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1960/59

THE PRECAMBRIAN GRANITES OF NORTH-WESTERN QUEENSLAND

by

Germaine A. Joplin,
Australian National University

and

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INTRODUCTION

In a preliminary report on the petrology of the Cloncurry Mineral Field one of us (Joplin, 1955) briefly described arkoses altered by granite and suggested that pebbles in a conglomerate of probable Lower Proterozoic age were derived from an earlier granite, which might be correlated with granitized schists and granitic rocks on Yaringa creek.

A coarse porphyritic granite invaded by micro-granite and both intruding strata believed to be of Lower Proterozoic age were also recorded and it was suggested that with the possible exception of an older basement granite, all the granites of the Cloncurry Mineral Field were of late Lower Proterozoic age.

Since this report, the Commonwealth Bureau of Mineral Resources has completed its reconnaissance and this more recent work, under the direction of Mr. E.K. Carter, has led to a better understanding of the stratigraphy and of the sequence of tectonic events and to the discovery of probable Upper Proterozoic granite north of the Nicholson River, 200 miles north-west of Mt. Isa.

Also since the completion of the preliminary report on the petrology, one of us (K.R.W.) has spent two field seasons with the Commonwealth Geological Party and has devoted some time to detailed petrology with special reference to the basic rocks which are very widespread throughout the area. This work has shown up a number of anomalies, and it is considered that the metamorphics of some of the basic rocks indicates several periods of granitic injection between that of the basement complex and that of Upper Proterozoic time. The petrographical work pointed so strongly to this conclusion that a special field trip was undertaken by the authors in the company of Messrs. E.K. Carter and W.C. White of the Bureau of Mineral Resources.

On Sunday Gully, a tributary of the West Leichhardt River, within an area suggested by the junior author, granite was found to be overlain by conglomerates and quartzites (Plate 1, Fig. 1). The granite has invaded acid lavas then believed to be of Archaean age, and the over-lying strata belong to the upper part of the Lower Proterozoic. Further, these strata are also intruded by granite, thus the junior author's belief in an early Lower Proterozoic granite appeared to be confirmed.

This interpretation is in accordance with the observations of Honman (1937) who noted that the granites invading the country between Sunday Gully and Mt. Remarkable (i.e. his Kalkadoon-Argylla series, the equivalent of the present Leichhardt Metamorphics) were overlain by the Mt. Isa series and he surmised that the granite was therefore either of Archaean or Lower Proterozoic age. Jensen (1940) disagreed with Honman and considered that there was definite evidence of granite invading the Mt. Isa series and postulated a faulted junction between this and the Kalkadoon-Argylla series.

It is possible that the granite in Sunday Gully may be correlated with old basement rocks west of Mt. Isa, but it is our belief that it is younger, and furthermore we suggest that the acid lavas which it invades may be of early Lower Proterozoic age and co-magmatic with it.

Field notes accompanying each rock description are based upon the Bureau maps and observations, but, unless otherwise stated, the present writers have contributed towards the mapping or observations or have visited the areas in the company of Bureau officers.

11 METHODS OF PRESENTATION AND STUDY

Nine separate masses of granite have been mapped by the Bureau of Mineral Resources, and the maps (scale 1 inch to 4 miles) indicating these areas will shortly appear separately, to accompany a bulletin by E.K. Carter, J.H. Brooks and K.R. Walker. Each mass has been formally named and in each case the rock has been designated by the term "Granite". The present study, however, has shown that granites, adamellites, and granodiorites, as well as their aplitic phases, occur, and that some of the granitic bodies are composite and contain rocks not only of different compositions but also of different ages. In order that the Bureau maps can be used in conjunction with the present paper and also to conform with the formal names, the field occurrences have been described on a strictly geographical basis as shown in Fig.1, under the heading of each unit, but at the same time the different rock types occurring within the particular named granitic mass have been described.

In so far as is possible the descriptions of granodiorites, adamellites and granites have been grouped, and though it is realized that masses of similar age may be separated by such a grouping, the relative ages of these bodies is still a matter of conjecture, and it is considered unwise to introduce any speculation into the descriptive section of the paper. As several masses are invaded by similar minor intrusions, and again, it is uncertain whether they represent a widespread type of one age or whether the several larger bodies have differentiated in a similar manner, it is deemed best to describe the minor intrusions separately.

The senior author (Joplin, 1955) compared seven granites from the Cloncurry Mineral Field on an orthoclase-albite-anorthite diagram, and concluded that all types were derived from a single magma that had suffered slight but varying degrees of hybridization. The points on this diagram were calculated from chemical analyses, and the gradual progression of the granite plots towards that for basalt seemed to suggest that hybridization was brought about by assimilation of basic material. It is now known that the analysed rocks came from only four of the nine mapped bodies.

As the chemical analyses had shown only minor differences, which might be attributed to either slight hybridization or to slight differentiation of a single magma, it was considered that a series of micrometric analyses might prove more useful. Micrometric analyses marked by a letter refer to those specimens that have been collected by the Bureau of Mineral Resources for future work on age determination.

Since many of the granites contain large phenocrysts, this presented difficulties with regard to micrometric measurement. Several sections were cut in random directions for each coarse-grained rock and the cut faces lightly polished. From these a tracing was made and the relative percentage calculated. The slides for these faces were then examined and groundmass minerals and phenocrysts measured independently. All the results for the groundmass of a single rock specimen and for its phenocrysts, plus intergrowths and inclusions, were then averaged separately and a composite mode was calculated for the proportions previously measured.

To test the accuracy of the method the volumetric analyses was calculated to a weight percentage and compared with that calculated from the chemical analysis. In most cases the comparison was satisfactory in view of the facts that small inclusions of accessory minerals were often missed in the count, that specific gravities of some minerals were only approximate, and that the actual chemical composition of the mafic minerals was unknown. The relative success by this method of comparison depends to some extent on the paucity of mafic minerals in these rocks.

As mapping is still at a reconaissance stage, and knowledge of exact field relationships uncertain in many places, no mineralogical work has been undertaken. The mineral zircon has not been measured in any of the micrometric analyses and it is rarely visible under the microscope, but concentrates of heavy minerals show that small quantities are commonly present in most of the granitic rocks.

111 NOMENCLATURE

A comparison of Fig.2, which is based on the relative proportions of potash feldspar, plagioclase and quartz, with similar diagrams used by Johannsen (1952 Figs. 51 and 92) will show that the granitic rocks of North-western Queensland fall into the granodiorite, adamellite, and granite groups. Many of them contain higher quartz than Johannsen's average for the group, but very few fall outside the limits for the group as indicated on his diagrams.

According to Chayes (1957) most of these rocks could be called granites with a prefixed number to indicate the division based on the relative proportions of the three essential minerals, and when further mapping, more micrometric analyses, and more accurate determinations of feldspar, have been made, it might be desirable to adopt Chayes method of classification, especially as the mapped bodies have already been named "Granites" by the Commonwealth Bureau of Mineral Resources, though it would still be necessary to delineate a number of different granites within the mapped units. In the meanwhile, however, we prefer to use the older and better known nomenclature, and in the next section the rocks will be described under the headings of granodiorites, adamellites and granites.

1V THE GRANITES

The Kalkadoon Granite

Reference to Fig.1 will show that the Kalkadoon Granite, as mapped by the Bureau of Mineral Resources, extends as a series of outcrops for a distance of 160 miles, from about 10 miles north of Dobbyn to about 40 miles south of Duchess. South of Duchess the outcrop widens and we suggest that the south-easterly portion, intruding the Corella Formation, would have been defined more appropriately as part of the Wonga Granite.

The greater part of the bathylith consists of granodiorite, which over the full length of its outcrop, according to our definition, is intrusive into the Leichhardt Metamorphics, a volcanic sequence consisting mainly of acid lavas with some interbedded basalts and limestones; and on the Duchess Road, 12 miles south-south-east of Mt. Isa, the granodiorite is hybridized by basic material occurring within the Leichhardt Metamorphics. However, an adamellite and at least three small masses of granite are known to occur within the Kalkadoon Granite and these have invaded younger strata. Thus, near the Crusader mine adamellite has invaded the Argylla Formation; granite occurs at Dobbyn, and may be the same as the one invading the Myally Beds west of Dobbyn; a granite also occurs on the Duchess Road 12 miles south-south-east of Mt. Isa; and again a granite has invaded the Mount Guide Quartzite 10 miles west of Butru Siding.

Near its southern end of Sunday Gully the Kalkadoon granodiorite is overlain by the Surprise Creek Beds which are probably high in the Lower Proterozoic succession.

In the West Leichhardt area, and on the road to the Kings Cross mine, basic dykes invade the granodiorite and at the last locality these are cut by aplite.

Kalkadoon granodiorite.

In hand specimen the granodiorite shows some variation over the distance of 160 miles, though the mineral composition remains fairly uniform. The rock is coarse-grained and commonly porphyritic. At the southern end of the mass the phenocrysts are white or grey in a coarsely crystalline black and white groundmass. In the north the phenocrysts are commonly pale pink and pink feldspar also occurs in the groundmass. Throughout its outcrop the granodiorite is mostly massive, but exceptions include a small area to the west of Bushy Park where both granodiorite and country rocks appear to have suffered dislocation metamorphism (Joplin 1955, p.56).

These rocks are porphyritic with phenocrysts of microcline and/or plagioclase measuring from 6 to 8 mm. The groundmass is in the main hypidiomorphic granular with the grainsize of different specimens ranging from 0.5mm to 6mm. It consists of quartz, plagioclase (acid andesine), microcline biotite, and, in some specimens, hornblende. Sphene, apatite and iron ores are accessory and epidote, white mica, and chlorite are found replacing plagioclase. Microcline may develop a coarse and peculiar type of hatching suggesting strain, and may be altered to myrmekite or albite along cracks. Quartz is commonly strained and may show undulose extinction coarse lamellae or complete granulation. Much of the biotite, associated with epidote, sphene and chlorite, occurs in nests of criss-cross flakes and possibly replaces original hornblende. Larger individual flakes of biotite sometimes show bending. These features suggest that the Kalkadoon granodiorite, though massive in most places, has been subjected to regional metamorphism of a type similar to that affecting the Leichhardt Metamorphics (Joplin, 1955), which it invades.

Reference to Table 1 will show that, though there is little variation in mineral content, relative proportions of minerals differ in specimens from different parts of the granodiorite mass. Micrometric analyses indicate that plagioclase is well in excess of orthoclase, and a comparison with the other tables shows that this is characteristic of this mass. The rock has been locally hybridized by assimilation of basic material, thus certain variations in the mineral percentages, and even in the mineral content, are to be expected over a distance of 160 miles.

A rock of this type from 5½ miles west of Wills Creek on the Duchess-Dajarra Road was analysed (Joplin, 1955), and described as a hybridized porphyritic granite. It is now believed that, although slight hybridization of the granodiorite may have occurred, its somewhat basic composition as compared with that of the other porphyritic granites is a

TABLE 1

MICROMETRIC ANALYSES OF KALKADOON GRANODIORITE

	1	A	2	B	3	4	C	5	6	7	8	9	10
Microcline	18.4	23.4	21.9	26.3	7.9	12.0	24.8	18.3	17.4	11.6	20.2	16.3	10.7
Plagioclase	23.3	40.5	32.0	42.6	46.8	22.3	27.7	29.0	28.5	33.2	39.2	23.7	56.4
Myrmekite	2.3	-	-	-	-	-	1.6	-	-	-	-	-	-
Quartz	37.2	24.9	27.3	17.5	27.3	35.3	34.4	36.7	34.3	28.3	31.9	36.1	18.8
Biotite (Chlorite)	17.7	10.5	16.4	11.9	9.5x	24.9	8.4	14.2	16.9	17.5	4.1	23.0	12.4
Hornblende (Chlorite)	0.1	-	-	-	-	-	2.9	-	-	8.8	4.6	0.9	0.3
Sphene	0.6	0.5	0.2	1.2	0.4	2.8o	0.3	0.2	1.7	0.5	-	-	0.9
Apatite	0.3	-	0.1	0.1	0.4	1.4	tr	0.6	0.2	0.1	-	-	0.5
Epidote	-	0.1	2.2xx	0.4	7.7	-	-	-	-	-	-	-	-
Muscovite	-	-	-	-	-	-	-	0.7	0.7	-	-	-	-
Iron ore	-	0.1	tr	tr	-	1.3	-	0.3	0.3	-	-	-	-
Scapolite		-	tr	-	-	-	-	-	-	-	-	-	-

x - Partly epidotized : xx - Mainly clinozoisite : o Mainly surrounding iron ore, elsewhere associated with biotite.

1. Near Stanbroke Station.
A 3½ miles south of Butru Siding
2. 5½ miles west of Wills Creek, Duchess-Dajarra Road.
B. Duchess Road, 30 miles from Mt. Isa.
3. Duchess Road, 12 miles from Mt. Isa.
4. West of Bushy Park Station.
C 1 mile east of Kings Cross Mine.
5. Road to Kings Cross Mine at Wonga Fault.
6. Cloncurry - Mt. Isa Road, near Wonga Fault.
7. West Leichhardt, near Sunday Gully.
8. West Leichhardt, near Sunday Gully.
9. West Leichhardt, Fisher's Track.
10. St. Pauls Creek, near Dobbyn.

characteristic of the Kalkadoon mass and is too constant to be attributed to assimilation _in situ_.

SiO_2	70.29
Al_2O_3	12.59
Fe_2O_3	0.69
FeO	2.49
MgO	0.96
CaO	2.31
Na_2O	3.72
K_2O	4.72
*H_2O +	0.64
TiO_2-	0.78
P_2O_5	0.38
MnO	0.02
	99.57
Sp.Gr.	2686
*H_2O-	0.08

CALCULATED MODES

	From Analysis Wt.%	From V% (2.Table 1) Wt.%
Orthoclase	20.90 ($Or_{79}Ab_{21}$)	20.9
Plagioclase	31.63 ($Ab_{78}An_{22}$)	31.6
Quartz	29.64	27.2
Biotite	13.90	17.0
Sphene	0.20	0.2
Apatite	1.01	0.1
Clinozoisite	1.92	2.8
Iron Ore	0.23	tr.

Anal. B.E. Williams.

(2) Granites associated with the Kalkadoon granodiorite.

These granites are porphyritic rocks with large pink phenocrysts of feldspar in a finer granular groundmass of quartz, feldspar and mica. The large phenocrysts give the impression of a coarse-grained rock, but the actual groundmass is from medium to fine. These granites are all massive, like the Kalkadoon granodiorite with which they are associated.

Under the microscope the granite from Dobbyn shows phenocrysts of microcline and plagioclase ranging in size from 3-5 mm. The granite which invades the Mount Guide Quartzite contains grains of microcline up to 12 mm. which enclose smaller grains (2.5 mm.) of quartz and sub-idiomorphic, much corroded crystals of plagioclase. This rock looks not unlike a granitized quartzite; if so, it is difficult to account for the sub-idiomorphic crystals of plagioclase. The groundmass in every case consists of quartz, microcline, plagioclase, biotite and hornblende. In a granite from the Duchess Road, about 12 miles south-south-east of Mt. Isa, small patches of criss-cross biotite associated with quartz and granular sphene suggest that this rock was originally richer in hornblende. In this rock apatite is present, and much saussuritized plagioclase contains small tufts of chlorite: these features suggest superimposed metamorphism.

Fluorite occurs in the granite invading the Mount Guide Quartzite and either is intergrown with quartz in a fine granular mosaic or replaces feldspar along cleavages, and thus forms odd-shaped angular grains, This is similar to the "fluorite-perthitization" described by Von Eckermann (1936) who considers that it may be a replacement of plagioclase stringers in the potash feldspar. The presence of fluorite suggest either a possible genetic connection between this granite and the Sybella granite or later preumatolytic alteration by the Sybella.

The modes of these three rocks have been measured and it is interesting to compare that of the Dobbyn rock with a rock from the southern end of the Sybella Granite mass (Table 1V, Anal. 3.) about 140 miles distant.

	1.	2.	3.
Microcline	24.3	37.3	32.8
Plagioclase	23.9	23.9	20.5
Myrmekite	0.1	-	-
Quartz	31.8	19.4	38.1
Biotite	16.3	16.6	8.2
Hornblende	0.9	1.0	0.3
Sphene	0.2	0.9	-
Apatite	-	0.9	0.1
Epidote	2.3	-	-
Fluorite	0.2	-	-

1. 10 miles west of Butru Siding.
2. Duchess Road, 12 miles south-south-east of Mt. Isa.
3. St. Pauls Creek, north of Dobbyn.

WIMBERU GRANITE.

The Wimberu Granite occurs in three separate outcrops as shown in Fig. 1.

We have examined only the eastern margin of the largest mass on the Malbon-Kuridala Track 13 miles from Malbon. At this locality the rock is a coarse-grained, massive, porphyritic adamellite, and is invaded by aplite and microgranite.

The handspecimen is a coarse-grained porphyritic rock that consists of pink phenocrysts measuring up to about 10 mm. in a groundmass of pink and yellowish white feldspar, quartz, and green mica.

Phenocrysts of both microcline and plagioclase occur in a fairly even-grained groundmass (4mm). Owing to alteration it is impossible to determine the composition of the plagioclase. Micrographic intergrowth between quartz and feldspar is present is some rocks. The mineral composition is shown in the following modes:-

	D	E	1.	2.	3.
Microcline.	22.2	27.1	27.7	32.7	43.5
Plagioclase.	36.6	27.9	40.6	40.4	27.7
Myrmekite.	-	-	1.3	0.5	-
Quartz	36.6	39.2	26.1	22.8	27.2
Biotite.	0.5	4.6	1.6	2.0	0.7
Hornblende	2.8	0.3	0.7	0.3	0.1
Iron Ore	0.5	0.3	1.0	0.6	0.2
Apatite	0.1	-	0.2	0.2	-
Sphene	0.8	0.5	0.8	0.5	0.6
Fluorspar	-	0.1	-	-	-

NARAKU GRANITE.

The Naraku Granite invades the Corella Formation and forms a series of small outcrops extending northwards from Cloncurry to 18 miles beyond Coolullah Homestead. The main road from Cloncurry to Dobbyn follows the granite fairly continuously as far as the Dugald River crossing and then it veers slightly west but the granite continues in a northerly direction.

The Naraku Granite has the composition of an adamellite. It is a fine-grained rock with a slightly variable grainsize and might be more fittingly termed a microadamellite. A small quarry at the junction of the Quamby and Mt. Isa Roads, about 3 miles from Cloncurry, exposes three slightly different types, which show variation, both in grainsize and in relative abundance, of constituent minerals.

The senior author (Joplin, 1955) originally grouped these microadamellites with the microgranites invading the Sybella Granite. Handspecimens show a variable grainsize, but are not distinctly porphyritic. The texture is normally hypidiomorphic granular and the grainsize ranges from about 2.5 mm. to 0.4 mm, though in some rocks it averages about 1mm. On the Kajabbi Road 6½ miles north of Quamby, and at a point 8½ miles south of the crossing on Cabbage Tree Creek the rocks have an allotriomorphic granular texture, but they are exceptional. Plagioclase (acid andesine) forms both large and small sub-idiomorphic tabular crystals and is responsible for the distinctive texture; sericitized and corroded cores of plagioclase are surrounded by clear rims. Microcline and quartz also occur as large or small grains, and the quartz commonly shows undulose extinction. Olive-green biotite occurs in small flakes and is associated with apatite, sphene, and a little epidote. Hornblende has been noted, but is not characteristic. A little muscovite is also recorded.

A rock from the junction of the Mt. Isa and Quamby roads has been analysed (Joplin 1955) and the analysis, together with the calculated mode, are given below.

SiO_2	73.49
Al_2O_3	14.06
Fe_2O_3	0.37
FeO	1.74
MgO	0.01
CaO	0.96
Na_2O	2.68
K_2O	5.63
H_2O +	0.33
H_2O -	0.03
TiO_2	0.78
P_2O_5	tr
MnO	tr
	100.08
Sp. Gr.	2.623
Anal.	J.K. Burnett.

CALCULATED MODES

	From Analysis Wt%	From V% (1, Table 11) Wt%
Microcline.	30.0	29.4
Plagioclase	28.1 ($Ab_{83}An_{17}$)	33.0
Quartz	31.0	31.0
Biotite	10.2	6.5
Iron Ore	0.7	-

TABLE 11.

MICROMETRIC ANALYSES OF NARAKU ADAMELLITE

	F	1.	2.	3.	4.	G.	5.	6.	7.	8.
Microcline	39.1	30.3	23.6	13.2	22.3	36.0	21.1	35.1	30.6	20.3
Plagioclase	18.7	33.4	33.0	47.2	32.8	23.3	43.2	27.0	17.1	43.7
Myrmekite	-	-	-	-	-	1.2	-	-	-	-
Quartz	37.9	30.6	37.1	32.4	40.7	35.1	31.3	32.4	49.2	26.4
Biotite	3.3	5.7	6.1	6.3	3.3	4.4	3.4	1.8	0.7	8.2
Hornblende	-	-	-	-	-	-	-	2.5	-	-
Sphene	-	-	-	0.5	-	-	0.3	0.9	0.9	0.3
Muscovite	0.7	-	-	-	0.5	-	0.1	-	-	0.4
Iron Ore	0.4	-	0.2	0.4	0.4	tr	0.6	0.4	1.5	0.4
Apatite	-	-	-	-	-	-	-	-	-	0.2

F. Junction of Quamby and Mt. Isa Roads, near Cloncurry
2. Same as F.
3. Road between Quamby and Cloncurry.
4. Police Creek Waterhole, Quamby Road.
G. Quamby Road, 22 miles from Cloncurry.
5. 4 miles west of Quamby.
6. 6½ miles north of Quamby on the Kajabbi Track.
7. 8½ miles south of Cabbage Tree Creek on the Kajabbi Track.
8. Magnet Mine.

WILLIAMS GRANITE

The Williams Granite forms a number of small separate outcrops lying in the south-eastern corner of the area mapped. The largest of these outcrops occurs on Squirrel Hills station which is drained by Bustard Creek. The total length of outcrop from north to south is about 60 miles and the maximum width at its southern end is approximately 40 miles.

The Williams Granite invades the Corella, Kuridala, Staveley and Soldiers Cap Formations and the Answer Slate, and so far as is known it is not overlain by any later Precambrian strata.

At its southern end the rock is a coarse granite or adamellite, cut by minor intrusions of finer grained types and by coarse mica pegmatites. The smaller outcrops to the north of Soldiers Cap consist mainly of microgranite, microadamellite and soda aplite which occur as sills, dykes and minor intrusions. The coarse rock on Squirrel Hills is contaminated by calcsilicate rocks and here the finer grained types locally pass into granitized country rocks.

On Squirrel Hills the rock is pink, coarse, and feldspathic, with large pink and white feldspar grains, less abundant quartz grains and patches of dark green hornblende. Some joint surfaces show a little slickensiding and quartz deposition.

The rock is coarse-grained (4-6mm) and allotriomorphic granular, and the plagioclase is oligoclase. The rock near Answer Homestead contains a very high proportion of plagioclase and low microcline owing to the fact that both feldspars have been albitized. Measurements indicate 33.3% of original plagioclase and 20.9% of new albite.

TABLE 111

MICROMETRIC ANALYSES OF WILLIAMS ADAMELLITE

	1.	H.	J.
Microcline	34.8	32.7	10.8
Plagioclase	44.8	33.5	54.2
Myrmekite	-	0.1	2.2
Quartz	16.4	21.2	30.9
Biotite	0.2	10.7	1.3
Hornblende	2.9	0.3	-
Sphene	0.4	0.5	-
Apatite	0.3	0.1	0.1
Iron Ore	0.2	1.0	0.1
White mica	-	-	0.2
Epidote	-	-	0.1

1. Squirrel Hills
H. Selwyn - Toolebuc Road, 23 miles from Selwyn.
J. Near Answer Homestead, north side of McKinlay River.

SYBELLA GRANITE:

Granite has been mapped as an almost continuous unit extending from about 5 miles south of the Barkly Highway on May Downs station, to Smoky Creek, a total distance of about 110 miles.

In the northern part of the outcrop area, coarse, foliated, porphyritic granite appears to surround a core of deeply weathered granite and arkosic material, which in places is contact-altered and granitized by the foliated granite (Joplin, 1955, p.42).

The foliated granite is believed to invade the Judenan Beds and appears to be overlain by the Mount Isa Shale. It extends approximately 90 miles south nearly to Ardmore Homestead, though the actual southern boundary against a more massive granodiorite on Rocky Creek, north of Sulieman Bore, has not been mapped, and the one type may grade into the other. The coarse, massive, porphyritic granodiorite contains abundant de-orientated sedimentary xenoliths. In places, there is some suggestion that granitization has occurred in this area, for example, on Waverley Creek, but it is of local occurrence only. South of Sulieman Bore the granite is only slightly foliated. Both the foliated and the massive types are intersected by small bodies or dykes of microgranite. These intrusions are especially numerous farther north, and on Kittys Plain on the May Downs Station, the microgranite contains numerous xenoliths of basalt and, in places, is much basified (see Joplin, 1955 pp.59-60).

Several small dyke-like masses of both soda aplite and albitite invade, or are marginal to, the microgranite on Kittys Plain and it has been suggested (Joplin, 1957) that these may be genetically related to the granite. The country rocks on the North-eastern margin are greisenized, and large dykes of mica pegmatite cut the granite and microgranite in this area.

(1) <u>Altered granite occurring within Sybella Granite</u>.

Much of the material forming the core of the Sybella Granite at its northern end consists of little sorted arkosic material and may have been a residual granitic soil. Contact-altered and granitized arkoses have been described from May Downs (Joplin, 1955, pp. 42-43). In handspecimen this core-rock is coarse and granitoid grading, in places, into arkose. Feldspar is entirely replaced by chalcedony, and the rock consists of large irregular grains of quartz interlocking with the feldspar pseudomorphs.

As it seems possible that granite pebbles, from a conglomerate within the Argylla Formation, were derived from this granite, two specimens have been examined. One of these is a medium-grained pink granite consisting of quartz, feldspar, and biotite, and the other a coarser grained type consisting of the same minerals. Both are allotriomorphic granular and contain microcline, plagioclase, quartz, muscovite, and biotite with a small quantity of sphene and iron ore. Feldspar grains measure up to 3mm. but the average grainsize is approximately 0.5mm. Quartz shows undulose extinction and is granulated. Plagioclase tends to form sub-idiomorphic tabular crystals, and is heavily sericitized; the less altered crystals are oligoclase. One specimen shows slight albitization of the microcline. In one rock biotite forms minute flakes between the larger grains of the other minerals and in others it forms independent flakes, or groups of small flakes that may measure up to 0.5 mm.

A comparison of the modal analyses of these two rocks, 1 and 2 below, with Table 1, makes it clear that these pebbles could not have been derived from the Kalkadoon granodiorite; thus it is not unreasonable to correlate them with the now deeply weathered and arkosic types on May Downs, which are obviously pre-Sybella granite in age.

	1.	2.
Microcline	44.3	33.9
Plagioclase	25.3	28.3
Quartz	20.2	36.4
Biotite	8.7	0.8
Muscovite	1.3	0.6
Sphene	0.2	-

(2) Sybella granite.

In the field one has the impression that this granite is a coarse-grained rock, and, though pink microcline phenocrysts may measure up to about 15 mm. in length, close examination shows that the groundmass consists of grains ranging in size from 3 mm. to 0.5 mm., which tend to group into clots or elongated patches. The general colour of the rock, and the degree of foliation, appear to vary with the biotite content.

The rocks are allotriomorphic granular and porphyritic, the edges of the large microcline, and occasionally those of the plagioclase, phenocrysts interlock with the granular groundmass. In many specimens microcline is fringed with myrmekite, and may contain albite intergrowths, or small sub-idiomorphic tabular and corroded inclusions of plagioclase. In the groundmass the plagioclase (oligoclase) always forms irregular grains, which contrasts the fabric of these rocks with that of the Kalkadoon granodiorite.

Towards the southern part of the foliated granite, near Waverley Creek, and elsewhere, some of the microcline appears to occur as porphyroblasts in an impure quartzite, However, some of these larger units contain sub-idiomorphic and corroded tabular crystals of plagioclase, which surely suggests that their origin was magmatic (Fig. 3).

Fluorite is a constant accessory, and, in some cases, appears to have replaced hornblende and feldspar, the replacement of feldspar being the more common.

Two of the foliated granites have been analysed (Joplin 1955) and the analyses are repeated here, together with their calculated modes.

In the calculations it is assumed that plagioclase comprises one third of the myrmekite and that a small quantity of albite is present in the microcline. In some places slight albitization of microcline can be seen, but not measured.

	1	11
SiO_2	72.68	71.26
Al_2O_3	12.83	13.95
Fe_2O_3	0.978	1.08
FeO	2.25	2.58
MgO	0.04	0.10
CaO	1.55	1.84
Na_2O	3.50	2.74
K_2O	5.03	5.65
H_2O+	0.50	0.37
H_2O-	0.20	0.07
TiO_2	0.43	0.26
P_2O_5	0.03	0.41
MnO	tr	tr
F	nd	nd
	99.83	100.31
Sp.Gr.	2,615	2.653

CALCULATED MODES

	From Analysis Wt.%	From V% (5, Table 111) Wt.%	From Analysis Wt.%	From V% (6, Table 111) Wt %
Microcline	33.3 ($Or_{79}Ab_{21}$)	33.3	39.0 ($Or_{83}Ab_{17}$)	38.0
Plagioclase	25.2 ($Ab_{89}An_{11}$)	25.2	17.5 ($Ab_{77}An_{23}$)	17.5
Myrmekite	-	0.1	11.4	11.6
Quartz	29.3	27.9	24.6	27.3
Biotite	6.8	6.8	3.1	3.4
Hornblende	5.4	5.6	-	-
Sphene	0.2	0.1	0.3	tr
Apatite	0.3	-	1.1	-
Muscovite	-	-	1.1	1.5
Iron Ore	-	-	1.9	-
Fluorspar	-	0.8	-	0.4

1. Porphyritic foliated granite, 5½ miles north-west of McKellars Bore.

11. Porphyritic foliated granite, near head of Mica Creek.

Anal. G.A. Joplin

TABLE 1V

MICROMETRIC ANALYSES OF SYBELLA GRANITE.

	1.	2.	3.	4.	K.	5.	6.	7.	8.	9.	L.
Microcline	34.4	35.5	32.8	41.7	33.7	35.6	39.0	43.7	39.3	37.0	44.7
Plagioclase	29.3	15.6	24.2	2.3	4.5	24.2	17.7	25.6	18.7	5.2	6.5
Myrmekite	2.1	-	-	tr	0.8	0.1	11.4	-	4.2	-	1.4
Quartz	30.4	32.6	38.9	36.2	52.8	27.8	26.9	27.0	29.3	49.4	44.6
Biotite	2.5	11.2	3.9	11.5	7.3	6.5	3.2	2.1	6.1	6.1	1.9
Hornblende	-	1.7	-	-	-	5.0	-	0.7	1.1	1.9	0.9
Sphene	0.3	1.9	0.2	1.1	-	0.1	-	-	0.9	0.2	-
Apatite	0.3	0.7	-	-	-	-	-	-	0.2	-	-
Epidote	tr	-	-	-	0.3	-	-	-	tr	-	-
Muscovite	-	-	-	4.9	-	-	1.4	-	-	-	-
Iron Ore	0.4	0.8	-	1.8p	-	-	-	-	0.2	-	-
Fluorite	0.3	-	-	0.5	-	0.7	0.4	0.9	tr	0.2	-
Chlorite	-	-	-	-	0.3	-	-	-	-	-	-
Allanite	-	-	-	-	0.3	-	-	-	-	-	-

p. Pyrite

1. Near Mutta Hut
2. 3 miles North-west of Sulieman Bore
3. 5½ miles N 60°W of Sulieman Bore.
4. 10 miles West of Butru Siding.
K. 5½ miles West of Upper Moonah Ck crossing on Mt. Isa - Wandangi Rd.
5. 5½ miles North-west of McKellars Bore.
6. Head of Mica Creek.
7. May Downs.
8. May Downs.
9. Mingera Creek, May Downs.
L. Back track to May Downs, 40 miles from Mt. Isa.

(3) Granodiorite associated with the Sybella Granite.

The Sybella granodiorite occurs at the southern end of the Sybella Granite near Sulieman Bore. The outcrops are massive and commonly crowded with xenoliths. In hand specimen the granodiorite is porphyritic and though the groundmass ~~averages only~~ ranges from 2mm. to 0.5mm., the specimens appear to be coarse-grained because phenocrysts average about 5 mm., but measure up to 10mm. They closely resemble the Kalkadoon granodiorite that occurs in the West Leichhardt area, the phenocrysts being pink and the groundmass fairly dark.

Both microcline and plagioclase occur as phenocrysts. Microcline forms large irregular grains and is commonly fringed with myrmekite; plagioclase forms sub-idiomorphic tabular crystals and is much sericitized. The groundmass has an average grainsize of about 0.5 mm. though slightly coarser types do occur. The constituent minerals are quartz, microcline, plagioclase, biotite, hornblende, sphene, and apatite. For an accessory mineral, apatite is relatively abundant.

Three modal analyses have been made of these rocks and a comparison with Tables 1 and 111 will show that they appear to have closer affinities to the Kalkadoon granodiorite than to the foliated Sybella granite with which they have been mapped.

	1.	2.	3.
Microcline	22.7	17.3	15.8
Plagioclase	33.4	38.6	25.4
Quartz	26.3	31.2	35.8
Biotite	12.4	8.8x	18.0
Hornblende	3.4	-	1.3
Sphene	1.7	0.9	1.3
Apatite	-	0.6	1.0
Muscovite	-	1.5	-
Iron Ore	-	1.1	1.3

x Partly epidotized.

1. Dajarra - Mt. Isa Track, 10 miles west of Dajarra.
2. North-west of Sulieman Bore.
3. " " " " ".

THE EWEN GRANITE.

The Ewen Granite extends, in four discontinuous outcrops, from Surprise Creek north to Gunpowder Creek, a distance of about 55 miles. The granite has invaded the Argylla Formation, a sequence of acid volcanic rocks with which it appears to be co-magnatic, and is overlain by an arkosic conglomerate that forms the base of the Eastern Creek Volcanics.

We have examined the rock only on Surprise Creek, where it is a massive, coarse-grained, red granite, but a small mass of grey adamellite is reported also within the area mapped as the Ewen Granite. Because the phenocrysts are close set in a fairly coarse groundmass, the rocks appears to be fairly even-grained. The feldspar is bright red and is surrounded by milky quartz and greenish grey chlorite.

Under the microscope phenocrysts of microcline measure up to 9mm., and are surrounded by an allotriomorphic granular groundmass with a grainsize of about 3mm., but between the larger grains of the groundmass are smaller grains (0.4mm.), or patches of smaller grains.

Micrometric measurements gave the following results:-

	1.	M.	N.	O.	P.	Q.
Microcline	46.8	34.2	51.5	39.3	48.3	44.7
Plagioclase	18.6	26.3	33.2	22.3	12.3	18.4
Quartz	29.9	34.0	5.9	36.3	38.3	35.5
Biotite	4.5x	5.6	9.5	2.1	-	1.4
Sericite	0.1	-	-	-	1.0	
Epidote	tr	-	-	-	-	-
Apatite	tr	-	-	-	-	-
Sphene	0.1	-	-	-	-	-

x Completely chloritized.

1. Surprise Creek.

M. 1½ miles north of Dynamite Ck., 35 miles north-west of Dobbyn.

N. ¾ mile east of M.

O, P, Q. Near Alsae Waterhole, Gunpowder Creek.

WONGA GRANITE.

The outcrop of the Wonga Granite is continuous from 5 miles south-south-west of Kajabbi to about 5 miles south of the township of Mary Kathleen, from where it extends further south as a series of outcrops to the Lady Fanny Mine. Although these outcrops comprise the mass as defined, we consider that it would have been more appropriate to also include in the Wonga Granite that part of the Kalkadoon Granite in the Corella Formation extending from Juenbarra siding south to the Cambrian contact.

The Wonga Granite invades the Corella and Argylla Formations and may be overlain by the Deighton Quartzite.

At the northern end of the outcrop the rock is coarse-grained and shows a great diversity of types, though the mineral constituents, and their relative proportions remain fairly constant. Here the granite is massive and prophyritic with a medium-grained base and large pink microcline phenocrysts; elsewhere the base may resemble a granitized micaceous sediment with large porphyroblasts of feldspar. Some rocks show a gneissic banding, resembling original bedding, and where the granite invades highly contorted calcsilicate rocks, it is a migmatite. In places on the Dugald River, where the granite looks igneous and massive, small intrusions of microgranite or aplite are common, and small pegmatite stringers are associated with many of the contorted metamorphic types. Further south, near the Lady Fanny Mine, small aplite veins form discrete injections, and an albitized pegmatite is recorded. In this same area banded and folded calcsilicate rocks (Plate 1, Figs. 2 & 3) gradually merge into a granite which appears to retain sedimentary structures and to have originated by a process of potash metasomatism (Plate 1, Figs. 4 & 5). Extensive, but unsystematic, collections from this area reveal some scapolite-bearing rocks unaffected by potash metasomatism, other rocks containing abundant microcline in addition to the normal minerals of the calcsilicate assemblage, and others containing all the minerals of a hornblende granite, but the exact inter-relations between them is unknown.

In the Duchess area, Edwards and Baker (1954) described banded rocks with scapolite-rich and pyroxene-quartz and hornblende-pyroxene seams. In the Lady Fanny Mine area some bands consist exclusively of bright green pyroxene, scapolite, and sphene, and others contain abundant microcline, smaller quantities of pyroxene and traces of quartz, albite, and fibrous scapolite (Figs. 4A & B). Since microcline appears to be confined to seams alternating with the pyroxene-rich assemblage, it may have replaced the plagioclase or scapolite in these bands. Although such bands contain a large proportion of potash feldspar such an assemblage as microcline-pyroxene-scapolite-sphene cannot be regarded as that of a granite (Fig. 4A). Some rocks, however, contain coarse bands or veins consisting of quartz, microcline, plagioclase, and hornblende (Fig. 4B) - the typical assemblage of the Wonga granite. Thus until more detailed work is carried out, it is impossible to decide whether the microcline-bearing bands are stringers of contaminated granite that has exploited sedimentary seams, already prepared by metasomatism, or whether they are metasedimentary seams that formerly consisted of hornblende, quartz, and plagioclase. Many of the banded rocks of this area show honeycomb structure (Plate 1, Fig. 2) which may have been caused by the differential weathering of microcline, scapolite, and pyroxene.

The Wonga granite is allotriomorphic to hypidiomorphic granular. In the northern area, it is porphyritic with large (about 10mm.) grains of microcline interlocking with the smaller (0.3mm) grains of the groundmass. In the Lady Fanny area the average grainsize is about 1 mm., but in banded types, individual seams, though themselves even-grained, may show a range from 3mm. to 0.3mm. between seams.

In both areas the granite consists of microcline, commonly fringed with myrmekite and, in places, slightly microperthitic, of sericitized andesine, quartz, biotite, and hornblende. Hornblende appears to be characteristic of the granite, though it is absent in a few parts of the northern outcrop areá. Pyroxene has been recorded in some specimens from the south. Plagioclase normally occurs in small irregular grains, but, in places, small tabular crystals or laths are included in the microcline. Quartz shows undulose extinction and is often cracked, and in gneissic rocks it may form bands.

Analyses and modes of a rock from the north, and from the south, are given below, and, though texturally dissimilar, it will be seen that they compare chemically and mineralogically.

	1	11
SiO_2	70.77	69.94
Al_2O_3	14.97	14.62
Fe_2O_3	0.36	0.28
FeO	2.78	3.12
MgO	0.18	0.45
CaO	1.86	1.90
Na_2O	3.23	2.38
K_2O	5.04	6.34
H_2O+	0.39	0.56
H_2O-	0.12	0.08
TiO_2	0.68	0.48
P_2O_5	nd	0.02
MnO	tr	0.03
	100.38	100.20
Sp.Gr.	2.702	

CALCULATED MODES

	1		11	
	From Analysis Wt.%	From V% (12, Table V) Wt.%	From Analysis Wt.%	From V% (6, Table V) Wt.%
Microcline	40.86 ($Or_{66}Ab_{34}$)	43.2	37.81 ($Or_{96}Ab_{4}$)	37.8
Plagioclase	21.00 ($Ab_{57}An_{43}$)	21.0	21.60	20.8
Myrmekite	0.40 ($Ab_{1}Q_{1}$)	0.4	2.70	2.7
Quartz	27.90	23.9	23.91	24.9
Biotite	5.48	7.0	7.60	6.7
Hornblende	-	-	6.10	6.1
Chlorite	2.88	2.9	-	-
White Mica	0.54	0.3	-	-
Sphene	-	tr	0.59	0.8
Apatite	-	0.3	-	-
Iron Ore	0.85	0.6	0.46	0.2
Fluorspar	-	0.3	-	-

1 - Dugald River area, 15½ miles west-south-west of Quamby. Anal. G.A. Joplin.

11 - Near Lady Fanny mine, - Anal. Avery and Anderson.

TABLE V

MICROMETRIC ANALYSES OF THE WONGA GRANITE.

	R.	1.	2.	3.	4.	5.	6.	7.	S.	8.	9.	10.	T.	U.	11.	12.
Microcline.	54.3	52.2	48.4	42.8	41.3	40.7	39.0	33.4	40.5	51.8	51.3	51.3	40.0	54.4	46.5	44.5
Plagioclase.	13.8	13.3	15.5	17.6	18.0	19.4	20.9	21.2	8.9	13.2	14.4	11.9	18.6	7.6	20.5	20.8
Myrmekite.	-	-	3.5	-	-	tr	2.7	2.5	0.3	tr	-	-	-	-	tr	0.4
Quartz.	26.2	27.8	26.8	31.2	28.3	37.9	24.9	36.9	41.0	34.5	16.7	24.7	37.2	28.9	24.9	23.6
Biotite. (Chlorite)	4.8	3.5	2.3	5.6	4.8	0.3	6.3	3.2	6.8	0.4	0.3	-	4.1	-	6.7	6.6
Hornblende. (Chlorite)	-	2.6	3.0	2.1	7.3	1.7	5.4	2.5	1.6	0.1	13.6	10.9	-	2.3	-	2.9*
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	-	-
Sphene.	0.2	0.6	0.5	0.7	0.3	-	0.6	0.3	0.5	-	3.0	1.2	-	2.3	-	tr
Apatite.	0.6	-	tr	-	-	-	0.2	tr	-	-	0.7	-	0.2	tr	-	0.2
White Mica.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.4	0.4
Epidote.	-	-	-	-	-	-	-	-	0.3	=	-	-	-	tr	-	-
Fluorspar.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2
Iron Ore	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3

* Wholly Chlorite.

R. On track crossing Pilgrim and Maiden Creeks, 11 miles south of Mayfield Homestead.

1-7. East of Lady Fanny Mine, 7 miles off Duchess Road past Green Creek Well.

S. Same as 1-7

8. Near Rosebud Mine.

9-10 Near Mt. Burstall.

T. On Cloncurry Road, 1 mile north-east of Wonga Fault.

U. ½ mile west of Cloncurry-Mary Kathleen Road.

11. South-west of Native Companion Bore.

12. 15½ miles west-south-west of Quamby.

WEBERRA GRANITE.

We are indebted to Mr. E.K. Carter for the following notes on field occurrence of the Weberra Granite, as we have not visited the area of outcrop.

Two groups of outcrops have been included in the Weberra Granite. The first group lies between the upper reaches of Fiery and Sandy Creeks in the Camooweal 4-mile Sheet area. The granite invades the Ploughed Mountain Beds and is exposed in a minor domal structure with which it is roughly concordant.

It is a slightly porphyritic, fine-grained, red granite. Finer grained types are associated and numerous dykes and apophyses, which include quartz-feldspar porphyry and granophyre, crop out over an area of about 20 square miles.

The second group of outcrops lies north of the Gregory River in the Lawn Hill 4-mile Sheet area. The rock is generally deeply weathered, and outcrops are small, though larger bodies may be covered by alluvium.

This granite is a fine-grained, even, massive, pinkish grey muscovite granite associated with pegmatite in which muscovite and tourmaline commonly occur; the adjacent sediments have been greisenised to some extent.

Only two specimens of rock have been examined, and, as each is rather different, it is impossible to say which, if either, is the predominating type, and thus, to make generalizations about the mass as a whole.

One specimen is a fairly coarse muscovite granite. It is allotriomorphic to hypidiomorphic granular and relatively even, with an average grainsize of about 3mm. Sericitized plagioclase forms crystals that average about 1.5mm. in length, and tends to be tabular. Much of the potash feldspar appears to be orthoclase. In places, this feldspar is intergrown with muscovite that may form independent flakes up to 3mm. The muscovite is pale greenish yellow, and basal sections contain small tufts and sheaves of minute rutile needles. Quartz forms irregular unstrained grains with an average diameter of about 3mm.

The mode of this rock is as follows:-

Potash feldspar	25.1
Plagioclase	26.0
Quartz	39.3
Muscovite	9.6

The amount of plagioclase seems unusually high for a rock so rich in muscovite, but the grey marginal phase of the Risberg granite of Sweden also shows this peculiar feature, the muscovite and plagioclase content being almost equal (Von Eckermann, 1936). The composition of the plagioclase in the Swedish granite is $Ab_{80}An_{20}$, but the Queensland feldspar is so much sericitized that its composition cannot be determined. In view of the presence of primary muscovite and the high content of quartz, the feldspar is likely to be an alkaline variety. Thus it is preferable to call the rock a granite rather than an adamellite.

The second type of Weberra Granite is a fine porphyritic rock, rich in microcline and free of muscovite, but its relation to the muscovite granite is unknown. Because of its finer grainsize and similarity to other microcline-rich rocks, it is described with the potash microgranites as a minor intrusion.

NICHOLSON GRANITE.

The Nicholson Granite occurring more than 220 miles to the north-north-west of Mt. Isa, is in an entirely different tectonic environment, and probably bears no relation to all the granitic rocks described above. We have not been into this northern part of the region and are indebted to Mr. E.K. Carter for the field notes and for the specimens.

The outcrop straddles the Northern Territory-Queensland border and covers an area of about 130 square miles of which about 30 square miles lie in Queensland.

The granite invades the Cliffdale Volcanics, a sequence of acid laves believed to be near the base of the Upper Proterozoic, and it appears to be co-magmatic. It is overlain by strata of fairly definite Upper Proterozoic age.

Two distinctly different rock types occur; one is a medium-grained, massive, porphyritic red granite associated with granophyre; the other is a coarse, pinkish grey granodiorite fairly rich in biotite, and is associated with more basic types. Jensen (1941) reported that the first occurs as a laccolith in the Cliffdale Volcanics, but its relation to the other type is unknown; petrographically the two types are dissimilar and as we have not examined these rocks in the field, only brief notes are appended.

Quartz-mica-diorite.

This rock is coarse, even-grained, hypidiomorphic granular and consists of plagioclase andesine, biotite, hornblende, and quartz.

Granodiorite or Adamellite.

This rock is coarse, fairly even-grained and hypidiomorphic granular. It differs from the quartz-mica diorite in that it contains orthoclase; the composition of the plagioclase is indeterminate owing to the heavy sericitization.

Modes of two of these rocks are as follows:-

Plagioclase	38.0	29.8
Orthoclase	22.5	31.8
Quartz	21.4	31.3
Biotite	17.6	6.9
Chlorite	0.2	0.2
Apatite	0.2	tr
Calcite	0.1	-

Granophyres.

In handspecimen the granophyres are stony pink to red rocks containing corroded grains of quartz and tabular orthoclase and andesine phenocrysts that measure from 6 to 1.5 mm.

The groundmass is made up of irregular grains of orthoclase graphically intergrown with quartz, or of a spherulitic arrangement of these minerals fringing feldspar phenocrysts. Chlorite also may be present.

V. MINOR INTRUSIVES.

Dykes, veins and small irregular intrusions of the more extreme types invade many of the major granites and have been mapped as part of the granite mass.

Locally they may occur as the predominating type, as, for example, the microgranite at the north-eastern margin of the Sybella Granite, and the microadamellite which forms most of the isolated outcrops of the Williams Granite.

1. THE SYBELLA AND WONGA MICROGRANITES.

As both Sybella and Wonga microgranites are very similar they are described together. Both occur as small high-level intrusions showing sharp contacts against the coarse porphyritic Sybella and Wonga granites and the finer aplitic type occurring as dykes or veins.

On May Downs much of the Sybella microgranite is hybridized, but as these hybrids have been described (Joplin, 1955) the present description is confined, so far as possible, to unhybridized rocks.

The microgranite is fine to medium-grained, pink or red rock, and is commonly massive, though foliated types have been recorded. As there is an almost complete gradation from grains of 1.5mm to 0.4mm, the rocks, though variable, cannot be called porphyritic. The texture is allotriomorphic granular and the larger grains are microcline, plagioclase, and quartz; the quartz commonly forms granular aggregates. Some specimens contain myrmekite fringing microcline, and one granophyric type is recorded. Plagioclase is much sericitized and rarely shows crystal outlines. Biotite may be completely bleached or altered to chlorite, but in many rocks it is deep olive-green. Muscovite is commonly present in small amount. In the foliated rocks, micas and chlorite, have a directional arrangement. Sphene, iron ore, and apatite are accessories, and sphene may form rims around grains of iron ore.

Only one specimen of Wonga microgranite has been micrometrically measured, and, like the Wonga granite, with which it is associated, it contains a very high percentage of microcline.

TABLE V1

MICROMETRIC ANALYSES OF SYBELLA AND WONGA MICROGRANITES.

	1.	2.	3.	4.	5.	V.
Microcline	41.9	40.4	45.8	30.0	40.2	46.2
Plagioclase	9.5	21.3	15.2	4.6	18.6	14.7
Quartz	38.2	36.6	35.8	61.4	37.3	36.2
Biotite	9.5	-	2.0	3.9	2.1	1.7
Sphene	0.5	-	-	-	0.5	-
Apatite	-	-	-	0.1	-	-
Muscovite	0.4	1.3	1.2	-	0.2	-
Iron Ore	-	0.4	-	-	1.1	1.3

1. Near Ardmore.
2. Near Duchess on the Mt. Isa Road.
3. Duchess Road, 12 miles south-south-east of Mt. Isa.
4. Mica Creek.
5. May Downs.

V. Cloncurry Road at Wonga Fault.

One rock of this type from the Old May Downs Homestead has been analysed (Joplin, 1955) and the analysis is repeated below together with the calculated modes -

			CALCULATED MODES from analysis Wt.%	from V% (5, Table V1) Wt.%
SiO_2	74.76			
Al_2O_3	14.01			
Fe_2O_3	0.83	Microcline	38.82 ($Or_{93}Ab_7$)	38.8
FeO	0.71	Plagioclase[x]	18.30 ($Ab_{88}An_{12}$)	18.3
MgO	0.32	Quartz	37.80	37.6
CaO	0.63	Biotite	2.60	2.3.
Na_2O	2.07	Sphene	-	0.6
K_2O	6.04	Iron Ore	1.92	2.1
H_2O +	0.35	Muscovite	0.36	0.3
H_2O -	0.01	Apatite	0.34	-
TiO_2	0.37			
P_2O	0.11			
MnO	tr			
	100.21			

x Excess muscovite added as feldspars slightly sericitized.

Sp.Gr. 2.594

Anal. J.K. Burnett and B. E. Williams.

2. MICROADAMELLITES.

Microadamellites are associated with the Williams and Wimberu adamellites, with the Sybella Granite and with the Kalkadoon granodiorite. They occur as small dykes or veins or as minor irregular intrusions cutting the coarser granitic rocks. In the northern part of the Williams Granite, microadamellite forms small isolated outcrops and, in places, passes into soda aplite: this may represent a marginal phase of the Williams adamellite. One mile south of Carters Bore, a slightly foliated microadamellite crowded with sedimentary xenoliths, is associated with the Sybella granite.

These rocks are pink to pinkish white; they are allotriomorphic to hypidiomorphic granular and have a variable grainsize, a single specimen showing a range from 3mm. to 0. 4mm.

The appended micrometric analyses show the mineral composition.

TABLE V11

MICROMETRIC ANALYSES OF MICROADAMELLITES.

	1.	2.	3.	4.	W.	5.	6.	7.
Microcline.	28.5	33.5	36.2	28.6	33.7	33.1	33.3	31.5
Plagioclase.	35.1	29.4	33.5	30.1	33.5	29.4	24.7	33.2
Myrmekite.	0.2	-	0.9	-	0.1	0.2	-	-
Quartz.	30.8	25.6	26.7	24.9	21.2	36.5	34.8	26.8
Biotite.	4.2[x]	7.2	1.4[O]	6.6	10.7	0.4	7.2	8.5
Hornblende.	-	-	-	-	0.3	-	-	-
Muscovite.	-	0.8	-	0.7	-	0.1	-	-
Sphene.	tr	0.3	0.5	0.2	0.5	0.2	-	-
Apatite.	0.2	0.1	tr	0.4	0.1	-	-	-
Iron Ore.	0.6	1.6	0.4	1.5	-	0.1	-	-
Chlorite.	-	0.3	-	6.1	-	-	-	-
Carbonates.	-	0.9	-	0.4	-	-	-	-
Fluorite.	0.4	0.3	0.4	0.5	-	-	-	-

O. Chloritized.
x. Biotite mainly altered to hydrates of iron.

1-3. Williams microadamellite - Soldiers Cap Area.
4. Williams microadamellite - 8 miles north of Kuridala.
W. Williams microadamellite - Selwyn-Toolebuc Road, 23 miles from Selwyn.
5. Wimberu microadamellite.
6. Sybella microadamellite (slightly foliated). One mile south of Carters Bore.
7. Kalkadoon Microadamellite. 4 miles south of the Crusader Mine.

(3) ALBITITE AND SODA APLITE. These rocks, which are associated with, and possibly invade, the Sybella microgranite and Williams microadamellite have been described already (Joplin, 1955, 1957) but as they appear to be genetically related to the granitic rocks it is pertinent to repeat a short description in the present paper for the sake of completeness.

Both rock types are allotriomorphic granular with a slightly variable grainsize. In general they are fine-grained with an occasional large grain, but few are porphyritic. Single specimens, however, may show a range from 1.5mm to 0.76 mm.; smaller grains are interstitial and form a texture resembling mortar structure.

The albitite grades into soda aplite by an increase in the amount of quartz and a concomitant decrease in feldspar. The feldspar is albite, ranging in composition from Ab_{100} to Ab_{92}, but traces of microcline have been noted in some specimens. Quartz commonly occurs as independent grains, but in many of the soda aplite specimens it is graphically intergrown with albite. Chlorite and muscovite occur in small amounts and small quantities of bleached biotite have been recorded. Sphene, ilmenite, and rutile are common accessories.

One specimen of albitite and two of soda aplite have been analysed (Joplin, 1957), but the soda content of the soda aplite from the Soldiers Cap area is believed to be too low, and the analysis is not repeated. The analyses of the other two rocks are given below, together with their calculated modes.

				1		11	
	1.	11.		From Analysis Wt.%	From V% (1 Table V111) Wt.%	From Analysis Wt.%	From V% (2 Table V111) Wt.%
SiO_2	67.84	77.68	Plagioclase	86.2 ($Ab_{93}An_5Or_2$)	86.5	43.0 ($Ab_{99}An_1$)	44.3
Al_2O_3	20.42	13.04					
Fe_2O_3	0.01	0.02	Quartz.	8.5	8.5	44.4	43.5
FeO	0.32	0.09	Chlorite.	3.4	3.9	6.1	4.7
MgO	0.14	1.52	Muscovite.	1.2	0.9	5.6	6.6
CaO	0.67	0.11	Ilmenite.	0.7	0.2	-	-
Na_2O	0.54	5.03	Rutile.	-	-	1.1	-
K_2O	0.51	0.46	Sphene.	-	-	-	0.8
H_2O+	0.07	0.61					
H_2O-	0.06	0.04					
TiO_2	0.18	0.15					
P_2O_5	tr	abs					
MnO	tr	abs					
	99.76	99.93					

1. locality as for 1, Table V111 Anal. G.A. Joplin.

11. locality as for 2, Table V111 Anal. J.K. Burnett.

TABLE V111

MICROMETRIC ANALYSES OF ALBITITE AND SODA APLITE.

	1.	2.	3.
Plagioclase.	87.5	45.4	75.3
Quartz.	8.0	43.3	22.7
Chlorite.	3.6	4.3	-
Sphene.	-	0.6	1.2
Iron Ore.	0.1	-	-
Muscovite.	0.8	6.4	0.8

1. Albitite, Kittys Plain, May Downs.
2. Soda aplite. Kittys Plain, May Downs.
3. Soda aplite, Soldiers Cap area.

4. POTASH - RICH MICROGRANITE.

Small dykes and veins, exceptionally rich in potash feldspar, invade a number of the granitic bodies. Some of the rocks in them are very similar in composition to the Wonga granite. A single specimen of the little known Weberra Granite also falls into this group; the potash-rich microgranite cutting the Kalkadoon granodiorite is considerably younger than the granodiorite, as the granodiorite is intersected by basic dykes which are cut, in turn, by the microgranite.

The specimens of potash-rich microgranite have a variable grainsize (3mm. to 0.1mm.) but are not definitely porphyritic. The larger grains normally consist of microcline and quartz, which, in places, may show graphic intergrowth. Plagioclase is much sericitized, and occurs as small irregular grains or as sub-idiomorphic laths. The rock from the Weberra mass contains orthoclase (5mm) fringed with small tabular crystals of plagioclase, giving it a Rapakivi-like texture; the phenocrysts are not unlike those described and figured from the hybrid facies of the Dartmoor Granite (Brammall and Harwood, 1932). Chloritization of biotite, sericitization of plagioclase, and the presence of carbonates and haematite, in some rocks, attest to the action of late magmatic fluids.

TABLE 1X

MICROMETRIC ANALYSES OF POTASH-RICH MICROGRANITES.

	1.	X.	2.	Y.	3.	4.	5.	6.
Microcline.	72.9	65.6	50.1	50.4	52.6	50.2	48.2	53.5
Plagioclase.	7.3	8.8	11.5	14.2	8.1	20.3	3.2	8.2
Quartz.	19.1	20.2	28.8	28.9	30.8	22.1	39.8	36.1
Biotite.	0.2	-	9.5	3.0	8.5	-	4.2x	0.1
Chlorite.	-	-	-	0.9	-	4.7	-	0.5
Muscovite.	-	-	0.1	0.2	-	-	3.5	-
Sphene.	-	2.3	-	1.6	-	-	1.1	0.2
Iron Ore.	- }	1.4 (Iron Ore and Haematite)	-	0.5	-	2.5	-	-
Haematite.	0.5 }		-	-	-	-	-	-
Fluorite.	-	-	-	0.2	-	0.2	-	-
Clinozoisite.	-	0.4	-	-	-	-	-	1.3
Carbonates.	-	0.8	-	0.1	-	-	-	0.1
Apatite.	-	0.4	-	0.1	-	-	-	-
Pyroxene.	-	0.1	-	-	-	-	-	-

x choritized

1. Intrusive into Wonga granite, near Lady Fanny Mine.
X. Intrusive into Wonga granite, west of Quamby.
2. Intrusive into Sybella granite, May Downs.
Y. Intrusive into Sybella granite.
3. Intrusive into Williams Granite Soldiers Cap area.
4. Intrusive into Williams Granite, Soldiers Cap area.
5. Intrusive into Kalkadoon granodiorite, where road to Kings Cross Mine crosses Wonga Fault.
6. Phase of Weberra Granite.

5. MICA PEGMATITE.

Large dykes of coarse pegmatite containing sub-commercial mica invade both the foliated, porphyritic granite, and the microgranite on the eastern margin of the Sybella Granite, and have been mined for mica on Mica Creek and for beryl about 6 miles west-south-west of Mt. Isa. Monazite is recorded from the pegmatite on Mica Creek and large red garnets occur in the beryl-bearing pegmatite. These outcrops of pegmatite contain soda feldspar.

Sub-commercial mica is also reported from the Fullarton River area on the eastern side of the Williams Granite, and mica pegmatite is also associated with the same granite further south-west on Gin Creek.

Mica is also reported from Naraku Siding (Shepherd, 1943), and E.K. Carter (per.comm.) has observed mica pegmatite invading quartzite at the Old Man Waterhole near the head of the Cameron River which he believes is the Deighton Quartzite.

Unfortunately, no petrographical work has been done on these rocks. However, graphic intergrowth between microcline and quartz is common and occurs both on a macroscopic and microscopic scale, and the potash feldspar is not infrequently perthitically intergrown with albite. Pegmatite dykes rich in microcline are probably younger than those with muscovite and soda feldspar.

V1. PETROGENESIS.

The granites of North-western Queensland have been emplaced under a number of different conditions, and all of the sub-divisions outlined by Buddington (1959) may be represented in this region. Thus, the Kalkadoon and Ewen Granites, which invade the Leichhardt and Argylla lavas respectively, and the much later Nicholson Granite, which invades the Cliffdale Volcanics, are possibly epizone types, because, as has been suggested, the lavas may be co-magmatic with the granites. Although we believe that some of the granites emplacements of this area may be correlated with depth, most of them can be more satisfactorily correlated with intensity of folding at the time of emplacement, and with the competence of the invaded country rocks. The Wonga Granite, which in places is gneissic, migmatitic and metasomatic, would probably be classified by Buddington as a catazone type, but field evidence precludes very deep burial, and the catazone features may be caused by its emplacement in yielding calcareous sediments, in the centre of the orogenic belt. Most of the other granites of this region are mesozone types.

ASSIMILATION

Joplin (1955) assumed that all the more basic types of granite in the region resulted from the hybridization of granite by basalt, but it is now known that in the original study only four masses were examined. Furthermore in making the present micrometric analyses obviously hybridized rocks have been excluded, so it is doubtful whether such a well-defined and extensive type as the Kalkadoon granodiorite, comprising the greater part of the mass known as the Kalkadoon Granite, could have originated from a process of assimilation <u>in situ</u>, or in fact that the differences observed between most of the rock masses were caused by this process, especially as basaltic rocks are widespread throughout the whole region, and as the mineral composition of each granite body is relatively constant.

Nevertheless, there is abundant evidence of local assimilation, as for example on the Duchess Road 12 miles south-south-east of Mt. Isa, where the Kalkadoon granodiorite has assimilated basic material in the Leichhardt Metamorphics and has been much basified in consequence. Farther south, west of Bushy Park, other examples of such a process may be seen.

Owing to the presence of numerous xenoliths it was suggested (Joplin, 1955, p.55) that the granodiorite within the Sybella Granite, north-west of the Sulieman Bore, ~~are~~ is a hybrid~~s~~, ~~but~~ and, although it is doubtful, ~~these rocks~~ it may represent an earlier differentiate of the granite.

The microgranite~~s~~ on Kittys Plain, May Downs, show excellent examples of local basification, and these are described in some detail elsewhere (Joplin, 1955, pp. 58-60). Also near this locality albitite has been hybridized by the incorporation of basic material and rocks not unlike basic diorites have resulted (Joplin, 1955, p.52). On Squirrel Hills, at the southern end of the Williams adamellite, a coarse-grained soda aplite has been contaminated by calcsilicate rocks, but the few slides that have been examined indicate that very little reaction has taken place, and that the incorporation seems to have been a mechanical rather than a chemical one. One such rock was found to contain 63.8% plagioclase, 23.3% quartz, 9.5% pyroxene, 2.5% sphene, 0.6% iron ore and 0.3% apatite.

2. THE ORIGIN OF THE WONGA GRANITE.

Potash metasomatism or granitization, and assimilation are ~~all~~ believed to have played a part in the formation of the Wonga granite. As indicated above, this granite everywhere contains an unusually high percentage of microcline, despite the variability of the rock. In the north it occurs as a porphyritic or porphyroblastic granite, as a gneiss and, in some places, as a migmatite; in the south a finer grained type shows sedimentary structures, which suggest the granitization of the folded calcsilicate rocks (Vide Plate, Figs. 3 and 4).

Banded calcsilicate rocks contain seams very rich in microcline and these may have been caused by potash metasomatism. Eskola (1956) and Schermerhorn (1956) have shown that potash metasomatism may result in the replacement of soda feldspar by potash feldspar and although such a replacement cannot be traced step by step in the material available from the Lady Fanny mine area, it may have occurred. Moreover soda scapolite may have been replaced by microcline. There are two difficulties with this explanation: firstly the scapolite in the pyroxene-rich bands has not been affected, and secondly perfectly fresh scapolite grains remain on the edge of these bands adjacent to the seams of microcline.

The large grains of microcline, which are characteristic of the granite at its northern end, may, in fact, be porphyroblasts rather than phenocrysts, again suggesting potash metasomation. In places, however, the rocks appear to be magmatic, and it is suggested that potash metasomatism preceded an uprising of granite, and that the magma finally assimilated parts of the metasomatized sediments, thus increasing the magma's potash content.

3. GRANITIZATION AND METASOMATISM.

Granitization and metasomatism have played a part in the genesis of some of the granitic rocks of North-western Queensland, but, although much of the Wonga Granite appears to be of metasomatic origin, the effects of these processes are generally very local, and they may be responsible for the variations only within a single rock mass rather than for the differences between different masses.

It is therefore pertinent to enquire into the possibility of differentiation as a means of bringing about these differences, as well as into the source of the soda and potash-rich fluids that are responsible for metasomatism and for the extreme granitic types. Before doing this, however, the mutual relationships of the feldspars should be examined.

4. THE MUTUAL RELATIONS OF THE ALKALINE FELDSPAR.

Vogt (1921, 1926) pointed out that orthoclase and albite form a series of solid solutions with a minimum melting mixture and that their miscibility decreases with falling temperature. Thus at high temperature a homogeneous feldspar forms and at lower temperatures the two crystallize separately as independent minerals. This has been confirmed by the experimental work of Bowen and Tuttle (1950), who have discussed the behaviour of feldspars in the presence of water vapour pressure. Their work shows that the presence of water tends to lower the temperature of the minimum melting mixture and that increase of pressure produces a further lowering of this temperature. Thus under high pressure homogeneous mixtures could be expected to crystallize at relatively low temperatures. They further state that if the vapours are free to escape, the only change during crystallization will be an unmixing of the feldspars. If, however, the vapours are retained by an increase in the volume of the magma chamber, then at lower temperatures a liquid will re-form, and this liquid, very rich in water and containing feldspar in solution, may have an important hydrothermal effect. Furthermore, when either a deficiency or an excess of silica exists, the liquids containing feldspar and water may get down into the region of two feldspars with less concentration of water.

Again, they state that if crystallization takes place at sufficient depth and under a high enough pressure, the relative amount of water in the residual liquid will increase at crystallization proceeds, and that under these deep-seated conditions the heat flow will be very small, so that the residual liquid will be present for a very long time.

In describing the granites of North-western Queensland it has been shown that the plagioclase is commonly sericitized. The mica may be paragonite or it may be due to a later potash metasomatism or, as suggested by von Eckermann (1936) in connexion with some Swedish granites, it may be due to an earlier crystallization richer in potash. In view of the experimental work mentioned above it might well be that small quantities of orthoclase were held in solid solution by plagiocalse at the initial high temperature of crystallization, and that they separate as temperature or pressure decreased.

In the petrographical section it has been shown that in calculating the modes from the chemical analyses of some granites, it has been necessary to assume that appreciable quantities of albite entered the composition of the potash feldspar. Thus orthoclase has been calculated as:-

Sybella microgranite	$Or_{94}Ab_6$
Sybella granite	$Or_{83}Ab_{17}$ and Or_{79} Ab_{21}
Wonga granite	Or_{96} Ab_4 and Or_{66} Ab_{34}

These figures suggest that the Sybella microgranite crystallized at a relatively low temperature or pressure, which is probably true, because much points to its being a fairly high level intrusion.

The Sybella granite, on the other hand, appears to have crystallized under a greater pressure or at a higher temperature, and although only a very small amount of unmixing has taken place in some rocks, it seems likely that the mass cooled slowly, and that at least towards the end stage, vapours were free to escape, for the contact zone on the eastern margin of the mass shows slight evidence of granitization and a later, more widespread, greisenization.

It has been pointed out that the Wonga granite mass possibly owes its origin to metasomatism, magmatic injection and assimilation, but without a very detailed study of this granite it is unwise to make any generalization concerning the history of its crystallization. The granite of the Wonga mass varies considerably, although all specimens show an unusually high content of microcline.

The lower albite content of the microcline in the granite from the Lady Fanny mine area supports the suggestion that this is a metasomatized granite, that was formed at a relatively low temperature and pressure, whereas the higher albite content of the microcline in the northern area suggests a possible magmatic origin.

TABLE X

MEAN ANALYSES OF MAIN ROCK TYPES AND ANALYSES OF SOME OF THE MORE EXTREME TYPE.

	1.	11.	111.	1V.	V.	V1.	V11.	V111.	1X.	X.	X1.	X11.	X111.	X1V.	XV.	XV1.	XV11.
Microcline.	17.7	44.1	30.6	27.1	30.6	18.6	26.1	-	37.3	40.8	30.0	-	45.8	55.7	72.9	18.2	31.4
Plagioclase.	34.2	21.8	34.8	31.9	17.1	32.1	44.2	75.3	16.7	14.0	4.6	87.5	16.3	10.2	7.3	32.1	22.8
Myrmekite.	0.3	-	0.3	0.1	-	-	0.8	-	1.9	-	-	-	0.6	-	-	-	-
Quartz.	30.0	29.9	30.4	35.3	49.2	31.5	22.8	22.7	35.1	40.9	61.4	8.0	29.5	28.2	19.1	31.5	29.8
Biotite.	14.4	3.7	1.9	4.3	0.7	13.1	4.1	-	6.1	3.2	3.9	-	3.5	3.2	0.2	13.1	13.7
Hornblende.	1.4	-	0.8	0.4	-	1.5	1.1	-	1.1	-	-	-	3.5	-	-	1.5	0.7
Sphene.	0.7	tr	0.6	0.4	0.9	1.3	0.3	1.2	0.5	0.1	-	-	0.6	0.6	-	1.3	0.4
Apatite.	0.3	tr	0.2	tr	-	0.5	0.4	-	0.1	tr	0.1	-	0.1	0.1	-	0.5	0.3
Epidote.	0.8	tr	-	-	-	-	tr	-	tr	-	-	-	tr	0.2	-	-	0.7
White Mica.	0.1	0.3	-	0.1	-	0.5	tr	0.8	0.6	0.5	-	0.8	0.1	0.4	-	0.5	0.3
Iron Ore.	0.1	-	0.3	0.4	1.5	0.8	0.1	-	0.4	0.5	-	0.1	tr	0.5	0.5	0.8	-
Fluorspar.	-	-	-	-	-	-	-	-	0.2	-	-	-	tr	0.1	-	-	-
Chlorite.	-	-	-	-	-	-	-	-	-	-	-	3.6	-	0.8	-	-	0.1
Carbonates.	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-

1. Kalkadoon granodiorite (mean of 13)
11. Ewen granite (mean of 6)
111. Wimberu adamellite (mean of 5)
1V. Naraku adamellite (mean of 10)
V. Extreme type of Naraku adamellite (7, Table 11).
V1. Microadamellite (mean of 8)
V11. Williams adamellite (mean of 3)
V111. Soda aplite (3, Table V111).
1X. Sybella granite (mean of 11).
X. Microgranite (mean of 6)
X1. Extreme type of microgranite (4, Table V1).
X11. Albitite (1, Table V111).
X111. Wonga granite (mean of 16).
X1V. Potash-rich microgranite (mean of 8).
XV. Extreme type of potash-rich microgranite. (1, Table 1X).
XV1. Sybella granodiorite (mean of 3).
XV11. Kalkadoon granite (mean of 3).

If it is assumed that homogeneity of the feldspar was the result of high temperature in a magma, the granite must have begun to crystallize before it was emplaced at the level where metasomatic solutions were already operating. If, on the other hand, homogeneity is caused by high pressure, which according to many petrologists would be suggested by the gneissic banding and possibly by the metamorphic grade of the country rocks, then lateral pressures must have been fairly considerable, because the granite was emplaced mainly in the Corella Formation, which is stratigraphically high in the sequence, and hence most probably the load of overlying strata would not have been very great.

5. DIFFERENTIATION, ORIGIN OF THE METASOMATIZING FLUIDS AND ORDER OF INTRUSION.

The mean micrometric analyses of each of the main rock rypes (Table X) have been plotted in a quartz-orthoclase-plagioclase diagram (Fig. 5) in an attempt to show the differentiation trends of the several granites; in doing this certain assumptions must be made concerning the order of intrusion.

Field evidence suggests that the Kalkadoon granodiorite and Ewen granite are related, as the Kalkadoon granodiorite invades the Leichhardt Metamorphics, a sequence of acid lavas with which it appears to be co-magmatic, and these lavas pass conformably upwards into the lavas of the Argylla Formation, which is invaded by the Ewen Granite. The Ewen Granite is overlain by the basal beds of the Eastern Creek Volcanics, and so far as we know, all the other granites of the region are younger than the Eastern Creek Volcanics. Points 1 and 2(Fig. 5) have consequently been joined to indicate the possible differentiation trend of the early magma. Points 16 and 17 represent respectively the Sybella granodiorite and the small patches of granite marginal to the Kalkadoon granodiorite. These points fall close to the line 1 - 2, and could be included in this trend if a curve were used instead of a line, but present field evidence does not justify this inclusion.

The Wimberu, Williams, and Naraku adamellites invade the Corella Formation, or its chronological equivalent - the Staveley Formation. The Wonga also intrudes the Corella

Formation, and the Sybella granite invades the Mount Guide Quartzite and Eastern Creek Volcanics. It is difficult to decide the order of these intrusions or whether, perhaps some of them are contemporaneous. The high soda content of the Williams Granite suggests that it may be associated with the regional soda metasomatism, and as it is known that potash metasomatism, with which the Wonga Granite appears to be associated, followed soda metasomatism, it would seem that the Wonga is a later intrusion than the Williams. Because of certain petrological similarities between the Wimberu, Williams and Naraku adamellites, we tentatively suggest that the Wimberu adamellite was intruded as the first of this group, and that it differentiated along three different lines of descent, controlled possibly by water pressure conditions. In Fig. 5, point 3 represents the Wimberu adamellite; point 4 the Naraku microadamellite, its siliceous differentiate, with point 5 the extreme of this trend; point 6 represents the average microademellite, indicating a slight potassic trend in the magma; and point 7 represents the Williams adamellite and point 8 a soda aplite, both showing the sodic trend. Some specimens of the Williams adamellite show replacement of original microcline by albite, some show new albite, and in others myrmekite is common. These replacements indicate that soda solutions were active and suggest that soda metasomatism may have been associated with the Williams Granite.

Point 9 represents the Sybella granite, point 10 the associated microgranite and point 11 the most siliceous representative of this trend. Microadamellite (point 6) is also associated with the Sybella granite, and soda aplite and albitite also occur. Thus, this granite, like the Williams adamellite, indicates a sodic trend which is shown in Fig. 5 by the curve passing through points 9,6, and 12.

It might be argued that all the sodic types are of one age and that the Williams and Sybella Granites are contemporaneous. The marginal development of mica pegmatites and the presence of small patches of granitized material associated with both granites also point to contemporaneity, but on the other hand all these features may be related to the similar tectonic positions of the two granites, which occur on the opposite margins of the orogenic belt. Again, it could be argued that the Wonga and Sybella granites are contemporaneous, because both are potash granites and both are invaded by very similar micrographites, furthermore some of the Sybella rocks suggest potash metasomatism (Fig. 3) which also suggests a parallel between this granite and the Wonga. If the Sybella and Wonga granites are of the same age, the differences between them may be caused by their different positions in the orogenic belt and by the different lithologies of the terrains into which they were intruded. If the Sybella granite is thus later than the Williams, soda enrichment must have occurred independently in each body, and was of two different ages: a view that we favour as the two granites are widely separated geographically, and one of us (Walker, 1958) has shown that the older basic rocks of the region are highly scapolitized, whereas younger ones are only slightly so.

In Fig. 5 point 13 represents the potash-rich Wonga granite and points 14 and 15 a more potassic trend which may be associated with it.

Tuttle and Bowen (1958, ~~p.89~~) have suggested that when the amount of soda in a magma exceeds the proportion of alumina necessary for the formation of albite, the residue is expelled into the country rocks and soda metasomatism results, and the experimental work of Bowen and Tuttle (1950) has shown that potash enrichment may follow soda enrichment as a granite melt begins to crystallize at a minimum temperature and decreasing pressure.

One of us has recorded small scale soda concentrations on the border of a granite at Cooma, N.S.W. (Joplin, 1942) and has suggested (Joplin, 1952) that the potash metasomatism has developed as a potash-front, original potash feldspar being albitized adjacent to the granite and the dispelled potash moving forward to produce potash-enrichment in the form of small stringers of feldspar and mica pegmatite. It seems possible that some of the mica pegmatites of North-western Queensland may have been formed in such a way, though many of them show a later enrichment in soda feldspar.

SUMMARY AND CONCLUSIONS.

One hundred and two micrometric analyses have been made of the granitic rocks contained in nine named granitic masses in North-western Queensland. Some of the mapped masses have proved to be composite bodies containing several rock types which may differ in age. The main intrusions are granodiorites, adamellites and granites and these are commonly invaded by minor intrusions of microgranites, microadamellites, potash-rich microadamellites, aplites, soda aplites, albitites and pegmatites.

It is considered that the granites have been emplaced under different tectonic conditions in different positions within the orogenic belt; and although granitic bodies showing the characteristics of Buddington's epizone, mesozone and catazone may all be recognized, it is believed that intensity of metamorphism at the time of emplacement, distance from the margin of the orogenic belt, and character of the invaded rocks are responsible for the observed differences rather than depth of burial at the time of emplacement.

It is suggested that three cycles of granitic intrusion occurred during the Proterozoic. The first is represented only by its epizone intrusions, the Kalkadoon granodiorite and Ewen Granite, which appear to invade co-magmatic lavas; the second is represented by a number of bathyliths belonging both to the mesozone and catazone; and the third, which occurred in an area to the far north-west, is represented only by an epizone type - the Nicholson Granite which appears to be invading consanguineous lavas.

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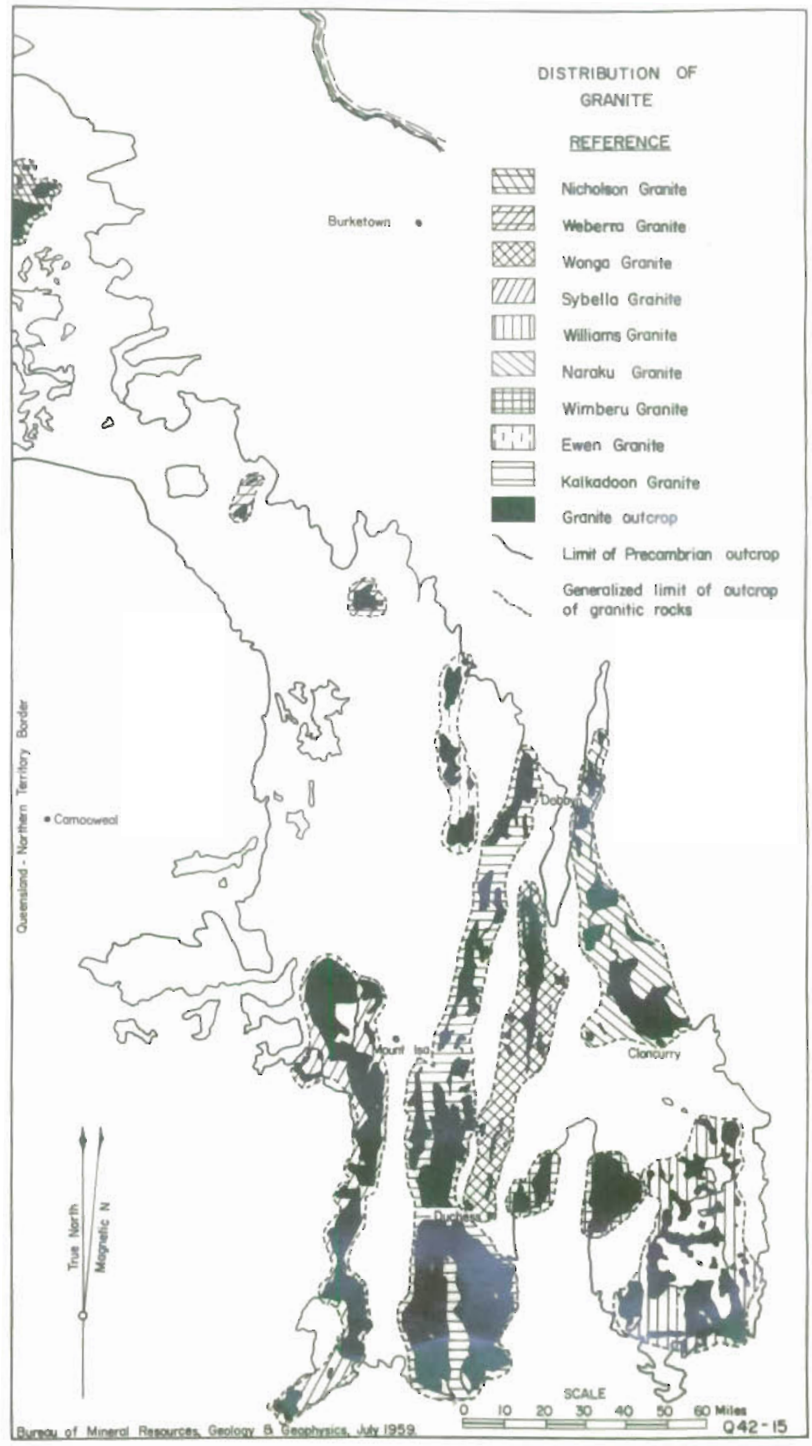

Fig. 1 - Map by Bureau of Mineral Resources, Geology and Geophysics showing areas occupied by nine named granite masses in North-western Queensland.

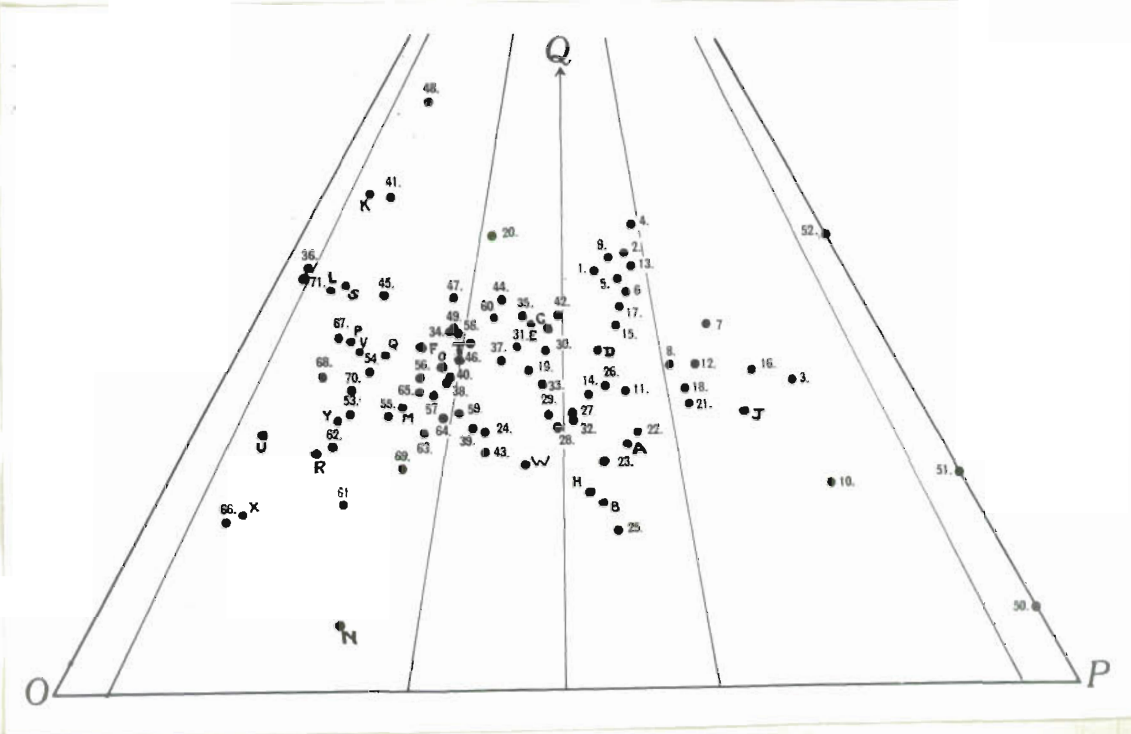

Fig. 2 - Microcline-quartz-plagioclase diagram showing plots of granitic rocks.

1-10 and A-C	Kalkadoon granodiorites.
11-13	Granodiorites associated with Sybella Granite.
14-21 and F-G	Naraku microadamellites.
22-24 and D-E	Wimberu adamellites.
25,H and J	Williams adamellites.
26-32 and W	Microadamellites.
33-41 and K-L	Sybella granites.
42-44	Granites associated with the Kalkadoon granodiorite.
45-49 and V	Sybella and Wonga microgranites.
50-52	Albitites and soda aplites.
53-64 and R-U	Wonga granites.
65 and M-Q	Ewen granites.
66-71 and X-Y	Potash-rich microgranites.

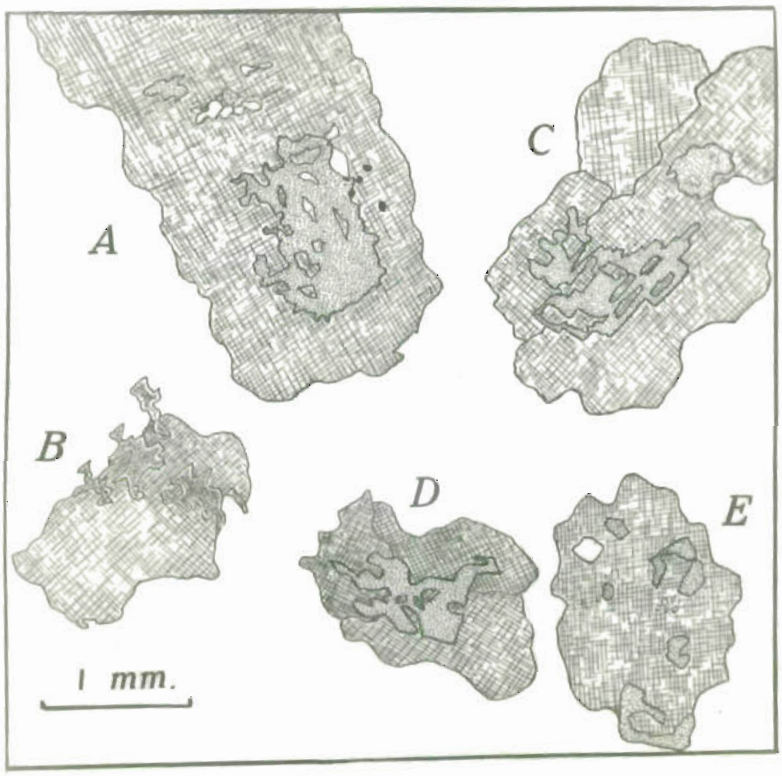

Fig. 3 - Partly resorbed crystals of plagioclase enclosed in grains of microcline.

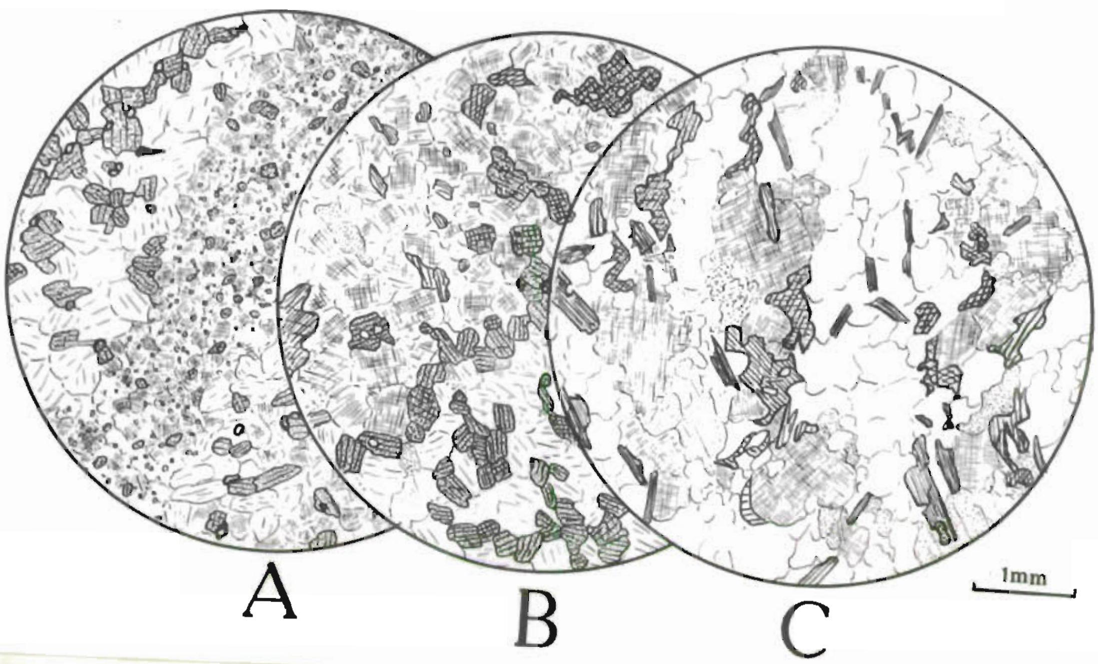

Fig. 4 - A. Banded calc-silicate rock altered by potash metasomatism, showing coarse pyroxene-scapolite band with some sphene, finer pyroxene-microcline band with little altered scapolite and medium-grained pyroxene-scapolite-microcline band.

B. Banded calc-silicate rock altered by potash metasomatism, showing hornblende-pyroxene-microcline band with sphene and altered scapolite and in right hand corner a band consisting of pyroxene and scapolite with a little altered scapolite on the edge of the microcline-rich band.

C. Metasomatic granite (see Plate 1, Figs. 4 and 5) consisting of quartz, biotite and hornblende-microcline bands.

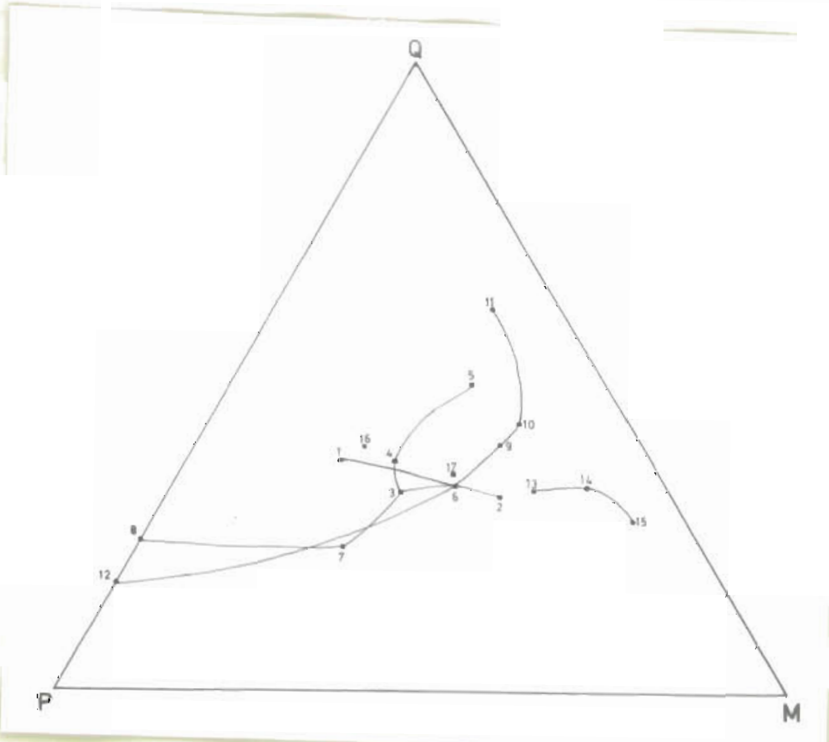

Fig. 5 - Microcline-quartz-plagioclase diagram showing plots of the mean micrometric analyses of the main rock types and analyses of some of the extreme individual specimens (Table X)

PLATE 1

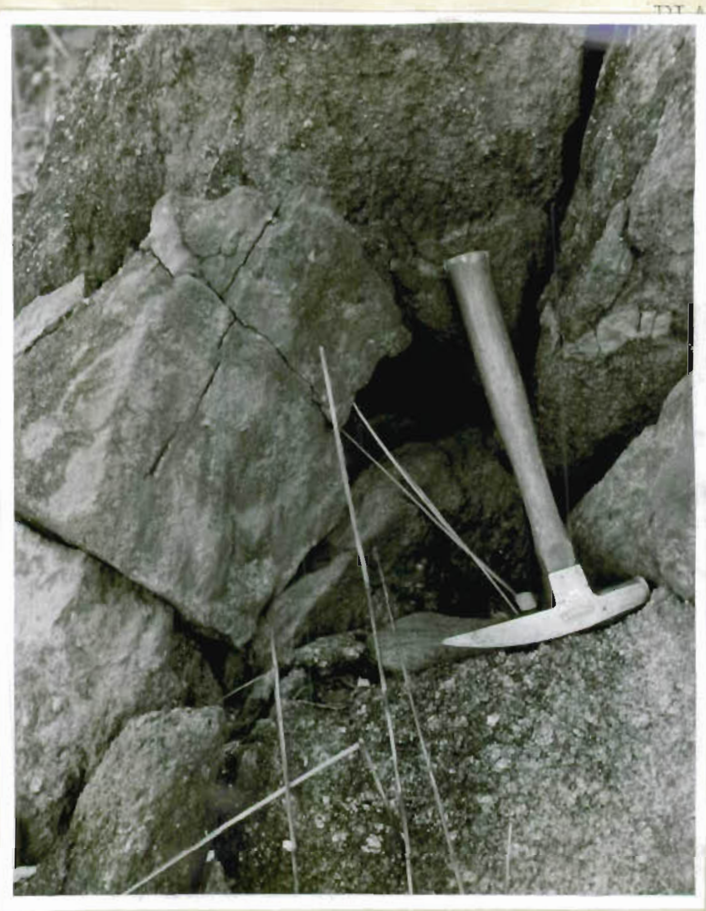

Fig. 1 - Kalkadoon granodiorite overlain by basal conglomerate of Surprise Creek Beds, Sunday Gully, West Leichhardt. (Photograph by W.C. White)

Fig. 2- Banded calcsilicate rocks showing differential weathering of bands, some honeycombed. 10 miles east of Lady Fanny mine, Duchess area.

Fig. 3 - Highly folded and banded calcsilicate rocks of Corella Formation Dugald River.

Fig. 1 - Metasomatized Wonga granite showing relict sedimentary structures. 10 miles east of Lady Fanny mine, Duchess area.

Fig. 2 - Handspecimen of above (Natural size)