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THE IGNEOUS GEOLOGY OF THE MOSSMAN 1:250,000 SHEET AREA, NORTH QUEENSLAND

by

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SUMMARY

The petrography of the Mareeba Granite and its associated dykes is described along with that of several specimens collected from the Nychum Volcanics, Almaden Granodiorite, Elizabeth Creek Granite, and some other minor intrusive rocks. Chemical analyses of some specimens from the intrusive and extrusive rocks are presented and discussed. Some general conclusions on the petrogenesis of the igneous rocks in the Mossman 1:250,000 Sheet area are made; these are summarized:-

1. The Mareeba Granite forms a series of epi-mesozoncal batholiths and stocks that were probably emplaced along ring fractures and by pushing aside its country rocks. The batholiths are simple intrusions, and the magma was mostly liquid at the time of intrusion.

2. Evidence is presented in an attempt to show that the Nychum Volcanics and the Almaden Granodiorite, which are closely associated in the field, are both the result of hybridization of basalt and the Herbert River Granite magmas.

3. Two xenolith-rich dykes near Mount Mulligan are probably related to the Herbert River Granite. The xenoliths enclosed in the dykes are believed to show evidence of fusion and renewed crystallization, and to have originated at depth.

GENERAL INTRODUCTION

The first report (Morgan, 1961) on the igneous rocks of the Mossman 1:250,000 Sheet area dealt with the field characteristics of the Carboniferous and Permo-Triassic igneous rocks, and included the petrography of the Nychum and Featherbed Volcanics, the Almaden Granodiorite, and the Elizabeth Creek and Cannibal Creek Granites; the petrography of some specimens of the Mareeba Granite, described by R.M. Tucker (G.S.Q.), was also included.

The present report summarizes the petrography of the Mareeba Granite and its associated dykes, and of additional specimens collected from the Nychum Volcanics, Almaden Granodiorite, the Elizabeth Creek Granite. Chemical analyses of some specimens are presented. Some general conclusions on the petrogenesis of the igneous rocks in this area are also included.

The specimens with numbers in the R. series were collected during the 1960 field season as part of the general survey of the Mossman area. Those numbered E55/1/1, etc., are specimens collected during the 1961 season as part of the age-determination programme.

The field characters of the rocks concerned were described in fair detail in the earlier report (Morgan, op.cit.), and so will be only briefly referred to here.

THE MAREEBA GRANITE, ITS ASSOCIATED INTRUSIVES AND HORNFELS

Introduction

This chapter deals with the petrography of the Mareeba granite and its marginal varieties, and of the stocks and dyke rocks associated with it. Specimens of a granite from the Thornton Peak area are also described, and, in addition, chemical analyses and norms of some of the rocks are presented. The chapter concludes with a summary of the characteristics of the intrusions, and of the problems associated with them.

The method of presenting the petrographic data is to write summary petrographic descriptions of suites of specimens; in Tables II to VII details such as grain-sizes, mineral percentages, plagioclase compositions, accessory minerals, and rock names are presented. The mineral percentages in Table III are the results of micrometric analyses of thin sections in which the potash feldspar was stained by sodium cobaltinitrite; the mineral percentages presented in Tables II and IV to VII were assessed by visual estimation only.

Table I gives the aerial photograph and geographical locations for all the specimens described in this chapter.

Summary of Field Characters

A more detailed account of the field occurrence of the Mareeba Granite and its associates can be found in the earlier report (Morgan, op.cit.). However, a very brief resume is given here.

In the eastern part of the Mossman 1:250,000 Sheet area, a number of batholiths and associated stocks and dykes extend from the southern to the northern boundary. The granite appears to be a petrographically uniform two-mica, coarse-grained, porphyritic rock; although some chilled margins and stocks consist of fine-grained porphyritic and aphyric rocks. However, chilled margins were not observed in all places visited. Acid porphyry dykes intrude the granites at Baker's Blue Mountain and Lighthouse Mountain, the stanniferous veins at Mt Holmes (Ball, 1912), and the country rock of the granite in the McLeod River - Spencer Creek area.

The batholith that crops out in the area between Bailey's Creek and China Camp appears to consist mostly of rock similar to the Mareeba Granite, although F. de Keyser noted that Thornton Peak, north-west of Bailey's Creek, is formed of a rather different type of granite: no boundaries between the two types were observed.

Petrography

1. The Granite. Here are described the coarse-grained rocks that were collected from the batholiths. The chilled marginal varieties and specimens from the stocks will be described in the following section.

The term 'granite' used in the heading and in the formational name is a loose 'rock-name'. In fact the specimens range from granite to granodiorite. Apart from the differences in ratios of potash feldspar to plagioclase in different specimens, the rocks are fairly uniform and coarse-grained. In fresh handspecimens the granites are very pale blue-grey, and are commonly speckled with biotite. They are coarse and fairly even-grained, and are commonly porphyritic, the feldspar phenocrysts ranging up to an inch in length.

TABLE 1

Localities of Specimens of the Mareeba Granite

Rock No.	Photo Location	Geographical Location	Table Reference
R.14156	Mossman, Run 3, photo 3213, point 1124	Spencer Ck - McLeod R. area	V
R.14157	Rumula " 5 " 431 " 1671	Baker's Blue Mountain	VI
R.14158	" " 4 " 405 " 1672	Lighthouse Mountain	VI
R.14159	" " 2 " 695 " 1675	1 mile N.N.E. of R.10299	VI
R.14161	Mossman " 5 " 593 " 1703	Spencer Crk - McLeod R. area	V
R.14162	" " 5 " 593 " 1718	" " " " "	V
R.14167	Ramula " 4 " 409 " 2189	North of Baker's Blue Mtn	VII
R.14168	" " 4 " 409 " 2189	" " " " "	VII
R.14169	" " 4 " 409 " 2190	" " " " "	VII
R.14170	" " 4 " 409 " 2192	" " " " "	VII
R.14171	" " 4 " 409 " 2193	" " " " "	VII
R.14172	" " 4 " 409 " 2193	" " " " "	VII
R.14173	" " 4 " 409 " 2195	" " " " "	VII
R.14174	" " 5 " 439 " 2201	" " " " "	VII
R.14175		Thornton Peak	-
R.14176		" "	-
R.14177		" "	-
R.14178	Ramula " 4 " 401 " 1673	Sweet William Mine	III
R.14179	" " 4 " 403 " 1674	Pom Pom Mine	III
R.14180	" " 2 " 695 " 1675	Wolfram battery Mt Alto	III
R.14181	" " 2 " 695 " 1676	1 mile N.N.E. of R.10299	III
R.14183	" " 3 " 713 " 1679)		III
R.14184	" " 3 " 713 " 1679)	1 mile west of 'Brooklyn" H.S.	III
R.14185	" " 3 " 713 " 1679)		III
R.14186	" " 1 " 651 " 1695	Vicinity Vera mine, Mt Carbine	III
R.14187	" " 1 " 651 " 1695	" " " " "	IV
R.14188	" " 1 " 651 " 1697	2 miles E.N.E. of Mt Carbine	III
R.14189	Mossman - Cairns " 6 " 5047 " 1700	1 mile E of Mulligan H'way/ McLeod R. Crossing	III III
R.14190	Mossman " 6 " 639 " 1701)	3 miles N.E. of Mulligan	III
R.14191	" " 6 " 639 " 1701)	H'way/McLeod River crossing	
R.14192	" " 4 " 5709 " 1725	5 miles N.N.W. of R.10309	III
R.14194	St Geo-rge R. " 7 " 101 " 2141	Dessailly Range	II
R.14200	Mossman -Cairns " 2 " 5129 " 1105	Hann Tableland	II
R14201	" " 2 " 5129 " 1107	West of 'Maitland Downs'H.S.	II
R.14202	" " 9 " 5205 " 1135	'Southedge' H.S.Hann T'land	II
R.14204	St Geor-ge R. " 5 " 33 " 1120	Vicinity of Kelly's H.S.	II
R.14212	Rumula " 3 " 713 " 1679	1 mile west of 'Brooklyn' H.S.	
R.14234	" " 2 " 697 " 202	Spencer Ck-McLeod area	V
R.10653	Hodgkin-son R. " 1 " 77 " 164	8 miles W of 'Curraghmore'H.S.	III
R.10794	Mossman " 2 " 3245 " 1127	Spencer Ck, Windsor Tableland	II
E55/1/1		George Ck-Mareeba/Dimbula road crossing, near Mareeba	-
E55/1/5	Mossman -Cairns " 7 " 5107	'Southedge' H.S. Hann T'land	II
E55/1/6	" " 5 " 5051	Mt Lewis Forestry Road	II
E55/1/7	" " 6 " 5065	Lighthouse Mountain 'Font Hills' road	II
E55/1/8	" " 5 " 5047	1 mile E of Mulligan H'way/ McLeod R. crossing	III
E55/1/9	" " 4 " 5007	Mt Spurgen track	II
E55/1/10	" " 4 " 5011	Mt Elephant	III
E55/1/11	" " 5 " 5043	8 miles W of 'Curraghmore'H.S.	III
E55/1/12	" " 3 " 5097	Vicinity of Kelly's H.S.	III
E55/1/14	" " 2 " 5129	4 miles S.E. 'Maitland Downs' H.S.	II
E55/1/15	Cooktown Coast run " 5021	Roaring Meg Falls near China Camp	II
E55/2/1	Mossman -Cairns 5 " 5055	10 miles from Mossman, on road to Cairns	II

TABLE II

Grain sizes, estimated mineral percentages and names of coarse-grained specimens of Mareeba Granite

No.	Grain Sizes Phen	g'mass	% Phen	Estimated Mineral Percentages Q3	K.feldspar	Plagioclase	Biotite	Musc.	Accessory	Accessory Minerals	Name
E55/1/5	25 mm	2.0 mm.	35	30	40 *	An20,20	5	5	Tr.	Zircon, sphene	Muscovite-biotite granite
E55/1/6	40 "	2.5 "	30	20	45 *	An25,25	10	Tr.	Tr.	Black iron ore,apatite, zircon, orthite.	Biotite adamellite
E55/1/7	8.5"	3.0 "	20	40	25 *	An30,20	2	3	Tr.	Tourmaline,zircon,garnet, Apatite.	Biotite-muscovite adamellite
E55/1/8	15 "	2.0 "	35	25	30 *	An10,40*	5	-	Tr.	Black iron ore,apatite, zircon.	Biotite adamellite
E55/1/14	8 "	1.5 "	13	30.5	25.2 *	An10,32.7	2.3	8.8	0.5	Apatite, garnet.	Biotite-muscovite adamellite
E55/1/15	20 "	4.0 "	35	30	40 *	An10,25	5	Tr.	Tr.	Tourmaline,apatite,zircon.	Biotite adamellite
E55/2/1	6 "	3.0 "	5	30	10	An10,45*	Tr.	15	Tr.	Tourmaline,apatite,sphere, leucoxene.	Biotite-muscovite adamellito
R.14194	10 "	4.0 "	Tr.	40	35	An40,20	5	Tr.	Tr.	Apatite,epidote,zircon.	Biotite adamellite
R.14201	- "	3.5 "	-	65	10	An15,25	Tr.	5	Tr.	Garnet, zircon.	Biotite granodiorite
R.14202	10 "	3.5 "	20	30	55 *	An30,10	3	2	Tr.	Apatite, zircon.	Muscovite-biotite granite
R.14204	15 "	5.0 "	25	40	5 *	An15,45	5	5	Tr.	Apatite, zircon.	Muscovite-biotite granodiorite.
R.14200	- "	3.5 "	-	40	10	An20,40	5	Tr.	Tr.	Black iron, garnet.	Biotite granodiorite
R.10794	- "	5 "	-	70	-	20	5	-	Tr.	Zircon, apatite.	Biotite granodiorite

* Present as phenocrysts as well as in the groundmass. Phen: Phenocryst; G'mass: groundmass; Qz: quartz; Musc.: muscovite; Tr.: trace.

All mineral percentages were estimated visually except in E55/1/14 for which a micrometric modal analysis was made. It was intended to make modal analyses of all specimens from stained rock slabs; this could not be done because of pressure of work in the thin section laboratory.

In thin section the texture is hypidiomorphic, and is commonly granular. Some specimens show granulation and recrystallization, especially of quartz. In E55/2/1 granulation and straining are fairly severe, the plagioclase twin lamellae showing bending and micro-gracturing. However, severe straining is not common in the other specimens examined.

The essential minerals in all the rocks are quartz, microcline, and plagioclase. Biotite and muscovite are seen together in most specimens, but, as may be seen from Table II, muscovite is absent from E55/1/9 and R.10794.

Quartz forms anhedral, commonly glomerogranular, interstitial to poikilitic grains that show some cracking and straining. In certain specimens - e.g. E55/1/5, E55/1/6, and E55/2/1 - granulation and recrystallization tend to mask its interstitial disposition.

The potash feldspar is microcline-perthite, although in some sections the multiple twinning is difficult to see. The mineral forms large phenocrysts, and is also present in the groundmass as anhedral poikilitic grains. The phenocrysts are roughly tabular, although their margins commonly merge with the poikilitic groundmass perthite; they generally enclose small euhedral crystals of biotite, slightly corroded plagioclase, and grains of quartz. Both groundmass and phenocrystic microcline contain perthitic exsolution lamellae and replacement patches. The potash feldspar is usually only slightly altered to kaolin, although in R.14201 the alteration is moderately strong.

Plagioclase occurs as roughly tabular crystals,whose composition ranges from about An_{10} to An_{40} in this group of rocks (Table II); where plagioclase occurs next to microcline-perthite, their edges are serrated as though corrosion has taken place, and a thin shell of albite has formed. Zoning is common, and is, of course, much stronger in crystals with higher percentages of anorthite. Oscillatory zoning was noted in R.14194. In all sections, slight alteration to sericite has taken place; some crystals in, for example, E55/1/5 are strongly sericitized.

Biotite forms subhedral, rather ragged flakes that are pleochroic from pale fawn to fox-brown. The flakes commonly show slight to moderate strain-effects, and, in all the slides examined, some alteration to chlorite has taken place. In two slides, E55/1/7 and E55/2/1, biotite has been partly replaced by golden-brown tourmaline (Fig. i).

Muscovite is present only in minor quantities in some specimens, and is intergrown with biotite, or forms small, ragged flakes. In specimens where it is more common, it occurs as larger subhedral and somewhat distorted flakes.

Accessory minerals observed were tourmaline, garnet, zircon, apatite, sphene, black iron ore, epidote, (?)orthite, and leucoxene. Tourmaline is usually pleochroic in pale golden brown, but in some slides it is zoned to pale blue at its margins. It quite commonly forms prismatic crystals, but in places has every appearance of being poikiloblastic, especially where it was observed to be partly replacing biotite. Garnet is colourless or very pale pink, and forms anhedral grains that appear to have been corroded. It is not certain whether or not they are xenocrysts, or early-formed crystals that have later reacted with the granitic magma. Zircon is euhedral and prismatic, and in some specimens contains numerous, minute,

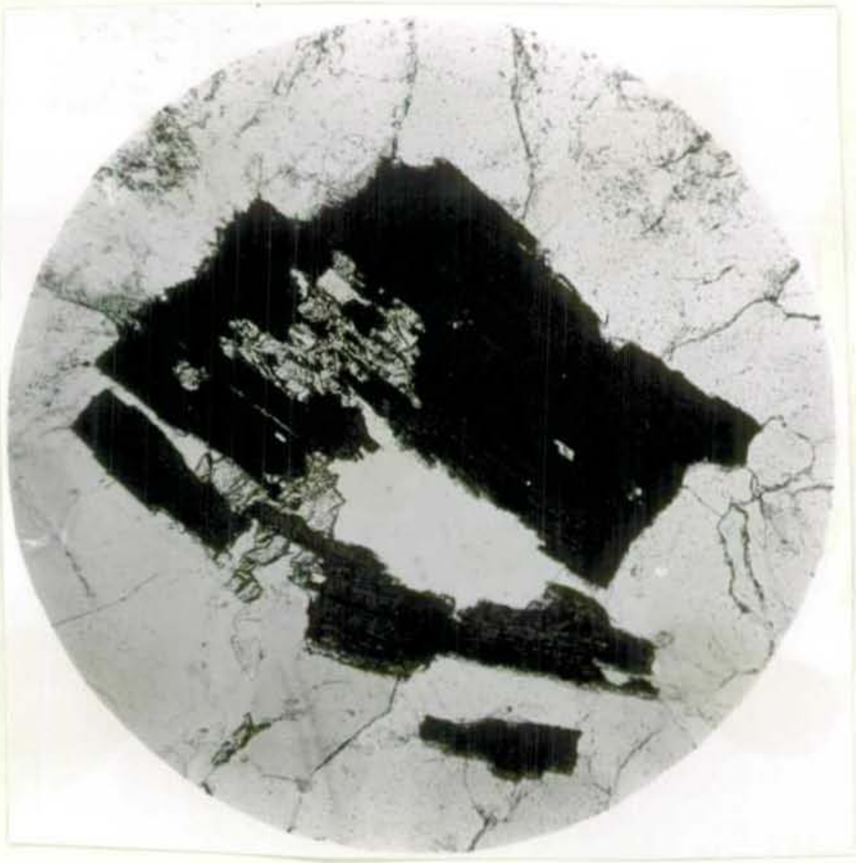


Fig. i": Specimen E55/1/7, biotite-muscovite adamellite. A flake of biotite (dark grey) partly replaced by tourmaline (the light grey mineral with high relief in the left centre of the photograph). Ordinary light. X 55. B.M.R. Negative number 64990.

opaque inclusions. Apatite is prismatic, and sphene, which occurs fairly rarely, is associated with biotite. Black iron ore and leucoxene are also associated with biotite. Epidote is uncommon, and a single grain of (?) orthite was observed in E55/1/6.

2. The Stocks and Marginal Varieties. The petrographical characteristics of the rocks described in this section are summarized in Table III. The field relationships of specimens R.14178 to R.14181, R.14183 to R.14186, and R.14188 are described in an earlier report (Morgan, op.cit.) on pp.4 and 5. The field relationships of R.14189 (E55/1/8) to R.14192 may be found on pp. 3 and 4 of the same report. Specimens E55/1/10 and E55/1/12 are from finer-grained marginal granite from the intrusion that crops out east of the Mulligan Highway between 'Maitland Downs' and Kelly's Homesteads.

The following generalized description applies to all the specimens except R.10297 (a leucocratic diorite), which will be described later. Most of the specimens are porphyritic, hypidiomorphic, and granular, and show very little evidence of strain, except for four specimens - R.14190, R.14191, E55/1/10, and E55/1/12 - which have stained quartz and plagioclase phenocrysts and distorted micas; - in these specimens the groundmass is xenomorphic - granular.

The minerals occurring as phenocrysts are indicated in Table III. Quartz phenocrysts are generally subhedral to anhedral, and commonly show evidence of resorption. Potash feldspar, plagioclase, and biotite phenocrysts are tabular; biotite tends to be strained.

In the groundmass quartz and potash feldspar are commonly interstitial to poikilitic: in the four strained specimens mentioned above they are granular, and in R.14186, there is, in places, a granophyric intergrowth between the two minerals. Plagioclase is normally tabular, and the micas form rather ragged flakes.

The potash feldspar in specimens R.14186, R.14190 to R.14192, E55/1/8, and E55/1/11, is perthite. In the others it is microcline-perthite; in R.14180 the alteration of the feldspar is strong enough to prevent observation of cross-hatch twinning, if it is present. Perthitic exsolution lamellae are common, and in some slides replacement patch perthite may be seen. In R.14186 replacement of potash feldspar by albite is particularly strong in areas where granophyric intergrowths are present. Alteration of potash feldspar to kaolin is normally slight to moderate.

Plagioclase compositions range from albite in some specimens to An_{50} in others (see Table III). The plagioclase with the higher anorthite content have the strongest zoning, and some have oscillatory zoning. Plagioclase is slightly to moderately altered to sericite; in one or two specimens, slight saussuritization has taken place.

Biotite is commonly partly altered to green chlorite; in R.14180 it has been completely chloritized, and the pseudomorphs are surrounded by a thin rim of fine muscovite flakes. In R.14186, biotite is pseudomorphed by pale brown smectite.

Muscovite is, in places, intergrown with biotite, but is most commonly found as discrete flakes. In R.14186 large, anhedral muscovite flakes are coarsely intergrown with quartz, in a manner suggesting the greisenization of a pre-existing feldspar phenocryst; however, no remnants of phenocrystic feldspar remain in the section examined. In R.14185

TABLE III. GRAIN SIZES MODAL ANALYSES, AND NAMES OF FINER GRAINED VARIETIES OF THE MAREEBA GRANITE.

No.	Grain Size Phen.	Grain Size G'mass.	% Phen.	Mineralogy Qz.	Kf.	Plagioclase		Bi	Musc.	% Accessory.	Accessory Mineral	Other.	Name
R.14179	-	0.8	-	30.5	38.7		19.5	10.5	-	0.8	Tourmaline, zircon apatite.	-	Porphyritic biotite microgranite.
R.14180	3.0	0.01	26	10.0x	0.2x	An_{0}.	13.1x	1.9	0.9	Tr	Sphene, apatite	73.9 G'mass.	Porphyritic muscovite-biotite, microgranodiorite.
R.14181	8.0	0.2	16	35.6x	11.1x	An_{10}.	40.2x	-	12.9	0.1	Tourmaline, garnet	-	Porphyritic muscovite, microgranodiorite.
R.14183. " 4/5. R.14212	0.6	0.2 to 0.6	Rare	21.8x	50.8x	An_{10}.	13.6	-	12.5	1.3	Tourmaline, apatite garnet.	-	Muscovite microgranite.
R.14186	-	1.0	-	36.4	15.1	An_{0}.	37.4	0.6	10.5	Tr.	-	-	Partly greisenized alkali microgranite.
R.14188	3.0	0.3	5	35x	19.3	An_{45}.	34.6x	10	1	0.1	Apatite, zircon, black iron ore.	-	Porphyritic partly chloritized muscovite-biotite micro adamellite.
R.14190 R.14191	5	0.5 0.15	43	37.2x	28.9x	An_{30}.	27.5x	6.3x	Tr.	Tr.	Garnet, zircon.	-	Porphyritic partly chloritized biotite micro-adamellite.
R.14192	5	0.5	52	42.0x	13.3x	An_{35}.	32.1x	11.4x	0.3	0.9	Apatite, black iron ore, zircon, zoisite.	-	Porphyritic partly chloritized biotite micro-granodiorite.
E55/1/8 R.14189	12	0.5	43	32.3x	32.2x	An_{50}.	28.0x	6.4x	0.2	0.5	Garnet, zircon, apatite.	0.4x (Hypersthene)	Porphyritic hypersthene-biotite micro-adamellite.
E55/1/10	3	0.3	25	38.2x	20.5x	An_{10}	27.3x	9.2x	4.3	0.6	Black iron ore, zircon apatite, sphene.	-	Porphyritic muscovite-biotite micro-adamellite.
E55/1/11	2.5	1.3	1	35.9	6.9	An_{50}	38.5x	18.1	0.3	0.3	Black iron ore, apatite zircon.	-	Partly chloritized muscovite-biotite microgranodiorite.
R.10653			7	31.0	1.4	"	47.4	18.1	-	0.5		1.6 (Hornblende)	Partly chloritized hornblende-biotite-trondhjemite.
E55/1/12	4	0.5	17	34.1	23.4x	An_{25}.	33.1	1.2	7.8	0.4	Garnet, apatite, zircon,	-	Porphyritic biotite-muscavite adamellite.

x Present as phenocrysts as well as in the groundmass. Phen. Phenocrysts; G'mass. Groundmass; Qz. Quartz: Musc. Muscovite.

muscovite is associated with poikiloblastic tourmaline, and is itself poikiloblastic. With tourmaline it forms replacement veins and fills cavities in the rock; the veins form a coarsely spaced meshwork of fairly straight lines cutting one another at acute angles.

Hypersthene occurs as phenocrysts in two specimens - R.14189 and E55/1/8. It forms colourless, prismatic crystals with embayed margins, and small flakes of biotite form a narrow reaction rim around the crystal boundaries.

Pale green actinolitic hornblende forms sparse clusters of small crystals in R.10653. Each cluster is partly or wholly surrounded by a rim of chlorite. This specimen comes from near the margin of the stock that crops out 8 miles west of 'Curraghmore' homestead. Another specimen, E55/1/11, collected from near the centre of the stock, contains no amphibole. It is, therefore, possible that the amphibole in R.10653 is xenolithic material.

The accessory minerals observed were apatite, zircon, tourmaline, garnet, sphene, and black iron ore. Apatite and zircon form small prismatic crystals. Tourmaline is pale golden brown but is, in some slides, zoned outwards to pale blue. Tourmaline is maybe prismatic, but commonly has a poikiloblastic habit, and in two specimens (R.14183 and R.14185) appears to be replacing potash feldspar. In R.14183 the mineral forms small vein-like segregations. Garnet forms anhedral, embayed grains, and is colourless to very pale pink. Black iron ore is anhedral to octahedral, and is commonly associated with biotite. Sphene and epidote are granular.

The leucocratic diorite, R.14178, is a marginal variation of the granite, and was collected from the Sweet William copper mine, 5 miles west of Mt Molloy. The rock is hypidiomorphic granular, with an average grain-size of 1 mm., and contains rare phenocrysts of feldspar measuring up to 5 mm. The rock consists mostly of tabular crystals of plagioclase (An_{30}), some of which have strained and bent twin lamellae. The crystals are marginally recrystallized, and are moderately to strongly kaolinized. The plagioclase phenocrysts have a chequered twinning similar to that of chess-board albite. Chlorite forms masses of fine interstitial flakes and has small amounts of smectite associated with it. Opaque dusty material is intergranular. Accessory apatite and sphene were noted.

3. Thornton Peak Area. In a traverse to Thornton Peak, 22 miles north of Mossman, F. de Keyser collected three samples of granite that are rather different from the usual Mareeba Granite types. R.14175 is a pale, pinkish-cream, aphyric, coarse - to medium-grained granite; R.14176 and R.14177 are pale cream, fine to medium-grained, and sparsely porphyritic microgranitic rocks.

In the thin section, R.14175 is hypidiomorphic and very inequigranular, the grain-sizes ranging from 1.5 mm. to 6 mm. Quartz (30%) is interstitial to poikilitic and is moderately to strongly strained. Microcline-perthite (55%) is tabular, but poikilitically encloses plagioclase. It has perthitic exsolution lamellae and replacement patches of plagioclase. Microcline is slightly to moderately altered to kaolin. Plagioclase (10%) crystals are tabular and very lightly sericitized, and their composition falls within the oligoclase range. The ferromagnesian minerals (5%) have been pseudomorphed by smectite, chlorite, quartz, epidote, and black iron ore. From crystal shapes the pseudomorphed minerals appear to have been biotite and amphibole. Accessory minerals are zircon, epidote, orthite, and sphene.

Fig. ii: Specimen R.14176 from the Thornton Peak area. The two adjacent crystals of potash feldspar (medium-grey, centre and right-centre of the photograph) are partly surrounded by a very thin and discontinuous zone of quartz (white). Each of the crystals is entirely enclosed by thick zones of potash feldspar that are not in optical continuity with each other, or with the enclosed potash feldspar crystals. Crossed nicols. X 25. B.M.R. Negative No.4994.

Specimens R.14176 and R.14177 are rather finer grained than R.14175, R.14176 is inequigranular, the grain-sizes ranging from 1 mm. to 4 mm.; R.14177 is more even-grained, and has an average grain-size of 1 mm. In both rocks the texture is mostly granophyric. In R.14177 some shearing has taken place in thin, linear zones; here quartz shows strong to moderate straining, and plagioclase is micro-fractured. The micro-fractures in the plagioclase show some evidence of having been partly healed by subsequent heating.

Quartz (45%) occurs both as granophyric intergrowths and as separate grains, and forms rare phenocrysts only slightly larger than the groundmass in R.14176. Microcline-perthite (30%) is partly tabular and partly in granophyric intergrowth with quartz - in some places, tabular areas consist of granophyrically intergrown potash feldspar and quartz. Some of the microcline is replaced by albite. Figure ii shows part of R.14176 in which two adjacent potash feldspar grains are surrounded by an inner thin discontinuous zone of quartz, and an outer, thicker zone of potash feldspar. Plagioclase (20%) has a composition of about An_{10}, and forms sub-tabular crystals, some of which contain intergrown quartz. The ferro-magnesian mineral (?biotite) forms about 5% of the rock, and has been mostly replaced by smectite, chlorite, and epidote. These minerals form tenuous, intergranular clusters of flakes and grains. Accessory minerals noted are apatite, zircon, sphene, and orthite.

4. Dykes Associated with the Mareeba Granite. The dykes will be dealt with as four groups. Their mineralogy and rock names are summarized in Tables IV to VII.

(a) Aplite. The specimen, a granite aplite, was taken from a 2-foot vertical dyke in a creek bed about half a mile west of the Vera mine. The dyke has a northerly strike, and intrudes the Mareeba Granite.

In thin section the rock is sparsely porphyritic, and has a fine-grained, xenomorphic-granular groundmass. There is a fine intergrowth of the constituent minerals on the grain boundaries. The rock (R.14187, Table IV) consists of interstitial to poikilitic, slightly strained quartz, sub-tabular microcline, and tabular to anhedral plagioclase. The rare phenocrysts are of microcline. Microcline is slightly kaolinized and plagioclase shows slight sericitization and kaolinization. Rare flakes of biotite and muscovite were noted, and the accessory minerals are apatite, black iron ore, epidote and sphene.

(b) Dykes from the Spencer Creek-McLeod River Area. These consist of micro-granite, micro-adamellite and micro-granodiorite, and information relevant to them can be found in Table V. R.14155 was collected from Spencer Creek, close to the batholith forming the Windsor Tableland; R.14161 and R.14162 were collected from close to the margin of the batholith forming Mt Spurgeon - the first specimen from Mt Spurgeon track, and the second from the McLeod River. All the dykes are intruded into sediments of the Hodgkinson Formation, and their trend is north to north-north-westerly, parallel to the strike of the sediments.

All the specimens are porphyritic, and the phenocrysts tend to be clustered. In each specimen the phenocrysts are enclosed in a fine-grained, xenomorphic-granular groundmass that is, in places, finely granophyric.

Quartz phenocrysts are rounded and embayed, and show slight to moderate zoning and some cracking. In the groundmass quartz is granular in R.14155, and in the other specimens it is

TABLE IV: ESTIMATED MINERAL PERCENTAGES ETC., OF APLITE FROM THE MAREEBA GRANITE, NEAR THE VERA MINE, MOUNT CARBINE.

No,	Grain sizes. Phen.	G'mass.	% Phen.	Qz.	Kf.	Plag.	Bi.	Musc.	Amph.	Accessory.	Name
R.14187	6	0.5	Rare	40	45*	An_{0-10}.15	Tr.	Tr.	-	Black rion ore, apatite, epidote, sphene.	Granite aplite.

TABLE V: ESTIMATED MINERAL PERCENTAGES ETC., OF DYKE ROCKS FROM THE SPENCER CREEK - McLEOD RIVER AREA.

No,	Grain sizes. Phen.	G'mass.	% Phen.	Qz.	Kf.	Plag.	Bi.	Musc.	Amph.	Accessory.	Name
R.14155	4	0.3	35	35*	15	An_{10-20}.40.	10	Tr	-	Apatite, zircon, black iron ore.	Chloritized porphyritic biotite granodiorite.
R.14161	2	0.2	30	30*	40*	An_{0-10}. 25*	-	5	-	Apatite, epidote, leucoxene.	Porphyritic muscovite alkali micro-granite.
R.14162	2.7	0.02	25	30*	35*	An_{25}. 25	Tr.	10*	-	Garnet, zircon, black iron ore.	Porphyritic muscovite micro-adamellite.
R.14134	0.4	0.15	Rare	10	40	An_{0-10}. 35	-	-	5	Zircon, apatite, black iron ore.	Chloritized and sausseritized porphyritic hornblende alkali micro-granite.

Abbreviations for Tables IV and V: No. Number; Phen. Phenocryst; G'mass. Groundmass; Qz. Quartz: Kf. potash feldspar; Plag. Plagioclase; Tr. Trace; * Present as phenocrysts.

poikilitic to granophyric. Potash feldspar phenocrysts are tabular, and show some alteration to kaolin. In R.14161, most of the potash feldspar is perthitic, but some has a fine cross-hatch twinning suggesting anorthoclase. In R.14162, the potash feldspar phenocrysts have a small 2Vx, suggesting that they are sanidine. Groundmass potash feldspar is interstitial to poikilitic, and forms granophyric intergrowths with quartz. Plagioclase forms tabular phenocrysts that are somewhat sericitized and, in R.14162, kaolinized. In R.14161 and R.14162, the multiple twinning is strained and micro-fractured. In the groundmass plagioclase is granular to tabular. In R.14156, biotite occurs as somewhat distorted and moderately chloritised phenocrysts that are pleochroic from pale to dark brown; it forms subhedral to interstitial flakes in the groundmass of this specimen and that of R.14162. Muscovite forms moderately distorted phenocrysts in R.14162, and occurs in the groundmass of this specimen and that of R.14161. Accessory minerals are zircon, apatite, black iron ore, leucoxene, and garnet. The garnet gives the appearance of being corroded.

(c) Dykes Intruded into Granite (Table VI). R.14157 (micro-adamellite) occurs at Baker's Blue Mountain, R.14158 (micro-tonalite) at Lighthouse Mountain, and R.14159 (micro-granodiorite) at Mt Alto.

All three specimens are porphyritic, their phenocrysts being enclosed in a fine-grained xenomorphic to hypidiomorphic granular groundmass. In R.14157 the groundmass is granophyric in places.

Quartz phenocrysts are rounded and somewhat embayed, and in the groundmass the mineral is interstitial to poikilitic in R.14158, and granular in the others. Potash feldspar forms tabular phenocrysts, is sub-poikilitic in the groundmass of R.14157 and R.14159, and granular in R.14158. In R.14158, potash feldspar forms antiperthitic structures in plagioclase phenocrysts: the antiperthite veins continue across adjacent plagioclase phenocrysts in one place. Phenocrystic and groundmass plagioclase in all three specimens is tabular, and is strongly sericitized in R.14158, but only slightly so in the other two specimens. Biotite formed phenocrysts and was present in the groundmass in R.14157 and R.14159; it has now been replaced by pale green chlorite intergrown with small amounts of leucoxene and sericite. The phenocrystic and groundmass ferromagnesian minerals in R.14158 are hornblende and augite. The hornblende occurs as subhedral to anhedral corroded grains, both as phenocrysts and in the groundmass. Hornblende phenocrysts are pleochroic with X= colourless, or pale pink, and Y= Z= pinkish brown, but the crystals are zoned to green on their margins; groundmass hornblende is also green. Hornblende is partly altered to chlorite, especially in the groundmass. Augite, as phenocrysts and in the groundmass, is colourless; some crystals have terminations of green hornblende. Muscovite forms small flakes in the groundmasses of R.14157 and R.14159. Accessory minerals noted were apatite, zircon, black iron ore, carbonate, and orthite. Small amounts of smectite were noted in the groundmass of R.14159.

(d) Dykes in the Area Between Baker's Blue Mountain and Mount Alto. The dykes in this area were observed by B.J. Amos to be intruded into the Hodgkinson Formation sediments, parallel to the cleavage. Ball (1912) noticed that similarly-trending dykes intrude granite and ore veins at Mt Holmes, about four miles south-south-east of Mt Alto. The dykes are referred to in Table VII; they consist of micro-granodiorite, micro-granite, micro-tonalite, and micro-adamellite.

TABLE VI: MODAL ANALYSES ETC., OF DYKES INTRUDED INTO MAREEBA GRANITE AT LIGHTHOUSE MOUNTAIN AND BAKER'S BLUE MOUNTAIN.

No.	Grain sizes in mm. Phen.	G'mass.	% Phen.	Qz	Kf	Plagioclase		Bi	Musc.	Amph.	Px	Accessory Mineral	Name
				Estimated Mineral Percentages									
R.14157	3.5	0.03	25	35ẋ	20ẋ	An0,	35ẋ	10	Tr	-	-	Apatite, zircon, orthite	Chloritized porphyritic biotite alkali micro-granite.
R.14158	2	0.15	5	25	Tr	An_{70}.	55	-	-	10ẋ	5ẋ	Black iron ore carbonate	Porphyritic augite-hornblende micro-tonalite
R.14159	2	0.2	15	30ẋ	20ẋ	An35,	45	5ẋ	5	-	-	Zircon, apatite.	Chloritized and carbonated porphyritic muscovite-biotite micro-granodiorite.

TABLE VII: MODAL ANALYSES ETC., OF DYKES FROM THE AREA NORTH OF BAKER'S BLUE MOUNTAIN.

No.	Phen.	G'mass.	Phen.	Qz	Kf	Plagioclase		Bi	Musc.	Amph.	Px	Accessory Mineral	Name
R.14167	2	0.2	10	30ẋ	40ẋ	An0-10,	20ẋ	10ẋ	Tr	-	-	Apatite	Chloritized porphyritic biotite microgranite.
R.14168	-	0.6	-	45	10	An_{80}	40	Tr.	-	5	-	Carbonate, black iron ore, epidote, apatite sphene.	Chloritized hornblende micro-granodiorite.
R.14169	3	0.2	20	15	Tr	An_{55}	75ẋ	5	-	5ẋ	-	Apatite, sphene.	Partly chloritized porphyritic biotite-hornblende micro-tonalite.
R,14170	3	0.1	15	35ẋ	15	An_{55}	45ẋ	3	-	2ẋ	-	Apatite, zircon, tour-maline, black iron ore.	Chloritized porphyritic hornblende -biotite microgranodiorite.
R.14171	1.5	0.02	35	20	Tr	An_{70}.	70ẋ	3	-	7ẋ	Trẋ	Apatite, black iron ore, sphene.	Porphyritic biotite-hornblende micro-tonalite.
R.14172	3	0.05	25	30ẋ	30ẋ	An_{40}	35ẋ	5ẋ	Tr.	-	-	Apatite, zircon, black ore, epidote.	Partly chloritized porphyritic biotite micro-adamellite.
R.14173	10	0.02	20	20ẋ	40ẋ	An_{5}	35ẋ	Trẋ	-	5ẋ	Trẋ	Zircon, apatite, tour-maline, black iron ore sphene	Chloritized porphyritic hornblende alkali micro-granite.
R.14174	2.	0.1	20	30ẋ	15ẋ	An_{75}	50	-	-	[illegible]	Tr.	Apatite, sphene, black iron ore.	Chloritized and carbonated porphyritic hornblende micro-granodiorite.

Abbreviations for Tables: No. Number; Phen. Phenocrysts; G'mass. Groundmass; Qz. Quartz; Kf. potash-feldspar; Bi. Biotite; Musc. muscovite; Amph. Amphibole ; Px. Pyroxene; Tr. Trace; ẋ Present as phenocrysts.

All the dykes except one (R.14168) are porphyritic. The aphyric specimen is hypidiomorphic and fairly equigranular. The groundmass of R.14167 is granophyric, and the plagioclase gives the impression of having been partly replaced by the granophyre. The groundmass of R.14173 is felsitic. In R.14171 the groundmass is mostly silicified: the few unsilicified parts of the specimen are hyidiomorphic-granular; in the silicified areas, equidimensional grains of quartz about 0.2 mm. across enclose small crystals of plagioclase, biotite, chlorite, and apatite. The groundmass in the other four specimens is hypidiomorphic-granular.

Quartz, plagioclase, and potash feldspar have similar textural habits and crystal shapes to those in the specimens described in (b) and (c) above. In R.14167 the minerals in granophyric intergrowth are quartz and potash feldspar, and some sodic plagioclase which probably replaces potash feldspar.

The potash feldspars are all more or less kaolinized. Most crystals examined show perthitic exsolution structures; no microcline twinning was noticed. When satisfactory interference figures were obtained, large to moderate negative optic axial angles were observed, indicating probable orthoclase. In R.14173, one potash feldspar pheenocryst showed a small 2Vx, and another crystal in the same specimen has a large 2Vx. Again, in the same specimen interstitial potash feldspar has a small negative optic axial angle. These observations indicate that a variety of types of potash feldspar are present in these rocks, and probably within one specimen. Detailed observations of such features have been made by Emeleus and Smith (1960).

Biotite is partly or wholly replaced by chlorite in R.14168, R.14170, R.14171, R.14172, and R.14173; in R.14167, biotite is replaced by smectite and clinozoisite in addition to chlorite.

Amphibole, in most specimens, is partly or wholly replaced by chlorite, epidote, carbonate, and sericite. In R.14171, it is partly replaced by biotite. Where it is unaltered, the amphibole is pale green actinolite or actinolitic hornblende, and forms fibro-prismatic crystals.

Evidence for the presence of pyroxene was noticed in three specimens. In R.14171, one partly uralitized, colourless crystal of clinopyroxene is present, but other crystals in the slide that are shaped like basal sections of pyroxene are now composed of biotite. In specimens R.14173, and R.14174 pyroxene is entirely pseudomorphed by chlorite.

5. Hornfels. The localities and rock names of the specimens described here are referred to in Table VIII. The specimens of hornfels collected from aureoles around the Mareeba Granite batholiths consist of recrystallized siltstone and slate, and partly recrystallized sandstone. In two specimens (R.14203 and R.14209) porphyroblasts of feldspar are present.

The siltstones and slates have hornfelsic textures superimposed on bedding and cleavage structures. In the slates, recrystallized micas tend to emphasize the cleavage and give the rocks a micro-schistocity. Quartz in most specimens forms mosaics of grains whose size ranges from 0.05 to 0.1 mm.; the original sedimentary banding in the quartz-rich areas in these slides is shown by differences in grain-sizes in different bands. Muscovite occurs as small flakes commonly oriented parallel to the cleavage in R.14202 and R.14206; small porphyroblasts of muscovite with random orientation can be seen in R.14211 and R.14214. Biotite porphyroblasts occur in R.14199, R.14206, and

TABLE VIII

Localities and names of specimens from the contact aureole of the Mareeba Granite

Rock No.	Photo locality	Geographical locality	Rock Name
R.14182	Rumula, run 3, photo 713, pt.1679	1 mile W. of 'Brooklyn' homestead	Tourmaline-muscovite-quartz hornfels.
R.14199	-	Queen Constance Mine	Muscovite-biotite-quartz hornfels
R.14202	Mossman-Cairns " 2, " 5129, " 1112	6 miles west of 'Maitland Downs' homestead.	Andalusite-muscovite-quartz hornfels.
R.14203	" " " 2, " 5129, " 1113	" " "	Recrystallized sandstone.
R.14206	Mossman " 3, " 3213, " 1125	Spencer Creek.	Biotite-muscovite-quartz hornfels.
R.14207	" " 2, " 3245, " 1126	" "	Recrystallized sandstone.
R.14209		Mossman River	Porphyroblastic sandstone.
R.14211	Rumula, " 4, " 403, " 1674	Pom Pom Mine	Quartz-biotite-muscovite hornfels.
R.14214	Mossman, " 5, " 593 " 1702	Mt Spurgeon track.	Cordierite-muscovite-biotite hornfels.

R.14214. The porphyroblasts of muscovite and biotite are anhedral, and both minerals have small inclusions of quartz. Biotite in R.14182 and R.14211 forms small tabular flakes. Andalusite, now mostly altered to fine sericite, forms tabular porphyroblasts in R.14202; the mineral is pleochroic from colourless to pale pink. Specimen R.14214 contains porphyroblasts of cordierite measuring up to 8 mm.; the cordierite poikiloblastically encloses numerous small inclusions of quartz, and porphyroblastic biotite and muscovite are associated with it. Some of the cordierite is pinitized. The distribution of the cordierite porphyroblasts suggests that they represent original shaly bands and lenticules in the rock. Colourless to olive-brown tourmaline is a common accessory in these specimens, and in R.14182 it is present in essential quantities. The mineral is commonly prismatic: in R.14199 small tourmaline porphyroblasts cut across the micro-folded slaty cleavage. Some prismatic zircon was noted in R.14182; in R.14199 tabular black iron ore is partly replaced by leucoxene, and in R.14211 irregular to octahedral grains of black iron ore are partly replaced by haematite.

Three specimens of metamorphosed sandstone were collected (R.14203, R.14207, and R.14209). Each of them is inequigranular, and contains angular and sub-angular grains. The sandstones are composed of quartz and smaller amounts of feldspar and mica. Sodic plagioclase occurs as originally clastic grains in R.14207. In the other two specimens it appears to have resulted from porphyroblastic growth. In R.14203 these crystals are no bigger than the usual grain-size in this specimen (i.e., 0.3 mm.), but are anhedral and poikiloblastic, and consist of untwinned oligoclase. In R.14209, the feldspar porphyroblasts consist of microcline-perthite and twinned and zoned sodic plagioclase; they range up to 25 mm. long. The micas in all three specimens are biotite and muscovite; the minerals are interstitial and poikiloblastic, and represent recrystallized, shaly, groundmass material.

Chemistry.

Chemical analyses and C.I.P.W. norms of specimens of the Mareeba Granite collected for age-determination are shown in Table IX. Figure iii shows the analyses plotted on a FeO+MgO - CaO - Na_2O+K_2O diagram. The five specimens scattered in the Na_2O+K_2O corner of the diagram probably represent the parent granite magma; an average of these is also plotted. The other four analyses plot in a curvilinear line away from the Na_2O+K_2O corner, showing them to be richer in CaO and MgO+FeO, i.e., basification. The most basic specimen, E55/1/11, was collected from the small intrusion 8 miles west of 'Curraghmore' homestead; another specimen collected from this intrusion shows, under the microscope, small hornblendic inclusions that probably represent xenolithic material. This suggests that contamination is responsible for the basification in the granites.

Normative albite, orthoclase, and anorthite are plotted in figure iv. These show a trend towards the alkali feldspars, mainly towards albite. One specimen (E55/1/15) is richer in potash feldspar than the others. It will be noted that in the trends shown in figures vi and vii, the specimens are arranged in the same order of increasing alkilinity. Included in Fig. iv is part of a projection of the liquidus surface and boundary curve in the system Ab-Or-An-H_2O at 5,000 bars water pressure (Yoder, Stewart, and Smith - 1957). It

TABLE IX

Chemical Analyses and Norms of age-determination specimens from the Mareeba Granite

A - Analyses

	E55/1/1	E55/1/5	E55/1/6	E55/1/7	E55/1/9	E55/1/11	E55/1/12	E55/1/15	E55/5/2
SiO_2	73.64	75.4	72.7	74.8	71.4	69.2	73.9	77.0	73.02
TiO_2	0.03	0.10	0.25	0.12	0.37	0.46	0.03	0.20	0.11
Al_2O_3	14.40	13.5	14.0	13.8	13.9	14.8	15.1	11.8	14.32
Fe_2O_3	0.48	0.23	0.21	0.34	0.32	0.44	0.19	0.30	0.41
FeO	0.40	1.01	1.81	0.97	2.70	2.85	0.82	1.41	1.81
MnO	0.10	0.05	0.05	0.03	0.05	0.06	0.04	0.02	0.08
MgO	0.90	0.12	0.57	0.33	0.65	1.69	0.08	0.30	0.80
CaO	0.45	1.09	1.74	1.05	2.50	2.95	0.65	0.73	2.02
Na_2O	4.56	3.35	3.35	3.50	3.00	2.90	4.15	2.90	2.76
K_2O	3.79	4.20	4.30	4.55	3.85	3.40	4.25	4.55	3.92
P_2O_5	0.07	0.20	0.13	0.11	0.12	0.17	0.13	0.15	0.07
H_2O-	-	0.16	0.16	0.08	0.17	0.19	0.05	0.07	-
H_2O+	0.84	0.60	0.68	0.35	0.85	0.87	0.55	0.34	0.67
CO_2	N.D.	0.03	0.05	0.03	0.08	& 0.08	0.04	0.07	N.D.
	99.66	100.04	100.00	100.06	99.96	100.06	99.98	99.84	99.99

B - Norms

	E55/1/1	E55/1/5	E55/1/6	E55/1/7	E55/1/9	E55/1/11	E55/1/12	E55/1/15	E55/5/2
Q_3	30.30	32.24	31.39	33.67	31.54	29.25	31.83	40.61	35.33
C	2.16	2.01	1.10	1.21	0.73	1.58	2.90	1.48	2.05
Or	22.38	24.82	25.41	26.89	22.75	20.09	25.12	26.89	23.16
Ab	38.60	28.35	28.35	29.62	25.39	24.54	35.12	24.54	23.34
An	1.75	3.91	7.47	5.21	11.11	13.02	2.12	1.69	9.54
Fs	0.48	1.59	2.83	1.36	4.18	4.22	1.37	2.05	2.94
En	2.24	0.30	1.42	0.82	1.62	4.21	0.20	0.75	2.00
Ap	0.17	0.47	0.31	0.25	0.28	0.40	0.31	0.36	0.17
Mt	0.70	0.33	0.30	0.49	0.46	0.64	0.28	0.43	0.60
Il	0.06	0.19	0.47	0.23	0.70	0.87	0.06	0.38	0.21

Analysts: E55/1/1 and E55/5/2 by S. Baker and A. McLure, B.M.R. E55/1/5, 6, 9 and 11 by H.W. Sears, A.M.D.L. The remainder by C.R. Edmunds and H.W. Sears, A.M.D.L.
E55/1/1 - Muscovite adamellite, four miles south of Mt Carbine. E55/1/5 - Muscovite-biotite granite, 'Southedge' Homestead. E55/1/6 - Muscovite adamellite, Mt Lewis forestry road.
E55/1/7 - Biotite-muscovite adamellite, Lighthouse Mountain. E55/1/9 - Biotite adamellite, Mt Spurgeon track. E55/1/11 - Muscovite-biotite microgranodiorite, 8 miles west of 'Curraghmore' Homestead. E55/1/12 - Biotite-muscovite micro adamellite, Kelly's Homestead.
E55/1/15 - Biotite adamellite, Roaring Meg falls, one mile west of China Camp.
E55/5/2 - muscovite-biotite granite, Mareeba/Dimbula road-Gorge Creek crossing.

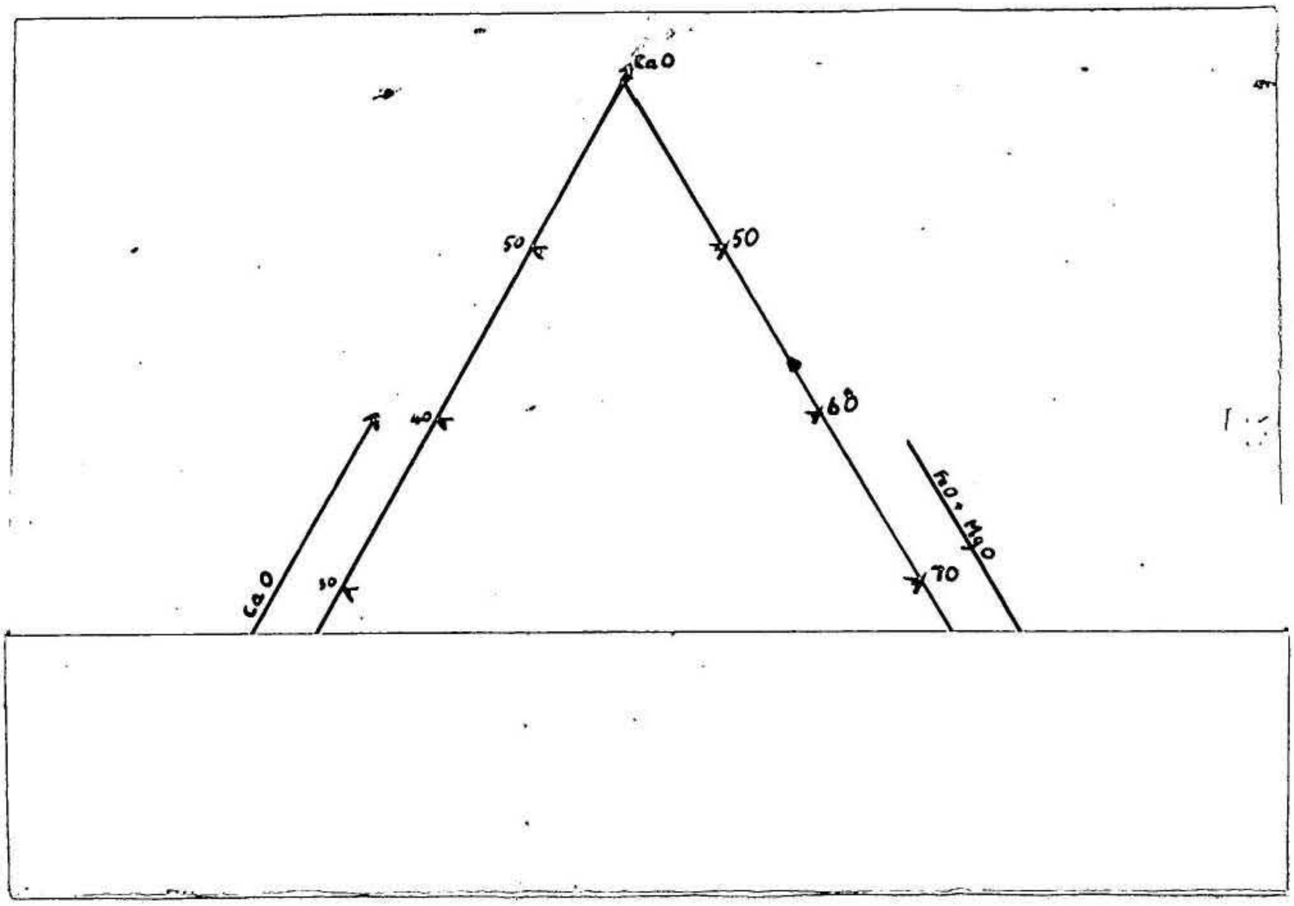


Fig. iii. MgO+FeO - CaO - K_2O+Na_2O Variation diagram for specimens of Mareeba Granite. The ringed cross represents an average for the five specimens around it.

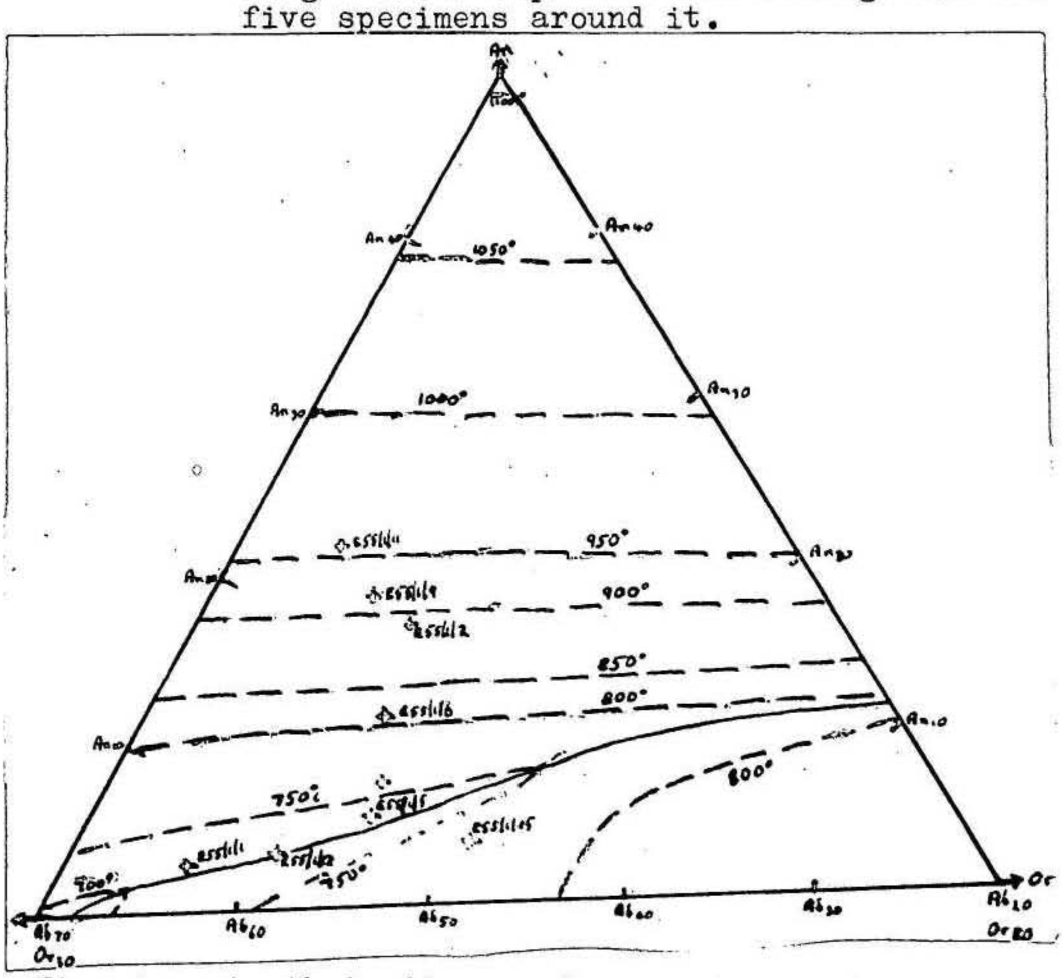
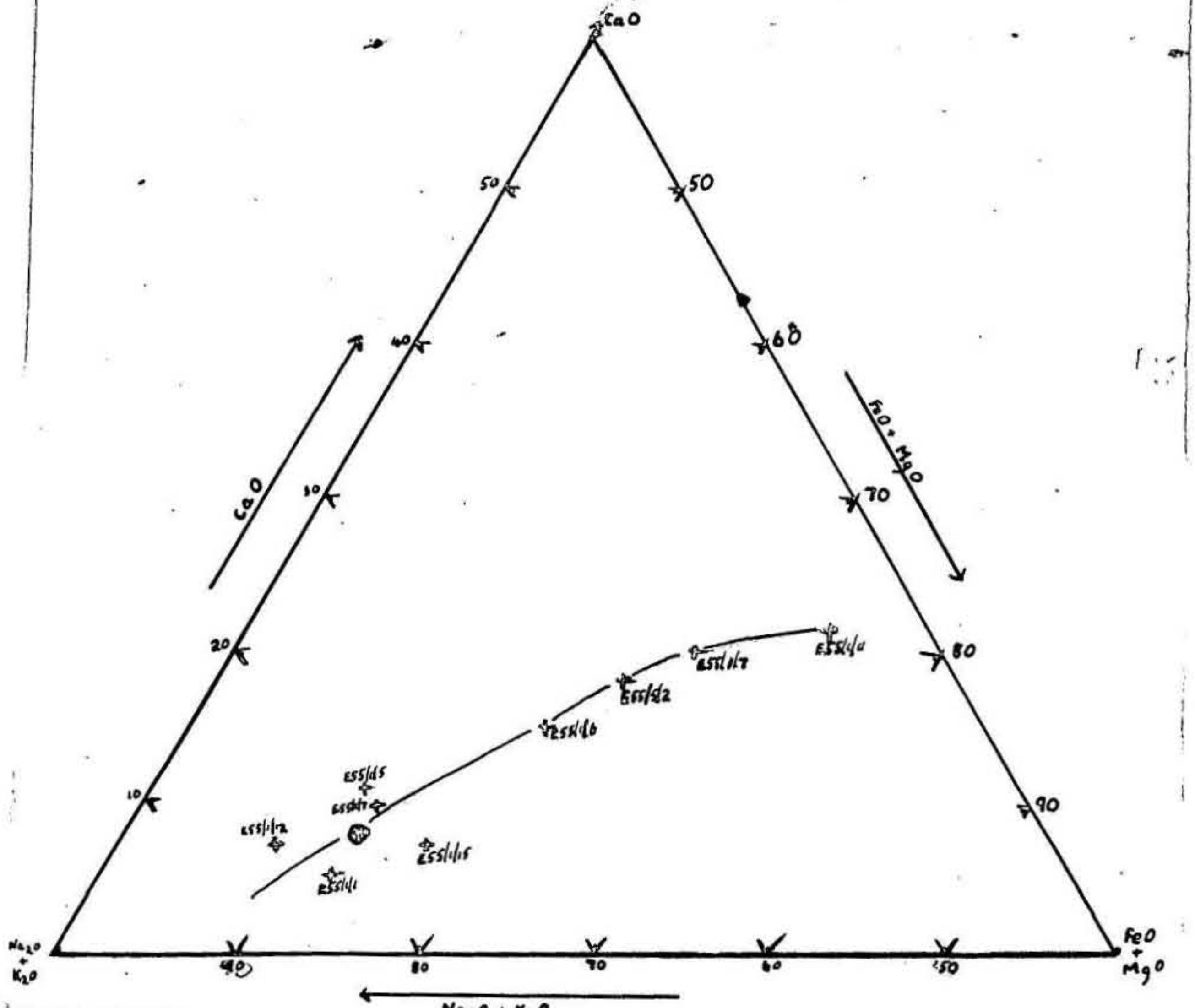


Fig. iv. An-Ab-Or diagram for specimens of Mareeba Granite, together with a part of the projection of the quaternary system Ab-Or-An-H_2O at 5,000 bars H_2O pressure. The dashed lines represent isotherms on the liquidus of the system. The boundary curve is represented by the continuous line. (After Yoder, Stewart and Smith, 1957.)



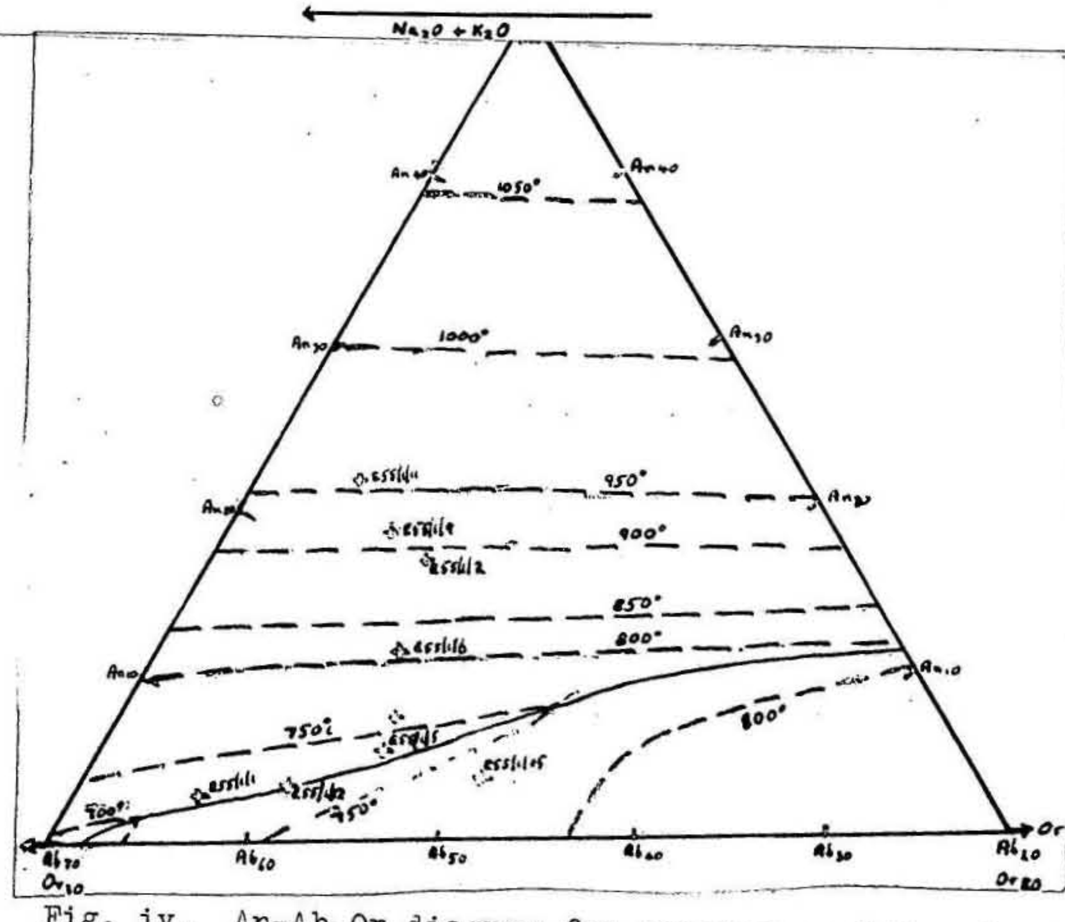


Fig. iv. An-Ab-Or diagram for specimens of Mareeba Granite, together with a part of the projection of the quaternary system Ab-Or-An-H_2O at 5,000 bars H_2O pressure. The dashed lines represent isotherms on the liquidus of the system. The boundary curve is represented by the continuous line. (After Yoder, Stewart and Smith, 1957.)

will be noted that five of the specimens are arranged roughly along the temperature valley in which the feldspar boundary curve occurs. This diagram does not necessarily indicate that these rocks crystallized exactly at the temperatures and pressure shown, but it does suggest that they are the result of the crystallization of uncontaminated material.

Conclusions and Comments:

My remarks here are more in the nature of a statement of the problems uncovered during the reconnaissance mapping of the Mareeba Granite than definite conclusions. However, I believe they are of some value because they at least provide a starting point for any future detailed work.

The intrusions are epi-mesozonal in the classification of Buddington (1959). The roughly elliptical outlines of the granite bodies is elongated parallel to the regional strike of the sediments, although in detail the contacts cut across the structures and strike of the sediments. The country rocks consist of strongly folded sediments that are only very slightly regionally metamorphosed, if at all. A narrow thermal metamorphic aureole is found adjacent to the granite contacts; the granites are thus disharmonious in the sense of Walton (1955).

The process of intrusion of the granites is another problem. The granite/country rock contacts are sharp and clean; there are no intrusion breccias, and xenoliths are almost entirely absent. All this suggests that the granites were not emplaced by piecemeal stoping. There is probably some significance in the fact that the batholiths showed preference for emplacement along a belt of slates rather than in the dominantly arenaceous sequences of the Hodgkinson Formation. The slates would be less competent than the sandstones, and it would be easier for the granite to push them aside during intrusion. In fact, there is some evidence for this on the map (Plate I); tectonic trend lines tend to be diverted close to the granite contacts, and strong mesoscopic folds have formed in some places near the contacts. However, if the granite is indeed 'high level', i.e., was emplaced within 5 or 6 miles of the earth's surface, it surely would have been easier for the magma to push its way to the surface, rather than push aside some 12 or 16 miles of country rock to form, for example, the granite massif of the Mt Windsor Tableland. Inspection of Plate I shows two other features worth noting. First, some of the tectonic trend lines are cut off by the granite, suggesting that some of the country rock was removed during emplacement. Secondly, the batholiths have elliptical or elongated elliptical outlines that give the impression that ring fracturing had taken place, and that large blocks of country rock had foundered, or had been pushed upwards. Thus, from the reconnaissance mapping it seems possible that the batholiths were emplaced by a combination of intrusion along ring fractures, and pushing aside of the country rocks.

The physical state of the magma at the time of emplacement differed from place to place. At many localities in the batholiths and in most of the stocks, the fine-to medium-grained chilled margins show that the magma was mostly liquid at the time of intrusion. Most of the chilled rocks contain up to 25 percent phenocrysts, suggesting that a quarter, or less, of the magma was composed of crystalline material. There are some exceptions, notably at the three small intrusions grouped around the McLeod River; here the rocks contain as much as 50 percent phenocrysts, and, judging by the somewhat strained appearance of the phenocrysts, were intruded as a crystal mush lubricated by interstitial liquids. In other places, the granites are coarse-grained right to their margins, and, in places, a marked foliation parallel to the contacts. It is probable that in these cases, the country rocks were heated by the continuous passage of magma past them, so that the magma cooled slowly against them; the foliation in such places probably results from flowage carrying on until the granite was solid.

An unusual feature noted at the flat-roofed stock a mile west of 'Brooklyn' homestead is the development of large crystals of potash feldspar just on and perpendicular to the roof contact (Morgan, 1961, p.5). The feldspar crystals are enclosed in a medium-grained tourmaline-bearing microgranite, and are probably pegmatitic. To explain their development it seems likely that, first, the magma was still, and secondly, that volatiles were able to accumulate at this contact, stimulating the growth of the pegmatitic feldspar crystals. The presence of volatiles during solidification is suggested by the thin replacement veins containing tourmaline and muscovite.

Many of the large batholiths described from various parts of the world are complex multiple intrusions containing rocks ranging from basic to acid. The Mareeba Granite batholiths, however, appear to be simple intrusions composed mostly of adamellitic rocks. Slight chemical and petrographical differences can, at present, be accounted for by contamination of the granites by their country rocks, rather than by magmatic differentiation or hybridization of magmas.

Considering the bulk of the granites, minor features such as aplites, pegmatites, and mineralized veins are rare. Only at Mt Carbine, in fact, is there any great development of these late-stage features.

The dyke rocks that I have, in this report, associated with the Mareeba Granite pose another problem. The fact that they tend to be concentrated close to the granite leads one to suspect that they are genetically related to the batholithic intrusions. Some of them cut the granite, showing that these, at least, were emplaced after the granite. However, the petrogenetic relationship between the dykes and the granite is not clear, as many of them are rather more basic and contain amphibole.

The conclusions made in this section are summarized:-

1. The granites are epi-mesozonal.
2. The process of intrusion is not properly known, but evidence suggests that emplacement took place partly by filling ring fractures, and partly by pushing aside the enclosing sediments.
3. The magma was mostly liquid at the time of emplacement.
4. The batholiths are simple intrusions.
5. Late-stage features such as aplites and pegmatites are not common.
6. The precise relationship of the dyke rocks to the granites is not known.

MINERALIZATION

The Mareeba Granite is responsible for wolfram, tin, and copper mineralization. Little zonation of these metaliferous deposits has been observed at any of the mines - e.g., at Mt Carbine, only wolfram has been obtained from the lodes; the Sweet William was worked for copper. In Cornwall, tin, wolfram, and copper minerals are associated in mineral zones (Dewey - 1925,

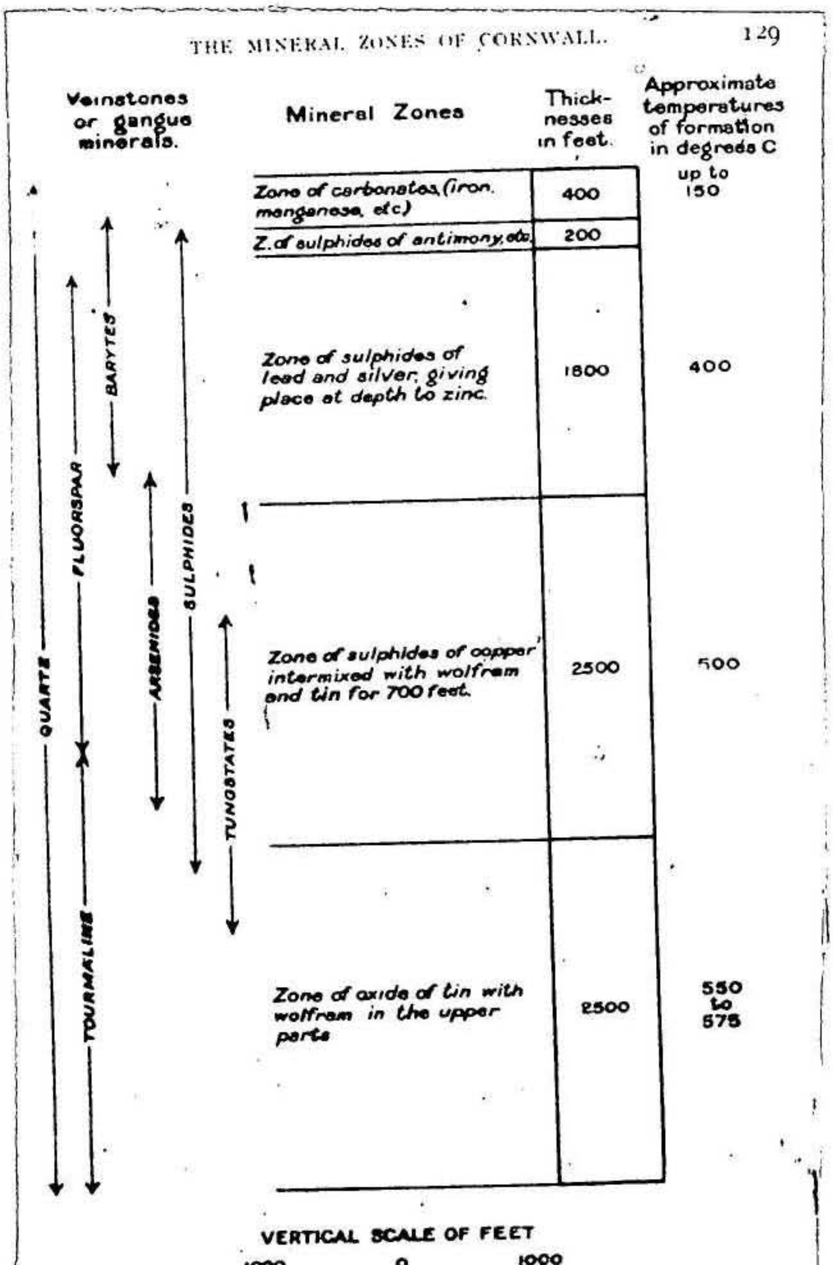


FIG. 7.—DIAGRAM SHOWING THE VERTICAL DISTRIBUTION OF MINERAL ZONES IN CORNWALL.

Fig.v. Diagram showing the vertical distribution of mineral zones in Cornwall (from Dewey, 1925).

Vokes and Jeffrey - 1955, and Dines - 1958). In the Cornish mines it has been noted that high temperature tin mineralization at depth gives place to medium temperature wolfram mineralization at somewhat higher levels. At still shallower depths wolfram gives way to low temperature copper mineralization. Fig. V is a reproduction of Dewey's (op.cit.) diagram illustrating the zoning. The mineralized veins outcropping in association with the Mareeba Granite may well represent various stages of erosion of similar mineralized zones. Thus, at depths below the extensive wolfram workings at Mt Carbine, there may be deposits of lode tin. This, however, is pure speculation, and should be regarded with great caution, because in Ball's description of the Mt Holmes tin mine, near Mt Carbine, the economic mineral zonation (cassiterite and wolfram) is apparently inverted when compared with the Cornish examples.

THE ALMADEN GRANODIORITE AND THE NYCHUM VOLCANICS

Introduction

The field relationships of the Almaden Granodiorite and the Nychum Volcanics have been described in the earlier report (1961). Here I shall describe some additional specimens and make some comments on some chemical analyses of the granodiorite and the volcanics. I shall also describe the petrography of the contaminated dykes that occur south and north-west of Mt Mulligan, and discuss their possible relationships to the Nychum Volcanics and the Almaden Granodiorite.

Petrography

The Almaden Granodiorite

In addition to those described in my earlier report (1961), four more specimens have been examined. The specimen localities, modal analyses and rock names are given in Table X.

Three of the specimens - R.10578, R.10580, and R.10583 - are texturally and mineralogically similar to one another. They are porphyritic and hypidiomorphic. The phenocrysts are subhedral to anhedral. In the groundmass, plagioclase and biotite are tabular, quartz is granular to interstitial, and potash feldspar is interstitial to poikilitic.

Plagioclase is slightly to moderately sericitized, and commonly shows oscillatory zoning; in R.10578 and R.10580 it has antiperthitic lamellae. Anhedral crystals of quartz show only slight straining. Potash feldspar has $2Vx = 0^{\circ}$ to very small, and is slightly to moderately kaolinized. Biotite is somewhat chloritized, and forms slightly flexed flakes that are pleochroic from straw-coloured to dark reddish brown. The amphibole is subhedral and is, in R.10580, mostly replaced by chlorite, epidote, and leucoxene; in R.10583 it is replaced by fine, randomly oriented flakes of biotite and some chlorite. In R.10578 the amphibole is a pale green actinolitic hornblende. Accessory minerals noted were black iron ore, zircon, epidote, apatite, and leucoxene. R.10578 contains some pyrite.

The fourth specimen, R.10582, is a hornblende granodiorite collected from a patch of ferro-magnesian-rich material close to the eastern contact of the granodiorite with sandstone of the Mount Garnet Formation at Nolan's Creek. The rock is aphyric and fairly equigranular and hypidiomorphic. Hornblende is segregated into clots in which feldspar is sparse. The plagioclase forms somewhat saussuritized and carbonated tabular

TABLE X

Grain-sizes, modal analyses, localities and names of specimens of the Almaden Granodiorite.

NO.	GRAIN SIZE		% PHEN	MINERALOGY						LOCALITY	NAME
	Phen,	G'mass		Quartz	K-feldspar	Plagioclase	Biotite	Amphibole	Accessory		
R.10578	7.5	0.25	36	22.1*	22.3	45.5* An_{43}	8.7*	0.4*	1.0	Nolan's Creek Yokas, run 3, photo 87, pt. 1528 A.	Porphyritic, partly chloritized hornblende-biotite granodiorite.
R.10580	3.5	0.1	36	23.1*	16.5	44.5* An_{48}	0.7*	0.6*	0.3	4 miles east of Nolan's Creek Yokas 3/95/1630.	(Chlorite: 12.2% epidote; 2.1%) Chloritized hornblende - biotite granodiorite.
R.10582	-	1.5 to 3.0	-	16.9	12.8	29.8 An_{70}	-	36.8	3.7	Nolan's Creek Yokas 3/87/1653.	Hornblende granodiorite.
R.10583	6.5	0.05	48	33.8*	6.5*	43.7* An_{56}	14.6*	Recorded with biotite*	1.3	Beaverbrook mine.	Altered hornblende-biotite tonalite.

* Occurs as phenocrysts as well as in the groundmass
Phen = phenocryst. G'mass = groundmass.

crystals and has antiperthitic lamellae. Quartz occurs as slightly strained interstitial grains. Potash feldspar is also interstitial, and is heavily kaolinized. Hornblende forms slightly chloritized fibro-prismatic crystals; it is pleochroic with X = pale olive, Y = olive green, and Z = pale bluish green. Accessory minerals are black iron ore, sphene, apatite, and zircon. Small inclusions of quartz sandstone and doleritic material are also present.

Additional field and petrographic information on the Almaden Granodiorite.

About three miles north-east of the water bore on the Mungana/Mitchell River track is a small area of apparent block-faulting. Within this area are outcrops of fine-grained greywacke and shales that contain small spots which, in section, are seen to be porphyroblasts of cordierite. This suggests that at no great depth beneath this area is an igneous intrusion which is possibly related to the Almaden Granodiorite. The apparent block-faulting possibly results from movement during the intrusion of this rock. A small boss of porphyritic microgranodiorite, probably related to the Almaden Granodiorite, occurs about 3 miles south-east of the water bore.

The north-eastward trending fault that crosses the Mungana/Mitchell River track in the vicinity of the water bore has formed a breccia composed of quartz sandstone fragments cut by irregular veins of fine-grained tourmaline (R.10585). It is possible, but rather unlikely, that this tourmaline mineralization may also be related to the Almaden Granodiorite.

The Nychum Volcanics: This part of the report contains some generalized descriptions of thin sections of specimens which were not prepared before my previous report (1961) was completed. The specimens are lithic tuffs, acid lavas, and andesites. In addition, two acid lavas occurring as pebbles in the Mt Mulligan Coal Measures are described. The names and localities of the specimens described are shown in Table XI.

The lithic tuffs were collected by B.J. Amos, and are from the lower part of the Nychum Volcanics succession north of Elizabeth Creek, and west of the Mungana/Mitchell River road. From field work and microscopy it is evident that what was formerly thought to be a sedimentary sequence at the lower part of the Nychum Volcanics is in fact a series of lithic tuffs that have, in part, been sorted by river action.

The lithic tuffs are represented by R.14225 and R.14227 to R.14229. R.14225 is, in hand specimen, pale cream rock and speckled with red, and contains a thin graded bed, about 2 cm. thick. In thin section the rock is inequigranular and vitroclastic, the grain-sizes ranging from 0.1 mm. to 0.9 mm. The grains are angular, and some show fretted and embayed margins. They consist of partly and wholly devitrified glass, some of which shows fine, rhyolitic flow-banding; in some of the glass rare microlites of tabular plagioclase are present. Some grains are zonally stained by hydrated iron oxide. The matrix to the grains consists of a pale fawn glass that has an approximate refractive index of 1.51, corresponding roughly to an SiO_2 percentage of 67 on the curve of W.O. George (in Williams, Turner and Gilbert, 1954, p.28). In the part of thin section that was cut across the graded bed (noted in the hand specimen description) the matrix glass has been altered to fine opaque clay minerals.

The other lithic tuff specimens are mineralogically and

TABLE XI

Localities and names of specimens of Nychum Volcanics described in the text.

Number	Photo Locality	General Locality	Name
R.14216		10 miles S.E. of Mt Mulgrave	Felsite
R.14217		King Cole Mine, Mt Mulligan	Altered rhyolite
R.14218		King Cole Mine, Mt Mulligan	Ignimbrite
R.14220	Maple, Run 8, photo 129, pt. 2060.	East of Elizabeth Creek, near Mungana/ Mitchell River road	Auto-brecciated felsite
R.14222	Maple, Run 8, photo 129, pt. 2062	As for 14220	Chloritized and somewhat silicified andesite
R.14223	Maple, Run 8, photo 127, pt. 2065	Justah mine road junction	Biotite dacite.
R.14224	Maple, Run 8, photo 125, pt.2078	Mitchell River/Mung-ana road just north of Elizabeth Creek	Albite dacite.
R.14225	Maple, Run 9, photo 121, pt.2012	East of Elizabeth Creek	Lithic tuff.
R.14227	Maple, Run 9, photo 121, pt. 2012	East of Elizabeth Creek	Lithic tuff.
R.14228	Maple, Run 9, photo 123, pt. 2063	As for R.14220	Lithic tuff.
R.14229	Maple, Run 9, photo 123, pt. 2079	As for R.14220	Lithic tuff.
R.10795		9 miles S.E. of Wrotham Park H.S.	Andesite.

texaturally similar to R.14225. Specimens R.14227 and R.14228 contain a few grains derived from lower Palaeozoic sediments, and most of the grains in R.14228 are stained by hydrated iron oxide. In R.14229, clay minerals and carbonate have taken the place of much of the devitrified glass.

Four acid lavas are described here. R.14216 is a pale cream-grey, flow-banded and aphanitic rock that, in thin section, is seen to consist almost entirely of a fine-grained, flow-banded felsite. Some small flakes of biotite and muscovite were observed, and vesicles and thin veins are filled with chalcedony.

R.14220 was sampled from a vent, and is an auto-brecciated felsite. In hand specimen it is a pale green, aphanitic rock that, on a wetted surface, is seen to be brecciated. The specimen consists of parts of two large fragments, between which are numerous sub-rounded fragments. In section the fragments and matrix consist of very fine-grained felsite that has somewhat contorted flow-structures. A few grains of pale pink garnet were noted in the hand specimen.

Specimens R.14223 and R.14224 are dacites. The first is in hand specimen, fawnish-green speckled with black, and has phenocrysts enclosed in an aphanitic groundmass. The mica phenocrysts have a flow orientation. R.14244 is pale mauve-pink and has phenocrysts enclosed in an aphanitic groundmass.

In thin section the groundmass of both specimens consists of a fine-grained felsite. Quartz phenocrysts in both specimens are subhedral to anhedral, and embayed. Plagioclase phenocrysts are tabular; in R.14223, the plagioclase is An_{40}, and contains antiperthitic layers of moderately kaolinized potash feldspar. In R.14224, the plagioclase consists of somewhat kaolinized albite. Tabular phenocrysts of slight to moderately kaolinized potash feldspar are found only in R.14224. Biotite occurs as tabular, contorted books in R.14223; some appears to pseudomorph amphibole. In R.14224 all the ferromagnesian material has been replaced by hematite and some chalcedony; some pyroxene-shaped pseudomorphs, and acicular crystals that may have been amphibole, were observed. Two or three small inclusions of altered basalt, and one of 'diorite' material were noted. Accessory minerals are apatite and black iron ore. Estimates of percentages of minerals present as phenocrysts are shown in Table XII.

TABLE XII

Estimated mineral percentages of specimens R.14223 and R.14224.

No.	Phenocrysts	Quartz	K-feldspar	Plagioclase	Biotite	Pseudomorphed Amphibole and Pyroxene
R.14223	20	35	Tr.	60	5	-
R.14224	15	15	5	70	-	10

Specimens R.14222 and R.10795 are andesites. In hand-specimen R.14222 is dark greenish grey, and has small phenocrysts enclosed in an aphanitic groundmass. Vesicles are streaked out parallel to the direction of flow. In thin section the specimen is seriate porphyritic and hyalocrystalline. The phenocrysts range up to 0.6 mm. across, and the groundmass has an average grain-size of 0.02 mm. Plagioclase (30%) forms microlites and small phenocrysts, and is partly or wholly replaced by chalcedony and chlorite. Small rectangular areas are composed of pale green chlorite and brown bowlingite, and make up about 20 percent of the rock - these areas appear to represent pseudomorphed pyroxene. About 45% of the rock is composed of a murky glass that is, in places, faintly anisotropic. Embayed phenocrysts of quartz (5%) are also present.

R.10795, in hand specimen, is black and stained by hydrated iron oxide on weathered surfaces. The rock is sparsely porphyritic and the phenocrysts are enclosed in an aphanitic, massive groundmass. In thin section the rock is porphyritic, and has an hyalopilitic groundmass. The phenocrysts range up to 0.8 mm. across, and the average grainsize of the groundmass is 0.03 mm. Plagioclase (30%) is An_{58} in the groundmass, and An_{78} as phenocrysts, and forms tabular, pellucid crystals. Augite is colourless, and forms prismatic to granular crystals that are confined to the groundmass. The interstitial glass forms 50 percent of the rock, and encloses myriads of minute transparent globules, 0.001 mm. in diameter. Accessory black iron ore is octahedral. Rare amygdales contain an outer rim of granular (?)pigeonite enclosing an unidentified flaky brown mineral that has a refractive index of about 1.5, and has $2V_z$ = very small.

The pebbles from the Mt Mulligan Coal Measures were collected by F. de Keyser to see if they resembled rocks from either the Nychum Volcanics or the Featherbed Volcanics. R.14218 is an ignimbrite that has a devitrified felsitic groundmass with a faint eutaxitic texture. The phenocrysts are anhedral and somewhat fractured, and consist of quartz, feldspar, and rare biotite. The rock is similar to types from both the Featherbed and the Nychum Volcanics.

R.14217 is an acid lava containing anhedral phenocrysts of quartz and altered feldspar enclosed in a patchily kaolinized and, in places, silicified groundmass that has a flow texture. It is rather similar to some acid lavas from the Nychum Volcanics.

Suggested Petrogenisis of the Nychum Volcanics and the Almaden Granodiorite

Introduction: The ideas expressed here are only meant to be possibilities, and are based on the regional mapping and a study of the general petrography of the volcanics and the granodiorite, together with some information derived from chemical analyses. My aim is to show that both the Nychum Volcanics and the Almaden Granodiorite may have resulted from the mixing of acid and basic magmas, the Nychum Volcanics representing an earlier stage of incomplete mixing and the slightly younger Almaden Granodiorite representing a later stage of more complete mixing. I shall deal firstly with the Nychum Volcanics.

The Nychum Volcanics: The volcanics are a gently folded series consisting mostly of acid tuffs and flows, with subordinate andesites and rare basalts. Some sediments are associated with them in the 'Nychum' homestead and Jug Water Hole areas. The details of the successions observed in the field differ greatly from place to place, but the intermediate and basic rocks appear to have been extruded in the lower parts of the succession.

Petrographically, the rocks range from basalt, through andesites and dacites, to rhyolites and rhyolitic pyroclasts. The intermediate rocks show some evidence of contamination, either by hybridization or assimilation (Morgan, 1961, p.21).

The evidence does, in fact, favour hybridization - for example, the basified plagioclase rims in specimen M1617L (Morgan, op. cit.p.42), and the strongly embayed quartz 'phenocrysts' in the andesite represented by M6210/1 (Morgan, op.cit.,p.41). Some of the more acid rocks (e.g., M1583, op.cit., p.40) contain inclusions of fine basalt. Such evidence is used by Larsen, et al (1938a, 1938b) to suggest magnatic hybridization in the differentiation of the volcanics of the San Juan region, U.S.A. The dominance of acid rocks over basic ones within the unit is evidence against the fractionation of the acid rocks from a basic magma, and there is no evidence of differentiation arising from immiscibility of contrasting liquids.

Chemical analyses of specimens from the Nychum Volcanics are shown in Table XIII. I have chosen a suite of specimens ranging from basic to acid in order to gain some idea of the trend of differentiation of the rocks. The basalt is rather poorer in MgO and richer in Na_2O when compared with basalts in general (Nockolds, 1954), and with those from some calc-alkali rock provinces (Kuno, 1960 and Steiner, 1958). Fig. vi is after Kuno (1960), and shows that the basalt is of a high-alumina type.

Fig. vii is an FMA diagram on which the Nychum Volcanics analyses are plotted, together with the 'typical tholeite trend' (Tilley, 1950). The diagram shows that the volcanics belong to the calc-alkaline association, and that the major trend is towards alkali-enrichment and little or no iron-enrichment. In other words, there is an almost straight zone between the ferromagnesian-rich rocks and the rocks rich in alkalis, indicating that the Nychum Volcanics may have resulted from the hybridization of acid and basic magmas.

Fig. viii consists of a series of linear variation diagrams in which silica percentages are marked along the abscissae, and the other major oxide percentages on the ordinates. The oxide trend-lines are almost straight; those for alumina, total iron oxide, and soda are slightly convex upward, magnesia is concave upwards, and potash and lime are virtually straight. This 'straight-line' characteristic again suggests hybridization.

The slight curves in the trend-lines may well result from some differentiation in addition to hybridization, as in the Montana Petrographic Province (Larsen, 1940).

To summarize: field examination of the rocks shows a dominance of acid volcanics over andesitic and basic-rocks, precluding the possibility of basic magma being the sole parent of the volcanics. Petrographic examination and chemical variation diagrams suggest that hybridization between acid and basic magma has taken place.

<u>The Almaden Granodiorite</u>: In the introductory part of this chapter I suggested that the Almaden Granodiorite and the Nychum Volcanics may have been formed by hybridization. However, Branch (1960) has suggested that the granodiorite was formed by assimilation of limestone by the Herbert River Granite. Some petrographic studies by Dallwitz (1961) of granodiorite specimens from close to its contact with the limestone near Chillagoe have shown that some reaction with the limestone has taken place, and that the granodiorite tends to be somewhat basified near its margins; this was taken as evidence to support Branch's opinion. Bearing this idea in mind, I would like to examine certain other features.

Rocks contaminated by assimilation commonly have abundant evidence for contamination in the form of numerous xenoliths -

TABLE XIII

Chemical analyses of specimens of Nychum Volcanics

	R.10381	R.10795	R.10368	R.10366	R.10375	R.10388
SiO_2	51.30	60.20	62.10	63.90	64.40	70.10
TiO_2	1.31	1.45	1.18	0.80	1.05	0.26
Al_2O_3	16.60	14.70	15.30	15.10	15.10	12.30
Fe_2O_3	2.90	1.70	1.39	1.66	2.63	0.70
FeO	5.65	5.20	4.80	3.55	2.59	1.82
MnO	0.13	0.11	0.10	0.08	0.06	0.03
MgO	5.50	2.35	1.38	0.99	1.41	0.26
CaO	9.60	5.50	4.70	4.40	2.75	1.44
Na_2O	3.10	3.35	3.80	4.10	3.85	3.80
K_2O	0.58	2.10	2.10	2.10	3.20	3.30
H_2O+	1.37	0.45	0.43	0.73	0.45	1.17
H_2O-	1.37	2.60	2.20	1.91	1.83	4.75
P_2O_5	0.18	0.29	0.25	0.29	0.22	0.05
CO_2	0.31	0.05	0.07	0.06	0.12	0.04
	100.5	100.1	99.8	99.7	99.66	100.0

All analyses are by H.W. Sears, Australian Mineral Development Laboratories, Adelaide.

R.10381. (thin section 5765, Morgan - 1961, p.45). Basalt from near the water pump, Mungana/Mitchell River road. 8 miles west of 'Nychum'.

R.10795. (this report, p. 27). Augite andesite, 9 miles S.E. of 'Wrotham Park'.

R.10368. (thin section 5967, Morgan - op.cit., p.41). Hypersthene-augite andesite, Yokas, run 6, photo 157, point 1530D. 9½ miles S.W. of 'Nychum'.

R.10366. (thin section 5880, Morgan, op.cit., p.43). Hypersthene andesite from a vent, Mossman - Cairns run 8, photo 5061, point 1642. 16 miles S.W. of 'Nychum'.

R.10375. (thin section 5836, Morgan, op.cit., p.34). Porphyritic dacite, Groganville, run 8, photo 27, point 621c/4. 6 miles S.E. of 'Mt Mulgrave'.

R.10388. (thin section 5960, Morgan, op.cit., p.36, illustrated by fig. vii, p.18a). Ignimbrite, Yokas, run 4, photo 55, point 1617B. 3 miles S.W. of 'Nychum'.

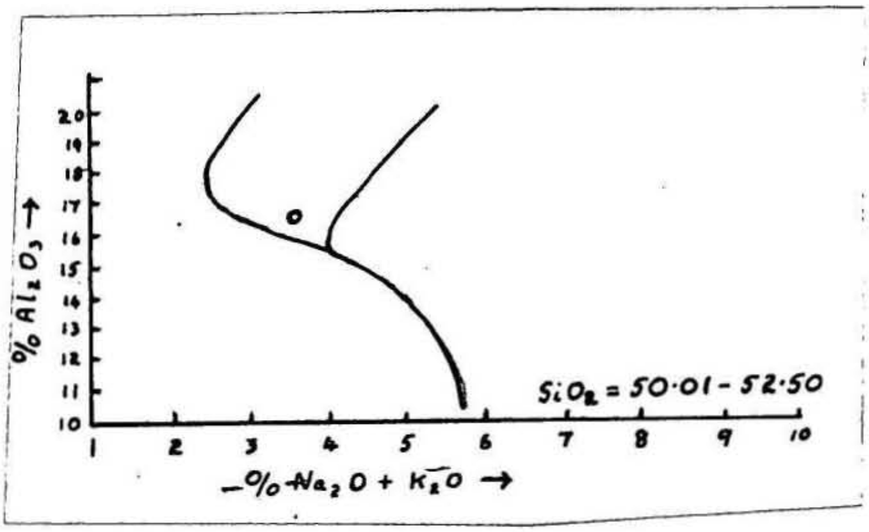


Fig. vi: Variation diagram showing the high-alumina characteristic of basalt from the Nychum Volcanics, after Kuno (1960). The circle represents R.10381, basalt from the Nychum Volcanics.

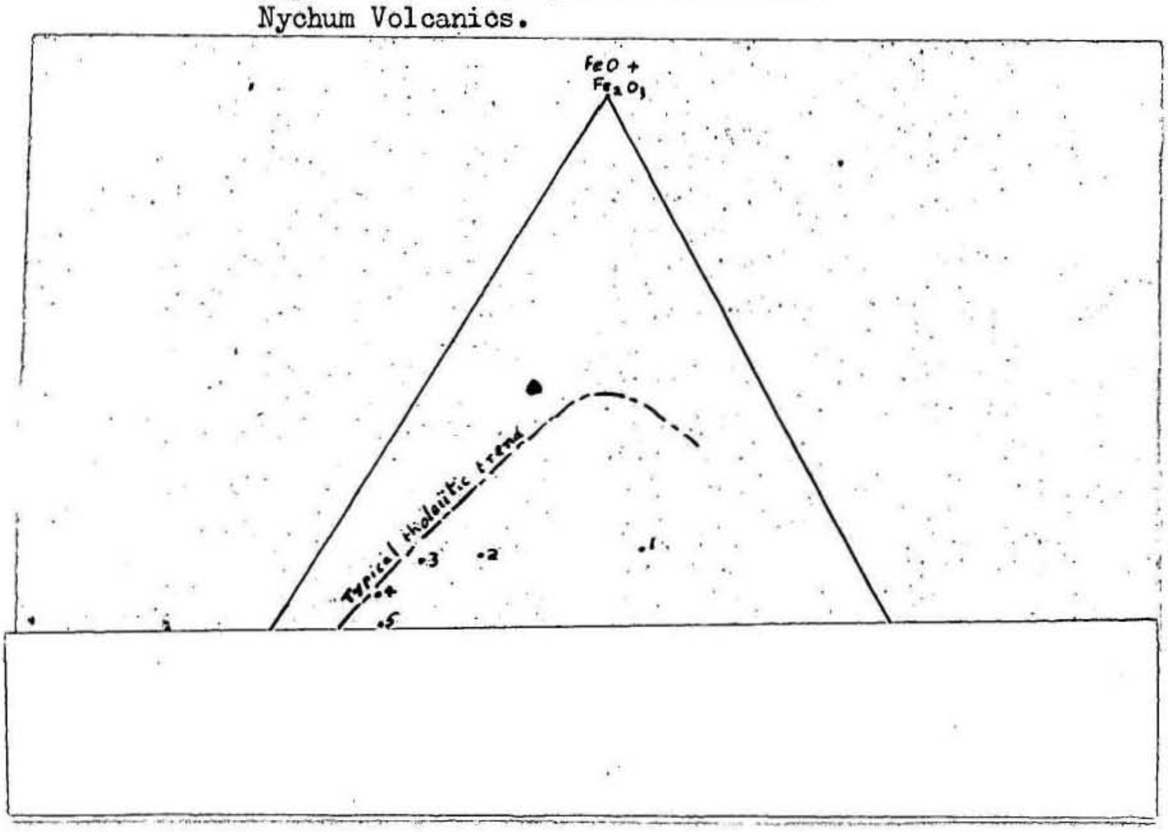


Fig. vii: FMA variation diagram for the Nychum Volcanics. The numbered points are the plots of the Nychum Volcanics analyses, and the dashed line is from Tilley (1950). 1 = basalt; 2, 3, 4 = andesite; 5 = dacite and 6 = rhyolitic ignimbrite.

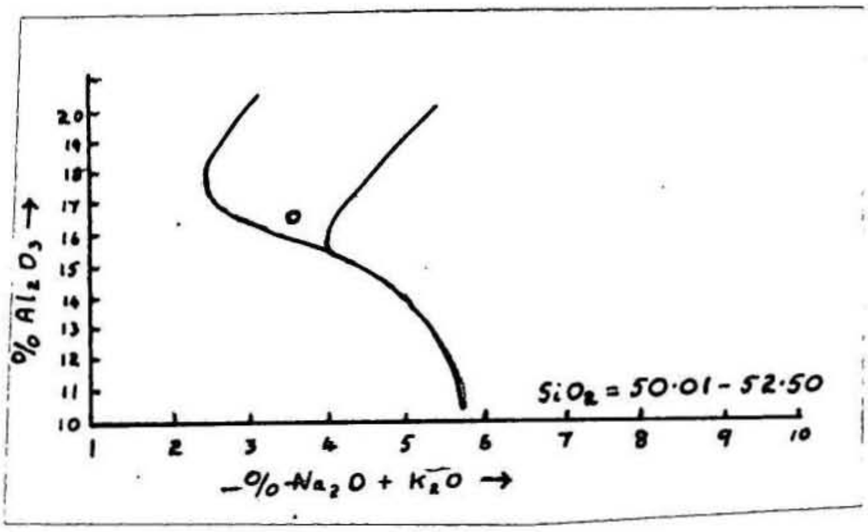
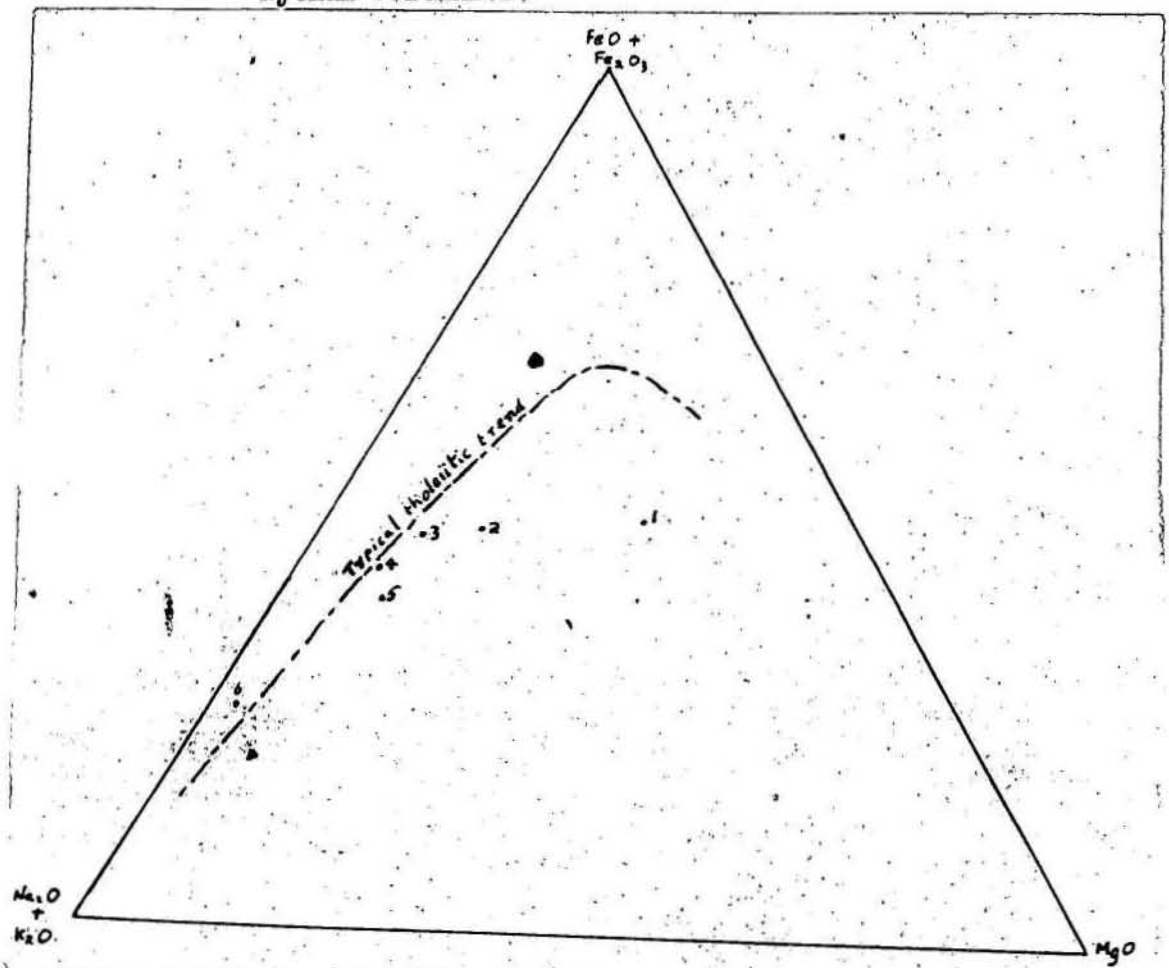


Fig. vi: Variation diagram showing the high-alumina characteristic of basalt from the Nychum Volcanics, after Kuno (1960). The circle represents R.10381, basalt from the Nychum Volcanics.



6 = rhyolitic ignimbrite.

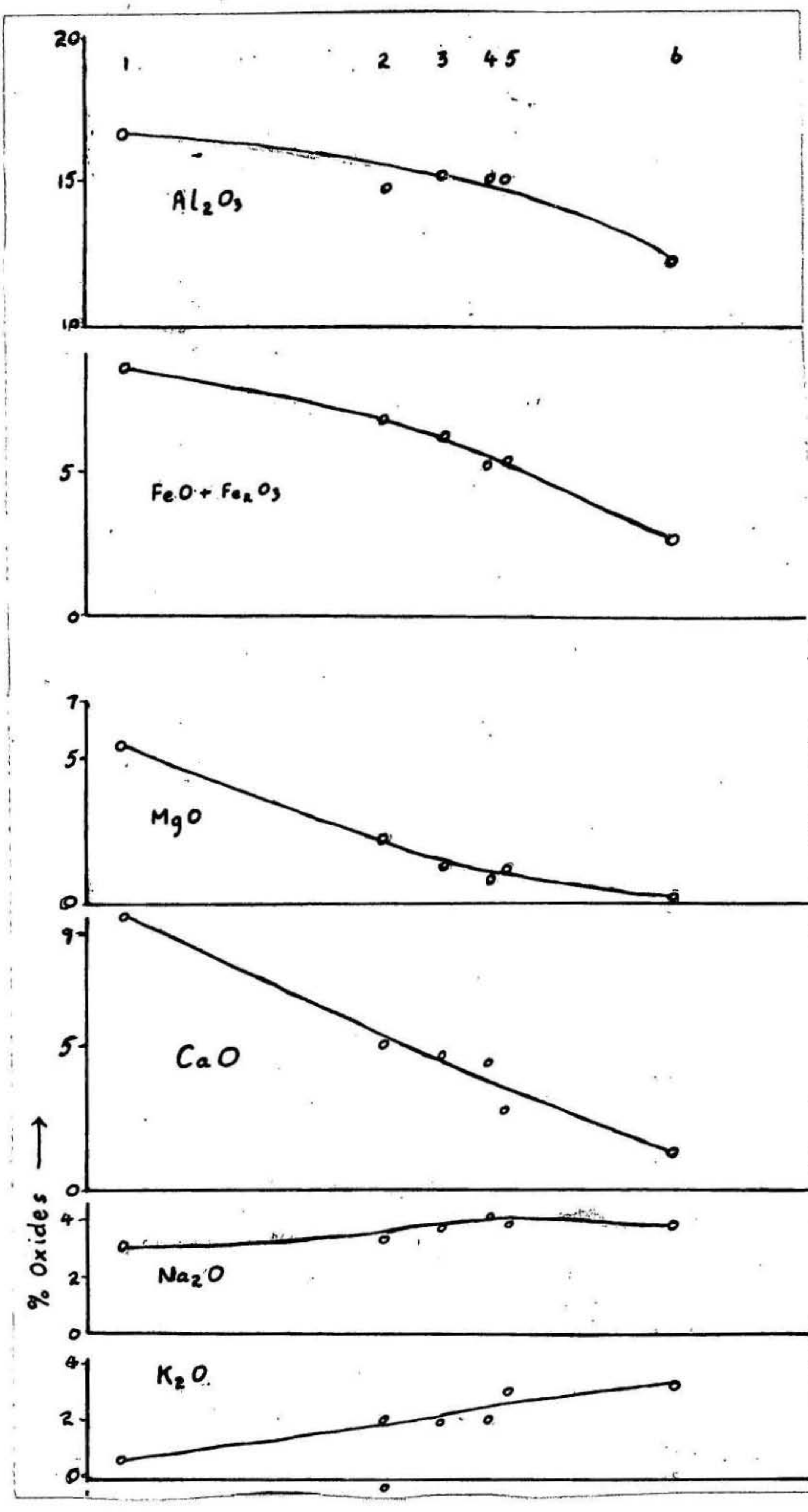


Fig. viii: Linear variation diagram for the Nychum Volcanics. SiO_2 is plotted on the abscissae, and the other major oxides in the ordinates. 1 is basalt, 2, 3 and 4 are andesites, 5 is dacite, and 6 is the ignimbrite.

e.g., the contaminated tonalites of Loch Awe, Scotland (Nockolds, 1934) enclose numerous xenoliths of country rock, whereas the uncontaminated tonalites there contain none. Again, at Arnage, in Scotland (Read, 1923) the contaminated norite is full of xenoliths of the country rocks. In both examples, the type of contamination of the igneous rocks can be related to the type of sedimentary rock enclosed. In the Chillagoe area, few xenoliths or even 'ghosts' of xenoliths are to be seen in the Almaden Granodiorite away from its contacts. At Nolan's Creek, 14 miles south-east of 'Wrotham Park', the granodiorite intrudes limestone and greywacke. No limestone xenoliths were observed, but in a marginal zone next to the greywacke the granodiorite is strongly contaminated, and encloses numerous greywacke xenoliths. Thus, contamination of the granodiorite here should result in enrichment in siliceous and argillaceous material. That this is not so is seen if one compares a chemical analysis of xenolith-free granodiorite from this locality (M1653A, Table XIV) with an analysis of Almaden Granodiorite sampled from near Almaden (E55/5/6, Table XIV). Hence, if assimilation of limestone has taken place, it is thought that the granodiorite should contain evidence of contamination by containing numerous inclusions of limestone in various stages of digestion by the granodiorite. As it is, pure limestone, like that at Chillagoe, is notoriously resistant to assimilation and granitization because its chemical composition is so unlike that of igneous rock.

If limestone is to be assimilated completely, then the magma responsible for this should have plenty of heat available for the reaction to take place. Modal analyses of the Almaden Granodiorite in the Mossman 1:250,000 Sheet area (p. of this report) show that 36 to 46 percent of the rock consists of phenocrysts, suggesting that about 40 percent of the magma had crystallized prior to emplacement; the remainder of the granodiorite crystallized to a fairly fine grain-size, showing that it cooled relatively quickly. Another feature is that the granodiorite has only a very slightly metamorphosed aureole. In addition, I suggested in my earlier report (1961) that the granodiorite is an extremely high level intrusion, because it intrudes the Nychum Volcanics at Nolans Creek and near Chillagoe these volcanics were probably never more than 500 feet thick. Thus, with nearly half the magma crystallized prior to emplacement, and with only a small metamorphic aureole, the granodiorite was obviously quite cool at the time of intrusion. Furthermore, because the intrusion was so close to the earth's surface, what heat it had left would be quickly dispersed.

Two points arise from the discussion so far. First, the magma would have insufficient heat to assimilate large quantities of limestone, and leave no trace. Secondly, because nearly half of the magma had crystallized probably prior to intrusion, the magma must have attained its present chemical composition in the original 'magma chamber' in the depths from where it was intruded. If, then, the Almaden Granodiorite is, as suggested by Branch (1960), closely related to the Herbert River Granite, what is the cause of the basification of the granite? I suggest that it is by the hybridization of the granite magma with basic magma, for reasons given below.

In Table XIV are chemical analyses of the Almaden Granodiorite, together with an average of some analyses of the Herbert River Granite. Also shown is an analysis of the Trevethan Granite from the Cooktown area, an average of 65 analyses of hornblende-biotite granodiorites quoted from Nockolds (1954), and two averages of analyses of tonalites quoted from Larsen (1948). In comparing the Almaden Granodiorite analyses with the others, it will be seen that all the analyses are fairly similar. The Almaden Granodiorite, in fact, contains

TABLE XIV

Chemical Analyses of Almaden Granodiorite Herbert River Granite,
and some similar rocks quoted from the literature

	M1653A	E55/1/16	E55/5/6	Pga	Pgh	D55/13/1	N	LA	LB
SiO_2	62.74	67.5	66.76	65.67	73.63	65.9	65.50	66.4	62.2
TiO_2	0.25	0.05	0.29	0.16	0.16	0.63	0.61	0.6	0.7
Al_2O_3	16.66	15.3	15.32	15.76	13.80	14.6	15.65	14.8	16.6
Fe_2O_3	1.81	1.5	1.36	1.56	0.53	0.50	1.63	1.4	1.4
FeO	3.16	2.4	2.92	2.83	1.86	3.95	2.79	3.8	4.5
MnO	0.08	0.04	0.10	0.07	0.04	0.05	0.09	0.06	0.6
MgO	2.06	1.75	2.02	1.94	0.56	2.95	1.86	2.2	2.7
CaO	4.67	4.05	4.23	4.32	1.66	4.60	4.10	4.5	5.7
Na_2O	3.73	3.10	3.11	3.31	3.38	3.00	3.84	3.5	3.4
K_2O	2.15	3.20	3.22	2.86	4.03	2.70	3.01	2.1	1.6
H_2O-	-	0.14	0.11	0.08	0.10	0.09	0.69	0.5	0.6
H_2O+	2.15	0.87	0.80	1.27	0.48	0.65		-	-
P_2O_5	0.04	0.09	0.17	0.10	0.10	0.18	0.23	0.05	0.09
Co_2	-	0.03	-	-	-	0.04	-	-	-
	99.54	100.0	100.41	99.93	100.33	100.1	100.00	99.93*	100.09**

* includes 0.02% ZrO_2.   ** includes 0.05% BaO.

Locational information can be found on the next page.

M.1653A: Almaden Granodiorite from Nolan's Creek (Morgan, 1961, p.24). Analyst S. Baker. B.M.R.

E55/1/16: Almaden Granodiorite, an age - determination sample from the pluton 4 miles north of the Walsh River - Mitchell track crossing. Analysts - C.R. Edmunds and H.W. Sears A.M.D.L.

E55/5/6: Almaden Granodiorite, an age-determination specimen from near Almaden. Analysts: S. Baker and A. McLure, B.M.R.

Pga: Average of M.1653A, E55/1/16, and E55/5/6.

Pgh: Average of four analyses of Herbert River Granite (Morgan, 1961, p.24).

D55/13/1: Trevethan Granite, 20 miles south of Cooktown, North Queensland.

N.: Average of 65 analyses of hornblende - biotite granodiorites (Nockolds, 1954, p.1014).

LA: Average of Green Valley tonalite (Larsen, 1948, p.56, A).

LB: Average of Bousall tonalite (Larsen, 1948, p.66, 6).

slightly less MgO and CaO than the others, and slightly less of the alkali-oxides. Bearing this in mind, it should be noted that Larsen (op.cit.) considers his tonalites to have resulted from processes of magmatic differentiation, and possibly hybridization, and not from assimilation of limestone.

Fig. ix is a type of variation diagram used by Bowen (e.g., 1925, fig. i, p.826, and 1928, Fig. 22, p.76). SiO_2 is plotted on the abscissa, and the other major oxides on the ordinate. At the SiO_2 percentages 65.67 and 73.63 are drawn two vertical lines, representing the averages of analyses for the Almaden Granodiorite and the Herbert River Granite, respectively. On these lines are plotted the values of the other major oxides. The equivalent oxides are joined by straight lines, and these are prolonged to the low silica side of the diagram to a vertical line (A) at 47% SiO_2 - where the line representing K_2O reaches zero value. This vertical line represents the most basic rock that can be shown on the diagram - any rock more basic will have a minus quantity of K_2O, which is impossible. Thus, A in Table XV, is the theoretical basic rock with zero percent K_2O. This composition is not unlike that of a basalt, except for a very high Al_2O_3 content. If the K_2O value is fixed at 0.5 percent, this gives us a rock with 50 percent silica, shown as B in Fig. IX and Table XV. This rock, again, is like a basalt, and is, in fact, fairly similar to the analyzed basalt from the Nychum Volcanics (shown under C in Table XV). The main difference between it and the theoretical rock B is in the Al_2O_3 percentage; even so it has already been shown that the Nychum basalt is a high-alumina type (Fig. vi). However, the Nychum Volcanics basalt as compared with basalts in general, has rather low MgO and high Na_2O, and it should be noted that the theoretically obtained composition B in Table XV has nearly similar values for these oxides. Under D is part of an analysis of norite, given for comparison, from the San Marcos Gabbro (Miller, 1937); this is associated with the tonalites given in Table XIV and with granites in the Batholith of Southern California (Larsen, 1948). Note the high alumina content. Thus, it seems possible that the Almaden Granodiorite could well owe its origin to the hybridization of acid and basic magmas.

TABLE XV

Comparison of hypothetical rock compositions with that of basalt from the Nychum Volcanics

	A	B	C	D
SiO_2	47.3	50	51.3	52.12
Al_2O_3	21	20.1	16.6	20.88
Total Iron Oxide	9.6	8.8	8.55	6.86
MgO	5.6	5	5.5	6.90
CaO	11.1	10	9.6	10.14
Na_2O	3.2	3.3	3.1	2.40
K_2O	0	0.5	0.58	0.25

A. Theoretical composition of basalt with 0% K_2O obtained from Fig. ix.
B. Theoretical composition of basalt with 0.5% K_2O obtained from Fig. ix.
C. Analyzed basalt from the Nychum Volcanics.
D. Part of analysis of norite from San Marcos Gabbro (Miller 1937), given by comparison.

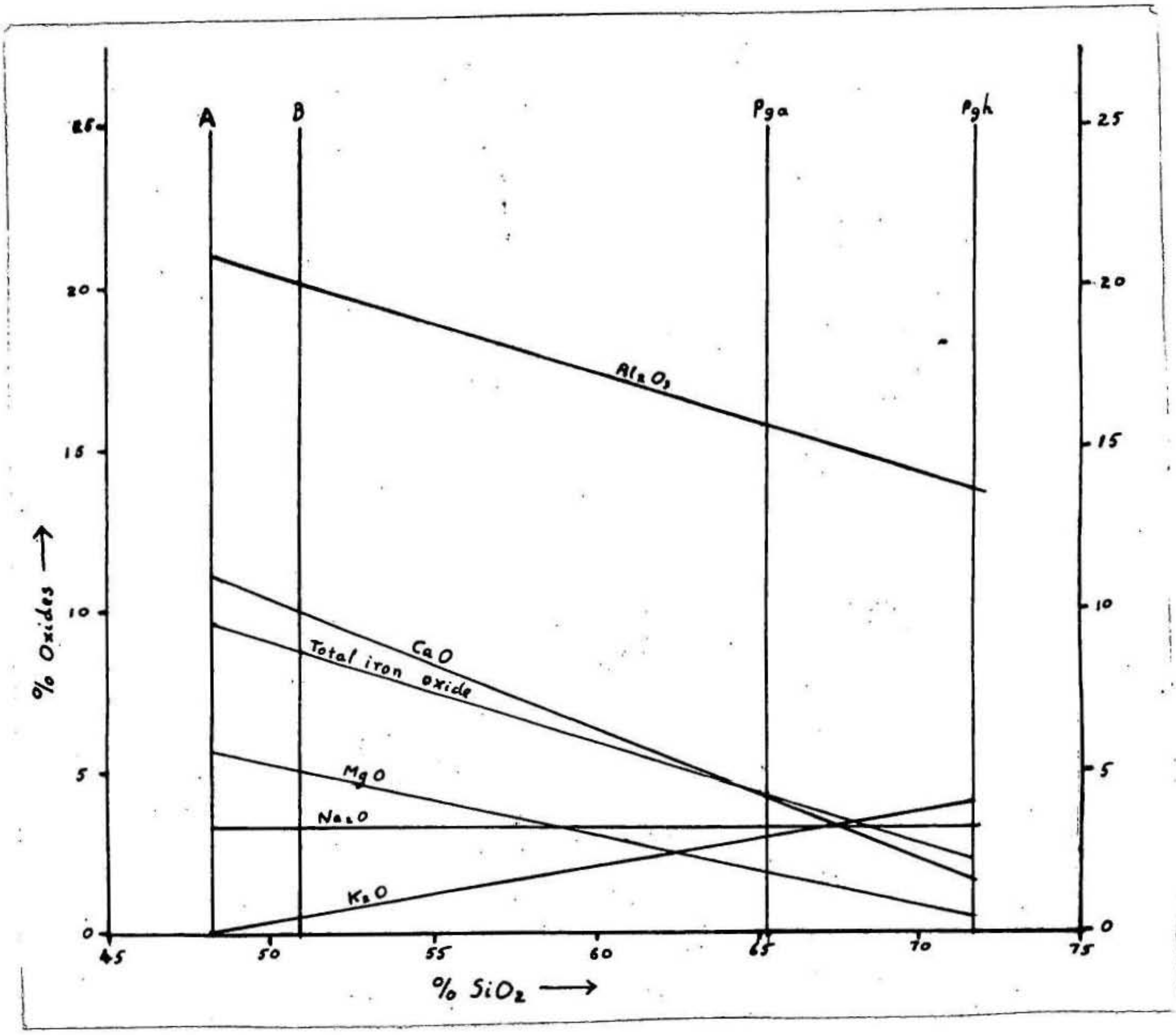


Fig. ix: Variation diagram to show hybridization between the Herbert River Granite and a basalt to produce the Almaden Granodiorite.
Pgu = Almaden Granodiorite.
Pgh = Herbert River Granite.
A = hypothetical composition at 0% K_2O.
B = hypothetical composition at 0.5% K_2O.

Relationship of the Almaden Granodiorite to the Nychum Volcanics: In my earlier report (1961) I suggested that the Volcanics and the Granodiorite are petrographically related to each other because of their close relationship in the field. The volcanics are intruded by the granodiorite, but nevertheless the ages of the two rock-bodies are very similar. I still think that they are related, but had considered the granodiorite to be the parent of the volcanics, and that the variety of the volcanic rock-types resulted from crystallization differentiation of the granodiorite. I do not consider this to be so now.

Instead, I think it possible that the volcanics were erupted during the early stages of hybridization of the basic and acid magmas. The later granodiorite represents a more complete stage of hybridization; it is, texturally, a fairly uniform rock, and the only possible clue to its dual parentage is the occurrence of cores bytownite to anorthite in the plagioclase phenocrysts in some specimens: these may well be relics from the acidified basic magma.

The Herbert River Granite is a large batholith trending northwestwards, and it seems rather curious that a small part of its north-western extremity should be more basic. In the area of the Nychum Volcanics is the western edge of the Lower Palaeozoic geosyncline, marked by the Palmerville Fault between the Silurian Chillagoe Formation and the (?)Pre-Cambrian Dargalong Metamorphics. This faulted unconformity is regarded by White (1961) as the hinge-line of the geosyncline, and its trend changes from north-west in the Chillagoe-Mungana region to northerly along the western edge of the Mossman 1:250,000 Sheet area. This position of change of trend is, in the opinion of Branch (pers. comm.), likely to be a zone of weakness along which basalt may rise and react with the Herbert River Granite magma.

The xenolith-rich dykes near Mt Mulligan

Two kykes were examined in the field by F. de Keyser. One dyke is south of Mt Mulligan, and strikes north-north-west; it is faulted against the Triassic sediments of Mt Mulligan and its relationships to the Featherbed Volcanics is not known. The other dyke is north-west of Mount Mulligan; it strikes east-north-east, and is faulted against both the Featherbed Volcanics and Nychum Volcanics. Neither dyke intrudes any other intrusive igneous rocks. Both dykes are thought to be 'high level', and are believed to be associated with the igneous activity that produced the Nychum Volcanics, Herbert River Granite, Featherbed Volcanics, and Elizabeth Creek Granite (Morgan, 1961). The problem with the dykes is to decide whether they are related to the Almaden Granodiorite - Herbert River Granite - Nychum Volcanics association, or with the more acid Elizabeth Creek Granite - Featherbed Volcanics association. As will be seen, petrographic and chemical evidence suggest that the dykes are related to the former association, and, in particular, to the Herbert River Granite.

In outcrop the dykes are seen to contain many inclusions: specimen R.12045 was sampled by F. De Keyser as a rock free from inclusions and its chemical analysis is shown in Table XVI. In hand specimen the rock is seen to be medium-grained, pale greenish-grey, and very sparsely porphyritic, and the thin section shows that it is a hornblende-biotite adamellite. Its texture is hypidiomorphic-granular; rare micropegmatite structures are present. Sodic plagioclase (35%) forms fairly strongly sericitized tabular crystals in the groundmass and rare phenocrysts. Quartz (30%) is subhedral to interstitial, and is unstrained. Moderately kaolinized perthite (30%) is sub-poikilitic and is, in places, intergrown with quartz. Green prismatic hornblende (3%) and small, ragged, slightly chloritized flakes of biotite (2%) are present. Accessory zircon and apatite were noted.

By the nature of its ferromagnesian minerals - i.e., hornblende and biotite - the rock is similar to the Herbert River Granite types rather than to the more leucocratic, biotite-bearing Elizabeth Creek Granite types. However, it could be said that the hornblends results from contamination of the magma by the inclusions. This may be so, but from the nature of the inclusions, which are described below, this idea is discounted; the inclusions themselves do not contain hornblende or pseudomorphs after hornblende.

F. de Keyser collected five specimens of xenoliths from the dyke south of Mt Mulligan. These are R.14152, R.14153, R.14154, R.14155 and R.14237. As seen in thin section their textures suggest that the acid igneous material of which they consist has been partly melted. The probable sequence of events in the suggested melting of these inclusions is fairly well shown by these specimens, and the descriptions that follow are arranged in order from the least affected to the most.

Specimens R.14153 and R.14237 (Fig. x) are seen to be xenomorphic and inequigranular rocks consisting of anhedral crystals of heavily kaolinized perthite (45%), sericitized sodic plagioclase (25%), quartz, and rare pseudomorphs of chlorite and smectite after biotite. The grain-sizes range from 0.6 mm. to 2.1 mm. . In these specimens granophyric material is sparse and intergranular, and is concentrated mostly between quartz and feldspar grains, although some occurs, in places, between grains of feldspar. The granophyre may represent an early stage in the melting of the xenoliths, particularly where it is concentrated between quartz and feldspar; in this position it represents quartzo-feldspathic material resulting from fusion just above the eutectic melting point, of the quartz and feldspar. The granophyric material occurring in smaller amounts between feldspar grains may be the same material that has migrated slightly from a quartz-feldspar boundary.

Specimen R.14155 contains sinuous zones of granophyre ranging up to 1 mm. in width, which separate complex, rather lobate areas consisting of either plagioclase or quartz - these minerals do not occur together in any one area; they are always separated by a zone of granophyre. Both the quartz and the feldspar areas have curved and embayed margins as though they have reacted with the granophyre. In each of their areas, quartz and feldspar are separate from each other, and each forms coarse, anhedral, and somewhat intergrown crystals (Fig. xi). In this specimen, melting has gone a stage further, and the granophyre represents the crystallized fused material.

Specimens R.14153 and R.14154 contain sparse grains and multigrain fragments composed of quartz or sodic plagioclase, but again, nowhere do both occur together in one fragment. These are enclosed in an abundant groundmass of granophyre, and have embayed margins (Fig. xii). In fact, the rock gives the impression of being a porphyritic granophyre, but instead the embayed 'phenocrysts' are remnants within a xenolith that has been almost completely fused.

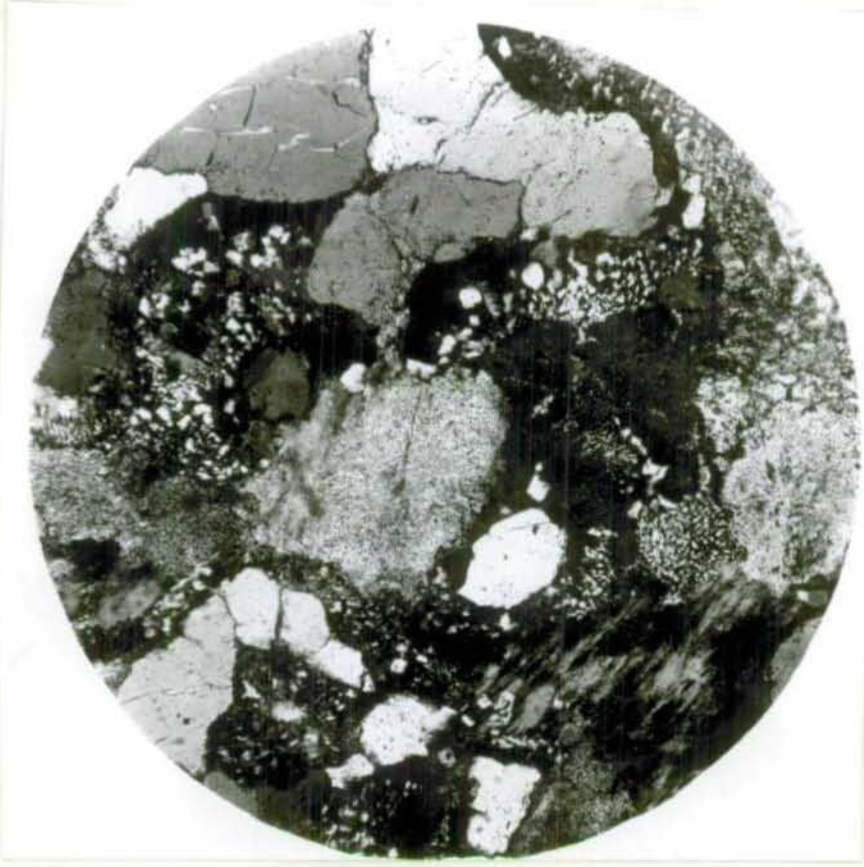


Fig. x: Specimen R.14152 from the xenolithic dyke south-west of Mt Mulligan. An early stage in the fusion of a xenolith. Micrographic material may be seen on crystal boundaries. Crossed nicols, X55. B.M.R. Negative No.G4991.

Fig. xi: Specimen R.14155 from the xenolithic dyke south-west of Mt Mulligan. A later stage in the fusion of a xenolith. Feldspar (dark grey, top and bottom of the photograph) almost entirely separated from quartz (very pale grey to white, photograph centre) by granophyric material. Note the embayed and corroded form of the quartz. Crossed nicols X20. B.M.R. Negative No.G/4992.

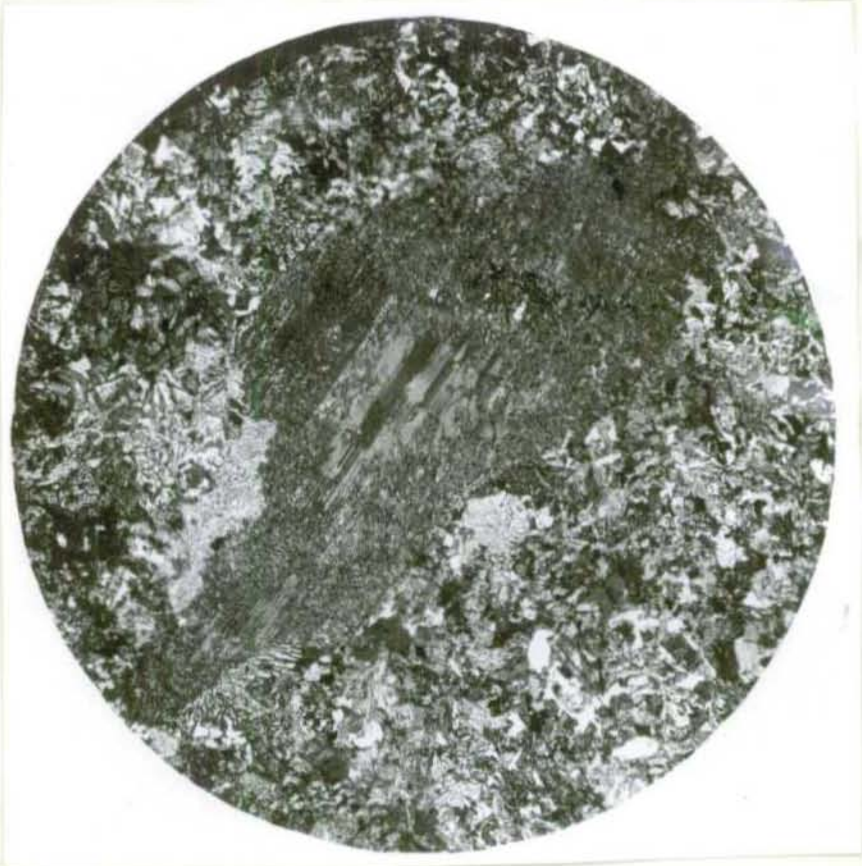


Fig. xii: Specimen R.14153. A corroded grain of plagioclase enclosed in a micrographic groundmass, representing a late stage in the fusion of a xenolith from the xenolith-rich dyke south-west of Mt Mulligan. Crossed nicols, X25. B.M.R. Negative No.G/4995.

These specimens illustrate extremely well the effect of heating quartzo-feldspathic rocks above the eutectic melting point of a mixture of quartz and feldspar. Fusion has taken place, at first, at the boundaries between the two minerals. In the case of some of these specimens, the temperature of the enclosing magma was well above the quartz-feldspar eutectic melting point, so that the zone of fusion between the two minerals increased until eventually almost all the original xenolithic material was melted; the end product in these slides has the appearance of a porphyritic granophyre.

Hawkes (1929) has described, from Iceland, acid igneous xenoliths within a granite stock, in which fusion has produced textures similar to those in R.14155. However, fusion of acid inclusions by acid magmas are of rare occurrence. Fusion of quartzo-feldspathic rocks by basaltic magmas has often been described (Harker, 1939, pp. 68-9; Ackermann and Walker, 1960; Butler, 1961; Wyllie, 1961). In the references quoted, the authors have described feldspathic sandstones which are partly fused by basalt magma, and the earliest stages of fusion are shown by the production of glass, or granophyric structures (Harker, op. cit.), between quartz and feldspathic grains. In these examples, the basalt forms a near-surface intrusion, and the fused sandstones occur as part of the metamorphic aureole around the intrusions. In the example described by Hawkes, it appears that the fused inclusions have been brought up from depth by the granite magma; this is also the case in the specimens I have described, because the dyke does not intrude coarse-grained igneous rocks at the surface. Hence, the fusion of the xenoliths took place presumably at depth, prior to the emplacement of the dyke. Even then, at depth, the magma must have had a fair amount of excess heat in order to melt the xenoliths, because, most often, granitic magma reacts with inclusions and brings them into chemical equilibrium with itself, without fusion, and it may then disintegrate them mechanically - a good example of this process is seen in the Bibette granite of Alderney, in the English Channel Islands, described by S.R. Nockolds in 1932.

Thus, I consider that these xenoliths were picked up and partly or almost completely fused by the dyke magma at depth, prior to intrusion of the dyke material to its present position. At depth, the magma must have been held at a high temperature for a long while, in order that the fusion could take place. I very much doubt if this process would occur in the magma in the present position of the intrusion, because heat would have been lost quickly to the surrounding country rocks. In fact it is probable that by the time the intrusion took place the magma was fairly cool, because another xenolith, R.14236 from the dyke north-west of Mt Mulligan, consists of a somewhat metamorphosed probable acid volcanic rock that shows no sign of having been fused. This xenolith may well have originated from the Nychum Volcanics, against which the dyke is faulted in this area.

The degree of contamination of the dyke magma by the fused xenolithic material is not known. It is possible that, owing to the fact that acid magma is much more viscous than basaltic magma, the xenolithic and magmatic liquids did not mix at all freely. In Table XVI I have presented an analysis of the dyke rock (R.10245), together with an analysis of the Herbert River Granite. The dyke rock is very similar to the average Herbert River Granite, the main differences being that it is richer in FeO, and contains somewhat less SiO_2. However, the partly fused inclusions appear to be of a plutonic acid igneous rock which could not have appreciably affected the composition of the original dyke magma.

The composition of the Almaden Granodiorite (M1653A Table XVI) is seen to be considerably more basic than that of the dyke rock. In Fig. xiii is shown a variation diagram similar to that in Fig. ix (p. 37), and it is used here to determine the composition and amount of the most acid rock that the Almaden Granodiorite can assimilate in order to form the dyke rock. The vertical line B in the diagram represents this most acid rock, which contains no MgO; the vertical line A is a hypothetical rock containing 0.3% MgO. The compositions of the hypothetical rocks A and B are shown in Table XVII; both are seen to be potash-rich granites. It can be read from Fig. xiii that to form the dyke rock, the Almaden Granodiorite would have to assimilate 90% of its own weight of material of composition A and 75% of its own weight of B. It is, however, very doubtful if the temperature of the Almaden Granodiorite magma was high enough, or could be sustained for sufficient time at a high temperature, for this to happen. Another argument against the assimilation of this hypothetical material by the Almaden Granodiorite is that the compositions of both hypothetical rocks A and B are those of potash-rich granite, whereas the inclusions observed with the microscope are adamellitic and granodioritic.

To summarize, the dyke is a hornblende-biotite adamellite that contains numerous inclusions in various stages of fusion. The dyke magma is thought to have been only slightly modified, if at all, by the inclusions, and is considered to be more closely related to the Herbert River Granite than to the Almaden Granodiorite.

TABLE XVI

Chemical analyses of Herbert River Granite, Almaden Granodiorite, and the xenolithic dyke near Mt Mulligan

	R.10245	Pgh	M1653A
SiO_2	70.40	73.63	62.74
Al_2O_3	12.70	13.80	16.66
Fe_2O_3	0.25	0.53	1.81
FeO	4.01	1.86	3.06
MgO	0.46	0.56	2.06
CaO	1.51	1.66	4.67
Na_2O	3.00	3.38	3.73
K_2O	4.85	4.03	2.15
H_2O+	0.03	0.10	-
H_2O-	1.47	0.48	2.15
TiO_2	0.48	0.16	0.25
MnO	0.04	0.04	0.08
P_2O_5	0.13	0.10	0.04
CO_2	0.46	-	-
	99.79	100.33	99.50

R.10245: Hornblende-biotite adamellite dyke rock. Analysts: Sears and Rowley, A.M.D.L.

Pgh : Average of four analyses of Herbert River Granite. Analysts: S.Baker and A. McLure, B.M.R.

M1653A : Almaden Granodiorite from Nolan's Creek (Morgan, 1961, p.24). Analyst: S. Baker B.M.R.

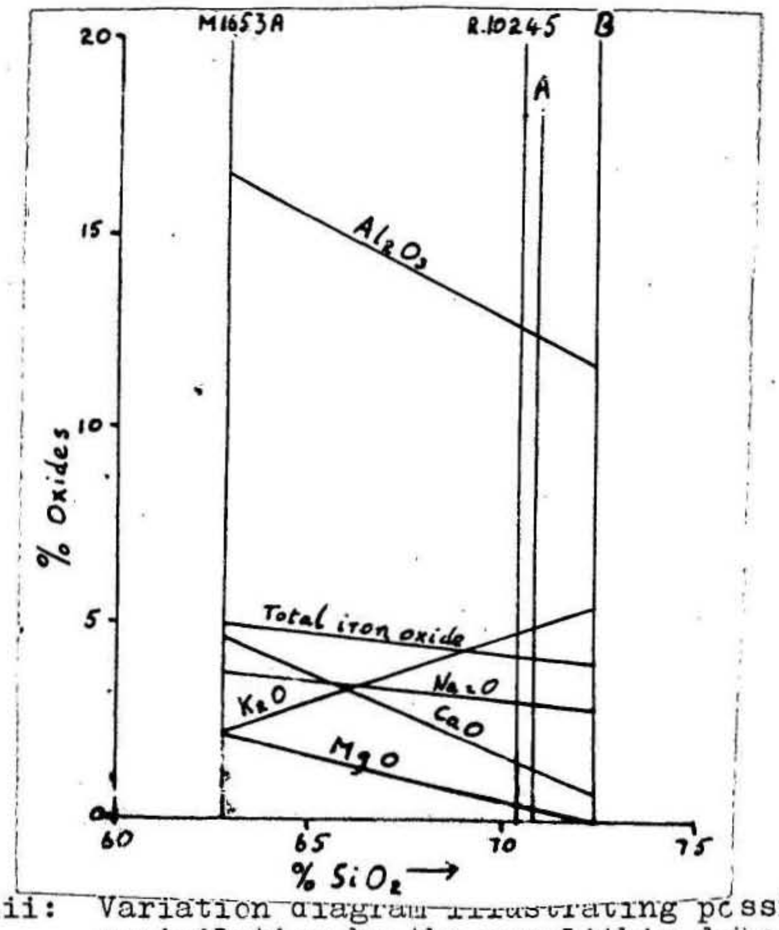


Fig. xiii: Variation diagram illustrating possible assimilation by the xenolithic dyke. M1653A: Almaden Granodiorite, R.10245: xenolithic dyke, A and B: hypothetical rock compositions.

TABLE XVII

Hypothetical chemical analyses derived from Figure xiii

	A.	B.
SiO_2	71.3	72.5
Al_2O_3	12.3	11.8
Total iron oxide	4.2	4.1
MgO	0.3	-
CaO	1.2	0.6
Na_2O	2.9	2.8
K_2O	5.1	5.6

THE ELIZABETH CREEK GRANITE

A brief description of the aplogranite mentioned in my earlier report (p.12) is given here. In hand specimen the rock (R.10579) is pink, fresh, and massive, and has very sparse quartz and feldspar phenocrysts enclosed in a medium-grained groundmass. In thin section the specimen is seen to be hypidiomorphic - granular, and has an average grain-size of 0.75 mm.; the rare phenocrysts range up to 4 mm. across. Quartz is granular to interstitial and shows slight strain-effects and cracking. Potash feldspar is tabular to anhedral; some of its poikilitically encloses quartz. The potash feldspar contains coarse exsolution lamellae and thin film lamellae, and is slightly to moderately kaolinized. Zoned digoclase (15%) crystals are tabular, and are slightly sericitized. Biotite forms subhedral, somewhat distorted flakes, and is usually pleochroic from pale straw to very dark smoky brown. Some biotite is bleached and somewhat iron-stained. Accessory black iron ore, zircon, and apatite were observed.

A modal analysis from a stained thin section of the specimen showed the following mineral percentages: potash feldspar: 46.1, quartz: 35.2, plagioclase: 17.7, biotite: 0.8, and accessories: 0.3. The rock is a leucocratic microgranite.

DYKE ROCKS

Included in this chapter are brief descriptions of acid and basic dykes; their localities are given in Table XVIII.

TABLE XVIII

Localities and names of Dyke Rocks

No.		
R.14163	Maple, Run 1, photo 127, point 2027B	Silicified and chloritized albite dolerite
R.14164	Maytown	Carbonated, silicified, and sericitized porphyritic dolerite.
R.14185	Mossman - Cairns Run 9, photo 5023, point 2176B	Keratophyre
R.14166	Mossman - Cairns Run 9, photo 5023, point 2176C	Chloritized and carbonated porphyritic micro-adamellite
R.14232	St George's River Run 7, photo 115, point 143	Altered olivine-bearing dolerite
R.14233	St George's River Run 9, photo 55, point 160	Granophyric and porphyritic micro-adamellite
R.14234	Rumula Run 2, photo 697, point 202	Granophyric and porphyritic micro-adamellite
R.14235	St George's River, Run 5, photo 25, point 235	Granulated porphyritic micro-adamellite.

Acid Dykes

R.14166. Chloritized and carbonated porphyritic micro-adamellite.

In hand specimen the rock is mottled pinkish green, fine-grained, and porphyritic. In thin section its texture is seen to be hypidiomorphic-granular; the average grain-size of the groundmass is 0.02 mm., and the phenocrysts range up to 2 mm. across. Quartz (30%) forms small, somewhat embayed subhedral phenocrysts, and is anhedral in the groundmass. Potash feldspar (30%) is sub-poikilitic and moderately kaolinized.

Plagioclase (25%) has a composition of about An_{25}, and forms tabular phenocrysts and groundmass crystals; it is fairly strongly carbonated and sericitized. Carbonate is interstitial, and also occurs with leucoxene and epidote in segregations (5%) that probably pseudomorph an unidentified ferromagnesian mineral. Hydrated iron oxide is intergranular.

R.14233. Granophyric and porphyritic micro-adamellite.

In hand specimen small phenocrysts of quartz and feldspar are seen to be enclosed in a pale greenish-cream aphanitic groundmass. In thin section the rock is seen to consist of microcline-perthite (40%), quartz (30%), plagioclase-An15 (25%), and muscovite and pseudomorphed amphibole (5%). The phenocrysts, 0.6 mm. across, tend to be clustered, and are enclosed in a fine granophyric and spherulitic groundmass consisting chiefly of quartz and alkali feldspar. Muscovite occurs as fine flakes in the groundmass, and with chlorite in the pseudomorphed amphibole.

R.14234. Granophyric and porphyritic micro-adamellite.

In thin section the specimen is porphyritic, the phenocrysts - measuring about 0.4 mm. across - being enclosed in a hypidiomorphic, partly granophyric groundmass that has an average grain-size of 0.1 mm. Potash feldspar (40%) is moderately kaolinized, and forms stubby tabular to interstitial crystals. The plagioclase (40%) is albite, and occurs as somewhat sericitized and saussuritized tabular phenocrysts and groundmass crystals, commonly surrounded by a rim of granophyre. Quartz (10%) forms poikilitic to granophyric grains in the groundmass; larger crystals have the appearance of being xenolithic material. Amphibole phenocrysts are pseudomorphed by chlorite and smectite (10%); these two minerals also occur as interstitial flakes in the groundmass. Accessory zircon, apatite, and black iron ore were noted.

R.14235. Granulated porphyritic micro-adamellite.

The hand specimen is pale cream and sparsely porphyritic. The phenocrysts are enclosed in a phaneritic groundmass in which rare garnet may be seen. In thin section the phenocrysts range up to 1.5 mm., and the average grain-size of the groundmass is 0.4 mm. The hypidiomorphic texture is modified by strain-effects and granulation; in places, granophyric intergrowths between quartz and microperthite are present. The phenocrysts consist of quartz and microcline. The rock comprises plagioclase An_{35} (40%), quartz (30%), microcline-perthite (30%), and sparse muscovite flakes. Accessory minerals are garnet and zircon.

Basic Dykes

R.14163. Silicified and chloritized albite dolerite.

In hand specimen the rock is dark grey, amygdaloidal, and sparsely porphyritic. In thin section the texture is found to be doleritic. Albite forms thin laths. Quartz, much of which is probably introduced, is interstitial and poikilitic, and the one or two 'porphyritic' grains are probably xenocrystic. Prismatic pyroxene is pseudomorphed by chlorite, luecoxene, and haematite. Chlorite forms interstitial fine grains. Apatite is accessory.

R.14164. Carbonated, silicified, and sericitized porphyritic dolerite.

The hand specimen is pale greenish-grey and fine-grained. In thin section the texture is doleritic and porphyritic. The phenocrysts, measuring 1 mm. across, are now completely altered to calcite, which apparently pseudomorphs plagioclase and ferro-magnesian minerals. In the groundmass completely sericitized and carbonated plagioclase occurs as a typically doleritic meshwork of thin laths. These are enclosed in anhedral quartz, which is maybe introduced.

R.14165. Keratophyre.

The hand specimen is dark grey and sparsely porphyritic, the phenocrysts being enclosed in a phaneritic groundmass. In thin section the rock is seen to consist of equal amounts of albite and alkali feldspar. Albite forms randomly oriented microlites, 0.1 mm. long, and is enclosed by poikilitic alkali feldspar. Smaller quantities of interstitial chlorite are present. The rare phenocrysts consist of plagioclase, potash feldspar, and quartz.

R.14232. Altered olivine-bearing dolerite.

The hand specimen is grey, fine-grained, and sparsely porphyritic. In thin section the texture is seen to be doleritic. The rare phenocrysts consist of augite, plagioclase, and serpentinized olivine. In the groundmass the plagioclase (50%) with a composition of An_{68} forms slightly sericitized, interlacing crystals. Augite (30%) occurs as colourless acicular to granular crystals that are only rarely in subophitic relationship to plagioclase. Green to olive-green hornblende (10%) forms outgrowths from augite, and occurs as prismatic crystals that have small, irregular cores of augite. Olivine (5%) is now entirely pseudomorphed by serpentine; the pseudomorphed crystals are clustered. Rare quartz, which may have been introduced, is interstitial, and some chlorite partly replaces augite and hornblende. Accessory minerals consist of leucoxene, acicular black iron oxide, sphene, and apatite.

?

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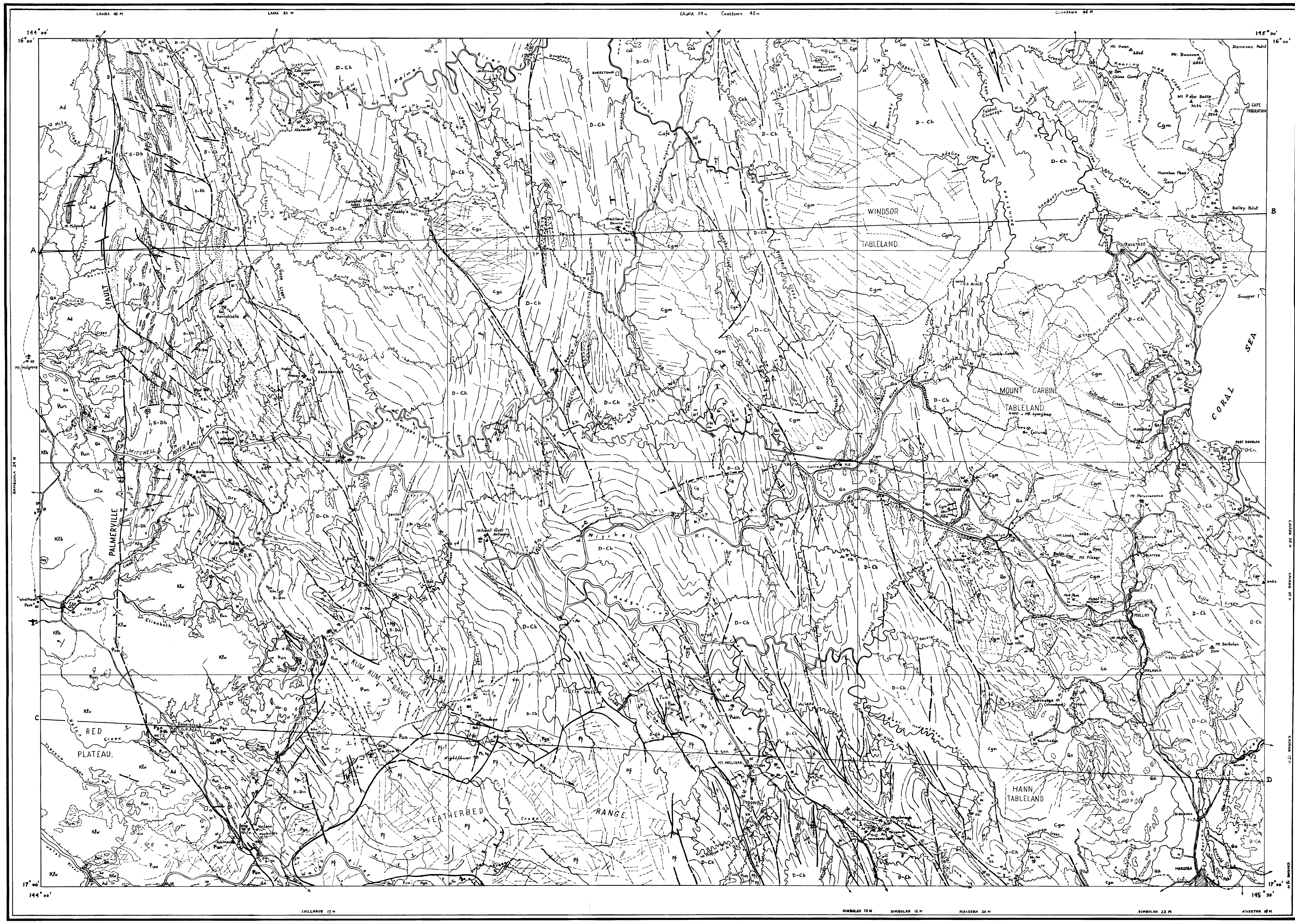
AUSTRALIA 1:250,000

MOSSMAN

QUEENSLAND

1:250,000 GEOLOGICAL SERIES SHEET SE 55-1



PROVISIONAL EDITION 1962
SUBJECT TO AMENDMENT

REFERENCE

CAINOZOIC	QUATERNARY.		Qa	Alluvium, soil
			Qr	Beach sands.
		Atherton Basalt	Cza	Olivine basalt.
			Czb	Olivine basalt
			Czy	Quartz gravel and silicified quartz sandstone ('billy')
MESOZOIC	LOWER CRETACEOUS	Blackdown Formation	Klb	Grey shale, siltstone, sandy shale; some lenticular sandstone; calcareous concretions
		Wrotham Park Sandstone	Klw	Pebble conglomerate, feldspathic and pebbly sandstone; glauconitic sandstone
	JURASSIC	Dalrymple Sandstone	Jl	Conglomerate, sandstone
	TRIASSIC ?	Pepper Pot Sandstone	Rp	Floggy argillaceous sandstone and siltstone overlying massive red conglomerate and sandstone
	U. PERMIAN to TRIASSIC ?	Elizabeth Creek Granite	Pgz	Pink leucocratic biotite granite
		Featherbed Volcanics	Pf	Massive grey ignimbrites; subordinate acid lavas.
		Almaden Granite	Pga	Grey biotite - hornblende granite
		Undifferentiated	Pzu	Hornblende granodiorite, rhyolite
PALAEOZOIC	UPPER PERMIAN	Mount Mulligan Coal Measures	Pum	Conglomerate, sandstone, siltstone, shale, volcanic conglomerate; coal.
		Nychum Volcanics	Pun	Acid lavas, pyroclasts, ignimbrites; subordinate basalt and andesite Arkose, siltstone, impure coal, tuffaceous sediments
	CARBONIFEROUS?	Cannibal Creek Granite	Cgc	Cream, muscovite-biotite-microcline granite.
		Mareeba Granite	Cgm	Grey porphyritic, muscovite-biotite-microcline granite
		Undifferentiated	Cg	Diorite
	CARBONIFEROUS	Montalbion Sandstone	Cm	Quartz sandstone
				Greenschist, serpentine, talc-carbonate rock
	M. DEVONIAN to L. CARBONIFEROUS.	Hodgkinson Formation	D-Ch	Micaceous greywacke siltstone slate, chert, basic volcanics Main areas of chert and basic volcanics. Limestone Main conglomerate lenses Low-grade metamorphic greywacke, slate, siltstone, formerly "BARRON RIVER METAMORPHICS"
	U. SILURIAN to L. DEVONIAN	Mount Garnet Formation	S-Dm	Quartz greywacke, arkose, siltstone, chert, basalt Limestone. Main conglomerate lenses
		Chillagoe Formation	S-Dh	Chert, quartz greywacke, siltstone, conglomerate, breccia, basalt Reef limestone Main areas of basic volcanics.
PRECAMBRIAN	ARCHAEAN ?	Dargalong Metamorphics	Ad	Schist, gneiss, augen gneiss, granulite, quartzite, amphibolite

Trend of bedding
Geological boundary
Geological boundary with dip
Fault
Relative horizontal movement
Relative vertical movement: U = up, D = down
Anticline, showing plunge
Syncline, showing plunge
Where location of boundaries, folds, and faults is approximate line is broken; where inferred or indefinite queried; where concealed, boundaries and folds are dotted, faults are shown by short dashes.
Strike and dip of strata
Overturned strata
Vertical strata
Horizontal strata
Generalized strike and dip of folded strata
Top of strata
Direction of transport of sediment
Dip < 15°, Dip 15 - 45°, Dip > 45°, Joint pattern } air-photo interpretation
Strike and dip of foliation
Vertical foliation
Strike and dip of cleavage
Vertical cleavage
Apparent dip of bedding on cleavage.
Apparent dip of cleavage on bedding
Main areas of very strong cleavage and or shearing.
Plunge of lineation
Horizontal lineation
Dyke or vein
Volcanic vent, { d = dolerite, gr = granite, q = quartz, r = rhyolite }
Macrofossil locality
Microfossil locality
Plant fossil locality
Minor mineral occurrence,
Prospect;
Mine, quarry, large open cut, or group of mines and prospects
Prospect, position doubtful
Old battery, smelter, or treatment plant

Ag = Silver, As = Arsenic, Au = Gold, Bi = Bismuth, C = Coal, Co = Cobalt, Cu = Copper, Hg = Cinnabar, Ls = Limestone, Mn = Manganese, Pb = Lead, Sb = Antimony, Sn = Tin, W = Tungsten.

Trig station, height in feet } datum mean sea level
Spot height in feet
Highway
Road
Vehicle track
Swamp.
Water hole
Waterbore with windpump
Water tank
Dwelling
Homestead
Town
Site of former village, now abandoned or non-existent
Yard
Fence
Telegraph line.
Railway with siding.
Landing ground.
Dam

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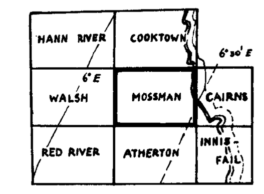
INDEX TO ADJOINING SHEETS

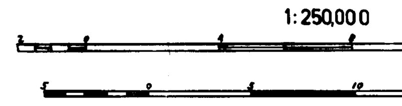
Showing Magnetic Declination



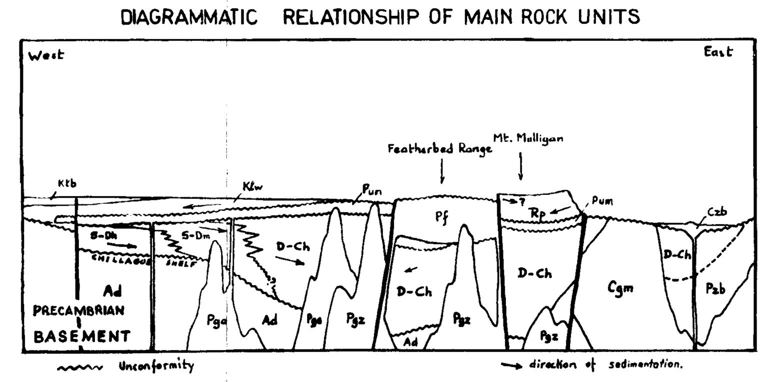
Annual change 2' E.

Scale

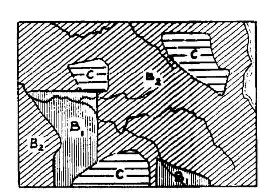
1:250,000



DIAGRAMMATIC RELATIONSHIP OF MAIN ROCK UNITS



GEOLOGICAL RELIABILITY DIAGRAM



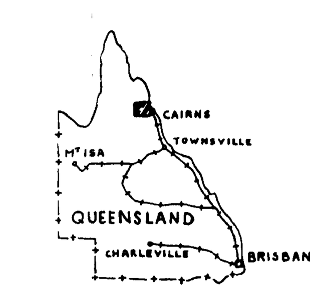
B_1 Detailed reconnaissance: numerous traverses and air-photo interpretation

B_2 Reconnaissance: traverses and air-photo interpretation

C Air-photo interpretation

Geology by: F. de Keyser, K.G. Lucas, W.R. Morgan, B.J. Amos, R.M. Tucker.

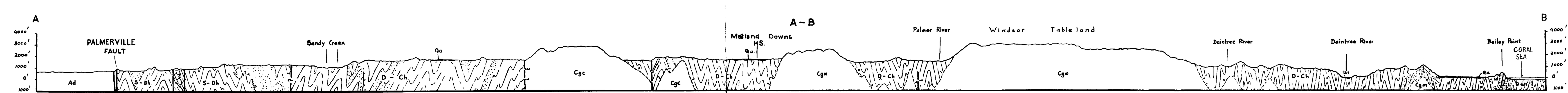
Compiled by: F. de Keyser, May 1961.



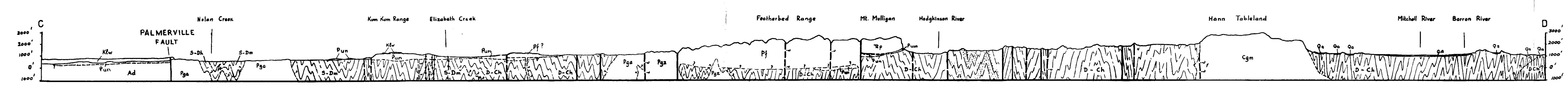
SECTIONS

Scale V/H = 4

A - B



C - D



MOSSMAN

SHEET SE 55-1

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