COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Records 1965/118

THE IGNEOUS PETROLOGY OF THE COOKTOWN 1:250,000 SHEET AREA, NORTH QUEENSLAND

by

W.R. Morgan

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SUMMARY

Two main periods of igneous activity have been distinguished in the Cooktown 1:250,000 Sheet area; first, the emplacement of dominantly acid plutons, minor intrusives, and extrusives in late Palaeozoic times; secondly, the extrusion of alkaline olivine basalts in Cainozoic times.

Three late Palaeozoic granite types are recognized. The Finlayson Granite, which crops out in the Annan River area, contains sodic plagioclase, microcline-perthite, quartz, biotite, and muscovite, and is responsible for the tin and tungsten mineralization in the Annan River Tinfield. The Trevethan Granite crops out in an area some twenty miles south of Cooktown; the granite and its associated dykes contain intermediate to basic plagioclase, quartz, biotite, actinolite, and small amounts of potash feldspar. No mineralization is associated with this granite. The Puckley Granite crops out in and south of the Battle Camp Range, some thirty miles west of Cooktown, and also in the north centre of the Cooktown 1:250,000 Sheet area. It contains orthoclase perthite, intermediate plagioclase, quartz, and biotite. Some alluvial tin ore has been exploited in the area of the granite.

All the granites are epizonal. Chemical analyses of age-determination samples suggest that the Finlayson and Trevethan Granites are related in a petrogenetic series with the Mareeba Granite in the China Camp area (Morgan, 1961a and 1964a). It is also suggested that hybridization of acid with basic magma could be responsible for the formation of the Trevethan Granite.

Some minor acid and basic dykes were intruded in late Palaeozoic times in the Annan River Tinfield area. Permian acid volcanics in the Normanby Formation occur west of Cooktown.

The Cainozoic alkaline olivine basalts form flows, scoria cones, and composite cones. The only differentiates observed are olivine analcitites, and in this respect the basalts are similar to those in the Cairns Hinterland (Best, 1960; Morgan, 1961b), and it is suggested that the basalts in both areas form a North Queensland olivine basalt - olivine analcitite association.

The olivine analcitites result from enrichment in alkalis without enrichment in silica; they are probably the products of quenching resulting from a sudden, explosive eruption.

INTRODUCTION

This report deals with the field occurrence, petrography, and chemistry of late Palaeozoic and Cainozoic igneous rocks in the Cooktown 1:250,000 Sheet area.

The late Palaeozoic intrusions form a northerly extension of an acid igneous complex described in earlier reports by Branch (1965) and Morgan (1961a and 1964a). Like those in the areas farther south, the intrusions are epizonal; however, no volcanic rocks have been found associated with them.

The Cainozoic igneous rocks are olivine basalt and subordinate olivine analcitite. In the Annan River Tinfield, stanniferous gravels underlie some basalt flows.

The general geology of the Cooktown 1:250,000 Sheet area is described by Lucas (1962).

LATE PALAEOZOIC IGNEOUS ROCKS

GENERAL INTRODUCTION

The Tasman geosynclinal arenites and argillites of the Hodgkinson Formation were strongly folded, but sustained only very slight regional metamorphic effects, in Upper Devonian and Lower Carboniferous times. Subsequently, they were intruded by three distinct varieties of granite, together with some minor intrusives. The field occurrence, petrography, and some chemical analyses, are dealt with in this part. The chemical analyses are of samples collected for age-determination.

The three granite types are the Finlayson, Trevethan, and Puckley Granites.

FINLAYSON GRANITE

Introduction

The name "Finlayson Granite" is derived from the Mount Finlayson Range, situated about twenty-three miles south of Cooktown. The granite forms several small bodies intruding the Hodgkinson Formation sediments in the south-east corner of the Sheet area (Plate I). The granite crops out over about 50 square miles; the areas of individual intrusions range from small dyke-like bodies of a few hundred square yards up to the large intrusion, 40 square miles in area, that extends south from Big Tableland to the source of Water Melon Creek (Plate II).

The Relationship of the Granite to Topography

In most places the granite forms a bold upland which has a rough trellised drainage that appears to be controlled by jointing. The strongly folded Hodgkinson Formation sediments form hilly topography that has less relief than the granite country, and which has a dendritic drainage. However, in some places, hornfelsed sediments occur as ridges with higher relief than the granite country - e.g., the ridge north of Mount Tolbert, Mount Yates, and Mount Misery. Near Hartley Creek, about two miles north-west of Mount Hartley, hardened sediments overlying nearly horizontal granite contacts have granite-like jointing, so that the drainage pattern is more similar to that of the granite areas than to those of the sediments. The cross-sections shown in Plate III illustrate the topographical relationships of the granite and its country rock.

The Country Rocks

The Finlayson Granite is intruded into the strongly folded rocks of the Hodgkinson Formation; the forms of the intrusions bear little relationship to the tectonic trends of the sediments.

The Hodgkinson Formation sediments consist of slates, sandstones, volcanics, and some conglomerates. Close to the granite contacts, the sediments are somewhat metamorphosed, commonly forming hard, dark rocks in which, in some places, the sedimentary structures have been emphasized by the metamorphism. The width of the metamorphic aureole is hard to estimate because of the irregular attitudes of the contacts; however, it appears to be several hundred yards wide.

The grade of metamorphism in the aureole is not high. A thin section of a hardened sediment collected near Mount Leswell (R.10068) shows a medium-grained, inequigranular greywacke in which angular to sub-angular grains of quartz, chert, and feldspar are enclosed in a recrystallized matrix composed of fine, unstrained flakes of biotite and muscovite.

Nearly vertical sheet-like bodies of quartz keratophyre are present in an area about a mile north of the Jubilee workings. They have a cleavage parallel to that in the sediments, suggesting that they were intruded prior to the folding, and are not, therefore, dykes associated with the granite. Detailed observations at an exposure at the Annan River - Mount Sampson forestry track crossing shows that the bodies were intruded as sills into partly consolidated sediments (Morgan, 1965).

Contact Phenomena

Actual contacts between hornfels and granite are not commonly exposed. Those seen display a variety of attitudes and forms, suggesting that the contacts are irregular.

In the bed of O'Keefe's Creek, about a quarter of a mile west of the present (1961) Big Tableland, tin workings, the contact is sharp and straight, and dips at about 25° to the north-north-east; no xenoliths are enclosed in the granite. In the bed of O'Keefe's Creek, about a hundred yards north of the Lion's Den tin lode, the contact is sharp and irregular, and xenoliths are present in the granite close to the contact, suggesting that stoping has taken place. The contact here dips at about 50° to the north.

Close to the source of Trevethan Creek, just over two miles west-north-west of Mount Amos, the contact is somewhat irregular, and large, blocky xenoliths are enclosed in the granite; the attitude of the contact here is not known.

At the foot of the steep slope immediately north-east of the Moore's Creek workings, two miles south-east of Rossville, the granite contact is roughly horizontal. On the slope, the contact dips steeply north-east, and is covered by a thin shell of hard black hornfels.

Another contact is exposed in Granite Creek, a tributary of the Bloomfield River. The exposure is poor; however, the contact is sharp, and no sign of stoping was noted.

The few exposures observed suggest that the granite contacts are, in general, irregular. This impression is strengthened when granite and sediment outcrops are related to the Queensland Forestry Department's contoured map of the area; this was done by drawing the cross-sections shown in Plate II. From these it can be inferred that the several granite intrusions in this area possibly represent the partly exposed roof-zone of a single large intrusion.

Xenoliths and stoping were observed at only some of the contacts. Away from the contacts, xenoliths are very rarely seen. Because of this, it seems likely that the granite was emplaced by some means other than by stoping.

The Granite

Field Characteristics.

In most places examined in the field the intrusions have a fine - to medium-grained chilled margin of variable thickness that grades inwards to a coarse-grained, commonly porphyritic rock. This relationship was seen, for example, on the ridge between Mount Tolbert and Mount Leswell, in the area east of Mount Poverty, on the western slopes of the Mount Finlayson Range, near Mount Amos, and on parts of Big Tableland (near the source of O'Keefe's Creek). A medium-grained marginal rock was also observed at Granite Creek, the tributary of the Bloomfield River.

In some places, coarse-grained rock extends to within two or three inches of the contact. This was observed in Trevethan Creek, north-west of Mount Amos, and in O'Keefe's Creek, near the Lion's Den tin lode. In the latter place the presence of volatiles may have influenced the grain size; a thin section of a specimen (R.10095) collected here shows evidence of greisenization.

In Romeo Creek, close to the Romeo tin workings, blocks of marginal microgranite appear to have been engulfed in coarse-grained granite.

In the small area either side of the Annan River, about a mile west of Mount Tolbert, microgranite typical of the marginal type forms a series of north-north-westerly trending dykes whose thickness ranges from ten to twenty feet.

Petrology

Modal analyses and some petrographical details of specimens of the marginal and coarse-grained granites are shown in Table 1.

The coarse-grained granites (D55/13/8, R.10064, and 10096 - all shown in Table 1) examined are pale bluish to creamish grey, coarse-grained, and porphyritic. In thin section they are seen to contain microcline-perthite, sodic plagioclase, quartz, biotite, and muscovite. Quartz forms anhedral grains that are moderately to strongly strained. Microcline-perthite occurs as tabular phenocrysts, and in the groundmass is seen to be subhedral and poikilitic; it is slightly to moderately kaolinized, and, in some specimens, is microfractured. Tabular, somewhat strained crystals of plagioclase are slightly sericitized, and their composition lies between An_{10} and An_{20}.

The marginal microgranites found near the contacts in most places are pale grey, granular rocks that commonly weather to dull orange-cream. In some places, such as at O'Keefe's Creek, near the present Big Tableland tin workings, they are almost aphyric, but in most other places they are porphyritic. Specimens R.10069, R.10073, R.10090, and R.10093 are typical examples of this rock, and petrographical details of them are shown in Table 1. In the thin sections, phenocrysts of somewhat embayed quartz, tabular microcline-perthite, and sodic plagioclase are enclosed in a xenomorphic-granular groundmass containing these minerals with, in addition, biotite and, in most specimens, very small amounts of muscovite. Accessory zircon, apatite, sphene, and (?)ilmenite are present.

In some specimens of this type, small rounded tourmaline segregations, measuring up to an inch in diameter, are present. In thin section (R.10093, from O'Keefe's Creek) these are composed of subhedral, irregularly zoned, brown to blue tourmaline and anhedral quartz, and result from the replacement of both plagioclase and microcline.

At Rossville (D55/13/5), Granite Creek (R.10092), and at a locality about a mile south of Mount Poverty (D55/13/9) the marginal rocks have a similar mineralogy to those described above, but are more coarse-grained. Furthermore, specimens D55/13/5 and D55/13/9 show the results of strong straining; in D55/13/5 the quartz shows strong distortion, but there is little or no granulation. In outcrop this rock shows a preferred orientation of phenocrysts roughly parallel to the contact; the straining in this rock may be due to flowage of almost completely solidified magma.

Specimen D55/13/9 shows strong straining and some granulation throughout the rock; this is probably due to the effects of a fault that cuts the granite close to this specimen's locality.

The specimen from the Bloomfield/Granite Creek locality (R.10092) has suffered only slight straining and granulation, followed by some recrystallization.

Late Stage Activity

The formation of small tourmaline-quartz segregations was mentioned above; these are to be seen in O'Keefe's Creek, near the present tin workings, and at the Clearwater Wolfram workings. Near Rossville, tourmaline-quartz segregations measuring up to four feet in diameter were observed. These contain radiating acicular tourmaline crystals enclosed in quartz, some of which is pale pink.

Greisens were not commonly observed in the Finlayson Granite. A 6

TABLE 1. PETROGRAPHIC DETAILS AND MODAL ANALYSES OF SPECIMENS OF FINLAYSON GRANITE.

No.	Grain - sizes		%Phen.	Mineralogy								Locality	Name
	Phen	G'mass.		Qz.	kf	Plagioclase		Bi	Musc.	Accessory	Accessory Minerals		
D55/13/5	15 mm	0.5 mm	16	35.3	31.2	An 25	25.3	7.7	-	0.5	Zircon, black iron oxide	Rossville	Biotite micro-adamellite
D55/13/8	10 "	2.5 "		31.9	42.4	An 20	21.9	2.5	0.7	0.6	Tourmaline, apatite	Mt.Poverty Track	Muscovite-biotite granite
D55/13/9	11 "	0.7 "	23	35.6	20.2	An 10	33.1	6.7	4.1	0.3	Apatite	Mt.Poverty	Muscovile-biotite micro-adamellite
R.10064	4.0"	1.0	Tr	38.8	44.3	An 10	10.9	2.3	1.2	2.4	Tourmaline, zircon, apatite, leucoxene.	Romeo workings.	Muscovite-biotite granite.
R.10069	6.6"	0.15"	19	33.3	30.5	(About (An 20	26.5	7.6	-	2.1	Tourmaline, ziroon, sphene, black iron oxide.	Jubilee track	Biotite-micro adamellite
R.10073	5.0"	0.1 "	21	31.6	32.9	An.15	31.4	3.0	0.9	0.2	Tourmaline, zircon.	Clearwater workings.	Muscovite-biotite micro-adamellite.
R.10090	4.0"	0.6 "	9	34.6	27,1	An.15	31.5	2.0	4.7	0.1	Black iron oxide, zircon, ?)orthite	Half-mile N.W. of Mt.Misery	Biotite-muscovite, micro-adamellite.
R.10092	5.0"	1.2"	18	35.5	19.9	An 27	38.7	5.7	0.2	0.1	Apatite, zircon, (?)orthite	Granite Ck.via Bloomfield Stlment.	Biotite-adamellite.
R.10093	3.3"	1.2"	Tr.	35.6	34.3	An 3	25.0	-	0.5	4.6	Tourmaline, apatite.	O'Keefe's Ck.	Tourmaline-bearing adamellite
R.10094	9.0"	2.5"	-	38.4	39.2	An 20	16.6	Tr.	2.7	3.1	Tourmaline, apatite, leucoxene.	O'Keefe's Creek.	Muscovite-granite
R.10095	-	1to 4"	--	48.0	19.6	An 10	16.7	-	14.4	1.2	Tourmaline, black iron oxide sphene, apatite, zircon.	O'Keefe's Creek.	Muscovite-adamellite
R.10096	-	1.5 to 6 mm.	-	46.0	25.4	An 10	20.0	2.9	5.7	Tr	Zircon	North side of Big Tableland, near source of TrevethanCk.	Biotite-muscovite, adamellite.

Abbreviations: Phen = phenocrysts. G'mass = groundmass. Qz = quartz. Kf = potash feldspar. Bi - biotite. Musc. - muscovite. Tr = trace.

specimen (R.10431) collected from the Collingwood Lode, about two miles south of Rossville was seen, in thin section, to consist mostly of coarse randomly oriented flakes of muscovite and very inequigranular quartz. The quartz and muscovite have almost entirely replaced plagioclase and potash feldspar; some grains of quartz enclose remnants of feldspar that give the impression of having been ramifying veins in quartz. Small amounts of biotite, pleochroic from pale straw to apple green, occurs as small flakes that are interstitial to quartz, and, in places, partly fringe muscovite flakes. Accessory apatite and zircon are present.

Cassiterite is known to occur in thick veins of quartz-tourmaline rock. Such bodies are found at Mount Leswell, the Lion's Den lode, and the Phoenician mine (near Mount Amos). These lodes are all within granite. A quartz-tourmaline dyke devoid of cassiterite, cuts the granite country rock near the Archibald workings, 1½ miles north-north-east of Mount Amos. This body is twenty feet thick, and trends east-west. In thin section (R.10097) the rock is seen to have an average grain-size of 2.5 mm., and to consist of granular, somewhat strained quartz and tabular to poikilitic golden brown tourmaline. No evidence for the replacement of feldspar by tourmaline was seen.

Hornfelses exposed by alluvial mining at the Doloros tin workings, 2¼ miles east north east of Rossville, are cut by thin veins of fine quartz-tourmaline material parallel to the bedding.

At the Clearwater wolfram workings, marginal microgranite is cut by quartz-tourmaline veins, a quarter to one inch thick, that contain small amounts of wolfram. The veins trend north-west, and are two to six inches apart where they are closely spaced; however, there are zones up to six feet wide where they are almost entirely absent. A younger set of veins, containing soft kaolinitic material, cuts the microgranite in a north-easterly direction; these measure between half and two inches in thickness, and are up to four feet apart. The microgranite at this working is strongly weathered, and the wolfram was obtained by sluicing away the soft microgranite.

Some 250 yards south of the present Clearwater workings is an old pit following the course of a four foot-wide, north-westerly trending quartz vein that contains small amounts of tourmaline and wolfram.

Chemistry

A chemical analysis of a specimen of Finlayson Granite (D55/13/5) is shown with its C.I.P.W. norm in Table 2.

TABLE 2. ANALYSIS AND NORM OF D55/13/5

(This specimen was collected a mile north-west of Rossville)

Analysis		Norm	
SiO_2	75.1	Q_3	34.35
TiO_2	0.24	Or	29.21
Al_2O_3	12.7	Ab	27.02
Fe_2O_3	0.36	An	3.86
FeO	1.45	C	0.65
MnO	0.05	En	0.72
MgO	0.29	Fs	2.12
CaO	0.91	Mt	0.54
Na_2O	3.20	Il	0.05
K_2O	4.95	Ap	0.46
P_2O_5	0.10	H_2O	0.69
H_2O+	0.64		
H_2O	0.05		
CO_2	0.03		
Total	100.07		

Analyst: Australian Mineral Development Laboratories, Adelaide.

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TABLE 3.

Chemical analyses and C.I.P.W. Norms of the Mareeba Granite from the Mossman and Atherton 1:250,000 Sheet areas.

A. Analyses

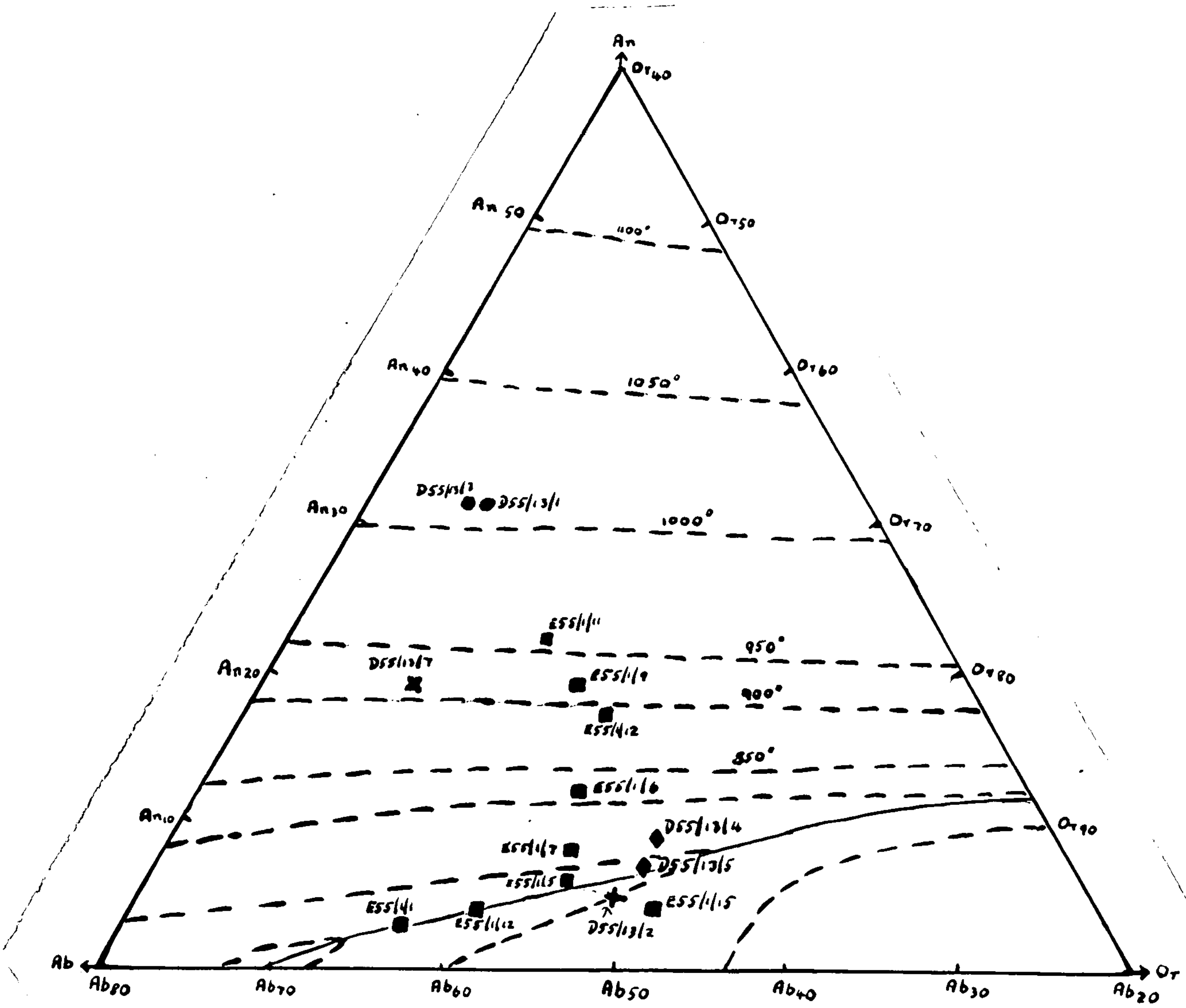
	E55/1/1	E55/1/5	E55/1/6	E55/1/7	E55/1/9	E55/1/11	E55/1/12	E55/1/15	E55/5/2
SiO_2	73.64	75.4	72.7	74.8	71.4	69.2	73.9	77.0	73.02
TiO_2	0.03	0.10	0.25	0.12	0.37	0.46	0.03	0.20	0.11
Al_2O_3	14.40	13.5	14.0	13.8	13.9	14.8	15.1	11.8	14.32
Fe_2O_3	0.48	0.23	0.21	0.34	0.32	0.44	0.19	0.30	0.41
FeO	0.40	1.01	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

Analysts: E55/1/1 and E55/5/2 - S. Baker and A. McLure, B.M.R. E55/1/5, 6, 9, and 11 - H.W. Sears, A.M.D.L. The remainder - C.R. Edmunds and H.W. Sears, A.M.D.L.

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	37.24	31.39	33.67	31.54	29.25	31.83	40.61	35.33
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
C	2.16	2.01	1.10	1.21	0.73	1.58	2.90	1.48	2.05
En	2.24	0.30	1.42	0.82	1.62	4.21	0.20	0.75	2.00
Fs	0.48	1.59	2.83	1.36	4.18	4.22	1.37	2.05	2.94
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
Ap	0.17	0.47	0.31	0.25	0.28	0.40	0.31	0.36	0.17
H_2O	0.84	0.76	0.84	0.43	1.02	1.06	0.60	0.41	0.67

E55/1/1 - Muscovite adamellite, 4 miles south of Mount Carbine.
E55/1/5 - Muscovite-biotite granite, "Southedge".
E55/1/6 - Muscovite adamellite, Mount Lewis Forestry road.
E55/1/7 - Biotite-muscovite adamellite, Lighthouse Mountain.
E55/1/9 - Biotite adamellite, Mount Spurgeon track.
E55/1/11 - Biotite microgranodiorite, 8 miles west of Curraghmore Homestead.
E55/1/12 - Muscovite-biotite microgranodiorite, 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.



D55/A13/30

Figure 1.
Normative An-Ab-Or diagram for specimens of the Mareeba, Finlayson, Treyethan, and Puckley Granites, together with a part of the quaternary system Ab-Or-An-H_2O at 5000 bars H_2O pressure. The clashed lines represent isotherms on the liquidus of the system. The continuous line is the feldspar boundary curve (after Yoder, Stewart, and Smith, 1957).

+ = Mareeba Granite; x = Finlayson Granite; • = Trevethan Granite;
[•] = Puckley Granite; [x] = Granophyric dyke at Black Gap.

For comparison, chemical analyses and C.I.P.W. norms of specimens of the Mareeba Granite are given in Table 3. It will be noted that although the analysis of the Finlayson Granite specimen is somewhat similar to most of those of the Mareeba Granite, it is closely similar to E55/1/15, which was collected near China Camp. Both these sepcimens have low alumina and high potash, when compared with analyses of other samples of Mareeba Granite.

Figure 1 is an An-Ab-Or diagram on which normative anorthite, albite, and orthoclase for specimens of Finlayson Granite and Mareeba Granite are plotted. The positions for analyses of the Trevethan and Puckley Granites are also plotted; these will be discussed in their relevant sections. Most of the specimens of Mareeba Granite trend in a curve from more lime-feldspar rich specimens (E55/1/11) to the soda-feldspar rich ones (E55/1/1). One specimen (E55/1/15 - from China Camp) is much richer in potash feldspar. The plot of the normative feldspar from the Finlayson Granite (D55/13/5) is closer to that of the China Camp specimen than it is to the trend of the plots of the normative feldspars from the main Mareeba Granite. This suggests that the granite intrusion in the China Camp area is more closely related to the Finlayson Granite than it is to the Mareeba Granite.

Faulting

At only one locality has evidence for faulting of the granite been observed. This is on the line of the north-south fault that cuts the granite in the Mount Poverty area. Alluvial mining in the Normanby Workings have exposed a highly sheared and foliated granitic rock. The foliation trends 010° roughly parallel to the trend of the fault as visible on aerial photographs.

Aerial photograph interpretation suggests that two north-westerly trending faults cut the area on either side of Mount Finnigan. However, the margins of the granite, where they cross the fault lines, are not displaced; hence, if the faults are present, they may be older than the granite.

Related Intrusives.

The small acid intrusion that forms Mount Cook and Grassy Hill, and which underlies the eastern part of Cooktown is fairly similar to the Finlayson Granite, and it is suggested that it be included under that name. Another similar granitic rock forms a very small intrusion that crops out two miles west of Mount Piebald, i.e., about sixteen miles north-west of Cooktown.

As in the tinfield area, the country rock is formed of strongly folded Hodgkinson Formation sediments. In the vicinity of Cooktown these consist of sandstones and thin-bedded shales and siltstone. On the foreshore of the headland formed by Grassy Hill, thin-bedded shales and siltstones are seen to be cut by the granite, and, are thermally metamorphosed. A thin section of a metamorphosed siltstone (R.10078) shows the rock to have a fine, granoblastic texture, and to consist of a mosaic of quartz grains with subordinate, randomly oriented biotite flakes. Slight concentrations of biotite flakes mark relic sedimentary structures which, in outcrop, appear to be current bedding. The bedding is cut by thin veins which, in thin section, are seen to consist of quartz; either side of the veins the rock is enriched in biotite, and small crystals of pyralspite garnet and ilmenohematite are present. The fact that the garnet occurs only close to the veins suggests that it is metasomatically emplaced. It has a refractive index of 1.811, and the X-ray spectrograph shows it to contain manganese, indicating it to be a garnet rich in the spessertine molecule.

The granite contacts are sharp and somewhat irregular. They cut across the bedding, but xenoliths are of rare occurrence. On the foreshore near Grassy Hill the contacts have attitudes ranging from horizontal to vertical.

The granite is coarse-grained and porphyritic to within about ten feet of the contact, where it grades into a fine-grained, porphyritic microgranite. In some places, very irregular zones, up to about two feet thick, are present, and consist of coarse-grained granite containing small quartz-tourmaline segregations and a few pegmatitic schlieren. Pegmatite veins, 12 to 18 inches wide, which cut the hornfelsed sediments near the contacts on the Grassy Hill foreshore, are additional evidence of late-stage activity.

TABLE 4

PETROGRAPHIC DETAILS AND MODAL ANALYSES OF SPECIMENS OF FINLAYSON GRANITE FROM GRASSY HILL, COOKTOWN

No.	Grain Sizes		%	Mineralogy							Locality	Name
	Phen.	G'mass	Phen.	Q_3	Kf.	Plagioclase	Bi	Musc.	Accessary	Accessory Minerals		
D55/13/4	8.0	1.5	10	29.7	29.4	31.0	6.9	2.5	0.5	Apatite, zircon, B.1.0.	Cooktown.	Muscovite-biotite adamellite.
R.10065	7.0	1.0	27	32.0	35.9	An_{10} 25.4	0.1	11.1	0.4	Tourmaline	Grassy Hill - dyke.	Muscovite micro-adamellite.
R.10211	6.5	1.25	14	40.3	29.0	27.1	-	3.4	0.2	Zircon	2 miles west of Mount Piebald.	Biotite adamellite.

Some details of the petrography of the granite (D55/13/4 from Grassy Hill, and R.10211, two miles west of Mount Piebald) are shown in Table 4. The specimen from Grassy Hill is a coarse-grained, porphyritic, hypidiomorphic biotite adamellite containing quartz, microcline-perthite, sodic plagioclase, biotite, and uncommon muscovite. Some of the biotite is chloritized. The microcline-perthite contains numerous plagioclase exsolution lamellae, giving it a braided effect. Specimen R.10211 is petrographically similar, except that it contains no biotite. Both specimens contain tabular areas consisting of masses of fine sericite flakes that possibly represent altered plagioclase.

Another specimen (R.11296) from 2 miles west of Mount Piebald is a medium-to coarse-grained adamellite containing xenocrysts and small xenoliths of plagioclase and hornblende.

A vertical dyke, 18 to 24 inches wide, and with a northerly trend, cuts the hornfelsed sediments on the Grassy Hill foreshore. In thin section it is seen to be petrographically similar to the granite (R.10065, Table 4).

Table 5 shows a chemical analysis and C.I.P.W. Norm of D55/14/4. The specimen is plotted on the Or -

TABLE 5.

Analysis and Norm of D55/13/4

Analysis		Norm	
SiO_2	75.40	Q_3	36.82
TiO_2	0.24	Or	27.75
Al_2O_3	12.80	An	4.56
Fe_2O_3	0.18	C	1.33
FeO	1.56	En	1.01
MnO	0.03	Fs	2.37
Mgo	0.40	Mt.	0.26
CaO	1.11	Il	0.45
Na_2O	2.90	Ap	0.41
K_2O	4.70	H_2O	0.67
H_2O+	0.59		
H_2O	0.08		
CO_2	0.01		
Total	100.17		

Analyst: H.W. Sears, A.M.D.L.

Ab-An diagram shown in fig.1. The analysis is very similar to that of the specimen of Finlayson Granite (D55/13/5 - Table 2), and on the diagram in fig. 1, plots fairly close to this specimen.

No mineralization is known to be associated with these intrusions.

A specimen of granite (R.10339) collected by K.G. Lucas from the small intrusion that forms the divide between Slaty and Granite Creeks, east-southeast of Big Tableland, is seen to consist of hornblende-biotite adamellite; apart from the presence of hornblende and the absence of muscovite, the rock is mineralogically and texturally more similar to the Finlayson Granite than it is to the Trevethan Granite. Furthermore, the Trevethan Granite is not responsible for tin mineralization, whereas the intrusion from which this specimen was collected appears to be the source of the alluvial cassiterite in Slaty and Granite Creeks. This intrusion is thus referred to the Finlayson Granite.

Discussion

The Finlayson Granite intrusions appear to be epizonal (Buddington, 1959). They cross-cut the country rock structures in general and in detail. They have a fairly thin, low-grade metamorphic aureole, and a chilled margin is commonly present in the granite.

The method of emplacement is not known. There is little evidence for the country rocks having been pushed aside during intrusion. The paucity of xenoliths within the intrusion, and their uncommon occurrence at contacts suggests that emplacement of the granite was not by stoping.

In the area of the Annan River Tinfield, the Finlayson Granite has been responsible for tin and tungsten mineralization. Tin is still being mined on a small scale from a few alluvial deposits and lodes.

TREVETHAN GRANITE

Introduction

The Trevethan Granite forms a single intrusion that crops out over an area of about 20 square miles in the wide floor of Trevethan Creek valley, about 15 miles south of Cooktown. The formation name of the granite is derived from Trevethan Creek.

Over most of its area, the granite forms a fairly flat alluvium-covered plain on which isolated bouldery hills of granite occur. However, the south-western part of the body forms the Black Trevethan Range; the hills forming this range are merely vast piles of huge granite boulders without soil cover, and with very little vegetation - these hills are very similar to the "metal hills" found in the area between Almaden and Chillagoe, about 100 miles west of Cairns, and which are formed of the Almaden Granodiorite. In fact, the general form of outcrop of the Trevethan Granite - i.e., a flat plain with "metal hills" - is very similar to that of the Almaden Granodiorite in the Chillagoe area. As will be seen later, the petrography of the Trevethan Granite is also similar to that of the Almaden Granodiorite - they are both hornblende-biotite granodiorites.

The reason for the development of these "metal hills" is not clear. It has been suggested by W.B. Dallwitz (pers. comm.) that the hills of Almaden Granodiorite in the Chillagoe area are the exposed parts of gigantic tors, the formation of which began by deuteric alteration of the granite along joint planes. A continuation of this process would form large amounts of altered granite enclosing rounded nuclei of fresh granite. Erosion would remove the altered granite, leaving large tors composed of fresh granite boulders. Linton (1955) has suggested this mode of formation for granite tors in south-west England.

Country Rocks

The Trevethan Granite intrudes strongly folded sediments of the Hodgkinson Formation. The sediments are contact-metamorphosed; on the western side of the intrusion the aureole is about 100 feet wide, and the contact dips steeply to the west. To the north of the granite outcrops, the range culminating in Dowling's Hill (Plate II) is formed of hornfels; hornfels can also be found in the range about two miles north-east of Mount Ellen (5 miles north-west of Dowling's Hill, see Plate II), suggesting that the northern contact dips fairly gently towards the north.

The sediments are metamorphosed to a fairly low grade; a thin section of a semi-pelitic specimen (R.10074) obtained from close to the contact about a mile south-west of the Black Gap shows a granoblastic rock, with an average grain-size of 0.1 mm., containing granular quartz and plagioclase, and sub-poikiloblastic, randomly oriented flakes of brown biotite. Some accessory octahedral black iron ore, and zircon are present. The biotite tends to be chloritized, some of the plagioclase is sericitized, and the black iron ore is partly altered to hematite.

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The Granite

Field Characteristics.

In the field the granite is a pale speckled grey, medium- to coarse-grained, porphyritic rock consisting of feldspar, quartz, biotite, and amphibole. In some specimens, ambphibole phenocrysts have thin veins formed of fine biotite flakes. Xenoliths are not common, and are invariably recrystallized.

About a mile south of the granite/sediment contact near the Mulligan Highway-Trevethan Creek crossing, the granite is fine-grained and porphyritic, suggesting that the contact is nearby, and that, prior to erosion, it dipped gently to the north; this idea is supported by the distribution of hornfels, at Dowling's Hill and farther north, mentioned above (p. 11).

The margin of the granite exposed in Trevethan Creek about a quarter of a mile south-east of the Mulligan Highway crossing is complex, and the contact itself is sharp, but appears to be irregular. In an outcrop over an area of about 10 or 12 square yards, the country rocks are seen to be intruded by a fine-grained, acid porphyry, and to form xenoliths within the porphyry. This porphyry, and the country rocks are, in turn, intruded successively by two more rather more coarse-grained porphyries which contain xenoliths of the other rock-types. The relationship between the three porphyries, and the Trevethan Granite is not seen, but it is possible that the porphyries represent early solidified parts of the granite magma. They contain a few pegmatitic pods, two inches wide and eight inches long, which are connected by thin northerley-trending vertical veins.

Elsewhere in this creek exposure, the country rock is intruded by thin dyke-like bodies of coarse-grained, amphibole-rich, acid igneous rock; the relationship of this (R. 10084, Table 6) rock to the fine- and medium-grained porphyries, and to the main granite, is not seen, but it is suspected that it represents a contaminated or basified variety of the granite.

A poorly exposed contact zone, on the southern margin of the granite, near the source of Trevethan Creek appeared to be equally complex.

Petrography.

Modal analyses and some details of the petrography of the granite and its country rocks are shown in Table 6.

The rock typical of the main part of the intrusion is represented by specimens D55/13/1, D55/13/3, and R. 10066. In general, the specimens are hypidiomorphic-granular and porphyritic, although the percentages of phenocrysts are not high. Plagioclase, occurring as phenocrysts and in the groundmass, forms tabular crystals that show oscillatory zoning and are slightly sericitized. It is zoned from about An_{60} in the cores to oligoclase on the margins. Quartz is interstitial and poikilitic, and is slightly to moderately strained. Brown, partly chloritized biotite forms roughly tabular books, which, in some places, are interstitial to quartz. Very pale green actinolite occurs as phenocrysts and in the groundmass, and forms prismatic crystals that have small, irregular cores of colourless augite, and are partly pseudomorphied by biotite. The augite is an uncommon constituent of the rock. Accessory black iron ore, apatite, zircon, and shpene were noted.

The fine-grained porphyritic rock cropping out a mile south of the granite/sediment contact near the Mulligan Highway - Trevethan Creek crossing is represented by R. 10089 (Table 6). This specimen is sericete/glomeroporphyritic, the phenocrysts of plagioclase, quartz, potash feldspar, and biotite being enclosed in a fine-grained groundmass composed mostly of tabular plagioclase and micrographically intergrown quartz and potash feldspar. The modal analysis (Table 6) shows no amphibole in the thin section; the few crystals of altered amphibole are seen to be entirely pseudomorphed by clusters of randomly oriented biotite flakes.

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TABLE 6

PETROGRAPHIC DETAILS AND MODAL ANALYSES OF SPECIMENS OF TREVETHAN GRANITE

No.	Grain-sizes: Phen.	Grain-sizes: G'mass	% Phen.	Mineralogy: Q_3	Kf	Plagioclase: Comp.	Plagioclase: %	Bi.	Act. & Px	Accessory Minerals: %	Accessory Minerals: Minerals	Locality	Name
D55/13/1	6.5mm	1.7mm	9	27.8	6.8	An_{58}	42.8	18.1	4.5	Tr.	Zircon, apatite, sphene.	Half mile north of Helenvale turn-off, on Mulligan Highway.	Actinolite-biotite granodiorite.
D55/13/3	4.5mm	1.6mm	16	22.6	7.3	An_{58}	52.5	12.6	5.0	Tr.	Black iron oxide, apatite, zircon.	Black Mountain.	Actinolite-biotite granodiorite.
R.10066	4.0mm	1.5mm	5	27.0	0.7	An_{40}	45.2	19.7	7.1	0.3	Zircon.	Trevethan Creek, quarter mile south of Mulligan Highway bridge crossing.	" " "
R.10083	5.5mm	0.75mm	13	14.2	4.0	An_{58}	45.5	16.1	19.9	0.5	Black iron ore, zircon, apatite.	" "	Biotite-actinolite granodiorite.
R.10084	-	0.3mm	-	13.6	-	An_{60}	44.7	13.9	25.8	1.8	Black iron ore, apatite.	" "	Biotite-actinolite quartz micro-diorite.
R.10085	1mm	0.3mm	0.6	36.8	3.4	Oligo-clase	34.3	25.4	-	0.1	Black iron ore.	" "	Biotite micro-granodiorite.
R.10086	3.5mm	0.4mm	9	36.2	0.8	An_{50}	38.3	24.4	-	0.2	Apatite, zircon.	" "	Biotite micro-granodiorite.
R.10087	3.5mm	1.1mm	Tr	21.3	-	An_{50}	41.2	21.8	14.7	1.0	Black iron ore, apatite.	" "	Actinolite-biotite micro-granodiorite.
R.10089	3mm	0.1mm	38	17.0	14.6	An_{45}	56.6	11.8	-	Tr.	Black iron ore, zircon, apatite.	1 mile south of Mulligan Highway bridge crossing, in Trevethan creek.	Biotite micro-granodiorite.

Abbreviations:- Phen. - phenocryst; G'mass - groundmass; Q_3 - quartz;
Kf. - potash feldspar; Bi. - biotite; Act. - actinolite;
Px. - pyroxene; comp. - composition; Tr. - trace.

Specimens collected from the complex contact-zone described are R.10084, R.10085, and R.10086, and are shown in Table 6. Specimen R.10084 appears to be a quartz microdiorite. In thin section it is seen to contain randomly oriented laths of labradorite, prismatic pale green actinolite, and poikilitic biotite, together with irregularly distributed pools of poikilitic quartz. This specimen probably represents a very early, somewhat basic phase of the Trevethan Granite that had solidified prior to the emplacement of the later, more acid phases.

The quartz micro-diorite is intruded by the rock represented by R.10085, which is a dark grey, fine-grained, sparsely porphyritic specimen. In thin section it contains anhedral quartz and plagioclase, with interstitial biotite and potash feldspar. This is intruded by another porphyritic rock, represented by R.10086, which, in section, is seen to have a fine-grained groundmass of granular quartz and plagioclase, tabular to interstitial biotite, and small amounts of interstitial potash feldspar. Clusters of fine biotite flakes may represent pseudomorphed amphibole. The phenocrysts consist of tabular labradorite showing oscillatory zoning. These two specimens, together with R.10084 (described above) have higher colour indices and lower potash feldspar content than the typical specimens of Trevethan Granite (Table 6); the specimens are probably early, more basic phases of the granite.

Specimens R.10083 and R.10087 are more coarse-grained rocks from the complex contact locality in Trevethan Creek, and form small bodies that intrude the sedimentary country rocks. They have a higher colour index than the typical rocks from the main part of the intrusion (Table 6).

Thus, to summarize the petrography, the Trevethan Granite mostly on actinolite-biotite granodiorite. Specimens from the tin, complex contact-zones show that small amounts of somewhat more basic quartz dioritic rocks were emplaced prior to the main intrusion. It is not known whether or not these more basic types are the result of contamination with country rocks at depth, or of hybridization of basic and acid magmas.

Chemistry.

Two chemical analyses and C.I.P.W. norms of age-determination samples are shown in Table 7. The analyses are quite similar to those of the Almaden Granodiorite (Morgan, 1964). The normative feldspars calculated from these analyses are plotted in Fig.1. The two rocks are richer in intermediate to basic plagioclase than the Finlayson and Mareeba Granites; they also lie on a prolongation of the Mareeba and Finlayson Granite trend. The petrogenetic significance of this is not clear, although it may indicate basification of acid magma by basic magma prior to the emplacement of these rocks. Contamination of granitic magma by sediments is considered to be less likely when the nature of the Hodgkinson Formation, which forms the country rock to the intrusion, is taken in to account. This formation consists mostly of greywackes and slates; limestone is uncommon.

Associated Dykes

Described here are three dykes that are petrographically similar to the Trevethan Granite. At each locality, the dykes intrude Hodgkinson Formation sediments; their actual field relationship to the Trevethan Granite is not known.

The dykes crop out at Bald Hill, at a locality about a mile north-east of the Trevethan Creek crossing. They both consist of grey to dark grey, feldsporphyric rocks in which the phenocrysts are enclosed on aphanitic groundmass.

The third dyke is exposed in a road cutting on the Mulligan Highway, and is a composite body. The total width of the dyke is about 120 yards. The central part, roughly 100 yards wide, is composed of a dark grey felds-porphyric rock with a fine-grained groundmass. This has sharp, vertical, but somewhat irregular, contacts on either side with a medium-grained, aphyric quartz-dioritic rock which forms the marginal parts of the composite dyke. 17

TABLE 7

CHEMICAL ANALYSES AND C.I.P.W. NORMS OF TREVETHAN GRANITE

D55/13/1 Analysis		Norm		D55/13/3 Analysis		Norm	
SiO_2	65.9	Q_3	21.42	SiO_2	66.6	Q_3	22.82
TiO_2	0.63	Or	15.99	TiO_2	0.59	Or	15.99
Al_2O_3	14.6	Ab	25.19	Al_2O_3	14.9	Ab	26.20
Fe_2O_3	0.50	An	18.78	Fe_2O_3	0.35	An	18.79
FeO	3.95	Di	2.66	FeO	3.75	Di	2.63
MnO	0.05	Hy	11.91	MnO	0.07	Hy	11.69
MgO	2.95	Mt.	0.72	MgO	2.45	Mt.	0.59
CaO	4.60	Il	2.00	CaO	4.65	Il	1.12
Na_2O	3.00	Ap	0.44	Na_2O	3.10	Ap	0.41
K_2O	2.70	H_2O	0.75	K_2O	2.70	H_2O	0.67
P_2O_5	0.18			P_2O_5	0.18		
H_2O+	0.65			H_2O+	0.59		
H_2O-	0.09			H_2O-	0.08		
CO_2	0.04			CO_2	0.08		
	99.84				100.09		

D55/13/1. Actinolite-biotite granodiorite. Mulligan Highway, half a mile north of the Helenvale turn-off.

Analyst: Australian Mineral Development Laboratories, Adelaide.

D55/13/3. Actinolite-biotite granodiorite. Mulligan Highway, one mile north of the Black Gap.

Analyst: Australian Mineral Development Laboratories, Adelaide.

The quartz-dioritic marginal rock shows no chilled borders against the feldsporphyre; however, the number of phenocrysts in the feldsporphyre decreases towards the contacts, suggesting that the rock occurring in the centre is probably younger than the marginal quartz-dioritic rock.

Some details of the petrography of these dykes are shown in Table 8. The dyke occurring near the Phoenician tin mine (R.10215) is porphyritic, with a hypidiomorphic-granular groundmass. It contains phenocrysts of tabular labradorite, with somewhat rounded margins, and prismatic actinolitic hornblende. Colourless augite phenocrysts are not common, and are largely replaced by actinolitic hornblende. The groundmass consists of andesine, biotite, quartz, and hornblende; biotite also forms small flakes around amphibole phenocrysts. Accessory apatite, leucoxene, and black iron ore are present.

Specimen R.10225 was collected from the dyke on Bald Hill, and is an augite-biotite-actinolite tonalite. It is porphyritic, with phenocrysts ranging up to 5 mm. across; these are enclosed in a groundmass with an average grain-size of 0.05 mm. Mineralogically, this rock is roughly similar to R.10215, except that augite phenocrysts are more abundant, and that pseudormorphs after probable orthopyroxene are present. These pseudomorphs are prismatic, and consist of a colourless, fibrous amphibole. A modal analysis was not made on this specimen because the groundmass was too fine-grained for accurate work.

The porphyritic rock forming the central part of the composite dyke (R.10081) is texturally and mineralogically similar to the two specimens described above, except that no pyroxene is present, and the groundmass is coarser-grained. The rock forming the marginal parts of the dyke (R.10082) is mineralogically similar, but is much coarser-grained, and has only a few phenocrysts. Augite is present in minor amounts, forming irregular relics enclosed in hornblende. The modal analysis shows that it has a much higher colour index than the other dyke rocks, and that it contains more hornblende than biotite.

SUMMARY

The Trevethan Granite is an actinolite-biotite granodiorite that intrudes middle Palaeozoic sediments, and has rather complex contact zones. The composition of the marginal phases suggests that the granite may have formed by magmatic hybridization. Associated with the granite are some microdioritic and tonalitic dykes.

The granite intrusion is epizonal; it cuts across the country rock structures in detail and in general, and a fairly narrow, low-grade metamorphic aureole is present.

The age relationship of the Trevethan Granite to its neighbour, the Finlayson Granite, can not be established as no contact between the two can be seen in the field.

PUCKELY GRANITE

Introduction

The Puckley Granite crops out in separated areas in the centre and north-central part of the Cooktown 1:250,000 Sheet area. For the most part, the granite is covered by Mesozoic sediments. Farther south, basalt may cover some granite in the "Springvale" - "Butchers Hill" area. The partly uncovered granite outcrops may form parts of a single intrusion, but it is also possible that these are a series of related intrusions. The granite outcrops cover a total area of about 50 square miles.

The granite forms low craggy hills that are like islands rising though the unconformably overlying Mesozoic sediments. The hills have poor vegetation, and the slopes abound in large and small boulders of fairly fresh granite.

TABLE 8

DYKES ASSOCIATED WITH THE TREVETHAN GRANITE.

No.	Phen.	G'mass	% Phen.	Q_3	Kf.	Plagioclase		Bi.	Am.	Accessory	Accessory Minerals	Locality	Name
R.10081	10	0.3	39	6.8	-	An_{65}	61.5	20.0	6.3	2.5	Apatite, black iron ores. (Epidote = 2.8%).	Mulligan Highway, 1½ miles north-east of Trevethan Creek Crossing.	Hornblende-biotite microdiorite.
R.10082	3.6	1.5	Tr.	10.7	-	An_{60}	43.1	8.1	37.6	0.5	Apatite, black iron ore.	" " "	Biotite-hornblende tonalite.
R.10215	4.0	0.1	45	5.4	10.9	An_{60} (Phen) An_{40} (g'mass)	64.8	14.6	2.8	1.4	Apatite, leucoxene, black iron ore.	1 mile north-north-east of the Phoenician tin mine.	Hornblende-quartz-biotite micro-diorite.

* The small amounts of augite are included with amphibole.

Phen. : phenocryst; G'mass : groundmass; Q_3 : quartz;

Kf. : potash feldspar; Bi.: biotite; Am : amphibole.

The formational name is derived from Puckley Creek, a moderately-sized water-course that crosses the granite about 30 miles west-north-west of Cooktown.

Country Rock

The granite intrudes strongly folded Hodgkinson Formation sediments. Near the contact, thermal effects have caused slight metamorphism. A specimen of the hornfels (R.10203) collected near the former Cooktown-Laura railway, on the Battle Camp Range, is, in thin section, seen to be a fine-grained, recrystallized feldspathic sandstone. Grain-sizes range from 0.01 mm. to 0.75 mm. The rock contains sub-angular, partly recrystallized grains of quartz (60%), anhedral grains of lightly to moderately kaolined plagioclase and potash feldspar (35%), and small amounts of sericite and biotite. Biotite is partly replaced by green chlorite. Accessory minerals are tourmaline, zircon, and apatite. Cubes of pyrite with associated calcite are also present.

The Granite

Field and Petrographic Characteristics.

The granite forms low hills, largely covered with rounded boulders which are partly obscured by soil and vegetation. In hand specimen the granite is a hard, pale grey, coarse-grained porphyritic rock which, on weathering, becomes friable, and is stained reddish-brown by iron oxides.

Table 9 shows modal analyses and some petrographical details of two specimens (D55/13/7 and R.10099). The rocks are biotite adamellites. They are hypidiomorphic-granular and porphyritic. Quartz forms single or multigrain areas that are poikilitic, and show some straining. The potash feldspar is perthite; it encloses plagioclase, biotite, and quartz. Perthite also forms the phenocrysts; these are roughly tabular, but on their margins they poikilitically enclose other minerals. Plagioclase occurs as slightly to moderately sericitized, tabular crystals that show fairly strong oscillatory zoning. It is zoned from calcic andesine to oligoclase. Phenocrysts of this mineral are present but not common. Biotite occurs as subhedral flakes which are pleochroic, in D55/13/7, from straws to fox-brown, and in R.10099, from pale to very dark brown. Accessory zircon and apatite are present. The Puckley Granite is thus petrographically distinct from the Finlayson Granite in that it contains more calcic plagioclase and orthoclase instead of microcline.

Xenoliths are rare in the granite; those seen are recrystallized and fine- to medium-grained. One specimen (R.10505) had a thin section cut across the contact between granite and the xenolith. The granite close to the xenolith is equigranular, and has a grain-size of 1.35 mm. The contact with the xenolith is sharp, and there is only a slight tendency for the granite minerals to occur interstitially to the xenolithic minerals. The xenolith itself is divided into layers of differing grain-size that appear to be a relict bedding. The average grain-size range from 0.15 mm. to 1.0 mm. from layer to layer. In every layer, the texture is granoblastic, and the rock consists of sodic plagioclase, quartz, and randomly oriented biotite.

The contacts of the granite with its country rock are poorly exposed, and it is not known whether or not the granite has a chilled margin, or if the contact is sharp. However, judging from the low grade of the metamorphic aureole, the contact is unlikely to be of the diffuse type associated with low-level granites.

Chemistry.

A chemical analysis of an age-determination sample of Puckley Granite is shown, with its C.I.P.W. norm, in Table 10.

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TABLE 9.

PETROGRAPHIC DETAILS AND MODAL ANALYSES OF SPECIMENS OF PUCKLEY GRANITE

No.	Grain - sizes.		% Phen.	Mineralogy							Locality	Name
	Phen.	G'mass.		Qz	Kf.	Plagioclase		Bi.	Accessory			
						comp.	%		%	Minerals		
D55/13/7	7.0	2.5	11	27.9	25.6	An_{40}	37.6	8.5	0.3	zircon, apatite	Half mile south of intersection of Old Palmer road and Cooktown/ Laura railway.	Biotite adamellite.
R.10099	7.5	3.5	8	37.6	19.3	An_{50}	30.3	12.0	0.8	zircon, apatite.	36 miles north-west of Cooktown.	Biotite adamellite.
R.10076	-	0.5	-	32.5	38.7	Sodic oligoclase	27.9	0.9	Tr.	zircon, apatite.	Battle Camp Range.	Aplite.

Abbreviations: Phen. : phenocryst; G'mass : groundmass; Q_3 : quartz:
Kf. : potash feldspar; Bi.: biotite.

TABLE 10.

ANALYSIS AND C.I.P.W. NORM OF D55/13/7

Analysis		Norm	
SiO_2	73.5	Q_3	32.63
TiO_2	0.23	Or	17.82
Al_2O_3	13.9	Ab	33.05
Fe_2O_3	0.21	An	11.65
FeO	1.89	C	0.28
MnO	0.03	En	1.02
MgO	0.41	Fs	2.96
CaO	2.46	Mt.	0.31
Na_2O	3.90	Il	0.44
K_2O	2.95	Ap	0.21
P_2O_5	0.08	H_2O	0.43
H_2O+	0.31		
H_2O-	0.12		
CO_2	0.05		
	100.04		

Half mile south of intersection of the Cooktown-Laura railway and the old Palmer Road.

Analyst: Australian Mineral Development Laboratories, Adelaide.

The chemical analysis is roughly similar to those of the Finlayson Granite. The most significant differences are that the Puckley Granite is richer in lime and soda, and poorer in potash, than the Finlayson Granite. The plot of the normative feldspars is shown on Fig.1. It is seen to be well away from the Mareeba Granite-Finlayson Granite trend, suggesting, therefore, that the Puckley Granite is not closely related to these granites.

Associated Dykes

Two petrographically distinct rock types occur as dykes intruding the granite in the Puckley Creek area. These are aplites and fine-grained porphyries.

The widths of the aplite dykes range from a few inches to 30 feet. The thinner dykes form veins intruded along vertical and horizontal joint planes in the granite. The thicker ones form part of a minor dyke swarm that trends at about 110°. Under the microscope these rocks are typical aplites, with a roughly saccharoidal texture, containing orthoclase, quartz, sodic plagioclase, and minor quantities of biotite. A modal analysis of one specimen (R.10076) is shown in Table 9.

The fine-grained acid porphyry dykes also trend at about 110°, and range up to 30 feet thick. A thick dyke examined in the bed of Puckley Creek was flow-lined at its margins, and massive in its centre. The porphyries have coarse phenocrysts enclosed in a fine-grained aphanitic groundmass. In thin section (e.g., R.10103 and R.10104) they are seriate porphyritic; grain-sizes range from 0.03 mm. in the groundmass to 5 mm. in phenocrysts, which consist of quartz (35%), potash feldspar (20%), plagioclase (40%), biotite (5%), and (in R.10104) small amounts of muscovite. Accessory minerals are apatite, zircon, and (in R.10104) brown tourmaline. Quartz forms embayed phenocrysts, and is interstitial to granular in the groundmass. Tabular crystals of plagioclase (sodic oligoclase zoned to albite) occur as phenocrysts and in the groundmass; they show some sericitization. Potash feldspar forms small tabular phenocrysts in R.10103, and occurs interstitially in the groundmass of both rocks. Biotite flakes are mostly chloritized in both rocks. Muscovite occurs as small flakes in the groundmass of R.10104.

The Post-Granite Unconformity

The unconformity between the granite and the overlying Mesozoic sediments was examined in the Puckley Creek area. The unconformity is extremely irregular, the granite forming islands against which the sediments abut and which they overlap. At outcrop scale, the unconformity is also very irregular, the granite forming small tor-like features that have been buried in the sediment. The sediment immediately overlying such features is composed of pebbly and bouldery coarse arkosic sandstones, the pebbles and boulders consisting of somewhat weathered granite, and vein quartz.

In some places there is a weathered zone within the granite beneath the unconformity; this zone occurs generally close to the unconformity, and so appears to be a pre-Mesozoic weathering zone. This weathering has made the granite soft and friable, so that where granite occurs beneath a scarp slope of the sediment, the granite itself forms a considerable part of the scarp.

It is evident that the granites were probably more or less covered by the sediments at one time. In one or two places, boulders of sandstone rubble were found over granite outcrop some 300 yards uphill from the main scarp outcrop of the Mesozoic sandstone.

Around the granite outcrop in the north centre of the Sheet area, thirty-six miles north-west of Cooktown, the association of well-jointed sandstones overlying well-jointed granite seems to have favoured natural water storage. Even after two or three poor "wet" seasons, deep but narrow streams of absolutely clear water were still flowing. That this place has consistently been well-watered is suggested by the presence of aboriginal cave paintings in the area.

Summary and Notes

The Puckley Granite is a biotite adamellite that intrudes middle Palaeozoic sediments, and is overlain by Mesozoic sediments. Petrography and chemical analysis show that the granite is distinct from the Finlayson and Trevethan Granites. Associated with the granite is a small swarm of aplite and porphyritic microgranodiorite dykes.

The age of the granite is probably late Palaeozoic; a sample has been submitted for radio-active age-determination.

No economic mineral deposits are at present worked around the Puckley Granite. At one time, however, some alluvial cassiterite was obtained from the granite area, close to the Cooktown/Laura railway, near Puckley Creek.

MINOR INTRUSIVE ROCKS

Introduction

Dyke rocks associated with the Trevethan and Puckley Granites have been described in earlier parts of this report. This section deals with some dolerites and two varieties of acid porphyry dykes that occur in the Annan River Tinfield area. The age of these intrusions is not clear. The dolerites and one variety of the acid porphyry intrude Hodgkinson Formation sediments and the Trevethan and Finlayson Granites; the other type of acid porphyry intrudes the Hodgkinson Formation and the Trevethan Granite. These dykes have been observed only in the Tinfield area, so that it is quite possible that they are associated with the major intrusive igneous activity in this area and thus may be referred to the late Palaeozoic. No igneous activity has been noted in the Mesozoic sediments, and the dolerite dykes are, petrographically, quite distinct from the Tertiary olivine basalts that are found in the Tinfield and the Butcher's Hill area.

Some erratic pebbles of lamprophyric rocks were found, and these are also described in this section.

Dolerite

Modal analyses and some petrographical details of specimens from the dolerite dykes are given in Table 11.

A dolerite dyke that intrudes Trevethan Granite about 4 miles north-west of Mount Amos is vertical, and trends 165°. It is 10 to 12 feet wide, and is medium-grained but has thin chilled margins. Small dykes of dolerite, 6 inches to a foot wide, intrude the granite parallel to the main dyke, and within 3 feet of it. A thin section of a specimen (R.10080) from the dyke is seen to be aphyric. Clear plagioclase laths are randomly oriented in the fashion typical of dolerites, and are "sub-ophitically" enclosed by sub-prismatic crystals of hornblende. The hornblende is pleochroic with X = very pale yellow, Y = pale olive green, and Z = pale bluish green. Minor quantities of biotite are associated with the hornblende. In some places, small, very irregular crystals of colourless pyroxene are enclosed in hornblende. Black iron ore is octahedral, and apatite is prismatic.

The Finlayson Granite is intruded by a thin dyke of partly uralitized dolerite in the vicinity of Gap Creek, about 2 miles north-east of Mount Finnigan. The dyke trends north-west, and is vertical. A thin section of specimen R.10091 shows that the rock contains a few phenocrysts of tabular, embayed plagioclase enclosed in a fine- to medium-grained, ophitic groundmass. Randomly oriented plagioclase laths are zoned from calcic labradorite to andesine, and are ophitically enclosed by very pale green augite that is partly replaced by pale bluish-green actinolite and some chlorite.

The dyke intruding Hodgkinson Formation sediments at Archer Point is 15 feet wide, and dips at 60-65° to the west. It contains a few scattered feldspar phenocrysts that are aligned parallel to the contact. A thin section (R.10216) shows that the rock is very similar to R.10080 (the specimen collected from the Mount Amos track), except that it is sparsely porphyritic, and that it contains some interstitial chlorite that, in places, fills microfractures in plagioclase. One or two grains have a serpentine-like arrangement of chloritic minerals, and may represent crystals of pseudomorphed olivine.

Two parallel, north-westerly trending dolerite dykes crop out in the Normanby River near Mount Poverty. One is 3 feet wide, and the other 4 feet, and they are 18 inches apart. A specimen (R.10234) from one of them shows, in thin section, a sparsely porphyritic rock containing an interlacing meshwork of plagioclase laths prismatic crystals of very pale violet titaniferous augite which are partly replaced by small pale brown flakes of biotite. Pale green fibrous actinolite occurs interstitially. Thin veins are filled by a somewhat fibrous, pale bluish-green amphibole.

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TABLE 11

PETROGRAPHIC DETAILS AND MODAL ANALYSES OF SPECIMENS FROM DOLERITE DYKES

No.	Grain-sizes: Phen.	Grain-sizes: G'mass	Mineralogy: Plagioclase comp.	Plagioclase %	Px.	Am.	Bi.	Chlor.	Acc.	Accessory Minerals	Locality	Name
R.10080	-	0.5	An_{50}	45.0	-	43.6	2.1	-	9.3	Black iron oxide, apatite.	Mt. Amos track, 4 miles north-west of Mount Amos.	Hornblende dolerite.
R.10091	1.0	0.4	An_{68}	25.0	46.0	27.0	-	-	2.0	Black iron oxide, apatite.	Gap Creek, 9 miles north-north-west of Bloomfield.	Partly uralitized dolerite.
R.10216	2.5	0.75	An_{64}	46.9	-	41.2	3.2	1.3	7.4	Black iron oxide, sphene.	Archer Point	Uralitized dolerite.
R.10234	2.0	0.3	An_{60}	38.6	14.2	3.0	39.9	-	4.2	Black iron oxide, sphene.	Normanby River, near Mount Poverty.	Augite-biotite dolerite.

Abbreviations: Phen.: phenocryst; G'mass: groundmass; comp.: composition; Px.: pyroxene; Am.: amphibole; Bi.: biotite; chlor.: chlorite; Acc.: accessory.

These dolerites all appear to be related in that they contain fairly substantial quantities of hydrous ferro-magnesian minerals (hornblende and biotite) replacing the original pyroxene. This alteration os hydrothermal, and due to late stage activity in the dolerite, and not to metamorphism.

Granophyric Dykes

Several strongly porphyritic acid dykes with northerly and north-westerly trends were seen to intrude the Hodgkinson Formation and the Trevethan and Finlayson Granites at several localities. A specimen (D55/13/2) from the dyke intruding Trevethan Granite at the Black Gap is seen, in section, to be a porphyritic and granophyric biotite micro-adamellite, containing quartz (35%), potash feldspar (30%), plagioclase (30%), and biotite (5%). The phenocrysts measure up to about 5 mm. across, and are enclosed in a fine-grained, granophyric, groundmass of average grain-size about 0.1 mm. The phenocrysts consist of somewhat embayed quartz, tabular microcline-perthite and oligoclase, together with biotite. In the groundmass quartz and potash feldspar are micrographically intergrown, and plagioclase is tabular. Biotite forms thin flakes. Phenocryst and groundmass biotite is moderately to strongly chloritized. Accessory apatite, black iron oxide, and zircon are present.

TABLE 12.

CHEMICAL ANALYSIS AND C.I.P.W. NORM OF D55/13/2

Analysis		Norm	
SiO_2	76.70	Q_3	38.78
TiO_2	0.19	Or	26.69
Al_2O_2	12.10	Ab	26.72
Fe_2O_3	0.19	An	2.78
FeO	1.34	C	1.02
MnO	0.04	En	0.60
MgO	0.23	Fs	1.85
CaO	0.90	Mt.	0.23
Na_2O	3.15	Il	0.46
K_2O	4.50	Ap	0.34
P_2O_5	0.09	Cc	0.30
H_2O+	0.40	H_2O	0.46
H_2O-	0.06		
CO_2	0.11		
	100.00		

Analyst: Australian Mineral Development Laboratories, Adelaide.

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A chemical analysis of D55/13/2 (an age-determination specimen) is shown in Table 12. The analysis is very similar to those of the Finlayson Granite (D55/13/5, Table 2, and D55/13/4, Table 5). The normative feldspars are plotted in Fig.1; they are slightly less rich in anorthite than those from the Finlayson Granite specimens, and richer in normative orthoclase than those from the Mareeba Granite. The diagram indicates that the dyke is probably related to the Finlayson Granite.

Porphyritic Alkali Microgranite

Two dykes of this rock-type are known in the Annan River area. One crops out in the bed of the Annan River, about a quarter of a mile north of the Mulligan Highway crossing; it is sixty feet wide, trends west-north-west, and intrudes Hodgkinson Formation sediments. The other dyke intrudes the Trevethan Granite in an area about three miles west-north-west of Mount Amos and trends east-south-east. In hand specimen and thin section (R.10218 and R.10340 respectively) the rocks are very similar to each other. The hand specimens are pale creamish-grey, and have numerous phenocrysts of quartz, feldspar, and white mica enclosed in an aphanitic groundmass. In thin section, the phenocrysts are seen to measure up to 5 mm. across, and are enclosed in a xenomorphic-granular groundmass of average grain-size 0.01 mm. in R.10218, and 0.04 mm. in R.10340. The phenocrysts consist of embayed quartz, tabular crystals of potash feldspar (moderately kaolinized) and albite (partly sericitized), and muscovite flakes. In R.10340 some biotite is intergrown with muscovite. The groundmass contains tabular to granular sodic plagioclase, interstitial quartz and potash feldspar, together with fine flakes of muscovite. Accessory colourless garnet forms embayed grains in the groundmass and enclosed in some phenocrysts; the mineral is present in both specimens. Zircon and black iron oxide are also present.

Lamprophyre

At Archer Point, and in one or two of the creeks draining southwards from Dowlings Hill, some rounded pebbles of dark greenish-grey, finely porphyritic rock were found. Although a search was made, none was seen in outcrop. However, it is possible that this rock forms dykes or some other type of small intrusive body intruding Hodgkinson Formation sediments. In hand specimen, the rock has small acicular amphibole phenocrysts enclosed in an aphanitic groundmass. In thin section it is seen to be a spessartite; it has phenocrysts of brownish-green amphibole enclosed in a fine-grained felted groundmass consisting mostly of flow-oriented plagioclase laths that measure about 0.15 mm. by 0.03 mm. Small amounts of hornblende and biotite, together with some potash feldspar, are also present. Apatite, leucoxene, and rutile are accessory.

THE LATE PALAEOZOIC IGNEOUS ACTIVITY

All the igneous rocks so far described are intruded into the Middle Palaeozoic Hodgkinson Formation sediments. Jurassic sediments overlie the Puckley Granite, and there is no evidence that any igneous activity accompanied the Mesozoic sedimentation, so that the intrusions are, on field evidence, older than the Jurassic. Radio-active age determinations on specimens of Finlayson Granite, Trevethan Granite, Puckley Granite and the granophyric micro-adamellite dyke show that these bodies are of Middle to Upper Permian age. It is not yet known whether these determinations show the actual date of emplacement, or are a reflection of some tectonic activity; however, there is no field evidence for any thorough-going post-consolidation tectonism in the granites.

THE NORMANBY FORMATION

The Normanby Formation crops out in three narrow, northerly-trending areas west of Cooktown. The most northerly outcrop is immediately west of Mount Rose; the central one occurs across the disused Cooktown - Laura railway line, about 20 miles west of Cooktown; the southern outcrop extends from Oaky Creek to Kings Plains, about 22 miles west of Archer Point.

The formation occurs in narrow faulted blocks, each about a mile wide, and ranging between 3 and 8 miles long. The rocks in each of the blocks are steeply dipping, and their strike is parallel to the northerly trending boundary faults of the blocks.

The formation consists of Permian terrestrial rocks - sandstone, shale, and coal, together with some volcanics. Little is known of the formation, but it is thought that the volcanics form the top of the succession.

The volcanics consist of aphanitic acid lava flows together with some volcanic breccias. Some of the lavas are flow-banded and, in places, autobrecciated. Thin sections of two specimens showed that the flows consist of felsite. Joints in some flows are filled with quartz veins.

CAINOZOIC ALKALINE BASATLS

Introduction

No igneous activity is known to have occurred during Mesozoic times. In Tertiary times the landscape was formed roughly as it is at present, some gravels were laid down, and the alkaline basalts were erupted as flows, cinder cones, and composite cones.

In the Cooktown 1:250,000 Sheet area, two formations of alkaline basalt are distinguished. The MacLean Basalt crops out in the south and south-east of the area; the Piebald Basalt occurs in the north-east. In this report a brief account of the field and petrographic characteristics of the basalts is given, and a comparison is made with the Cainozoic basalts that occur south of the area, in the Cairns Hinterland (Best, 1960; Morgan, 1961b).

THE MACLEAN BASALT

Introduction

The MacLean Basalt crops out over an area of about 130 square miles in the southern and south-eastern parts of the Sheet area. It extends from the southern border of the Sheet area northwards to "Springvale", and from Mount Amy in the east to a point some forty miles westward. The main body of the basalt underlies the flat plain of the Butcher's Hill - Mount MacLean area; the remainder forms smaller outliers around this, and extending southwards into the Mossman 1:250,000 Sheet area. There are also about three outcrops of Cainozoic basalt in the Annan River Tinfield, near Shipton's Flat (Plate 2); these are included with the MacLean basalt.

Field Characteristics

The basalts occur as near horizontal flows tending to fill valleys and form plains, as in the Butcher's Hill area; also they occur on dissected plateaux in the Byerstown Range and Racecourse Mountain areas. The dissection of these plateaux has taken place since the basalts were erupted; small patches of basalt remain perched as caps on hilltops in the hilly country around Racecourse Mountain, near the northern border of the Mossman 1:250,000 Sheet area. In some places, such as Mount MacLean, the basalts are intersected by vents that have formed lava and cinder cones of basalt overlying the flows. Some localities at which the basalts were examined in the field will be described in the following paragraphs.

About 4 miles south-east of "Springvale", a small mesa consists of four flows of fine-grained and porphyritic basalts that have thicknesses ranging between six and seventy feet, with a thirty feet bed of bouldery gravel lying between the two flows (Fig. 2). The outcrops at this locality are not good;

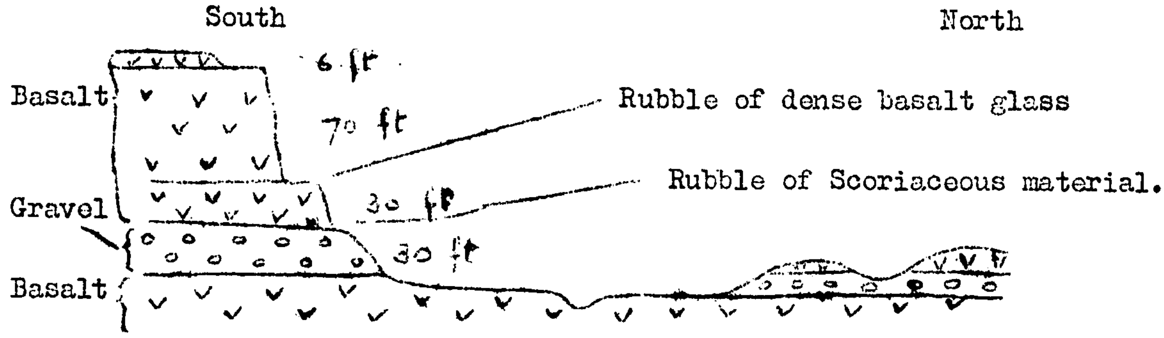

Fig. 2: Sketch showing the succession 4 miles south-west of "Springvale"

the junctions between flows can be distinguished only by the topography, and by the rubble associated with the changes in topography. The individual flows are marked by small scarp faces, and the junctions by small, gently sloping benches that have formed on the major scarp of the whole succession. On the benches, close to the base of a flow the rubble consists of rounded pebbles of dense basalt glass (see Fig.2); this material probably represents the chilled base of the flow, and is quite different in appearance from the crystalline basalt that occurs in the flow centres. The tops of the flows are marked near the edges of the topographical benches by the presence of glassy, scoriaceous basalt.

About 3 miles north of the Mulligan Highway/Cooktown-Laura road junction a large basalt plain ends abruptly in a north-facing scarp slope about 100 feet high; the whole appears to be formed of a single flow of basalt that is somewhat vesicular at its top.

In a creek bank just south of the road about 5 miles west of the Mulligan Highway/Laura road junction, twenty feet of strongly weathered tuffaceous material is overlain by a sixty-foot thick basalt flow. The tuffaceous material overlies some old river gravel, and is a dark, strongly weathered rock that, in some places, contains mica flakes. A specimen of rather similar, but fresh rock, interbedded with basalt at a place about 4 miles south of this locality, was found to be a tuffaceous analcitite (R.10196), and is described below. K.G. Lucas (pers. comm.) states that this rock forms a bed about four feet thick, and lies immediately over a thin basal flow. The bed is laminated, and has apparent scour-and-fill textures.

At the south of the basalt plain around the Butcher's Hill area there are four flows ranging between 20 and 50 feet in thickness, the succession having a total thickness of about 150 feet.

In the Annan River Tinfield, three outcrops of Tertiary basalt are known - at Shipton's Flat, the Recompense workings, and half a mile north-east of the Jubilee workings. At Shipton's Flat a flow occupies an old valley, and overlies river gravels. The old stream is now represented by two streams that have cut small valleys on either side of the flow. At the Recompense claim, 2½ miles south-west of Rossville, a remnant of a once extensive lava flow is now about 100 square yards in area. It is 5 feet thick, and overlies about 20 feet of stanniferous gravels. Near the Jubilee workings, a remnant of a flow occurs on the divide between the Annan River and Romoo Creek.

About 14 vents have been identified in the area of the MacLean Basalt, mainly from aerial photographs. They all appear to be scoria cones, and are similar to those described by Best (1960) in the Atherton, McBride, etc., basalt provinces south-west of Cairns, Queensland. Some of those in the MacLean Basalt area were visited, and were seen to be built up of cindery scoriaceous material, together with volcanic bombs. Most of them have shallow apical craters, the rims of which are usually highest on the western side, owing probably to the influence of the prevailing wind at the time of eruption. On 30 one or two of the cones, small areas of basalt resulting from the accumulation of spatter can be seen. The northern cone of the two cropping out either side of the main road, a mile west of the Mulligan Highway/Laura road junction, has a small flow spreading out on its northern side. The western boundary of this flow is marked by a roughly vertical basalt ((?)feeder) dyke extending northwards from the cone to a low mound of basaltic material that has accumulated from spatter.

The basalts, in the main, contain no inclusions. However, the basalt forming the cone just described contains numerous inclusions; these consist of Hodgkinson Formation sediments, ultrabasic material, diopside, spinel, and some granitic rock.

Petrology

No really detailed work on the petrology of these basalts has as yet been done by the writer. Brief examination of thin sections of some specimens has shown that they are alkaline olivine basalts together with a few basic alkaline differentiates, such as olivine analcitite.

Some basalts are holocrystalline and others are hyalocrystalline. They are usually porphyritic, the phenocrysts commonly being embayed crystals of olivine; some specimens contain augite, and one or two have strongly embayed plagioclase phenocrysts. The aphyric rocks, and the groundmass of the porphyritic rocks, contain tabular calcic plagioclase, prismatic pyroxene, granular olivine, octahedral and tabular black iron ore, and less common interstitial analcite and chlorite; in the hyalocrystalline rocks, some glass is present. Olivine is partly replaced by several alteration products, of which iddingsite is the most common; bowlingite and hematite have also been observed. The pyroxene is usually a colourless or very pale green variety; in some specimens, pale lilac titanaugite has been seen. Vesicles are usually empty, but in some specimens they contain calcite or analcite.

A specimen of dense basalt glass collected from the base of one of the flows forming the scarp 4 miles south-east of "Springvale" was seen, in thin section, to consist almost entirely of pale brown glass. Enclosed in the glass were small crystals of olivine, less common clinopyroxene, and uncommon plagioclase. These are obviously the very first minerals to crystallize from the lava, and the crystallization must have taken place over a small range of temperature before the lava froze to a glass; this observation agrees with the experimental work/of Yoder and Tilley (1957) on the freezing of alkali basalt from Maunakea, Hawaii. In this work, Yoder and Tilley found that olivine, pyroxene and plagioclase appeared at 1160°C, and that the melt had completely crystallized at 1040°C.

An analcitite is, ideally, a basic rock containing analcite, pyroxene, and magnetite. Olivine analcitites are present in the MacLean basalts. These contain phenocrysts and groundmass crystals of strongly iddingsitized olivine, very pale green augite, and magnetite, all enclosed in a featureless matrix of isotropic analcite. Olivine analcitite forms the two upper flows at the exposure 4 miles south-east of "Springvale".

Another specimen, collected in the Annan River Tinfield area, near the Jubilee Workings, is mineralogically similar to the analcitites except that, in addition, it contains small, roughly equant crystals of nepheline (R.10130, Table 13).

A distinctly unusual rock, related to the analcitites, was found at an exposure some 4 miles south of the weathered tuff locality (p. 23). The rock represented by this specimen is interbedded with basalts and, in hand specimen, looks like a coarse grit. A thin section shows it to contain angular to sub-angular grains of Hodgkinson Formation chert, siltstone, slate, and carbonate, together with small basalt lapilli and xenocrysts of basaltic minerals, all enclosed in a matrix composed of analcite. A few large (⅛" to ¼") flakes of brown biotite are also present. No reaction had taken between the analcite and the siliceous fragments. The rock may be termed an analcitite tuff.

THE PIEBALD BASALT

Introduction

The Piebald Basalt crops out over an area of about 55 square miles in the north-eastern part of the Sheet area. The main area of the basalt occurs in the plains around the McIvor River. Some basalt is also found farther south, around the old cones forming Mount Piebald and Bald Hills, and on top of the Mesozoic Scarp between Bald Hills and the McIvor River.

Field Characteristics

Like the MacLean Basalts, the Piebald Basalt forms near horizontal flows that fill valleys and form plains - for example, the flows in the McIvor River, and those south of Bald Hills. The pre-basalt landscape in the area of the Piebald Basalt must have been similar to that of the present time - i.e., small hills over the area of outcrops of the Palaeozoic sediments, and Mesozoic sediments forming a strong east-facing scarp. The basalt occurs in valleys over the Palaeozoic sediments, and also occurs on top of the Mesozoic Scarp.

In the Piebald Basalt area about 10 cones have been identified. Some are scoria cones, others are probably composite cones, and at least one is possibly a pit crater. The scoria cones are similar to those in the McLean Basalt area, but appear to be more strongly dissected. Mount Piebald is probably a composite cone - at least, a considerable amount of it is composed of lava, as well as cinders. This cone was examined briefly; although it has suffered some erosion since its formation, it is possible to get some idea of its original form.

The cone is perched on a high hill composed of Mesozoic sandstone, and a lava flow on its northern side forms an apron extending down to the cultivated plain on which "Boiling Springs" homestead and Hope Vale Mission Station stand. At its summit, the cone has a rim extending almost all the way around the remains of the apical crater; the rim is formed of material accumulated by lava spatter, and forms a fairly prominent, though discontinuous ridge that is highest on the western side. This ridge has been pierced by a steeply descending creek on the north-western side; the creek has its source in the apical crater. The ridge has also been pierced by a smaller creek on the southern side. The centre of the cone is marked, topographically, by a gentle divide that appears to be formed by a basalt plug. Another possible plug occurs on the south-eastern rim of the crater - the basalt forming this plug has vertically lineated vesiculation. It is probably a fairly old part of the cone because the inner wall of the plug has lava spatter splashed onto it. A vertical basalt dyke trends eastward and cuts the cone on its eastern side, extending down the outside of the cone from the spatter ridge.

The probable pit crater occurs about 5 miles north-north-west of Mount Piebald. This crater has a roughly circular wall formed of spatter. Around the south-eastern side is an additional semi-circular wall probably forming part of an older crater. Inside the younger crater there is a roughly flat bench which, at its centre, has a distinct pit. The bench presumably forms part of an old lava lake. The basalt on the south-eastern wall is full of angular inclusions, about an inch across, formed mostly of Mesozoic sandstone; some are formed of coarse basic igneous rock, diopside, and spinel.

Petrology

As with the MacLean Basalt, no detailed petrological work has been done on the Piebald Basalt. Those basalts examined in thin section are, mineralogically and texturally, similar to the MacLean Basalt. Unlike the MacLean

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Basalt, no analcitites were observed - however, this may be due to incomplete sampling rather than to their complete absence.

Some Petrological Notes

The Cainozoic basalts in the Cooktown area are petrologically similar to those occurring farther south in the Cairns Hinterland (Best - 1960, Morgan - 1961b). They are olivine basalts which have, as their only differentiates, olivine analcitite and nepheline basanite (Morgan, 1963b). It is probable, therefore, that the MacLean and Piebald Basalts form the northerly extension of a North Queensland olivine basalt - olivine analcite association. This association, or magma province, differs from the Cainozoic association occurring in the Bowen Basin area (R.G. Mollan, pers. comm.); here, the volcanics have been found to consist of rock types ranging from olivine basalt, through intermediate types such as mugearite and trachy-andesite, to trachyte and peralkaline rhyolite.

Chemical analyses of five specimens of the MacLean Basalt, and one of the Piebald Basalt, are shown in Table 13A. The specimen of olivine basalt (R.10116) is rich in Fe_2O_3, due, probably, to the alteration of olivine to iddingsite. The porphyritic olivine basalt glass (R.11910) probably provides a more nearly true picture, from this point of view. This sample has a fairly high alkali content, although in its norm (Table 13), small amounts of hypersthene are present; thus, in spite of the alkali-content, this specimen, in the view of Yoder and Tilley (1962), would be termed an olivine tholerite. However, the specimen may be a typical of the basalts as a whole, because the differentiates are certainly strongly alkaline, as can be seen from Table 13.

The olivine analcitites commonly contain inclusions of high level country rock (i.e., granite, unmetamorphosed sediment, etc.) associated with them. This suggests explosive activity at the time of their extrusion. Evidence that this is the case is seen in the presence of analcite in place of feldspar and nepheline. The inclusions and the analcite together suggest that an alkali-enriched hydrous magma that was extruded by blasting its way to the surface because of high water pressure. Wilkinson (1962) found that the analcite in the groundmass of olivine-analcitite specimens from northern New South Wales is probably a high temperature form enriched in potash, and is formed under conditions of high temperature and pressure. This analcite in lava flows, therefore, represents a quench produced by sudden eruption. If the eruption had not been sudden, dehydration would have taken place, and, instead of analcite, plagioclase and nepheline would have crystallized.

According to Best (1960) the upper part of the Atherton Basalts in the Cairns hinterland consists of pyroclastic material. Explosive vulcanicity is not common in alkali olivine basalts. However, a specimen of olivine analcite has been described from the Atherton Basalt (Morgan, 1961b). It is, therefore possible that the pyroclastics result from olivine analcitite vulcanicity; however, a good deal more detailed field and petrological work would be needed to show whether or not this is the case.

TABLE 13. CHEMICAL ANALYSES AND C.I.P.W. NORMS, TERTIARY BASALTS, COOKTOWN AREA.

A. ANALYSES

	R.10115	R.10116	R.10119	R.10130	R.11910	R.14530
SiO_2	44.2	49.5	43.3	41.2	49.9	42.1
TiO_2	2.35	1.93	2.25	2.45	2.05	2.35
Al_2O_3	11.10	12.90	12.30	11.20	13.20	12.40
Fe_2O_3	8.20	5.95	4.80	3.50	1.53	4.20
FeO	4.35	5.25	6.95	8.90	9.15	10.20
MnO	0.19	0.16	0.18	0.20	0.14	0.28
MgO	9.25	7.80	10.20	11.50	9.30	7.70
CaO	10.10	8.90	9.30	10.70	8.30	9.70
Na_2O	3.95	2.85	4.50	4.30	3.30	4.20
K_2O	1.06	1.30	0.91	1.13	1.66	2.35
P_2O_5	1.05	0.47	0.98	1.16	0.45	1.04
H_2O+	2.25	1.23	2.25	2.85	0.96	2.20
H_2O-	1.49	1.22	1.66	1.03	0.24	0.61
CO_2	9.18	0.26	0.11	0.06	0.06	0.54
	99.72	99.72	99.69	100.18	100.24	99.87

B. NORMS.

		R.10115	R.10116	R.10119	R.10130	R.11910	R.14350
	Qz	-	3.00	-	-	-	-
	Or	6.29	7.78	5.56	6.67	10.01	13.90
	Ab	23.58	24.10	17.82	4.72	22.77	6.81
	An	9.17	18.63	10.56	8.06	16.12	8.06
	Ne	5.40	-	11.08	17.04	-	15.62
Di	Wo	13.46	8.47	11.08	15.54	8.82	12.64
Di	En	11.60	6.80	8.80	10.70	5.40	7.40
Di	Fs	-	0.66	1.85	3.56	2.90	4.62
Hy	En	-	12.70	-	-	1.90	-
Hy	Fs	-	1.06	-	-	1.06	-
Ol	Fo	8.12	-	11.76	12.60	11.06	8.40
Ol	Fa	-	-	2.65	4.90	6.32	5.71
	Mt	7.89	8.58	6.96	5.10	2.32	6.03
	Il	4.56	3.65	4.41	4.71	3.80	4.56
	Ap	2.69	1.34	2.35	2.69	1.34	2.35
	Cl	0.40	0.60	0.30	0.10	0.10	1.20
	He	2.72	-	-	-	-	-
	Water	2.43	2.45	3.91	3.88	1.20	2.81

R.10115 Olivine zeolitite, four miles south of "Springvale".
R.10116 Iddingsite-olivine basalt, four miles S.W. of "Springvale"
R.10119 Olivine analcitite, Mulligan Highway, two miles north of Byerstown Range.
R.10130 Olivine-nepheline analcitite, near the Jubilee workings, Annan River Tinfield.
R.11910 Porphyritic olivine basalt glass, four miles S.W. of "Springvale".
R.14530 Nepheline basanite, Starcke River, about four miles S. of Munburra.
Analyst: C.R.Edmonds and H.Sears, Australian Mineral Development Laboratory.

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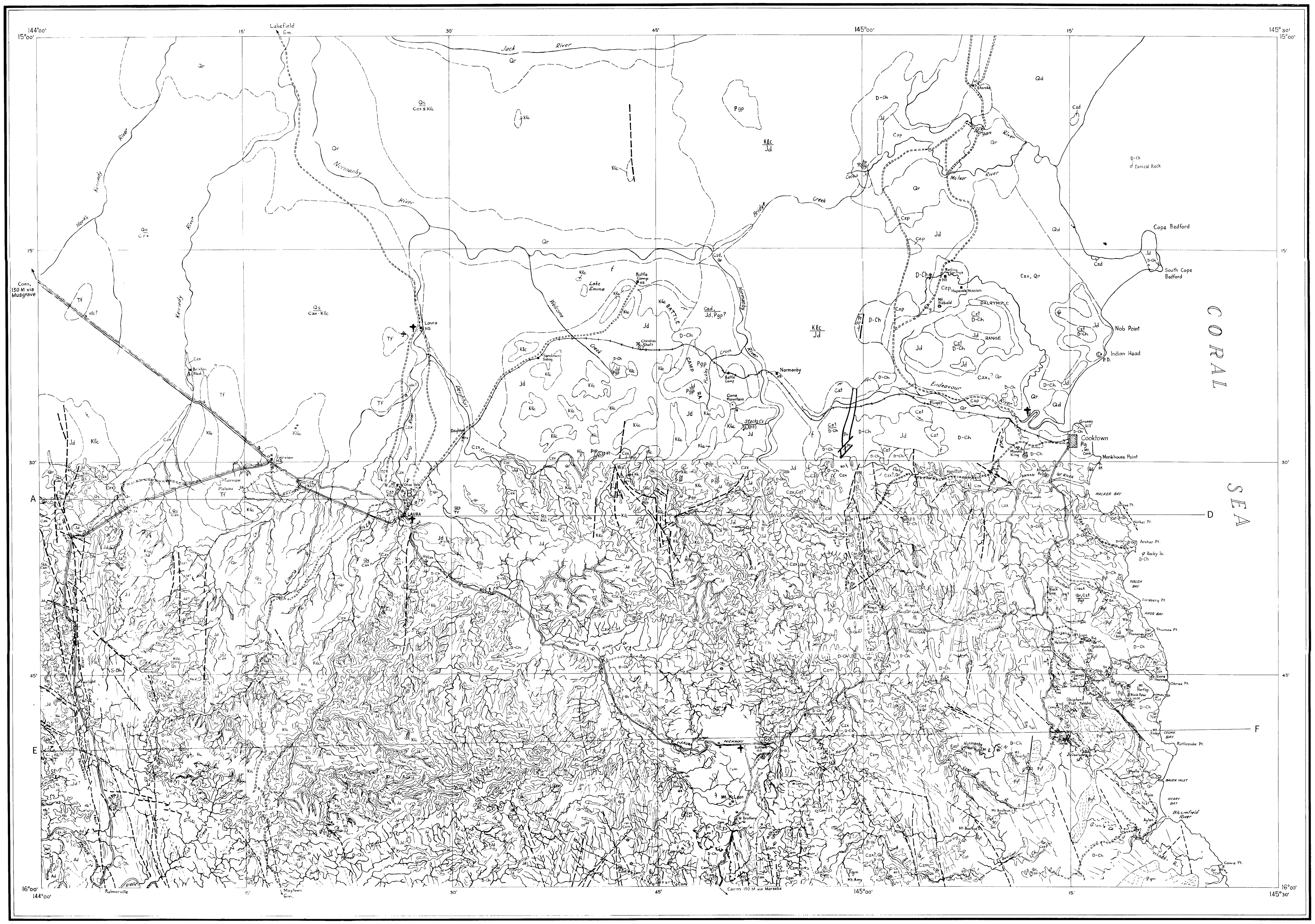
AUSTRALIA 1:250,000

COOKTOWN

QUEENSLAND

1:250,000 GEOLOGICAL SERIES SHEET SD55-13



Reference

CAINOZOIC	QUATERNARY		Qr	Alluvium - Grey silty clay, sand and gravel
			Qb	Alluvium - Black and red clay (basalt derived)
			Qs	Interfluvial sand - Loose orange and white sand
			Qd	Younger dune sand - white sand
			Czd	Older dune sand - Iron-stained, aeolian cross-bedded sand
			Czt	Piedmont fans - Earthy fossil breccia, slightly ferruginous
		Brixton Formation	Czx	Mottled clayey sand, gritty and pebbly
	TERTIARY (?)	Piebald Basalt	Czp	Olivine basalt
		McLean Basalt	Czm	Olivine basalt, pyroclasts, gravel
	TERTIARY	Fairview Gravel	Tf	Rounded quartzose pebble gravel, sandstone, billy
MESOZOIC	LOWER CRETACEOUS	Wolena Claystone (ALBIAN)	Klo	Pale weathering, olive-grey, silty and sandy claystone with calcareous concretions
		Battle Camp Formation (APTIAN-NEOCOMIAN)	Klc	Conglomerate, glauconitic sandstone, shaly sandstone, leached shale
	JURASSIC	Dalrymple Sandstone	Jd	Quartz sandstone, conglomerate, grit, shale
PALAEOZOIC	PERMIAN	Normanby Formation	Pr	Feldspathic sandstone, siltstone, conglomerate, limestone and coal; rhyolite
		Little River Coal Measures	Pur	Sandstone, shale, impure coal and limestone
	PERMIAN (?)	Puckley Granite	Pgp	Coarse, porphyritic adamellite; aplite dykes
		Trevethan Granite	Pgt	Medium-grained hornblende-biotite granodiorite
		Finlayson Granite	Pgf	Medium-grained porphyritic adamellite
		Mareeba Granite	Pgm	Coarse, porphyritic granodiorite and adamellite
		Unnamed Granite	Pg	Medium to coarse porphyritic granite
	? LOWER CARBONIFEROUS-MIDDLE DEVONIAN	Hodgkinson Formation	D-Ch	Greywacke, slate, minor volcanics and limestone
	LOWER DEVONIAN-UPPER SILURIAN	Chillagoe Formation	S-Dh	Volcanics, chert, sandstone, limestone
PRECAMBRIAN	ARCHAEAN	Dargalong Metamorphics	Ad	Schist, gneiss, amphibolite, quartzite

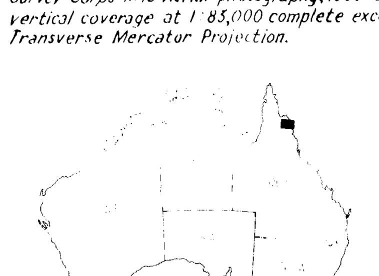
Geological boundary
Fault, showing relative vertical movement
Where location of boundaries and faults is approximate, line is broken; where inferred, queried; where concealed boundaries are dotted, faults are shown by short dashes.
Strike and dip of strata
Overturned strata
Vertical strata
Horizontal strata
Trend of bedding
Dip of strata - Air-photo interpretation
Direction of sediment transport
Joints
Strike and dip of cleavage
Dyke or vein {gy: granophyric mi: microgranite am: alkali microgranite; t: tonalite d: dolerite}
Basic volcanic vent
Macrofossil locality (Marine)
Plant fossil locality
Mine
Alluvial workings

•Mn	Minor mineral occurrence	Mn	Manganese
Sb	Antimony	Hg	Mercury
C	Coal	Ag	Silver
Cu	Copper	Sn	Tin
Au	Gold	W	Tungsten

Circle around mineral symbol indicates unexploited deposit or prospect

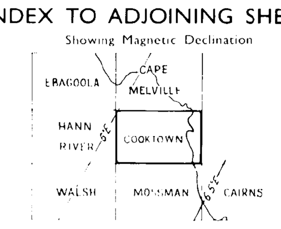
•A Water bore - Artesian
•SA Water bore - Sub-artesian
•N Water bore - Saline
•W Well
•T Tank
Wind pump
Abandoned bore
Hamilton Abandoned settlement
LAURA •HS Homestead
Telegraph line
Landing ground
Road
Vehicle track
Railway (abandoned)
Scarp
P.D. Position doubtful

Compiled and issued by the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, in conjunction with the Geological Survey of Queensland. Southern half of topographic base compiled by the Royal Australian Army Survey Corps 1961, northern half compiled by Department of Public Lands, Queensland and issued by Australian Army Survey Corps 1943. Aerial photography, 1960-62, by Adastra Airways Pty. Ltd; vertical coverage at 1:85,000 complete except for south-east corner. Transverse Mercator Projection.



INDEX TO ADJOINING SHEETS

Showing Magnetic Declination



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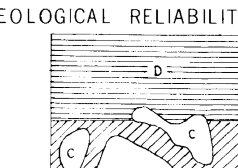
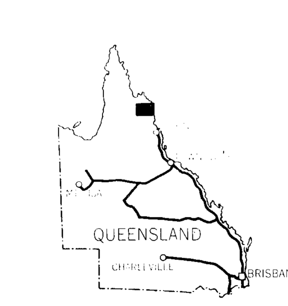
MILES / KILOMETRES

GEOLOGICAL RELIABILITY DIAGRAM

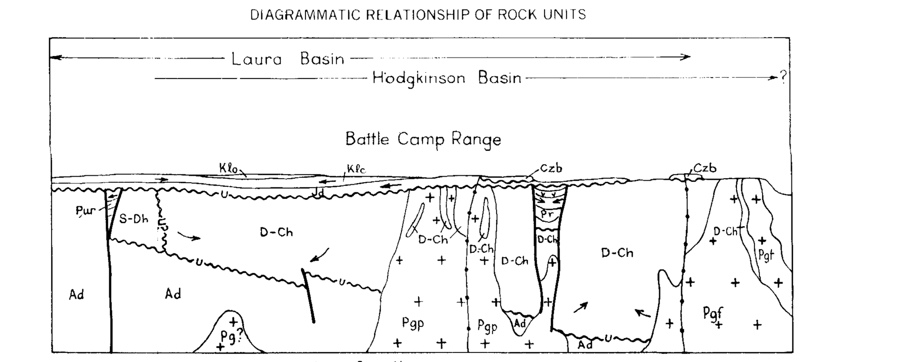


B Reconnaissance - traverses and air-photo interpretation
C Air - photo interpretation
D Uncontrolled topographic base, traverses and air-photo interpretation

Geology by: K.G. Lucas, W.R. Morgan, B.J. Amos (B.M.R.)
L.G. Cuttler, J.T. Woods (G.S.Q.) 1961
Compiled by: K.G. Lucas 1962
Drawn by: P.J. Brown



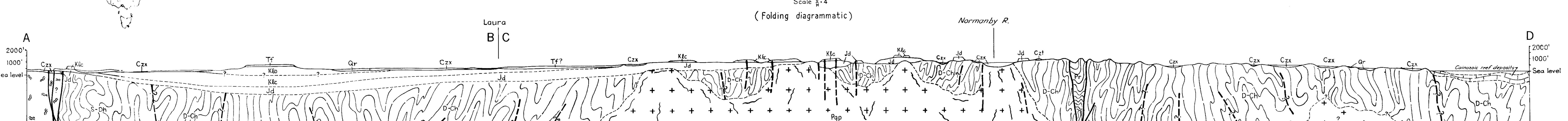
DIAGRAMMATIC RELATIONSHIP OF ROCK UNITS

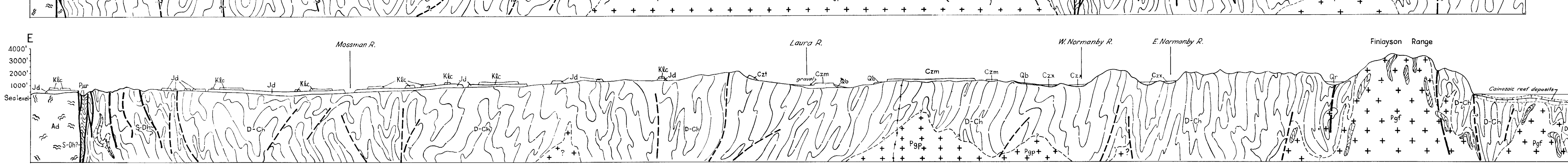


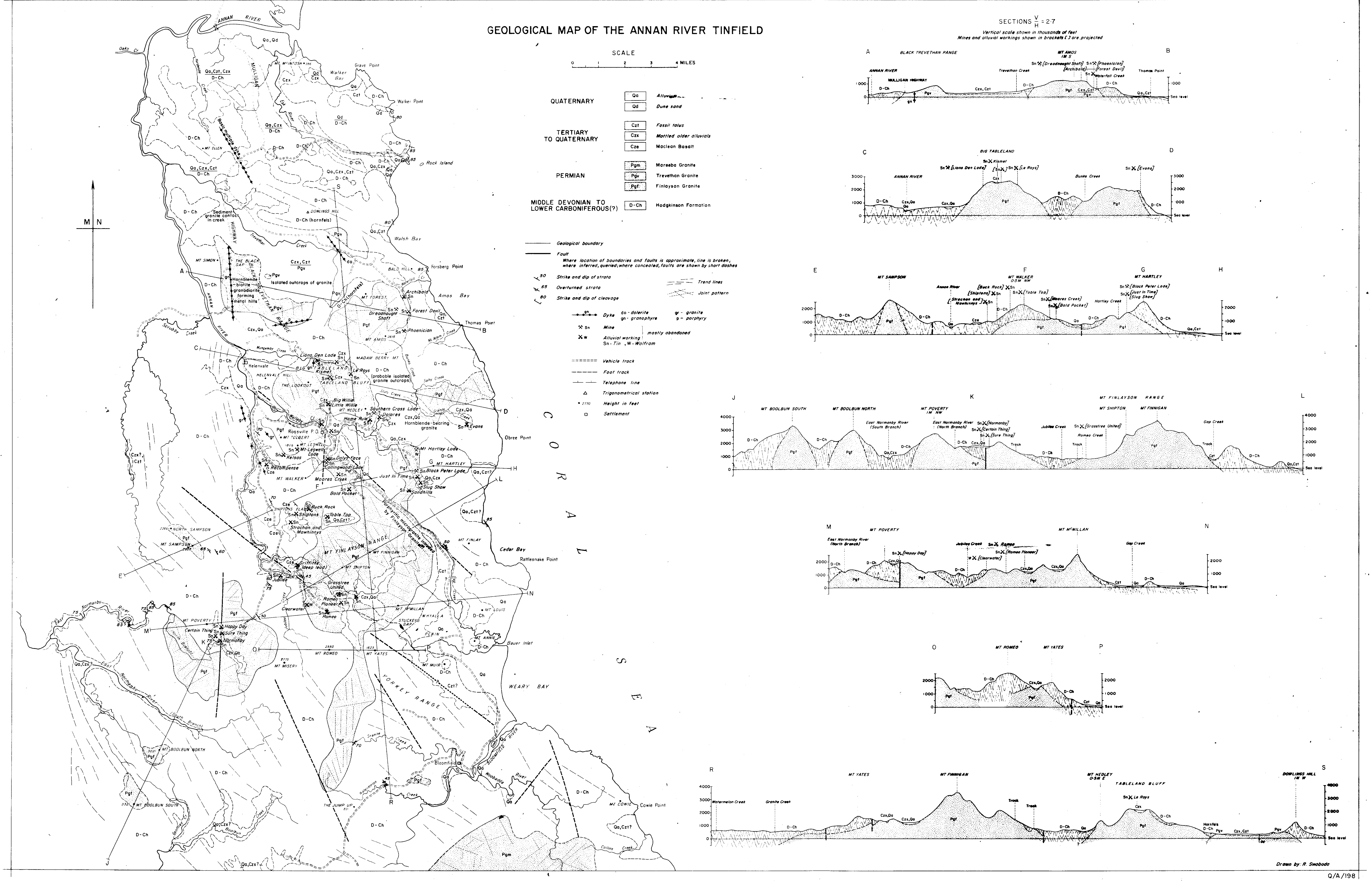
Unconformity
Direction of sedimentation

Sections

Scale V/H 4
(Folding diagrammatic)






GEOLOGICAL MAP OF THE ANNAN RIVER TINFIELD
SCALE
0 1 2 3 4 MILES
QUATERNARY
Qa Alluvium
Qd Dune sand
TERTIARY TO QUATERNARY
Czt Fossil talus
Czx Mottled older alluvials
Cze Maclean Basalt
PERMIAN
Pgm Mareeba Granite
Pgv Trevethan Granite
Pgf Finlayson Granite
MIDDLE DEVONIAN TO LOWER CARBONIFEROUS(?)
D-Ch Hodgkinson Formation
Geological boundary
Fault
Where location of boundaries and faults is approximate, line is broken, where inferred, queried; where concealed, faults are shown by short dashes
Strike and dip of strata
Overturned strata
Strike and dip of cleavage
Trend lines
Joint pattern
Dyke do - dolerite gn - granophyre gr - granite p - porphyry
Mine
Alluvial working Sn - Tin, W - Wolfram
mostly abandoned
Vehicle track
Foot track
Telephone line
Trigonometrical station
Height in feet
Settlement
CORAL SEA
SECTIONS V/H = 2·7
Vertical scale shown in thousands of feet
Mines and alluvial workings shown in brackets [ ] are projected
Drawn by: R. Swobodo
Q/A/198