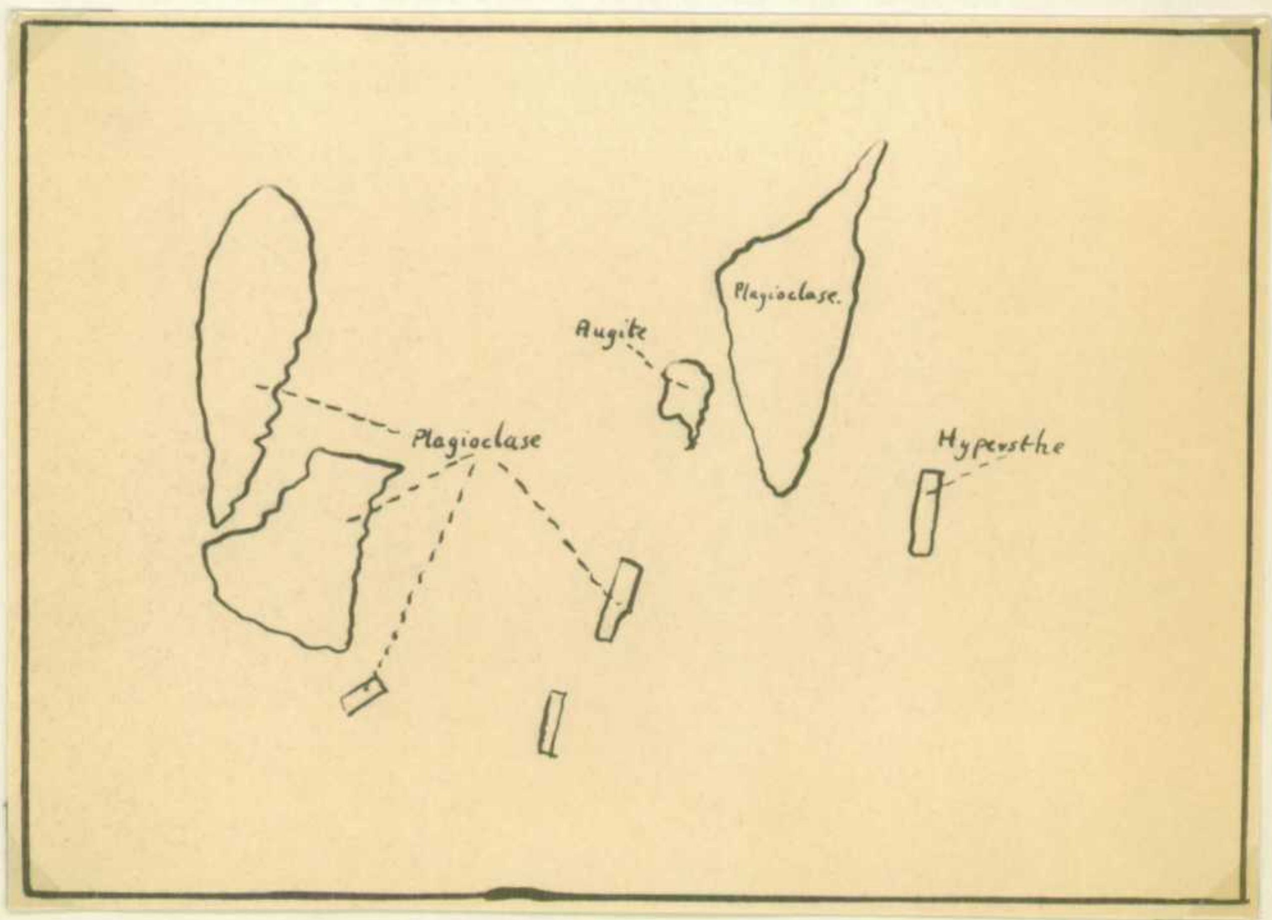


Fig. x. . Specimen M1530D. Hypersthene-augite andesite, Nychum Volcanics. X100, crossed nicols. B.M.R. Negative G/3371.

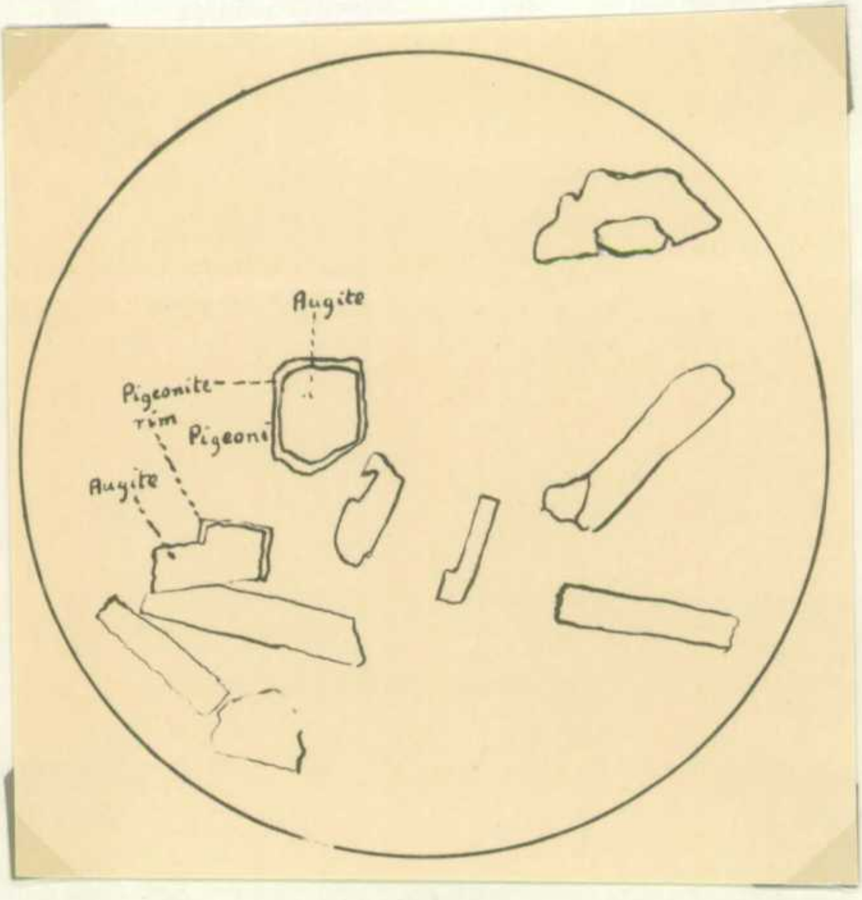
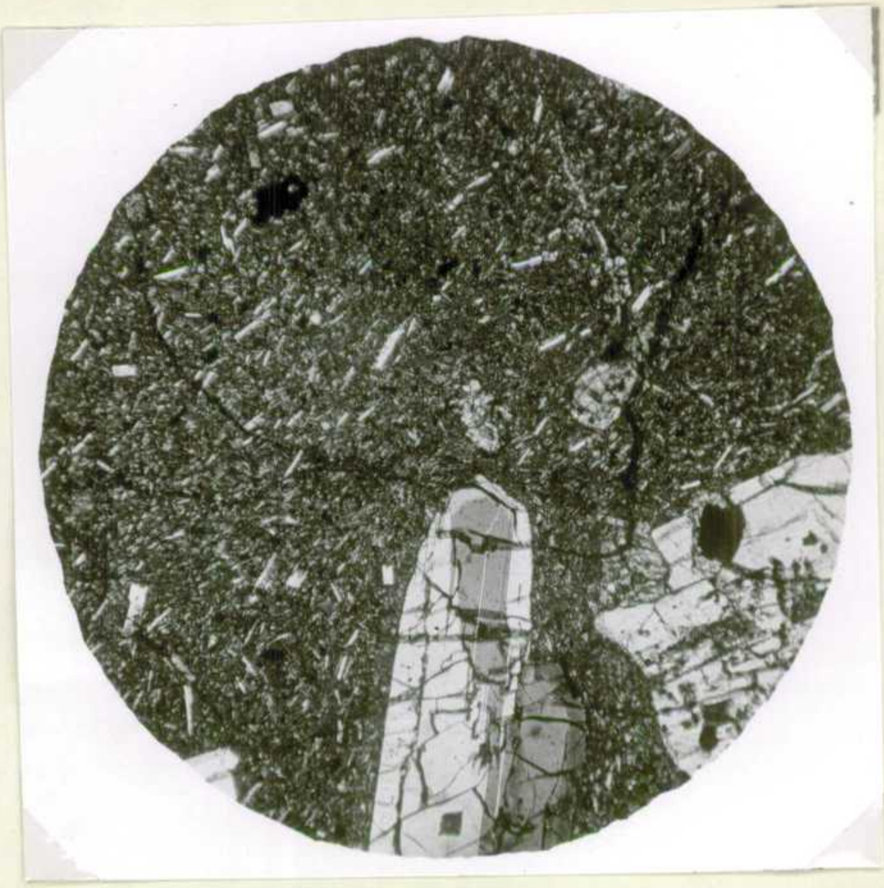


Fig. xi. Specimen M1617L. Andesite, Nychum Volcanics, showing pigeonite rims on augite. X50, crossed nicols. B.M.R. Negative G/3384.



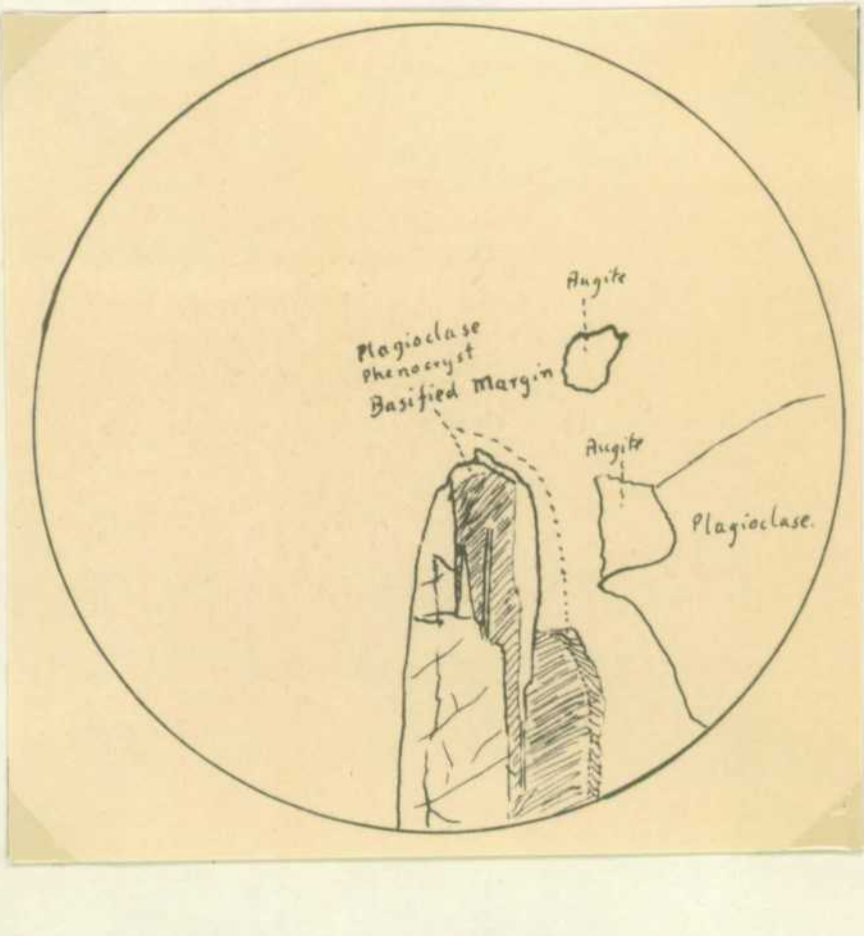


Fig. xii. Specimen M1617L. Andesite, Nychum Volcanics. X45, crossed nicols. B.M.R. Negative G/3376. Shows basified rim on plagioclase phenocryst.

olivine is described as occurring in acid glasses by Carmichael (1960), and I intend later to do some optical work on the crystals in order to determine the composition of the olivine. In the crystal tuffs and other ignimbrites, hornblende and rare biotite are replaced by late stage secondary minerals - carbonate, nontronite, sericite, leucoxene, chlorite, and quartz.

Two specimens of ignimbritic microbreccias were obtained by F. de Keyser from the Jug Water Hole area. One is glassy (M621 c/3 (fig. viii)), and the other is devitrified (M621 c/2). The devitrified specimen contains subangular to angular fragments of basalt and andesite, and also acid ashstones and tuffs, together with crystal grains of quartz and plagioclase, all enclosed in a fine felsitic groundmass that has eutaxitic texture. Specimen M621 c/3 has fragments of glass, basalt, ignimbrite, acid tuff, rhyolite, quartz, and metamorphic rocks, enclosed in a groundmass of glass.

The volcanic breccias that occur around Nychum Homestead, and which are associated with andesite in the vent west of the Mungana/Wrotham Park road, are coarse-grained and inequigranular. They contain angular fragments of cream flow-banded rhyolite that generally range in size from the limits of visibility to one or two feet in diameter. One block of rhyolite was about ten feet long. All the fragments are enclosed in a fine-grained, purple matrix.

Acid Lavas. Thin sections were made of two porphyritic rocks and some flow-banded phenocryst-poor lavas. The porphyritic rocks (M621 c/4 and M621 c/5) are both dacites, and contain phenocrysts of plagioclase, quartz (in M621 c/5), and pseudomorphed pyroxene. The groundmass of M621 c/4 is composed of plagioclase, clinopyroxene, quartz, alkali feldspar, and chlorite. M621 c/5 has a groundmass of flow-oriented plagioclase laths enclosed in a mosaic of granular quartz that has probably resulted partly from silicification.

M662 is a carbonated, silicified, and devitrified rhyolite containing phenocrysts and inclusions of sedimentary rocks, that were probably derived from the Lower Palaeozoic succession. M1583 (fig. ix) is similar, and has a cognate inclusion of basalt instead of the sedimentary xenoliths: this specimen comes from a probable vent. M1660 is an aphyric, flow-banded devitrified obsidian. M1627 is a ferruginous felsite.

Intermediate lavas: Two types of andesite were observed. One is represented by specimens M621 c/1, M1530D (fig. x), and M1642. All are fine-grained microporphyritic hypersthene-augite andesites that occur as flows (M621 c/1 and M1530D), and in vents (M1642). M621 c/1 has included xenocrysts of quartz and feldspar and xenoliths of basalt and andesite. The second type of andesite (represented by M1617L and shown in figs. xi and xii) contains no hypersthene: phenocrysts of augite have a thin rim of pigeonite (fig. xi) and plagioclase (labradorite) phenocrysts have basified margins (fig. xii).

Specimen M1598A is probably an altered trachyte, and was seen to have a pilotaxitic-trachytic texture. Flow-

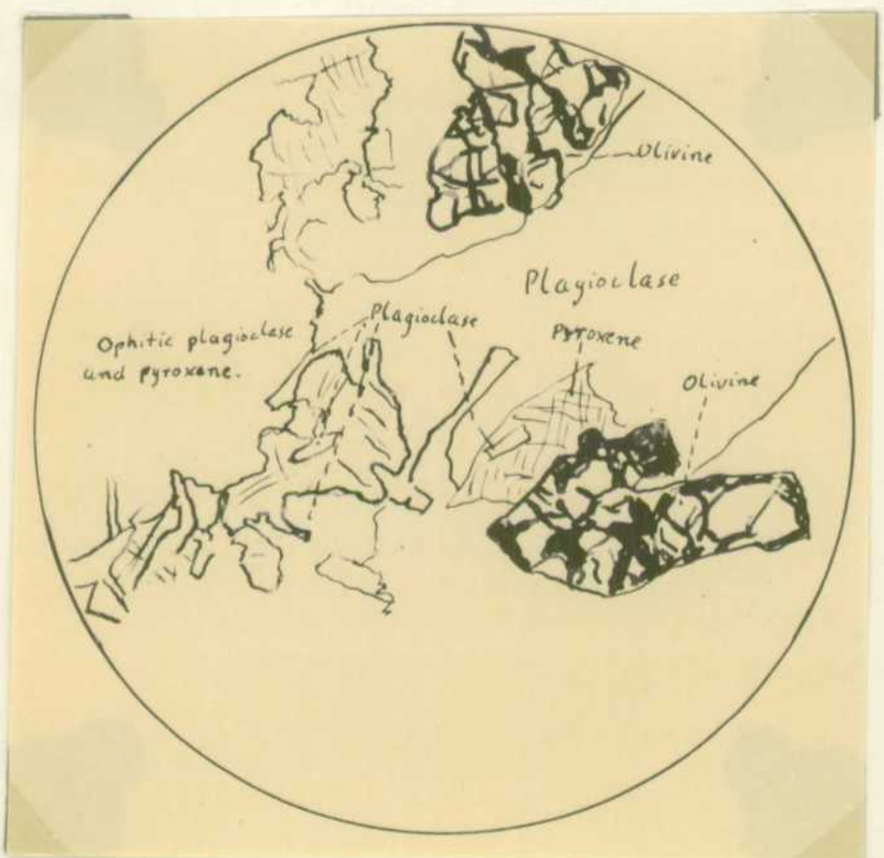


Fig. xiii. Specimen M1591. Basalt, Nychum Volcanics. X35, ordinary light. B.M.R. Negative G/3375.

oriented laths of (?)sodic plagioclase and rarer flakes of sericite are embedded in interstitial (?)alkali feldspar and chlorite.

Basic lavas: . Three basalts, M621A, M1591 (fig. xiii), and M1664B, were sectioned. The basalts are porphyritic. They contain plagioclase (labradorite) and clinopyroxene, which, in M1591, is probably tifaniferous, and in M621A, is mostly pseudomorphed by carbonate. M1591 and M1664B contain small amounts of olivine (pseudomorphed by bowlingite in M1664B). All three specimens contain small amounts of basic glass.

Notes on Petrogenesis. Two main problems arise: firstly, the composition of the parent magma and the process of its differentiation; and secondly the source of the magma. With regard to the parent magma, I have already suggested (p. 19*and 20) that the volcanics and the Almaden Granite are closely associated. The dominantly acid nature of the volcanics supports this idea.

The mechanism of differentiation is in doubt, and for the time being will remain so, as I have not sufficient chemical and detailed mineralogical data to warrant a full discussion. However, several points worth noting have come to light.

Two specimens of andesite contain phenocrysts that appear to be foreign to their enclosing groundmass. Specimen M621 c/1 has rare strongly embayed seemingly foreign "phenocrysts" of quartz and plagioclase, as well as euhedral phenocryst plagioclase which probably belong to the rock. Specimen M1617L has plagioclase phenocrysts with basified margins (fig. xii). These suggest contamination by assimilation, or else mixing of basic and acid magmas.

Assimilation of sediments has been invoked by Branch (1960a) and Dallwitz (1961) for the origin of the Almaden Granite. However, the "phenocrysts" described in the specimens noted above seem to have an igneous origin, so that assimilation of sediments may be discounted for these andesites. Assimilation of pre-existing igneous rocks is unlikely, as the Nychum Volcanics were extruded through Precambrian metamorphic rocks and lower Palaeozoic sediments.

If magma mixing is responsible for these andesites, we have to consider the origin of the basic magma, i.e., is it a differentiate of the parent acid magma, or is it unrelated? The chemical analysis of a basalt from the Nychum Volcanics (M1591, Table A) is rather similar to those of "high alumina" basalt (Tilley, 1950; Kuno, 1960; and Turner and Verhoogen, 1960, p. 282), in that it is higher in Al_2O_3 and lower in FeO and Fe_2O_3 when compared with tholeiitic or alkaline basalts. High alumina basalts are supposed to be typical of basalt-andesite-rhyolite associations, for example, the lower basalts of the Newberry Volcano, Central Oregon (Williams, 1935). This, therefore, suggests that the basalts of the Nychum Volcanics are derived from the acid parent magma.

If this is so, the basalts and possibly some of the andesites may have originated by the sinking of early crystals. However, none of these rocks has textures that indicate an accumulative origin, but Tilley (op. cit.) considers that sinking crystals may be resorbed to form a basic magma.

In some places, e.g., at Flaggy Creek (plate 2), basalt is associated with andesite. In others, as at Jimmy's Lookout (Plate 3) basalt is associated with rhyolites and acid tuffs, and andesite is absent. The latter case is an example of contrasting differentiation, and is not easily explained by a process of crystal sinking without the presence of an intermediate rock. A possible explanation is that the parent magma split into two immiscible fractions, one basic and the other acid. In spite of contributions on the subject of acid and basic silicate liquid immiscibility by Fenner (1948) and Holgate (1954), this possibility is regarded with suspicion by many petrologists. In any case, some of the andesites that I have described from the Nychum Volcanics (M1530D, M1642) seem to me to be truly intermediate, and not to have resulted from the mixing of two partly solidified liquids of contrasting composition which may have been immiscible when they were completely liquid. Bowen (1926) considers that if two immiscible liquids had existed, evidence for this would be the common occurrence of globular glassy inclusions in glassy lavas, which differ in composition from the enclosing lava: I have not seen any of these in the Nychum Volcanics.

The source of the magma is, at the moment, uncertain if we consider only the area of the Nychum Volcanics and the Almaden Granite. However, Branch (1961) has proposed an interesting theory in an attempt to account for all the Permo-Triassic igneous activity, including the source of the magma.

Featherbed Volcanics

The Featherbed Volcanics cover an area about 500 square miles in the south centre of the Mossman four-mile Sheet, and, in this area, are faulted against all the other rocks. The volcanics generally have a gentle northerly dip, although, close to the edges of the outcrop, they dip sharply away from the boundary fault.

The Featherbed Volcanics consist mostly of ignimbrites (M1598A, C, D, E, and F) and acid crystal tuffs (M570B) with some volcanic breccias, but rare lavas such as dacite (M570A) and intermediate types (M1598B) were observed.

The volcanics consist of rather monotonous greenish-grey acid rocks that appear to be equivalent to the "Upper Grey Ignimbrites" (de Keyser, 1958) in the succession to be observed at Fisherman's Hole on the Walsh River north of Chillagoe.

According to observations by C.D. Branch, the Elizabeth Creek Granite is related to the Featherbed Volcanics, and is thought to be only very slightly younger. It is better, therefore, for them to be considered together in a stratigraphical discussion. Both units are younger than the Almaden Granodiorite (Branch, 1960, 1961) and therefore are post-upper Permian. A problem arises, however, when considering an upper limit to their age. A possible solution to this problem may be seen from the relationships of the Mesozoic sediments of Mt. Mulligan to the Featherbed Volcanics. (Ball (1917) found Triassic plant fossils at the base of these sediments). These beds are faulted against the Featherbeds, and this fault appears to be associated with the ring fractures which, according to Branch, are partly the cause of the Featherbed vulcanicity. The Triassic sediments are not affected by the vulcanicity, i.e., they are not metamorphosed or indurated, neither have any dykes been observed to cut them. All this suggests that the Triassic sediments are younger than the Featherbed Volcanics, but were laid down before the completion of the faulting associated with the ring fractures. Hence, it is tentatively concluded that the Featherbed Volcanics and, presumably, the Elizabeth Creek Granite, are no younger than the Triassic.

SUMMARY OF THE IGNEOUS ACTIVITY

4.	(a. Elizabeth Creek Granite (b. Featherbed Volcanics	Triassic to Upper Permian
3.	Almaden and Herbert River Granites	
2.	Nychum Volcanics	
1.	(Cannibal Creek Granite (Mareeba Granite	Carboniferous

HISTORY OF THE IGNEOUS ACTIVITY

1. Shortly after the folding of the lower Palaeozoic sediments in late Devonian or early Carboniferous times, the Mareeba and Cannibal Creek Granites were emplaced.

2. After, or possibly during, the late stages of the earth movements uplift took place and the lower Palaeozoic rocks were eroded. In the western part of the area discussed, erosion must have proceeded to, roughly, the present-day land surface by upper Permian times. (p. 30).

3. The Nychum Volcanics and their associated sediments were laid down under terrestrial conditions.

4. The Almaden Granodiorite was intruded.

5. After the cooling of the Almaden Granodiorite there was a period of cauldron subsidence and ignimbritic eruptions, to form the Featherbed Volcanics. Partly contemporaneous with this vulcanicity was the intrusion of the Elizabeth Creek Granite.

CHEMICAL ANALYSES

The Nychum Volcanics

	(a) M1591	(b) M1530D
SiO_2	50.42	57.06
Al_2O_3	17.52	17.12
Fe_2O_3	0.59	2.27
FeO	6.55	4.51
MgO	5.95	3.62
CaO	9.25	5.52

Na_2O	5.43	5.22
K_2O	1.39	1.26
H_2O (at 105°c)	0.25	0.02
H_2O (loss on ignition)	2.05	2.19
TiO_2	0.60	0.58
P_2O_5	0.08	0.07
MnO	0.42	0.24
Total	100.50	99.68

a. M1591. Olivine-bearing basalt. Yokas 1-mile Sheet, Run 6, Photograph 157. Analyst: S. Baker.

b. M1530D. Hypersthene-augite andesite. Yokas 1-mile Sheet Run 6, photograph 157. Analyst: S. Baker.

The Permo-Triassic "Granites"

	(a) M1653A	(b) Pgh	(c) Pgz
SiO_2	62.74	73.63	77.55
Al_2O_3	16.66	13.80	12.64
Fe_2O_3	1.81	0.53	0.65
FeO	3.16	1.86	0.45
MgO	2.06	0.56	0.03
CaO	4.67	1.66	0.39
Na_2O	3.73	3.38	3.28
K_2O	2.15	4.03	4.69
H_2O (at 105°)	----	0.10	0.10
H_2O (loss on ignition)	2.15	0.48	0.56
TiO_2	0.25	0.16	0.03
P_2O_5	0.04	0.10	0.04
MnO	0.08	0.04	0.03
Total	99.50	100.33	100.44

(a) M1653A. Almaden Granodiorite : biotite - hornblende granodiorite. Yokas 1-mile photo 87, run 3. Nolan's Creek. Analyst: S. Baker.

(b) An average of chemical analyses of four Herbert River Granite specimens: E55/5/12, Atherton 6/5169; E55/5/B, Atherton 6/5/67; E55/9/10, Atherton 12/5089; E55/9/12, Atherton 4/5171. Analysts: S. Baker and A. McLure. Age determination specimens.

(c) An average of four Elizabeth Creek Granite specimens: E55/5/1, Atherton 5/5145; E55/9/3, Atherton 1/5179; E55/9/11, Atherton 3/5097; E55/9/13, Atherton 4/5/54. Analysts: S. Baker and A. McLure.

Comment

In the table above an average of the chemical analyses of four specimens of Herbert River Granite is compared with an analysis of Almaden "Granite" from Nolan's Creek. It will be seen that the "Almaden" Granite has lost silica and potash, and gained lime and magnesia, which agrees with the ideas of Branch and Dallwitz, that the Herbert River Granite was contaminated by limestone to form the Almaden Granite. The rock has also gained in alumina and total iron, which may presumably be accounted for by postulating the digestion of other materials besides limestone. The analysis of the Almaden "Granite" compares remarkably well with average analyses of tonalite given in Daly (1933, p. 15) and Turner and Verhoogen (1960, p. 344).

A specimen of the Elizabeth Creek Granite occurring in the area of the Mossman 4-mile area has not been chemically analysed. However, for completeness, an average of four chemical analyses of the granite in the area of the Atherton 4-mile has been included. The leucocratic property of the rock is reflected in the analysis, i.e., it is poor in the constituents of the ferro-magnesian minerals, and it is rich in silica.

The Mareeba and Cannibal Creek Granites

	(a) M1727	(b) E55/5/2	(c) E55/1/1	(d) M1688
SiO_2	69.20	73.02	73.64	72.80
Al_2O_3	15.85	14.32	14.40	14.50
Fe_2O_3	1.18	0.41	0.48	1.80
FeO	2.13	1.81	0.40	0.98
MgO	0.66	0.80	0.90	0.38
CaO	1.82	2.02	0.45	0.19
Na_2O	3.71	2.76	4.56	3.70
K_2O	4.42	3.92	3.79	4.42
H_2O (at 105^oc)	0.03	----	----	0.01
H_2O (loss on ignition)	0.38	0.67	0.84	0.74
TiO_2	0.03	0.11	0.03	0.04
P_2O_5	0.04	0.07	0.07	0.04
MnO	0.09	0.08	0.10	0.09
Total	99.54	99.99	99.66	99.61

(a) M1727. Mareeba Granite (not yet sectioned). Mossman - Cairns photograph 5051, run 7, Mt. Lewis Forestry road. Mossman 4-mile Sheet. Analyst: S. Baker.

(b) E55/5/2. Mareeba Granite - age determination sample. Muscovite biotite-microcline granite. Two miles west of Mareeba in Granite Creek near Dimbulah/Mareeba road crossing, on the Atherton 4-mile Sheet. Analyst: S Baker.

(c) E55/1/1. Mareeba Granite - age determination sample. Muscovite adamellite, Little Alto, four miles south west of Mt. Carbine, on the Mossman 4-mile Sheet. Analyst: S. Baker.

(d) M1688. Cannibal Creek Granite, similar to M1693, biotite-muscovite adamellite. Analyst: S. Baker.

PETROGRAPHY

I have put the detailed descriptions in for reference purposes; rather than interrupt the general text in the foregoing pages, I think it is better to place them all together in one place in this report. The formational names, e.g., Mareeba Granite, Featherbed Volcanics, are used as headings, and are in the same order as in the previous pages. Under each heading, the specimen descriptions are in numerical order.

Most of the descriptions were written by me. Ten specimens of the Mareeba Granite and its associated rocks (M1107, M1114, M1120, M1127, M1135, M1112, M1113, M1124, M1125, and M1126) were described by R.M. Tucker of the Queensland Geological Survey.

Mareeba Granite and Associated Rocks: (Including brief descriptions of M1107, M1114, M1120, M1127, M1135, M1112, M1113, M1124, M1125, M1127).

E55/1/1 (slide number 5193): Little Alto, four miles south of Mr. Carbine, Sample taken for age determination.

Muscovite Adamellite.

In thin section the grain sizes range from 0.25mm. to 2.75mm., and the texture is hypidiomorphic and inequigranular. The rock consists of perthite (27%), plagioclase (35%), quartz (37%), and muscovite (1%), with accessory tourmaline. The plagioclase is albite, and is slightly kaolinized and seritized, and forms tabular crystals that are often poikilitically enclosed by the more strongly kaolinized perthite. Quartz is anhedral, and muscovite forms rare, somewhat flexed flakes. Tourmaline is pleochroic from olive-brown to nearly colourless.

E55/5/2 (slide number 5208): Sample taken from Gorge Creek bridge on the Mareeba - Dimbula road for age determination.

Muscovite-biotite-microcline Granite

In thin section, the rock is medium- to coarse-grained, and porphyritic, and is hypidiomorphic and inequigranular. The grain-sizes range from 0.9mm. to 4.25mm., and the phenocrysts range up to 9.25mm. in size. The rock consists of microcline-perthite (45%), quartz (30%), plagioclase (15%), biotite (5%), and muscovite (3%). Zircon and apatite are accessory. Microcline-perthite is subhedral, and its grains have rather ragged margins that, in a few places where microcline crystals border each other, have thin skins of myrmekite. Microcline has plagioclase exsolution lamellae, and also replacement patches of plagioclase. Quartz is interstitial to granular. Sub-tabular plagioclase is somewhat sericitized, and is zoned from An_{50} to albite; some oscillatory zoning was noted. Biotite, partly replaced by pale green chlorite, is pleochroic from very pale fawn to reddish brown; enclosed zircon forms pleochroic haloes. Muscovite forms colourless flakes.

M1107. Slide 6285. Five miles east of Maitland Downs Homestead. Mossman-Cairns 2/5129.

Granodiorite. This is a coarse-grained igneous rock, composed of quartz, plagioclase, microcline, muscovite and minor biotite..

Quartz occurs as strained and fractured anhedral grains, up to 5mm. in diameter, and constitutes up to 50% of the section.

Plagioclase (oligoclase) occurs as subhedral grains, up to 2mm. in length.

Microcline - perthite occurs as subhedral to anhedral grains, up to 2mm.

Muscovite is present (approx. 5%) as large, thick books (2mm.).

Biotite occurs in accessory amount.

M1114. Slide 6288. Six miles south-east of Maitland Downs Homestead, Mossman-Cairns 2/5/29.

Granite.

Hypidiomorphic granular rock - quartz, oligoclase, microcline (with "replacement perthite"), biotite, and muscovite. Quartz grains composite.

M1120. Slide 6289. North of Kelly's Homestead, St. Georges River 5/33.

Granodiorite.

This is a medium-grained, hypidiomorphic granular rock composed of quartz, plagioclase, microcline, muscovite, and biotite. Plagioclase (oligoclase) is more abundant than potash feldspar.

M1127. Slide 6294. Spencer Creek, Mossman 2/3245.

Quartz diorite

This is a coarse-grained igneous rock, with an average grainsize 4 mm.

It is composed of plagioclase, quartz and biotite. The plagioclase is a zoned oligoclase, and occurs as euhedral crystals, up to 5mm. in length. The twinning is combined albite and pericline.

Quartz occurs as composite grains with boundaries sutured; this may indicate shearing.

Biotite is rare (less than 5%). It is anhedral and pleochroic, with pleochroic haloes.

M1135 - Slide 6296. Hann's Tableland, Mossman-Cairns 9/5625.

Granite

A hypidiomorphic granular rock, composed of microcline-microperthite, quartz, muscovite, biotite, and plagioclase.

Microcline occurs as combined Carlsbad/microcline twinned crystals up to 6mm. in length. The grains contain fine wisps of (?)plagioclase, and some small (0.5mm.) anhedral grains of "replacement perthite" plagioclase.

Quartz occurs as anhedral, interstitial grains, up to 4mm. in diameter.

Muscovite and biotite are present as subhedral plates, up to 2mm. in length. Biotite is markedly pleochroic, and has pleochroic haloes.

M1112. - Slide 6286. Mossman-Cairns 2/5129

This is a closely plicated quartz-sericite-graphite "schist", with a large (4mm.) porphyroblast of andalusite.

Sericite occurs as elongate, bent flakes, with fine-grained (0.05mm.) quartz.

The rock has undergone thermal metamorphism, which was preceeded by close-folding.

M1113 - Slide 6287. Mossman-Cairns 2/5129

This is an argillaceous sandstone, which has undergone very slight thermal metamorphism. It consists of about 75% of rounded quartz grains, the margins of which may now show evidence of recrystallization.

The argillaceous matrix has been recrystallized to very fine-grained biotite and quartz.

The rock is near the edge of the contact aureole.

M1124 - Slide 6291 - Dyke rock Spencer Creek, Mossman 3/3213.

Quartz-feldspar porphyry

This is a porphyritic igneous rock, composed of phenocrysts of quartz, feldspar, and mafic minerals, in a microcrystalline groundmass of quartz and feldspar.

Subhedral to euhedral, corroded crystals of feldspar up to 2mm. in diameter are present. These appear to be zoned plagioclases, but are too fractured and altered to be determinable.

Quartz occurs as cracked and corroded subhedral grains up to 2mm. in diameter.

(?)Biotite occurs as corroded flakes, showing various colours of brown - these are badly altered.

The groundmass consists of equidimensional grains, of about 0.05mm. in diameter.

M1125 - Slide 6292. Spencer Creek, Mossman 3/3213.

Recrystallized, fine-grained sediment (probably originally silty mudstone, now converted to quartz-biotite-graphite hornfels. Average grain size is less than 0.1mm.

Biotite is pale-brown to brown, and is poikilo blastic towards quartz.

This rock shows definite evidence of thermal recrystallization.

M1126 - Slide 6293. Spencer Creek, Mossman 2/3245.

Recrystallized, unsorted sediment now composed of quartz and feldspar grains, up to 1mm. in diameter, in a "groundmass" of recrystallized quartz, with porphyroblasts of biotite.

The margins of the larger quartz grains are very irregular, and appear to be growing out into the matrix.

The rock shows evidence of thermal recrystallization.

B. Cannibal Creek Granite and Associated Hornfels

M1693 (slide Number 5988). Byerstown 7/1.

Biotite-muscovite adamellite.

A light creamish-grey medium- to coarse-grained, sparsely porphyritic rock containing creamish-white feldspar, quartz, biotite, and muscovite. The mica flakes show a preferred orientation.

In thin section, the texture is seen to be hypidiomorphic. The groundmass, with an average grain-size of 2mm., encloses phenocrysts that measure up to 6mm. in length. Oligoclase (An_{20}) is quite commonly strongly zoned to albite, and forms tabular, somewhat sericitized, crystals. Microcline-perthite occurs as tabular phenocrysts, and as more anhedral grains in the groundmass. Plagioclase has corroded boundaries, and rims of myrmekite where it neighbours microcline. Microcline commonly has small, irregular patches of replacing albite. One microcline phenocryst has a rounded outline, and is enclosed in a shell of oglioclase, i.e., a rapakivi texture. Quartz forms irregular aggregates of poikilitic grains. Muscovite and biotite occur as anhedral flakes; biotite is pleochrioc from fawn to reddish-brown, and commonly has pleochroic haloes. Biotite is commonly replaced by pale green penninite. In this thin section accessory epidote and zoisite are associated with plagioclase, and apatite is prismatic. Another specimen, M1695, was crushed, and small amounts of zircon and pale pink garnet were noted. A modal analysis by R. M. Tucker (Q.G.S.) gave the following mineral percentages: Plagioclase: 45, quartz: 30, microcline - perthite: 17, muscovite: 6, and biotite and chlorite: 2.

M1687 (slide number 5986), Byerstown 7/1.

Biotite-muscovite micro-adamellite porphyry.

The specimen was collected from the contact of the adamellite with its country rock. The specimen is pale creamish-grey, speckled with black. Close to the contact the rock is fine-grained and porphyritic, and has a pronounced foliation. This decreases, and the groundmass grain-sizes increase, away from the contact, to give a medium-grained, porphyritic rock.

Under the microscope, the rock is seen to contain plagioclase, quartz, microcline, biotite and muscovite in about the same proportions as are found in M1693: all the minerals occur in the groundmass and as phenocrysts. The phenocrysts are euhedral to anhedral: some have a pseudo-poikiloblastic structure, with groundmass grains included in them close to their boundaries. Rarely, the phenocrysts are clustered.

Close to the contact, the groundmass has an average grain-size of 0.06mm.; the grain-size increased to 0.7mm. within 5mm. The groundmass is xenomorphic-granular and has a protoclastic texture.

M1689 (slide number 5987), Byerstown 7/5.

Biotite-muscovite-quartz hornfels.

The specimen was collected from the sediments very close to the adamellite contact. One of the more noticeable features of the specimen are the randomly oriented tabular crystals of andalusite that are now replaced by sericite. The enclosing rock is mostly composed of micaceous siltstone in which several somewhat folded layers ranging between 5mm. and 0.5mm. in thickness consist of quartz siltstone. Thin folia of small mica flakes emphasize a cleavage which cuts across the bedding.

In thin section the micaceous siltstone is found to consist of flakes of sericite and partly chloritized biotite set in a mosaic of quartz grains; the average grain size is 0.02mm. The cleavage noted in the hand-specimen is, in fact, a false cleavage that appears to have resulted from the crumpling of a lamination that ran roughly parallel to the bedding. The mica flakes in the folded laminae are not flexed, suggesting that their crystallization took place after the formation of the false cleavage, presumably at the same time as the contact metamorphism. The quartz siltstone band is formed of a mosaic of biotite oriented parallel to the false cleavage. In the micaceous siltstone and quartz siltstone portions of the specimen, tourmaline is accessory, though fairly common, and zircon is rare. Some hematite grains were observed.

Large prismatic crystals of pseudomorphed (?)andalusite range up to 12.5mm. in length, and are now replaced by fine sericite.

RESULTS OF CASSITERITE SEARCH

Four specimens were collected to see if they contained cassiterite :

M103 - quartz vein with tourmaline.

M1690 - quartz vein with muscovite, chlorite, and minor tourmaline.

M103 - Fine-grained adamellite from a contact.

M1695 - A medium- to coarse-grained adamellite.

Each specimen was crushed so as to pass through a 36 mesh sieve, and then treated on a superpanner in order to separate the heavy minerals. A qualitative investigation only was made. No cassiterite was found. Following are brief notes on the heavy minerals observed.

M103 (quartz vein) 2-3% of the rock was composed of tourmaline; the tourmaline is pleochroic with o=dark brown, almost opaque, e=pale fawn. Small amounts of green tourmaline were noted. Very rare colourless to pale pink garnet is present.

M1690 (quartz vein). This vein contained only minute quantities of brown tourmaline (pleochroic as in M103), zircon, and apatite.

M103 (fine-grained adamellite). The dominant accessory mineral is colourless to pale pink garnet. Apatite is very rare. The accessory minerals amounted to about 0.5% of the sample.

M1695 (adamellite). Only small quantities of accessory minerals present: zircon, apatite, and pale pink garnet.

C. Almaden Granodiorite.

M579A (slide number 5863). Mt. Mulligan 3/71

Granophyric actinolite-biotite adamellite.

The hand-specimen is pale creamish-grey, speckled with black, and is medium- to coarse-grained. Tabular greyish white feldspar and sub-hedral to euhedral biotite and amphibole appear to be poikilitically enclosed by pale cream feldspar. Quartz is fairly common. Uncommon porphyritic crystals are composed of the greyish-white feldspar and, very rarely, of quartz.

In thin section, the porphyritic crystals range up to 8.6mm. in length, and groundmass grain-sizes range between 0.4mm. and 2.2mm. The texture is hypidiomorphic and granophyric. Plagioclase occurs in the groundmass and as porphyrocrysts, and is tabular and somewhat sericitized; it commonly shows strong oscillatory zoning. Extinction angles on sections cut normal to the acute bisectrix were measured on several crystals, and normal to the z-bisectrix on one crystal; the composition of the crystals at their cores ranges from An_{30} to An_{60}; all are zoned to oligoclase at their margins. Actinolite is sub-prismatic and is colourless to pale green. Biotite is pleochroic from pale fawn to dark brown, and forms flakes which, in one or two places, have replaced antinolite. Quartz forms rare phenocrysts, but is most commonly interstitial, and is in graphic intergrowth with heavily kaolinized potash feldspar.

One or two basic inclusions were observed; one is composed of randomly oriented squat laths of plagioclase (An 50) intergrown with sub-prismatic crystals of green hornblende. Another consists of an aggregate of fine granules of antinolite that are partly replaced by biotite.

A modal analysis by R.M. Tucker (Q.G.S.) showed the following mineral percentages: Plagioclase: 36, quartz: 29, potash-feldspar: 18, amphibole: 7, biotite: 10.

M1651 (slide number 5888). Yokas 3/57.

Biotite - amphibole microgranodiorite porphyry

The hand-specimen is dark grey and has phenocrysts of feldspar, amphibole, biotite, and quartz enclosed in a fine-grained, dyscrystalline groundmass.

In thin section the rock is seen to be hypidiomorphic and seriate porphyritic, the grain-sizes ranging from 0.05mm. in the groundmass to phenocrysts measuring 3mm. The phenocrysts consist of plagioclase, amphibole, biotite, and quartz. Plagioclase is tabular and lightly sericitized: as seen in specimens M579A and M1653A, its crystals show strong oscillatory zoning, and are basic, e.g., one crystal has a core of bytownite (An 80). Hornblende is pleochroic from pale fawn-olive to olive-green; commonly it appears to have been recrystallized to an aggregate of randomly oriented pale green grains of actinolite that generally have small biotite flakes associated with them. Biotite phenocrysts are rare, and are pleochroic from fox-brown to reddish brown. Quartz phenocrysts are very rare, and form embayed crystals.

The groundmass contains zoned tabular, fairly basic plagioclase, roughly prismatic actinolite that is partly or entirely replaced by biotite, and interstitial quartz, commonly graphically intergrown with potash-feldspar. Pale green penninite replaces biotite. Black iron ore and sulphide are accessory.

M1653A (slide number 5889). Yokas 3/87

Biotite-hornblende granodiorite

The hand-specimen is rather like that of M579A except that it tends to be somewhat fine-grained, and that there is much less of the pale cream feldspar.

In thin section the rare phenocrysts range up to 5mm in size; the groundmass grain-sizes range between 0.4mm. and 1.7mm. The texture is hypidiomorphic and porphyritic. Plagioclase occurs as porphyritic crystals and in the groundmass as tabular crystals showing slight replacement by sericite, epidote, and carbonate. Plagioclase shows strong oscillatory zoning to oligoclase on its crystal margins, and commonly has basic plagioclase at crystal cores. On one crystal, extinction angles measured on a combined Carlsbad/albite twin gave a composition of An_{70} at the crystal core. On another, an extinction angle measured on a section normal to the z-bisectrix showed a composition of An90-95. Quartz is interstitial and poikilitic. Hornblende is pleochroic from pale fawnish-green to olive-green, and is commonly prismatic. It is partly replaced by biotite, which also forms rich-brown poikilitic books. Both biotite and hornblende show some replacement by hornblende. Partly kaolinized potash-feldspar is interstitial, and is not common. Accessory minerals are zircon, apatite, black iron ore, and blue tourmaline.

A modal analysis by R.M. Tucker (Q.G.S.) showed: plagioclase: 49%, quartz: 32%, potash feldspar: 10, biotite: 7, amphibole: 2.

M1656 (slide number 1656). Yokas 3/67

This specimen was collected within the Almaden Granodiorite close to the junction with the Nychum Volcanics, and consists of fine-grained, grey microgranite showing some flow structure and enclosing a xenolith of the volcanic rock.

In thin section the microgranite is seen to be xenomorphic granular and sparsely porphyritic. The phenocrysts range up to 1mm. in size, and the groundmass has an average grain-size of 0.1mm.; at the junction with the xenolith is a zone of microgranite 0.2mm. thick that has an average grain size of 0.04mm. The microgranite consists of granular to poikilitic potash-feldspar, granular-interstitial quartz, tabular and somewhat sericitized plagioclase (andesine zoned to albite), flakes of sericite, and tourmaline. Quartz also forms the sparse phenocrysts. Two varieties of tourmaline - brown, and smoky blue - are present; in places they are intergrown. Tourmaline appears to be late stage, as it forms anhedral "poikiloblastic" grains. The thin marginal zone of the microgranite is composed of feldspar, quartz, leucoxene, and tourmaline, and is stained by hydrated iron oxide dust.

The acid volcanic has phenocrysts, ranging up to 3.75mm. in length, enclosed in a fine groundmass whose average grain-size is 0.08mm. The phenocrysts are subhedral to anhedral and angular with fretted margins, and comprise quartz, slightly kaolinized orthclase, and somewhat sericitized albite. The groundmass consists of an inequigranular mosaic of grains of quartz, orthoclase, and albite, together with small flakes of sericite, and "poikiloblastic", anhedral grains of brown and blue tourmaline. Small amounts of pale green chlorite are present. The volcanic has evidently been recrystallized through heating by the granite; it is not known whether it was a tuff or a lava.

D. Elizabeth Creek Granite

M579B (Slide number 5864). Mt. Mulligan 3/71

Biotite adamellite

The hand-specimen is mottled pink, speckled with black, and is crowded with coarse porphyritic crystals, ranging up to 25mm. in size, that are enclosed in a medium-grained groundmass. The porphyritic crystals consist mainly of creamish-pink feldspar, and quartz, with small amounts of black biotite. The apparently granular groundmass contains all these minerals.

In thin section the groundmass is seen to be xenomorphic and inequigranular, and the grain-sizes ranges from 0.1mm. to 1.65mm. Potash-feldspar occurs both as phenocrysts and in the groundmass: as porphyritic crystals it forms roughly tabular crystals that are in graphic intergrowth with quartz on their margins. In the groundmass it is granular. Potash feldspar has 2V(X) small to moderate, and some crystals were seen to have a fine, indistinct multiple twinning, suggesting that it is anorthoclase. Plagioclase (oligoclase zoned to albite) forms somewhat sericitized, tabular crystals, and, in the groundmass, is commonly anhedral, often poikilitically enclosing quartz. Quartz phenocrysts are anhedral, and in the groundmass it is granular. Biotite, pleochroic from pale fawn to very dark brown, forms subhedral books. Black iron ore, zircon, and apatite are accessory.

A modal analysis by R.M. Tucker (Q.G.S.) showed:- quartz: 51%, potash feldspar: 26%, plagioclase: 22%, and biotite: 1%.

E. Nychum Volcanics.

1. Pyroclastic Rocks

M621 c/2 (Slide number 5866). Groganville 8/27

Ignimbritic volcanic breccia

The hand-specimen is a greenish brown volcanic breccia. The sub-angular to angular fragments of lava, etc., range up to 20mm. in diameter; numerous small grains of quartz, 0.5mm. to 1mm. in size, are enclosed in the matrix, and appear to have embayed margins. The matrix is very fine-grained, and in places a fluxion texture can be seen.

In thin section, crystal and lithic grains range in size from 0.5mm. to 4.5mm. The crystals are formed of quartz and plagioclase, and are commonly strongly corroded. The rock fragments are sub-angular to angular, and consist of more or less altered (sometimes highly ferruginous) basaltic and andesitic lavas, and more rare intermediate and acid ashstones and tuffs. The matrix is very fine-grained, and has eutaxitic texture which is highly developed where the fragments are crowded together. The matrix is composed of fine felsitic material, stained with hydrated iron oxide, and probably represents devitrified glass.

M621C/3. (Slide number 5867). Groganville 8/27

(?)Ignimbritic microbreccia (fig. viii)

The hand-specimen is a black volcanic glass containing sub-rounded crystals and lithic fragments that range up to 5mm. in size. On a weathered surface there is a suggestion of flow-banding.

In thin section, a matrix of colourless volcanic glass is seen to enclose numerous crystal, vitric, and lithic grains. The matrix glass, which has a refractive index of about 1.50 (suggesting an SiO_2 content of about 72% - W.O. George in Williams, Turner and Gilbert, 1954), is featureless, except that strings of minute hematite inclusions, small crystal fragments, and crystallites, suggest a flow-texture; otherwise there is no sign of eutdxitic texture. The minute crystallites appear to be feldspar, biotite, and (?)clinopyroxene.

The crystal grains (some of which may be phenocrysts) are intermediate to basic plagioclase, quartz (magmatic and some derived from metamorphic rocks), biotite (flexed flakes with X=pale olive-brown, Y=Z=very dark olive brown; bleached edges) nontronite, sanidine, clinopyroxene (usually colourless but some are pleochroic in pale green), rare muscovite, and a solitary crystal of euhedral, colourless garnet.

The lithic fragments are varied, and are listed in order of abundance :-

a. Obsidian. Colourless volcanic glass with strings of hematite inclusions; its refractive index is less than that of Canada balsam. Some fragments are porphyritic, and contain phenocrysts of embayed quartz, plagioclase, and biotite. The pleochroism of biotite is similar to that described above.

b. Basalt. Very fine- to fine-grained rocks, some of which are somewhat altered. The fine-grained varieties have a sub-variolitic texture, and consist of clouded plagioclase laths and intergranular pyroxene usually pseudomorphed by bowlingite. The less fine-grained varieties have pellucid basic plagioclase laths ophitically intergrown with colourless clinopyroxene, and contain interstitial chlorophaeite charged with fine hydrated iron oxide dust. One or two fragments were composed of microphenocrysts of pellucid plagioclase (An55-60) and colourless clinopyroxene enclosed in a matrix of brown basaltic glass. A fragment of medium-grained, ophitic dolerite was observed to contain plagioclase (An_{70}) and colourless clinopyroxene, with some bowlingite.

c. Ignimbrite. In some, the compressed glass shards have been devitrified to a fine felsitic mass, but in all, the characteristic eutaxitic texture was observed. Some contain embayed grains of quartz and plagioclase.

d. Vitric and lithic tuff. This fragment contains grains of quartz, plagioclase, basalt, and flow-textured porphyritic rhyolite. The groundmass is composed of glass.

e. Spherulitic rhyolite. A fine groundmass composed of spherulites of alkali felspar and (?)quartz encloses phenocrysts of quartz, plagioclase and colourless clinopyroxene;

the last-named mineral is surrounded by a rim of hematite.

f. A cluster of medium- to coarse-grained quartz grains; the grains have intergrown margins, and it seems likely that the fragment is of metamorphic origin.

g. A fragment containing tremolite, quartz, and sodic plagioclase. The grains have intergrown margins, and the original rock was probably metamorphic.

h. Granite. Fragments composed of coarse grains of quartz and biotite, and quartz, plagioclase and muscovite.

i. Schist. Contains plagioclase, sillimanite, and tremolite.

M1617B (Slide number 5960). Yokas 4/55

Ignimbrite (fig. vii.)

The hand-specimen is a black glass enclosing grains of quartz, feldspar, and ferromagnesian minerals.

In thin section, 75% to 80% of the rock is seen to be composed of colourless glass whose refractive index is about 1.50 (approximately 72% SiO_2. George, op. cit.). The glass shows a eutaxitic texture which "flows" around enclosed grains. The grains are mostly embayed and consist of quartz, plagioclase (An_{38}), sanidine, and pale green augite ($2V_Z$ = moderate to low), commonly partly or wholly chloritized. A solitary flake of brown biotite was observed, as well as some fragments of glass, elongated parallel to the "flow" texture. Some of the feldspar grains have a felsitic rim, probably of ignimbritic origin, but now devitrified and showing a eutaxitic pattern different from that in the groundmass, suggesting the fragmentation of a pre-existing ignimbrite. Other grains have rims composed of brownish (?)kaolinitic material. Granular (?)leucoxene occurs in the groundmass glass, and associated with the kaolinitic rims.

M1643A. (Slide number 5881). Mossman-Cairns 8/5063

Devitrified rhyodacitic crystal tuff

The hand-specimen is pink, speckled with green, and has numerous grains enclosed in a fine-grained groundmass.

In thin section the fine-grained groundmass (probably representing devitrified glass) is seen to enclose angular to sub-rounded grains whose sizes range between 0.03mm. and 3.3mm. The grains comprise quartz, fairly strongly sericitized albite, partly kaolinized sanidine, hornblende pseudomorphed by muscovite and leucoxene dust, and rare leucoxene. Spherulites of apparent alkali-feldspar measuring between 0.3mm. and 1mm. in diameter, have grown in the groundmass, and commonly contain hydrated iron oxide. Chalcedony forms small aggregates in the groundmass, and cuts the rock as thin veins.

M1643B (Slide number 5882). Mossman-Cairns 8/5063

Devitrified dacitic crystal tuff

The hand-specimen is dark grey, and has grains of feldspar, quartz, and ferromagnesian material enclosed in a fine-grained groundmass.

In thin section, the groundmass is seen to be very fine-grained, and consists of felsitic material which probably represents devitrified glass. The grains range in size from 0.05mm. to 3mm., and are subhedral to anhedral, very commonly having corroded margins. They consist of quartz, saussuritized plagioclase (zoned from andesine to albite), sanidine (with patchy replacement by albite), hornblende, biotite, and pyroxene. The ferromagnesian crystals have now been largely replaced by a mixture of carbonate, (?)talc, chlorite, and leucoxene; biotite flakes give the impression of having pseudomorphed some of the hornblende prior to this replacement. Black iron ore, apatite, and zircon are accessory minerals.

M1644. (Slide number 5883). Mossman-Cairns 8/5061.

Devitrified rhyolitic crystal tuff (?)ignimbrite

The hand-specimen is a dark greyish-green rock in which fairly coarse grains of feldspar, quartz, and ferromagnesian mineral are enclosed in a dark, aphanitic groundmass.

In thin section, the groundmass is seen to be a fine-grained felsite containing green chloritic and some opaque matter; it has a faint flow texture which is accentuated by strings of the smaller enclosed grains. The sizes of the grains range between 0.03mm. and 4.9mm. The grains are subhedral to anhedral, some being of fragmental nature, and commonly show the effects of strong corrosion. They consist of sanidine, quartz, partly sericitized albite, hornblende, and biotite. Hornblende and biotite are now completely replaced by carbonate, green chlorite, (?)talc, and leucoxene, and it is evident that some of the hornblende was pseudomorphed by biotite prior to this replacement. Leucoxene, replacing black iron ore, is accessory. The quartz and felspar grains commonly have thin veins of carbonate along cracks and cleavage planes.

M1646A (slide number 5884). Mossman-Cairns 8/5061

Devitrified ignimbritic crystal tuff

This specimen, which in the hand is dark greyish-pink, is, in section, seen to be fairly similar to M1644. The main differences are that sodic plagioclase predominates over potash feldspar; the normal sizes of the grains do not exceed 3mm.; and the fine, felsitic groundmass shows eutaxitic texture. Some granular carbonate is also present in the groundmass.

M1646. (slide number 5885). Mossman-Cairns 8/5061

Dacitic Crystal tuff

The hand-specimen is light pinkish-grey, and contains grains of quartz, feldspar, and mica enclosed in a fine groundmass.

The thin section shows that the rock is very similar in texture to specimens M1643 and M1644, i.e., fairly coarse, anhedral to subhedral grains enclosed in a fine, felsitic groundmass. The grains consist of albite, quartz, and biotite. The biotite probably pseudomorphs hornblende, and has since been replaced by quartz, nontronite, carbonate, and leucoxene. Accessory apatite, zircon, and leucoxene were noted. Carbonate forms aggregates of granules in the groundmass, and replaces some of the feldspar. The feldspar also shows some sericitization and kaolinization.

M1647 (slide number 5886). Mossman-Cairns 8/5061

Dacitic crystal tuff

A creamish-buff hand-specimen which has grains, ranging in size up to 5mm., and composed of feldspar, quartz, and ferromagnesian mineral, enclosed in a fine groundmass.

In thin section the groundmass is seen to be composed of fine, granular alkali-feldspar and quartz, with intergranular chloritic material. The grains are angular and subhedral to anhedral, and show corroded margins; they comprise albite, quartz, and pseudomorphed hornblende. The albite is somewhat sericitized and kaolinized; some large grains composed of granular carbonate appear to pseudomorph felspar. Hornblende is pseudomorphed by carbonate, chlorite, nontronite, and quartz. The grains show some alignment, as though resulting from flow.

M1648 (slide number 5842). Mossman-Cairns 8/5061

Devitrified dacitic crystal tuff (ignimbritic)

The hand-specimen is creamish-pink, and like specimens M1643 and M1644, has grains enclosed in a fine-grained groundmass.

In thin section, grains of albite, quartz, and muscovite are seen to be enclosed in a fine groundmass which is, in part, granular, but which is mostly a fine felsite showing a faint eutaxitic texture. Accessory zircon and leucoxene were observed.

M1649 (slide number 5887). Mossman-Cairns 8/5061

Devitrified ignimbrite

The pale cream yellow hand-specimen is very similar to that of M1648.

In thin section grains of sanidine, albite, quartz, and rare pseudomorphs of hornblende are enclosed in a fine felsitic groundmass showing a strong eutaxitic texture.

2. Bedded Pyroclastic Rock

M1556 (slide number 5963). Yokas 1/137

Stratified volcanic breccia

The hand-specimen is a medium- to coarse-grained bedded breccia which is white, speckled with black. In outcrop, the laminated, medium-grained portion overlies the massive, coarser-grained part.

In thin section the grain-sizes in the coarser-grained portion range between 0.15mm. and 2.25mm. The maximum grain-size in the finer-grained portion is 0.75mm., and here the grains are more well-sorted than in the coarse-grained part. Throughout, the grains are angular to subangular.

The grains mostly consist of partly or wholly devitrified glass: some are ignimbritic, and others are intermediate or acid lavas, commonly having microlites of plagioclase, and more rarely having flow-oriented strings of spherulites. Some grains consist of somewhat rounded and embayed quartz, and crystals of tabular plagioclase; these are evidently of volcanic origin. Less common are fragments of micaceous sandstone, slate, and muscovite microgranite.

3. Acid Lavas

M621 c/4 (slide number 5836). Groganville 8/27

Dacite porphyry

A greenish-grey, fine-grained porphyritic rock in which faint flow-banding may be discerned.

In thin section, the specimen is fine-grained, amygdaloidal, and porphyritic, and the groundmass is hypidiomorphic, with a pilotaxitic texture.

In the groundmass, plagioclase (with a refractive index greater than that of Canada balsam) forms flow-oriented laths 0.01mm. to 0.03mm. long. Small granules of (?)clinopyroxene are commonly pseudomorphed by nontronite. Pale green chlorite, alkali feldspar, and quartz are interstitial. Granules of black iron ore and accessory zircon are present.

The phenocrysts range up to 1.65mm. in size, and are flow-oriented. Plagioclase (An_{40} zoned to oligoclase) crystals are embayed and partly replaced by alkali-feldspar in veins and patches. Prismatic pyroxene has been entirely pseudomorphed by brownish-green nontronite. Quartz crystals show embayed margins.

Amygdales tend to be flattened parallel to the direction of the flow-texture, and are filled with green, spherulitic chlorite and, in places, chalcedony.

An estimation of the percentages of minerals present is :- plagioclase: 60, pyroxene: 20, quartz: 10, and alkali feldspar: 10.

M621C/5 (slide number 5868). Groganville 8/27

Partly silicified dacite porphyry

The specimen is a fine-grained, dull purple-red porphyritic rock, with an aphanitic groundmass enclosing phenocrysts of plagioclase, quartz, and pseudomorphed pyroxene. The phenocrysts range up to 4mm. in length. Some amygdales were noted to contain zeolitic and green chloritic matter.

In thin section the groundmass is found to be fine-grained, and has a pilotaxitic-trachytic texture. Laths of plagioclase (oligoclase of andesine) are flow-oriented, and measure about 0.03mm. in length. Much hematite dust is present, and small prismatic crystals of (?)pyroxene have been replaced by hydrated iron oxide and nontronite. Rare pale green chlorite is interstitial. The groundmass minerals are enclosed by equant grains of quartz that have somewhat intergrown margins, and which have an average diameter of 0.2mm.

Plagioclase phenocrysts (An_{50}) are tabular and somewhat corroded; some, as in M621C/4, are partly replaced by alkali-felspar (?sanidine - $2V_X$=small), and most crystals show some sericitization. Quartz phenocrysts are subhedral, and are mostly strongly corroded. Prismatic pyroxene has been totally pseudomorphed by green nontronite and hydrated iron oxide, and the crystals appear to have been corroded.

M662 (slide number 6484). N.W. of Mt. Mulligan

Carbonated, silicified, and devitrified rhyolite or dacite

The hand-specimen is a dark greenish-grey rock in which an aphanitic groundmass encloses small, sparse phenocrysts and some probable xenoliths that measure about 2mm. in diameter. The groundmass shows fine bent and contorted flow-banding.

In this section the rhyolite is seen to consist of two parts. In both, the groundmass consists of very fine-grained, flow-banded material. In one, the groundmass is a very fine felsite, and, in the other, the groundmass appears to have been a fine felsite that has been mostly silicified to form a fine mosaic of interlocking quartz grains that enclose fine opaque material. In both parts the flow-texture is accentuated by elongate, narrow cavities that have been filled with quartz and calcite. Other larger amygdaloidal cavities have also been filled by these two materials.

The phenocrysts consist of quartz, feldspar, and amphibole. Quartz is euhedral to anhedral and is commonly embayed. Feldspar has been partly pseudomorphed by calcite, and euhedral amphibole is replaced partly by calcite and nontronite. Small xenoliths of quartz greywacke and probable shale are present.

M1583 (slide number 5871). Yokas 3/81

Devitrified porphyritic dacite (fig. ix)

The hand-specimen is an extremely hard, flinty, pale blue-grey rock in which thin cream and brown bands mark flow texture. The aphanitic groundmass encloses few phenocrysts.

In thin section the few phenocrysts present measure up to 1-0mm. in size, and are of rounded quartz and tabular plagioclase (probably labradorite). The groundmass is composed of fine felsitic material which probably represents devitrified glass. This encloses a few flow-oriented laths of plagioclase that measure 0.06mm. long. The groundmass felsitic material exhibits a magnificent flow-texture which "swirls" around the phenocrysts and a cognate xenolith. The flow-texture is emphasized by bands of very fine opaque dust. The cognate xenolith is rounded, and measures 2.75mm. in diameter; it is a partly altered basalt.

M1627 (slide number 5879). Yokas 1A/147

Ferruginous felsite

The hand-specimen is dull red, aphyric and phaneritic. In thin section, microlites of feldspar are seen to be embedded in a very fine felsite that probably represents devitrified glass. The felsite is highly charged with fine hematite dust. Small flakes of sericite and biotite are present, and numerous small cavities having a common orientation are filled with granular quartz.

M1660 (slide number 5961). Mossman-Cairns 8/5061

Felsite or devitrified (?)obsidian

The hand-specimen is a dark aphanitic and aphyric rock with well-marked flow-lines.

In section the specimen is seen to be a very fine felsitic intergrowth that probably represents devitrified glass. Granules of black iron ore and rare porphyritic crystals of quartz are present. The flow texture is marked by lines of hydrated iron oxide dust.

4. Intermediate lavas

M621C/1 (slide number 5865). Groganville 8/27

Tuffaceous quartz-bearing hypersthene andesite

The hand-specimen is a black rock with an aphanitic groundmass enclosing small apparent phenocrysts of quartz. Conspicuous flow-banding may be seen on the weathered surface.

In thin section the andesite is found to have a fine-grained, pilotaxitic groundmass that has an average grain-size of 0.02mm. The groundmass is composed of microlites of intermediate plagioclase, faintly pleochroic prisms of probable hypersthene, flakes of nontronite, and much hematite dust. Flow bands in the groundmass are made of layers more rich and less rich in this hematite dust.

True phenocrysts are sparse and comprise euhedral tabular plagioclase (An55-60), and possibly euhedral quartz; their crystal margins show little or no embayment.

False phenocrysts, or xenocrysts of quartz and, more rarely, plagioclase are mostly strongly embayed, or else sharply angular, having a pyroclastic character. The phenocrysts and xenocrysts range up to 1.5mm. in size.

Several cognate xenoliths with rounded and elongate outlines are present, and consist of somewhat altered basalt and andesite.

M1530D (slide number 5967). Yokas 6/157

Augite-hypersthene andesite (fig. x and chemical analysis, Table A)

In hand-specimen the andesite is a dense, black aphanitic rock in which small phenocrysts may sometimes be discerned.

In thin section, the andesite is seen to be fine-grained and porphyritic the average grain-size of the groundmass being 0.07mm., and the phenocrysts lengths measuring up to 1mm. The phenocrysts are flow-oriented, and the groundmass texture is pilotaxitic and hypocrystalline. Small amygdales are present.

The porphyritic crystals are mostly plagioclase, with rare augite and hypersthene; usually, the phenocryst margins show some sign of corrosion. The plagioclase phenocrysts are slightly clouded with alteration products; measurements show a composition of An_{68}, zoned to An_{58}; some oscillatory zoning was observed.

In the groundmass; plagioclase (An_{60} to An_{37}) forms flow-oriented laths and commonly stubby tabular crystals. Colourless hypersthene ($2V_{\alpha}$=large, parallel extinction, and low polarization colours) occurs as somewhat lean, prismatic crystals and augite (also colourless, but with a high inclined extinction and moderate polarization colours) forms granular to stubby prismatic crystals. All these minerals are enclosed in a pale, murky brown glass with a refractive index of about 1.505 (i.e., an SiO_2 content of about 70% - George op. cit.) and which, very rarely, has devitrified to a very fine-grained felsitic mass of grains whose relief is negative. Carbonate is usually interstitial, but small amounts appear to have pseudomorphed (?)olivine. Rare chlorite is interstitial, and granular black iron ore is present.

An estimate of the percentages of minerals present is :- plagioclase: 50, hypersthene: 25, augite: 5, glass: 15, and other minerals: 5.

M1589A (slide number 5837). Yokas 6/157

Altered (?)trachyte

The hand-specimen is a pale buff-grey aphanitic and aphyric rock.

In thin section the rock is fine-grained and has a pilotaxitic-trachytic texture. Flow-oriented laths of probable sodic plagioclase, and rarer flakes of sericite are embedded in subordinate interstitial (?)alkali-feldspar and chlorite.

M1617L (slide number 5877). Yokas 4/55

Augite andesite (figs. xi. and xii.)

The hand-specimen is a fine-grained, porphyritic rock, with a black, phaneritic groundmass enclosing small phenocrysts of feldspar and pyroxene.

In thin section the specimen is seen to be seriate porphyritic, with a fine-grained (average grain-size 0.03mm.) hypocrystalline, pilotaxitic groundmass enclosing phenocrysts that range up to 2.25mm. in length.

The groundmass contains plagioclase, clinopyroxene, glass, and black iron ore. The plagioclase forms small, flow-oriented laths but are normally zoned from labradorite to oligoclase. Colourless clinopyroxene occurs as clusters of small prismatic crystals, and black iron ore is granular. All these minerals are enclosed in a pale grey-brown to colourless glass whose refractive index is about 1.51, suggesting an SiO_2 content of 68% - George, op. cit.

The phenocrysts consist of plagioclase, clinopyroxene, and black iron ore. Two forms of plagioclase phenocrysts are present. First there are small porphyritic crystals, ranging from groundmass size to 0.4mm. in length, which are normally zoned from labradorite (in one case, bytownite) to andesine or oligoclase; these show only slightly embayed margins, if at all. Secondly are the larger phenocrysts. These sometimes form clusters in which clinopyroxene has intergrown; they commonly have strongly embayed margins, and very often show oscillatory zoning - some of these have a sharply basified marginal zone surrounding a rather irregular core. One crystal has a core composition of An_{61}, and a margin of An_{65}. These points suggest that the larger phenocrysts do not belong to the original magma of the lava. The phenocrysts of clinopyroxene are prismatic. Commonly they have a core of augite ($2V_Z$ = moderate) with a thin rim of pigeonite ($2V_Z=0^o$). Black iron ore crystals are tabular to acicular (?)ilmenite. The rock is cut by thin irregular veins of hydrated iron oxide.

An estimation of the percentages of constituents present is :- Plagioclase: 45, clinopyroxene: 20, glass 25, black iron ore: 5. Prismatic apatite is accessory.

M1642 (slide number 5880). Mossman-Cairns 8/5061

Hypersthene andesite

The hand-specimen is a black, phaneritic rock in which distinct flow-banding may be seen.

In thin section, the andesite shows a pilotaxitic to trachytic hypocrystalline groundmass whose grain-sizes range between 0.003mm. and 0.01mm. Pronounced flow-banding is marked by lineation of felspar laths, and by trails of variolitic clots and layers. The groundmass encloses small porphyritic crystals whose average length is 0.2mm. (one attains a length of 1mm.).

The groundmass is composed of plagioclase, pyroxene, glass, and black iron ore. The plagioclase (andesine or labradorite) forms flow oriented laths, and also occurs as very long, acicular laths in the variolites. Pyroxene and black iron ore are granular, and the glass is pale grey to colourless, with a refractive index less than that of Canada balsam. The porphyritic crystals are mostly laths of plagioclase (about An_{60}), but rare prisms of (?)hypersthene were noted.

5. Basic lavas

M621A (slide number 5835) Groganville 8/27

Altered basalt

The hand-specimen is a dark brown-grey, fine- to medium-grained basalt, in which amygdales containing chalcedony range up to 7mm. in diameter. A test with cold dilute HCl showed the presence of calcite in the rock.

In thin section the rock is seen to be seriate porphyritic, with grain-sizes ranging from minute crystallites, 0.05mm. in length in the groundmass, to porphyritic crystals of plagioclase up to 2.1mm. long. The texture is interstitial, the interlacing plagioclase crystals and intergranular subhedral to euhedral clinopyroxene being embedded in a dense matrix composed of almost opaque palagonite, brown bowlingite, and probable alkali-feldspar.

Plagioclase porphyritic crystals and groundmass laths are zoned from An_{72} to An_{32}, and are slightly sericitized. Clinopyroxene is mostly pseudomorphed by calcite, bowlingite, and rarely chalcedony; almost opaque palogonite, and brownish-red bowlingite occurs interstitially, and the latter is also present as small veinlets and clots of flakes in plagioclase crystals. Also interstitial, and moulded on bowlingite, is probable alkali-feldspar. This mineral, and much of the bowlingite, is charged with fine hydrated iron oxide dust, so much so that the matrix is almost opaque. The dust also occurs enclosed in the margins of plagioclase crystals, and rarely, along their cleavage planes.

The amygdales are commonly filled with chalcedony, often in conjunction with small amounts of bowlingite and calcite. Rarely, only calcite and bowlingite are present. Thin veins of chalcedony and calcite cut the rock.

An estimation of the percentages of minerals present is :- plagioclase: 45, pseudomorphed clinopyroxene: 25, bowlingite, (?)alkali feldspar, and hydrated iron oxide dust: 30.

<u>M1591 (slide number 5872)</u>. Yokas 6/157

<u>Olivine-bearing basalt (fig. xiii)</u>

In hand-specimen the basalt is speckled dark bluish-grey, fine-grained, dyscrystalline, and porphyritic.

The basalt, in thin section, is found to be hypocrystalline and seriate porphyritic. The average groundmass grain-size is 0.2mm., and the phenocrysts range up to 4.5mm. in size. Groundmass plagioclase forms an interlacing meshwork of pellucid laths that are ophitically intergrown with anhedral plates of very pale lavender augite. Plagioclase, as phenocrysts, and in the groundmass, is zoned from An_{70} to sodic oligoclase. More rare subhedral to euhedral, partly serpentinized olivine is colourless, and has $2V_z$ = large, as compared with $2V_z$ = moderate for the augite. The birefringence of the olivine is 0.035-5; this, taken with its optic axial angle, suggests a composition of about Fe_{75-80}. In places, both the olivine and the serpentine are replaced by carbonate. Colourless glass is interstitial, and has a refractive index of about 1.53, suggesting an SiO_2 content of 58% - George, <u>op. cit</u>. The glass is highly charged with crystallites of felspar and (?) pyroxene, and fine, opaque dust. Rarely, fibrous chlorite may be observed. Amygdales are filled with fibrous carbonate. Tabular black iron ore is accessory.

An estimate of the percentages of components present is :- plagioclase: 45, augite: 35, olivine: 5, glass: 15.

M1664B (slide number 5765), Water Pump, Mitchell Bridge (Mungana road)

Olivine-bearing basalt

The hand-specimen is a dark, porphyritic rock, with phenocrysts of tabular plagioclase (up to 5mm. in length) and prismatic olivine (about 1mm. size) enclosed in a fine-grained, dyscrystalline groundmass.

In thin section, the texture of the groundmass is seen to be hypocrystalline and intergranular. Slightly clouded plagioclase, zoned from An_{63} to calcic oligoclase, forms a meshwork of laths, and augite occurs as granular to prismatic crystals that are only very rarely in ophitic intergrowth with plagioclase. Brown or green glass, and more rare finely crystalline bowlingite, are interstitial: glass has a refractive index of about 1.53, i.e., an SiO_2 content of about 58% - George op. cit. In one or two places, minute spherulites composed of (?)zeolite are enclosed in the glass. Tabular black iron ore, and prismatic green tourmaline are accessory.

The basalt is glomeroporphyritic, the phenocrysts being formed of plagioclase and altered olivine. The plagioclase is zoned from An_{80} to calcic oligoclase. Olivine forms clusters of prismatic crystals now pseudomorphed by bowlingite.

A mafic inclusion containing granular augite and pseudomorphs of bowlingite after olivine was noted.

Rare irregular cavities are filled by carbonate containing thin veins of bowlingite. The solitary amygdale observed in the section is filled with bowlingite.

An estimate of the percentages of constituents present is : - plagioclase: 50, augite: 25, pseudomorphed olivine: 8, glass and interstitial bowlingite: 15, black iron ore and tourmaline: 2.

6. Dyke Rocks

M1602 (slide number 5876). Yokas 4/59

Porphyritic obsidian

The hand-specimen is composed of a dark grey glass that encloses phenocrysts of feldspar, quartz, and ferromagnesian minerals. The phenocrysts range up to about 2mm. in size. Numerous pink spherical objects that measure up to 1mm. in diameter commonly have a grey substance at their centres; the pink and grey material are shown in the section to be alkali-feldspar and chalcedony respectively, forming spherulites.

In thin section, the glass is very pale olive brown, and has a refractive index less than that of Canada balsam. Perlitic cracks may be observed. The spherulites are sometimes clustered and commonly have a chalcedony core with a thick rim of alkali feldspar; many of them have a thin "ring" of hydrated iron oxide enclosed in the alkali feldspar, encircling the chalcedony core.

The phenocrysts are subhedral to euhedral, and are generally embayed, and are commonly surrounded by spharulitic material. They consist of sanidine, quartz, plagioclase, clinopyroxene, and olivine. Feldspar shows little alteration; sanidine has $2V_X$ = very low, and plagioclase has a refractive index greater than that of quartz, with $2V_X$ = large; an extinction angle indicates a composition of about An_{25}. Clinopyroxene is pleochroic from very pale brown to very pale green, and has $2V_X$ = moderate. Olivine has parallel extinction, a moderate to high birefringence, and $2V_X$ = large.

An estimation of the percentages of minerals and glass present is :- glass: 73, sanidine: 10, spherulitic material: 7, plagioclase, clinopyroxene and olivine: .5, quartz: 5.

M1617J (slide number 5841). Yokas 4/55

Trachyte

The hand-specimen is a pale purplish-green porphyritic rock with phenocrysts of feldspar and ferromagnesian mineral enclosed in an aphanitic groundmass.

In thin section the rock has a panidiomorphic, trachytic texture, and is seriate porphyritic, the grain-sizes ranging from 0.021mm. in the groundmass to phenocrysts of 1.25mm. The rock consists of plagioclase (65%), amphibole (3%), pyroxene (5%), sanidine (very roughly 5-10%), interstitial bowlingite and chlorite (10%), iron ore (5%), and groundmass alkali-felspar (5%). Rare (?)olivine may have been present. Many of the plagioclase and sanidine phenocrysts have been partly or entirely replaced by carbonate and chalcedony. The plagioclase that remains has a composition of An_{15}; sanidine has $2V_X$ = low. In the groundmass, plagioclase ((?)albite) forms flow-oriented laths embedded in a matrix of interstitial chlorite and bowlingite flakes, and alkali-feldspar. The euhedral ferromagnesian phenocrysts have all been pseudomorphed by brown bowlingite, but from their shapes it is evident that pyroxene, amphibole, and possibly olivine were present. Granular hematite and carbonate are present in the groundmass. Accessory sphene occurs as rare groups of crystals enclosed in plates of calcite. A rather angular cognate xenolith composed of altered porphyritic and variolitic basalt was observed. The rock appears to be a lamprophyre, and is named as such.

7. Pebbles from the Mt. Mulligan Coal Measures Conglomerate

M746B (slide number 6648), King Cole Mine, Mt. Mulligan

Devitrified ignimbrite

The hand-specimen is a pale greyish green rock that has grains of quartz, feldspar and biotite enclosed in an aphanitic groundmass.

In thin section, grains of embayed quartz and (?)alkali-feldspar, and subhedral biotite are enclosed by a very fine-grained, felsitic groundmass that probably represents devitrified glass. The groundmass has an indistinct eutaxitic texture.

This rock is similar to devitrified ignimbrites that have been described from both the Nychum and the Featherbed Volcanics.

M746C (slide number 6650), King Cole Mine, Mt. Mulligan

Porphyritic rhyolite

The hand-specimen is a grey, porphyritic, and flow-banded rhyolite. In thin section, embayed phenocrysts of quartz and alkali-feldspar, and sub-rounded grains of somewhat metamorphosed sandstone are enclosed in a fine-grained, felsitic, kaolinized, and partly silicified groundmass.

There is no specimen that I have seen in either the Featherbed or the Nychum Volcanics that can be compared with this one. It does, however, show some similarities to M662 (a rhyolite underlying the Mt. Mulligan coal measures north of Mt. Mulligan) in as much as it contains sandstone grains, and some silicification is present.

M658 (slide number 6648). North of Mt. Mulligan

Leucocratic adamellite

The hand-specimen is a pink, leucocratic granite that is medium-grained and equigranular, and, in hand-specimen is, according to C.D. Branch (in discussion), rather similar to certain more rare types of the Elizabeth Creek Granite.

In thin section the rock is xenomorphic to hypidiomorphic-granular, and the grains tend to have crenulated, interlocking margins. Thin bands of finely granulated material cut the rock. The minerals consist of strongly kaolinized and slightly sericitized feldspar, quartz, and rare muscovite. The feldspars are perthite and plagioclase (probable oligoclase), and the two appear to be present in equal quantities. Quartz shows slight granulation and has strain shadows between crossed nicols.

M1624 (slide number 5878). Yokas 1A/147

Amygdaloidal carbonated and silicified dolerite

The hand-specimen is of a dark grey, amygdaloidal, fine-grained, dyscrystalline, and aphyric dolerite. The amygdales measure up to 8mm. in diameter, and some are elongated; they are filled with quartz, chalcedony, and calcite.

In thin section the dolerite is found to have an average grain-size of 0.3mm. Its texture appears to have been typically doleritic. The ferromagnesian minerals have been entirely replaced by brown bowlingite and calcite. Plagioclase (about An_{50}) is mostly altered to quartz, calcite, and bowlingite. Ilmenite forms needles partly pseudomorphed by leucoxene. Bowlingite, chlorite, calcite, and quartz occur interstitially, and fill small voids. The amygdales are filled with calcite, quartz, and chalcedony.

F. Featherbed Volcanics

M570A (slide number 5862). Mt. Mulligan 4/121

Dacite

The hand-specimen is a mottled greenish-grey porphyry in which an aphanitic groundmass encloses phenocrysts of euhedral feldspar, anhedral quartz, and subhedral ferro-magnesians. The size of the phenocrysts range up to 1cm.

In thin section, the groundmass is seen to have an average grain-size of about 0.02mm., and consists of a fine mass of somewhat intergrown (sometimes granophyric) alkali-felspar and quartz, with subordinate chlorite, epidote, and leucoxene. The phenocrysts are commonly clustered, and consist of tabular, saussuritized and strongly kaolinized albite, strongly corroded quartz, (?) hornblende pseudomorphed by green chlorite and epidote, and biotite. The biotite also appears to have pseudomorphed hornblende, and has lenticles of epidote and prehnite lying along its cleavage. Accessory apatite and black iron ore are present.

M570B (slide number 5834) Mt. Mulligan 4/121

Dacitic crystal tuff

The hand-specimen is dull greenish-grey, and consists of grains of feldspar, quartz, and ferro-magnesian mineral that are enclosed in an aphanitic groundmass. Some of the quartz grains measure up to 8mm. across.

The groundmass, as seen in thin section, has an average grain-size of 0.02mm., and consists of somewhat intergrown alkali-felspar and quartz, together with subordinate green chlorite, carbonate, epidote, and leucoxene. The coarse grains enclosed in the ground-mass range in size from 0.05mm. to 4.5mm. These grains are euhedral to anhedral, and some (especially quartz) grains are angular fragments rather than crystals; they quite commonly show corroded margins. The grains consist of plagioclase, quartz, pseudomorphed biotite and hornblende, and fairly rare sanidine. Plagioclase (An_{40}) grains are usually subhedral to euhedral, and are, in places, clustered as though they crystallized together before the extrusion of this rock. The plagioclase is generally lightly saussuritized, although some is strongly so; it is apparently antiperthitic, as streaks of sericitized material that look very like perthitic exsolution lamellae run across most crystals; in some, the sericite was set in material that has a refractive index much less than that of the plagioclase. Hornblende seems to have been pseudomorphed in two ways: firstly, it has been replaced by carbonate, chlorite, and nontronite, and, rarely, hydrated iron oxide dust; secondly, it has been replaced by biotite which, in turn, was altered to chlorite, carbonate, sericite, epidote, and leucoxene. Accessory minerals observed were leucoxene, apatite, sphene, and zircon.

M1598B (slide number 5839). Yokas 4/59

Pseudobrecciated and veined, altered intermediate or basic volcanic

In the hand-specimen, the fine-grained, greyish-green rock is seen to be brecciated, and sub-angular fragments being separated by thin veins that contain greyish-white material. The veins are 1mm. to 5mm. thick and the fragments range up to 5cm. in size. The brecciation appears to have taken place, in situ.

In thin section, the rock has a pilotaxitic-trachytic texture, and is sparsely porphyritic. The average grain-size is 0.05mm., and the porphyritic crystals range up to 0.6mm. in length. The rare microphenocrysts are formed of albite. In the groundmass partly sericitized tabular albite is flow-oriented. Nontronite occurs in small prismatic areas pseudomorphing some pre-existing ferromagnesian mineral (amphibole or pyroxene), and, possibly, plagioclase - most certainly the plagioclase microphenocrysts are partly replaced by nontronite. Nontronite, with sericite and chlorite, also occurs as minute flakes in interstitial areas, and appears to have partly replaced albite phenocrysts (?)Potash felspar and carbonate are interstitial. Acicular apatite, octahedral black iron ore, tabular leucoxene, and granular epidote are accessory. Rare amygdales are filled with granular quartz.

The veins are composed of granular quartz and albite, with small amounts of green chlorite and, here and there, aggregates of black iron ore. In some places the groundmass contains interstitial quartz which may have been introduced.

M1598C (slide number 5874). Yokas 4/59

Devitrified rhyolitic ignimbrite

The hand-specimen is a mottled pink inequigranular rock, with grains ranging up to 7mm. in size enclosed in a very fine-grained groundmass.

In thin section the groundmass is seen to be a very fine-grained felsite, which in places is spherulitic, the spherulites probably consisting of alkali-feldspar. The enclosed grains are anhedral to euhedral and angular to rounded and embayed; they consist of quartz, carbonated sanidine, sericitized and carbonated albite, and ferromagnesian mineral pseudomorphed by nontronite, leucoxene and, commonly, calcite. Fragments of felsite and granophyre are present. Apatite and zircon are accessory, and small amounts of granular epidote are associated with the albite.

The groundmass which has an indistinct eutaxitic texture, has been replaced in one or two places by granular quartz and alkali-felspar ((?) albite). Within the quartz grains, trains of minute inclusions are arranged in the form of a eutaxitic texture. The quartz grains are aggregate into mosaics that are roughly rimmed by smaller, roughly equant grains of (?)albite; small clots of fine flakes of sericite are also present.

M1598D (slide number 5840). Yokas 4/59

Altered and devitrified ignimbrite

The hand-specimen is dark grey speckled with pink, and, like M1598C, has medium to coarse grains enclosed in a very fine groundmass.

In thin section the groundmass is seen to be a fine felsite (presumably devitrified glass) with a eutaxitic texture. The enclosed grains range in size between 0.1mm. and 2.25mm. The grains are subhedral to anhedral, and angular to embayed, and consist of quartz, strongly sericitized and carbonated feldspar, (?) hornblende pseudomorphed by nontronite, chlorite, calcite, leucoxene, and quartz. Rare grains of granophyre are present. Zircon, sphene, and apatite are accessory. The rock is cut by thin veins of quartz, and in one or two places neighbouring these veins, the groundmass has apparently been silicified.

M1598E (slide number 5875). Yokas 4/59

Devitrified, lithic, rhyolitic ignimbrite

A pale creamish-grey hand-specimen that contains mineral grains and lithic fragments enclosed in a very fine-grained groundmass. The lithic fragments normally measure up to 1.5cm., and the mineral grains about 3mm.

This specimen is very like the others in this suite, i.e., it has a fine-grained felsitic groundmass with a eutaxitic texture enclosing grains of quartz, sanidine, albite, and ferromagnesian. Sanidine and albite are strongly carbonated, the latter is also sericitized; the ferromagnesian minerals are replaced by nontronite, leucoxene, carbonate, and, commonly, chlorite. The lithic fragments observed include granophyre, altered (?) basic igneous rock, andesite, spherulitic acid lava, and felsite. Accessory minerals are leucoxene, zircon, and apatite.

M1598F (slide number 5838). Yokas 4/59

Altered devitrified ignimbrite

The hand-specimen is dark grey, speckled with pink; grains of felspar, quartz, and ferromagnesian mineral range up to 2mm. in size, and are enclosed in an aphanitic groundmass.

The thin section shows this rock to be similar in texture and mineralogy to the other ignimbrite specimens in this suite, except that the ferromagnesian minerals are replaced by chlorite and sericite, in addition to nontronite, leucoxene, and carbonate. Accessory minerals are apatite, leucoxene, zircon, and sphene. Lithic fragments include (?)dacite and probable andesite.

G. Dolerite Dyke, and inclusions from the dykes occurring near Mt. Mulligan

M628 (slide number 5869). Maytown 4/51

Quartz dolerite

In hand-specimen the dolerite is dark green, fine-grained, dyscrystalline, and aphyric. Some amygdales were noted.

The thin section shows the rock to be sub-ophitic and amygdaloidal, with an average grain size of 0.2mm. Slightly sericitized plagioclase is zoned from An_{58} to oligoclase, and forms an interlacing meshwork of laths that are in sub-ophitic intergrowth with pigeonite ($2V_Z$ = low). Chlorite, brownish bowlingite, and carbonate are interstitial. Black iron ore is octahedral to tabular, and minor quartz is interstitial. Sphene is accessory. Amygdales are filled with chlorite and minor carbonate.

An estimation of the percentages of minerals present is :- plagioclase: 45, interstitial minerals: 30, pigeonite: 20, and black iron ore: 5.

Specimens M752A, M752B, and M753B (slides 6651, 6652 and 6653, respectively), 2½ miles south of Mt. Mulligan

In the hand-specimen M572A is a coarse-grained leucocratic granitic rock in which large amoeboid grains of quartz occur in conjunction with pink feldspar. M572B is medium-grained and is composed of pink feldspar, quartz, and small amounts of ferromagnesian material. Specimen M753B is greenish and contains coarse grains of quartz and greenish-grey feldspar enclosed in a sparse matrix composed of fairly finely intergrown quartz and pink feldspar.

In thin section all the specimens are seen to be leucocratic aplitic or aplo-granitic rocks. M572A contains quartz, strongly kaolinized potash feldspar, and rare sodic plagioclase. M572B contains quartz and roughly equal quantities of sodic plagioclase and potash feldspar, and M573B is composed of quartz, sodic plagioclase and smaller amounts of potash feldspar. All the specimens contain intergranular granophyric intergrowths of quartz and alkali feldspar, specimen M573B containing much more than the other two. In this specimen plagioclase and quartz grains give the impression of being embayed during the formation of the granophyre.

These specimens are leucocratic granitoid rocks, but I would hesitate to correlate them with the Elizabeth Creek Granite.

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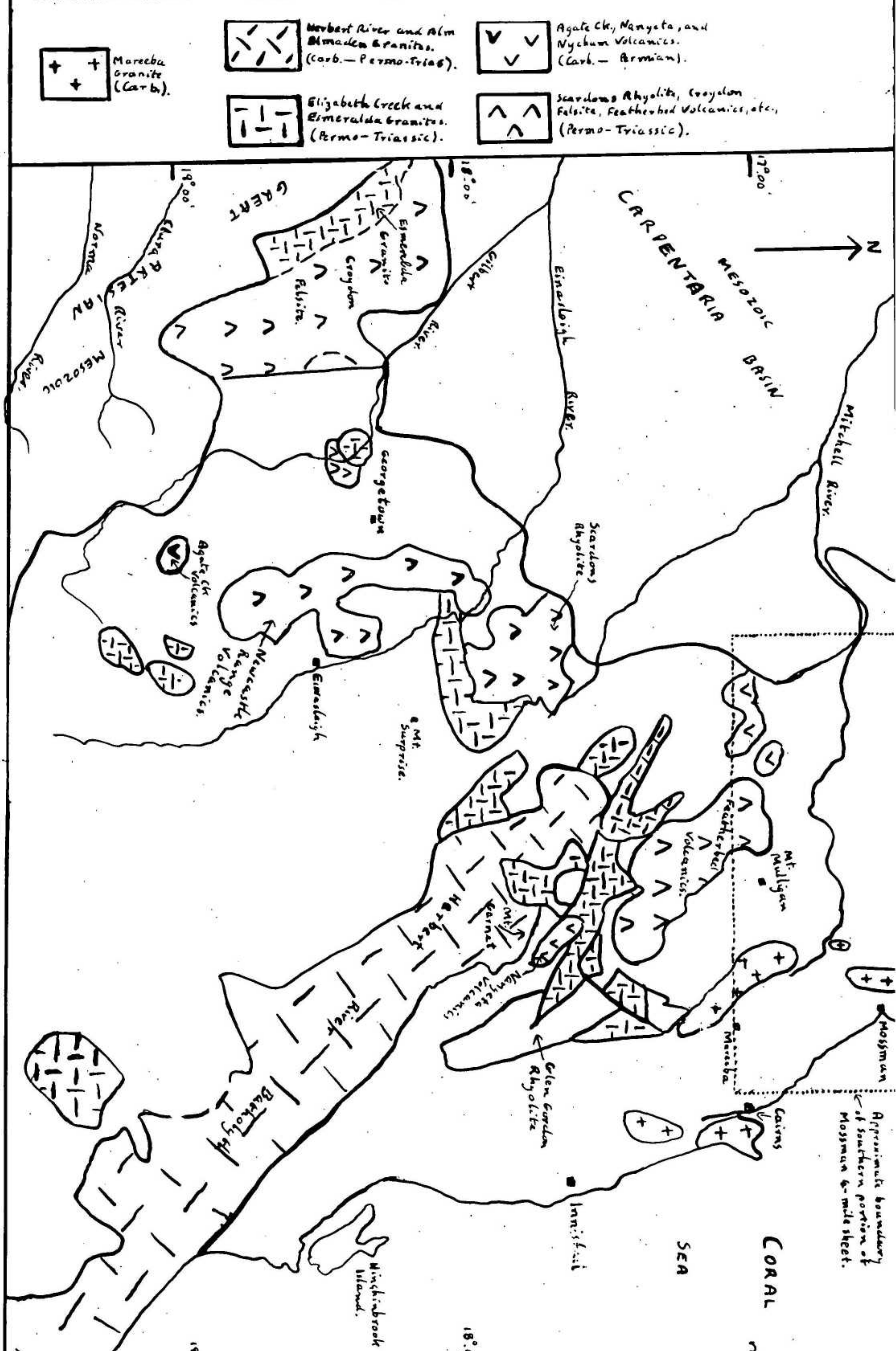
Fig. 1. Geological Sketch Map of the Carboniferous and Permo-Triassic Igneous Rocks of the Cairns Hinterland. Scale — 1 inch : 30 miles.



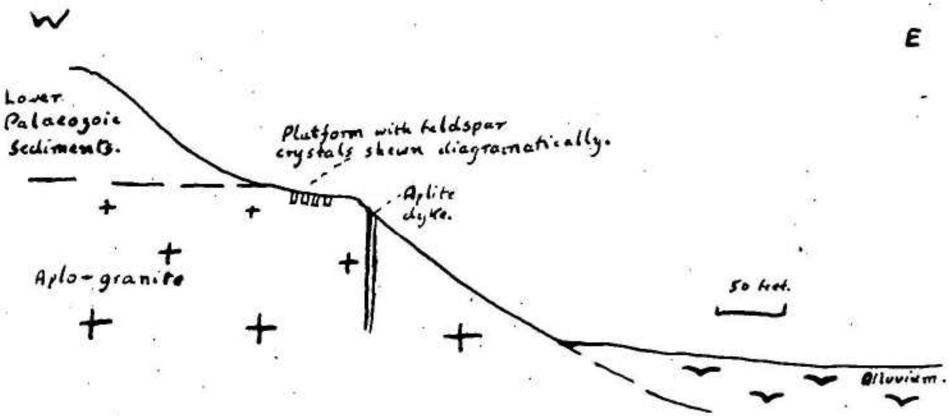


Fig. i. A section across the outcrop of the tourmaline-bearing aplo-granite, west of "Brooklyn" homestead.

Fig ii. Tongue of granite intruded into slate, at contact near Mt. Spurgeon track.

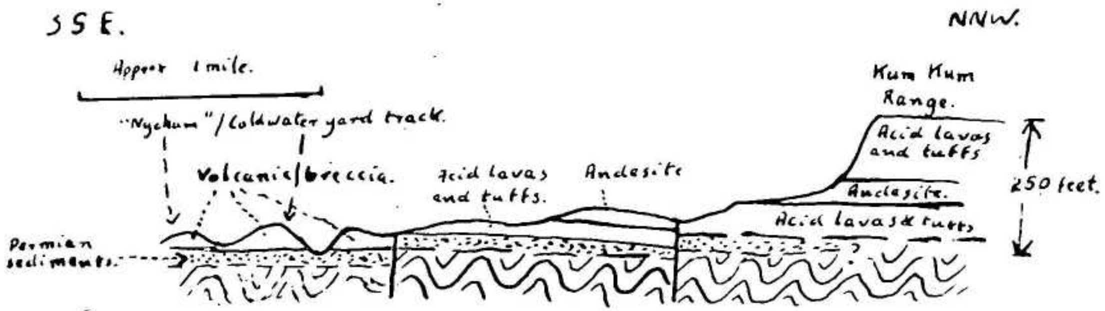


Fig. iv. A diagrammatic section to show the relationships of the various components of the Nychum Volcanics north and east of "Nychum" homestead.

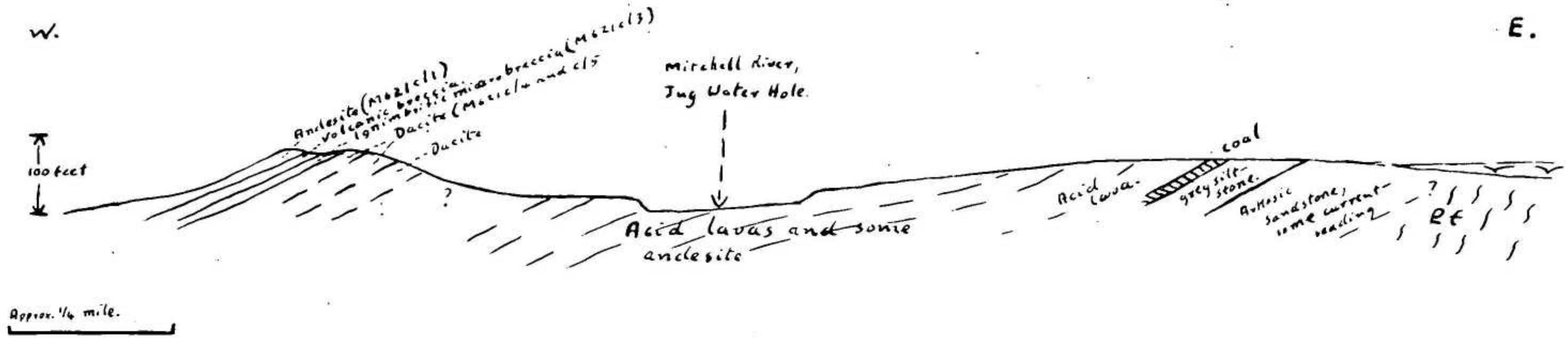


Fig. V. A diagrammatic section to show the relationship of the Permian coal-bearing sediments to the volcanics at Jug Water Hole.

PLATE I. GEOLOGICAL MAP OF THE CARBONIFEROUS AND PERMO-TRIASSIC IGNEOUS ROCKS.

PLATE 2. GEOLOGICAL SKETCH MAP OF THE S.W. AREA OF THE MOSSMAN 4-MILE SHEET.

PLATE 3.

GEOLOGICAL SKETCH MAP OF THE JUG WATER HOLE AREA.