THE PALMER GRANITE

AND

ASSOCIATED GRANITISED SEDIMENTS.

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A B S T R A C T.

The rocks under discussion outcrop in the vicinity of the township of Palmer, Hundred of Tungkillo, South Australia.

The writers are of the opinion that the Palmer Granite has arisen through granitisation of sediments in place.

Further they consider that the processes active at Palmer are connected with those which have wrought regional metamorphism and metasomatism on the rocks of the eastern Mt. Lofty Ranges on a grand scale. The Palmer district is but part of this province of regional metamorphism and granitisation.

INTRODUCTORY.

The area discussed comprises some 35 square miles, south of the Mannum - Adelaide road in the vicinity of Palmer. It includes portion of the eastern scarp of the Mt. Lofty Ranges together with a small area of the adjacent Murray Flats west of the Monarto - Sedan Railway.

No detailed geological work has previously been undertaken in the area. Acknowledgement of those writers who have dealt in some measure with parts of the area follows.

Hossfeld in his paper "The Geology of Part of the North Mt. Lofty Ranges", deals with the areas north and west of Palmer and briefly with the Palmer Granite.

R. L. Jack examined the Palmer Granite mainly with regard to its utilisation as a building stone. He submits an analysis by W. S. Chapman of the granite in his "Building Stones of South Australia".

H. Y. L. Brown submitted a report, published in 1903 in which he dealt with the Kitticoola Mine mainly from a mining and economic aspect.

The writers have conducted an intensive field survey coupled with petrographic examination in the laboratory and the conclusions they have arrived at are detailed in the following pages.

In the present instance the writers wish to acknowledge their indebtness to Professor Sir Douglas Mawson for the facilities which he placed at their disposal and the financial aid obtained.

THE BROADER PHYSIOGRAPHIC AND STRUCTURAL FEATURES.

~~The most prominent~~ physiographic features in the vicinity of Palmer are ~~the eastern escarpment~~ of the Mt. Lofty Ranges and the Murray Plains. The hills rise abruptly ~~out~~ of the plains along the line of the Tertiary fault which lies in an approximately north - south direction passing through the western boundary of Palmer township itself.

The Murray Flats consist of gently undulating country stretching eastwards from the Fault-line to the River Murray. The flats west of the Monarto - Sedan Railway and which lie in the area under discussion, are mantled with alluvium and with occasional cappings of nodular travertine limestone through which project isolated outcrops of older granitic rocks and metasediments. A thin interrupted capping of ferruginous fluviatile grits of Tertiary age is occasionally observed on the surface. East of the railway line the so called tonalite is prominent together with other granitic rocks and metasediments. Fossiliferous Tertiary marine limestones become notable eastwards towards the River Murray.

The Palmer Hills rise abruptly out of the plains. The present elevation of the scarp face is due to faulting ~~in the late Tertiary~~ "Kosciuskan epoch". Drainage is through several noteworthy creeks (Bakers, Harrisons etc.) which have cut steep gorges through the country rocks near the fault line. These creeks meet in the Reedy Creek in the vicinity of the Kitticoola Mine and thereafter the Reedy Creek passes out of the hills onto the flats flowing in an easterly direction towards the River Murray. Springs ensure permanent water in these creeks.

The rocks of the hills comprise schists and other metasediments with granitic rocks, the relationships of which will be dealt with below. The metasediments stand out prominently from the surface of the hills so that the line of strike can be traced visually for great distances. With their treeless nature and paucity of soil-covering, the Palmer hills are in strong contrast with those nearer Tungkillo and west of that township.

Several miles southwest of Palmer township quartz ridges are a prominent feature of the relief. These are long, level-topped ridges with steep sides, which are notably higher than the surrounding country. Atop of these are found interrupted patches of flatlying ferruginous and arkosic Tertiary fluviatile grits.

The structural features of the area will now be considered. The accompanying section across the area, illustrates the nature of the structure. The general country rock has been folded into a major unsymmetrical syncline pitching gently in a S.S.W. direction. Minor folding within this major structure is complicated, especially near the supposed base of the syncline where intense tight folding has occurred.

Much of the eastern scarp face is occupied by a major crush zone which attains considerable width in the vicinity of the Kitticoola Mine. At its maximum extent, it measures as much as three-quarters of a mile wide. The fault zone trends in a roughly N.-S. direction. Although the present elevation of ~~the scarp~~ is attributed to faulting in the Tertiary, it is believed that this later movement was renewed along early Palaeozoic lines. Most of the crushing in the fault zone is to be attributed to this early Palaeozoic faulting. This faulting must have been post-granite, as the granitic rocks involved, are shattered and veined. Shattering of granitic rocks and metasediments alike, has been considerable. Polished shear surfaces with slickensides are common.

Subsequent mineralization of the shatter zone caused widespread metasomatic changes within the granite and was responsible for the introduction of vein quartz, specular haematite, pyrites, arsenopyrites and carbonate minerals. In the Kitticoola region especially, gold, and ore minerals of copper achieve considerable importance in association with the above.

Rejuvenation along the older lines occurred in the late Tertiary "Kosciuskan Epoch" with a resultant uplift. This rejuvenation is evidenced by the bold prominence of the scarp and the steep gorges cut through it, as contrasted with the low lying areas to the east. Further evidence of the uplift is seen in the differential elevation of the Tertiary fluviatile grits which occur both on the flats and at high levels in the hills. An approximate estimation of the relative vertical movement is thus afforded.

The rocks of the area may be conveniently grouped according to the following scheme.

A. The Granitic rocks, including
  1. The Palmer Granites
  2. The Rathjen Granitic Gneiss
  3. Minor granitic masses
  4. The Pegmatites and granitic pegmatite veins

B. The Metasediments, including
  1. The general country rock comprising micaceous granulites, micaceous quartz schists, quartz mica schists and amphibolite schists.
  2. Metasomatised types, including
     (a) felspathised quartzites
     (b) biotite enriched schists
     (c) amphibolites and mica amphibolites
     (d) quartz plagioclase anthophyllite schist.
     (e) the migmatites
     (f) veined gneisses
     (g) contorted composite gneisses (ptygmatic migmatites)

C. Deposits of Tertiary and Recent Origin, including
  1. Tertiary fluviatile grits, ferruginous or arkosic.
  2. Pleistocene or Recent consolidated fluviatile conglomerate.
  3. Recent Alluvium and nodular travertine limestone.

THE GRANITIC ROCKS.

The granitic rocks dealt with occur in two main bodies west of Palmer township. The more westerly body has its greatest areal extent north of the Mannum - Adelaide road and for the most part consists of strongly foliated rocks more appropriately termed gneiss than granite. The body nearer Palmer lies mainly south of the Mannum - Adelaide road and includes rocks which are more appropriately termed granite. It is proposed to differentiate between these bodies and for convenience the body nearest Palmer will be termed the Palmer outcrop and the more westerly body the Rathjen outcrop.

Minor granitic masses outcrop amongst both the metasediments in the hills and the alluvium on the flats. These will be dealt with in later pages.

A. The Palmer Outcrop - The Palmer Granite.

Granitic rocks occupy much of the fault scarp face immediately west and south of Palmer. The outcrop itself is lenticular and elongate, trending in a general north-south direction. The main Mannum - Adelaide road cuts across it at its greatest width but north of the road it does not extend far; southwards it tapers notably. The Palmer Granite has a distinctive spheroidal mode of weathering which has given rise to the tor-strewn hills, so much a feature of the landscape on both sides of the Mannum Road immediately west of Palmer township. The tors range up to thirty feet and more in diameter and their mode of formation is well illustrated in the concentric cracks observable on the face of a road metal quarry some one and a half miles west of Palmer.

The granite is very variable over the outcrop. The most typical variety is that which has been used for monumental and building purposes and forms the bulk of the "tor"-granite. It is a medium to coarse-grained rock, pink in colour, and of pleasing aspect. The grain size is fairly even although the microcline felspar in particular tends to be of porphyritic habit. The foliation in this variety is not as prominent as in certain others.

Various aspects of the Palmer granite will now be considered in detail.

1. The Variability in the Granite.

The granite is extremely variable as regards its appearance, grainsize and other textural characters, relative proportions of component minerals, mode of weathering and jointing and in the degree in which foliation has been developed.

The most prominent variety is the coarse pink microcline granite in which the tor structure is most perfectly developed. This is the only variety which may be said to resemble true granite to any close degree. Other varieties associated with the coarse pink variety in the inner portion of the outcrop sometimes bear little resemblance to igneous rocks apart from their mineral assemblage. They include a fine grained grey schistose rock, porphyritic micro-granites, compact greasy quartzose types and a fine grained pink aplitic variety. A coarsely gneissose red granite is prominent near the Kitticoola mine.

R. Lockhart Jack noticed the variability in the granite and found it difficult to reconcile the strongly sheeted nature of the aplitic variety, as observed in the road metal quarries, with the adjacent tor structure in the coarse pink granite. The writers also could not envisage both types as arising from a single magma and subjected to the same conditions in later times. In explanation Jack proposed a "dyking" hypothesis whereby a younger granite was supposed to have dyked an earlier one. He believed that his hypothesis was supported by the relationships between the various types as revealed along the road cuttings.

Traverses made across the granite from east to west suggest that the more prominent varieties trend in conformity with the margins of the outcrops, that is, generally parallel to the strike of the adjoining metasediments.

This fact is significant in that it supports other evidence in favour of the theory proposed by the writers that the granite has arisen by granitisation of sediments in place. The facts which prompted Jack's "dyking" hypothesis are just as readily explained by a granitisation hypothesis.

2. The Shape of the Palmer outcrop.

The outcrop is elongated and lenticular in shape, tapering towards the south. The body as a whole is conformable with the country rock and bears no obvious transgressive relations to it as might be expected from a simple magmatic batholith. The margins are for the most part roughly parallel to the strike of the adjacent country rock. For several hundred yards north of the main Mannum road the margins were observed to have cross cutting relations to the strike of the country rock and here mica schists were seen to pass into migmatitic rocks and then in to biotite granite; likewise felspathised sandstones into a medium grained leuco-granite along the line of strike from the country rocks.

The writers believe that the elongation of the Palmer outcrop and its general concordance with the structure of the adjoining sediments is signifigant evidence in favour of granitisation.

3. Xenolithic Material within the Granite.

Dark schistose "xenoliths" are numerous in the granite. These vary in size from several centimetres to metres in diameter and achieve a notable density in certain areas. The larger bodies are more conspicuous but the smallest are seldom absent from any exposed area of the granite. In nature they are fine grained and biotite rich, a marked schistosity being imparted by the biotite. In shape they are invariably ovoidal or elongated and ellipsoidal with the longer axis and also the schistosity invariably orientated parallel to the direction of foliation in the granite itself. In the few cases where the orientation of the xenoliths and their direction of schistosity is oblique to the prevailing direction of foliation in the granite, it is found that the foliation of the granite has been locally distorted and that the schistosity is still continuous with the foliation.

It is difficult to explain this fact if the foliation in the granite is to be attributed to post-magmatic dynamic agencies, as has been done by Hossfeld. The present writers suggest that the effect is due to a state of plasticity and slight movement achieved by a local increase in the concentrations of the active fluids (emanations) and elevation of temperature during the transformations of the sediments.

The more basic types of xenoliths are thought to be basified remnants of country rock segregated at the positions they now occupy during the transformation of the sediments.

Lighter types of xenoliths are common though not as conspicuous as the dark biotite-rich types. They are often schistose and fine grained in nature but grade into "ghostly remnants" almost identical in mineral composition with the granites, and only distinguishable on fresh exposed surfaces by slight textural differences. These "ghost structures" are less regular in shape than the conspicuous basic xenoliths. The lighter types of schistose xenolith preserve the same general orientation and conformity with the foliation and often weather more readily than the enclosing normal granite.

North of the Mannum - Adelaide road where the outcrop has cross cutting relations to the contact rocks for some distance, thin bands of felspathised sandstone are preserved in a compact medium grained "leuco-granite", and may be traced outwards along the strike into felspathised sandstones at the contact.

4. The Gneissic Structure of the Palmer Granite.

The parallel structure of the Palmer granite is due mainly to the parallel orientation of biotite, although streaks and lenticles of hornblende contribute somewhat to it on the outskirts of the outcrop. The parallel structure might well be termed schistosity in the case of some of the granitic rocks as for example, with the grey micro-granites.

In the coarser granites the biotite flakes have segregated to give a pronounced foliated structure. The foliation may be strongly developed as in the case of the coarsely gneissic red granite of Kitticoola but is elsewhere not so well defined.

Its strike is everywhere parallel to the strike of the schistosity in the adjoining metasediments except where local distortion has occurred due to the transformed sediments achieving some degree of plasticity.

The subject will be treated in more detail after the Rathjen outcrop has been dealt with.

5. The Contact of the Palmer Granite.

The margins of the granitic rocks are for the most part roughly parallel to the strike of the adjacent metasediments and to the direction of foliation in the granite.

B. THE RATHJEN OUTCROP.

This body has several features which are even more signifigant than the neighbouring Palmer Outcrop.

The Rathjen gneisses occur in a body which has its greatest extent north of the Mannum - Adelaide road running northwards for some miles in a broad belt. Near the road the Rathjen body tails out and extends southwards for some miles as a narrower belt of uniform thickness (60-80 yards wide) until faulted out at the main Tertiary fault. The "tail" of the Rathjen outcrop is perfectly conformable with the adjacent metasediments. The contacts are parallel to the foliation of the gneiss and to the strike of the adjoining metasediments.

The Rathjen gneiss is somewhat variable but is typically a strongly foliated granitic gneiss. The foliation is in places weakly developed but is never absent. It is ~~being~~ everywhere parallel to the strike of the adjoining metasediments and is due to the segregation of laminae of biotite which impart a marked fissility to the rock. The tor structure has here been modified by the influence of the pronounced foliation, the outcropping rocks having rounded tops with flattened walls dipping at an angle to the ground surface, in conformity with the surrounding metasediments. Xenolithic segregations of similar nature to those in the Palmer outcrop occur and preserve their regional orientation. The Rathjen "tail" suffers shattering in the crush zone and is finally lost under the flats some two miles south of Palmer.

An analysis of the most typical gneiss is given later.

THE METASOMATIC MODIFICATION OF THE GRANITE.

Along the eastern ridge of the escarpment an abnormal phase of granite is seen extending from behind Palmer township southwards to Kitticoola and the Reedy Creek. This granite may be readily distinguished by its angular, jagged and blocky mode of weathering which contrasts strongly with the tor structure of the adjacent normal granite. The abnormal granite has been shattered and fractured as a result of faulting during an early Palaeozaic epoch. The infilling of the fissures by secondary quartz, haematite, pyrite, and rarely chalcedonic silica and calcite is characteristic. Polished shear surfaces and slickensides are a feature and are often outlined in quartz or haematite. The blocky mode of weathering is a consequence of the shattering and secondary veining.

From a study of the granite on the Kitticoola ridge and its relations with the coarsely gneissic red granite type which outcrops immediately to the west it is apparent that the abnormal granite is a pneumatolytic or replacement variant of the normal granite. All gradations from the coarsely gneissic red granite to the pink and green talcose granite may be observed along the banks of Reedy Creek in the vicinity of Kitticoola. The biotite and plagioclase can be seen in all stages of alteration. The red microcline is relatively unaffected. The texture and grainsize of the abnormal and normal types are identical except where veining with secondary silica has interfered.

Field study leaves little doubt as to the origin of the talcose granite, namely, through replacement effected in normal granite. Petrographic evidence supports this. Pegmatites within the granite have also suffered similar alteration to talcose types.

THE MIGMATITIC ZONES.

Adjoining both the Rathjen and Palmer outcrops on all sides are migmatitic zones which coalesce in the area between them. The rocks surrounding the Rathjen body seem to have been more greatly affected and to a wider extent than those surrounding the Palmer body despite the latter's greater lateral extent. The migmatitic zone surrounding the Rathjen outcrop is marked by a decided enrichment in biotite and is therefore more conspicuous than that surrounding the Palmer outcrop which is marked chiefly by feldspathisation, with no notable basification. The difference can be attributed to a fundamental difference in the nature of the beds being transformed. The Palmer granite was dominantly derived from fairly pure arkosic types with minor bands richer in biotite. Biotite is a negligible constituent of many of the granitic rocks of the Palmer Outcrop and it is scarcely likely that in the transformation of the quartzose rocks that there would be any excess of the Fe and Mg ions to be expelled into the surrounding country rock. The Rathjen outcrop, on the other hand, is apparently derived from a more impure psammitic type. Biotite is a prominent constituent of all the gneissic varieties of the Rathjen outcrop and no purely quartzo-felspathic rocks which are so frequent in the Palmer outcrop are observed in the Rathjen body. Considerable excess of Fe and Mg ions were available during the transformation and these were expelled as a "basic front" into the surrounding metasediments there to form a biotite enrichment zone. The biotite is segregated within the schists in planes parallel to the schistosity as folia which vary in thickness from thin laminae to broad sheets, ten feet or more in thickness. Quartz is often an associate in some of the folia.

1. The Rathjän Migmatitic Zone

This is characterised, as already noticed, by a marked enrichment in biotite which is segregated into sheets along the planes of schistosity of the country rock. Characteristic rock types in the migmatitic zone are veined gneisses, compact "permeation" migmatites, amphibolitic granulites, foliated amphibole-epidote gneisses and, biotite enriched schists.

(a) The Veined Gneisses.

These are a prominent feature of the zone adjacent to the Rathjän outcrop and less commonly occur about the Palmer outcrop wherever schistose and quartzo-felspathic bands. The granulites never develop this veined structure, their close textured recrystallised aggregate prohibiting the entrance of replacing emanations which was facilitated in the schist by the planes of schistosity.

The authors consider that the veined gneisses have been formed by replacement rather than by bodily injection of liquid material. The granitic layers are often rimmed with biotite layers which in the opinion of the writers are due to the enrichment of bands of schistose material in Fe and Mg ions during the transformation of adjacent bands into quartzo-felspathic (granitic) material. The writers fail to see how actual injection could produce such perfect parallelism of closely adjacent schistose and granitic layers for great distances without disturbance or distortion of the foliation in any way. They consider that layers of schist have been locally transformed through permeation and granitisation along the direction of schistosity.

The quartzo-felspathic layers are coarser near the Rathjän body itself and the veined gneisses may grade insensibly into the Rathjän Gneiss itself. It is apparent that the strongly foliated Rathjän Gneiss is merely an "ultravenite", the biotite folia which impart the strong foliation being merely the equivalent of the biotite rich schistose layers of the veined gneisses. In the field the quartzo-felspathic bands stand out prominently from an exposed surface of Rathjen Gneiss and their variation in width and extreme parallelism for long distances strongly support the view that the Rathjen Gneiss is an "ultro-venite", formed by the intimate replacement of schist along planes of schistosity with the segregation of biotite into lenticles parallel to these planes and the explusion of femic ions in excess of the requirements, into the frontal zone of surrounding metasediments.

Outwards from the Rathjen outcrop, the granitic bands of the veined gneisses become of finer grain equivalent to that of the schistose layers and may ultimately merge into the permeation migmatites.

(b) Permeation Migmatites.

Close textured even grained crystalline rocks with no banded structure are met with in the migmatic zones. They are the so called "granitic schists" of Brown.

(c) Ptygmatic Migmatites.

Contorted composite gneisses are prominent along the cliffs of Harrison's and Baker's creek.

2. THE PALMER MIGMATITIC ZONE.

On the eastern side of the Palmer Outcrop, the crush zone interferes with any proper study of the contact rocks. On the western side, the granitic rocks are bounded for considerable distances by compact granulites. The granitic rocks at the outskirts of the granite body are often fine or medium grained quartzo-felspathic rocks in which green hornblende has been segregated into streaks and lenticles, imparting a rude foliation. These no doubt represent granitised equivalents of the hornblende granulites into which they pass outwards from the contacts and in which streaks and bands of hornblende are also segregated. The contact granulites are often felspathised but pass intermittently along the strike into dark amphibolitic rocks. A similar phenomenon has been observed at Rocky Gully. Aplitic and pegmatitic veins in the granulites are often rimmed with dark amphibole bands. This basification about quartzo-felspathic material is illustrated well in instances where pegmatitic dykes are seen cross-cutting the granulites. An illustrative case was observed where two parallel pegmatites about six yards apart were seen crosscutting the granulites. Between the pegmatites the rock is a compact, fine grained amphibolite, resembling a basic dyke in its field appearance. Felspathised rims are seen about the pegmatite. On the outer sides of the pegmatites the rocks are a normal grey granulite in which thin streaks and bands of hornblende are visible. The most likely explanation of such pseudo-dyking which are seen in several places, is that the pegmatites and the amphibolite are complimentary and represent replacement products of the granulite.

Migmatitic rocks with coarse foliation imparted by bands of hornblende, actinolite and epidote are met with adjacent to the granite. They often carry large crystals of sphene. Veined gneisses occur where the contact rocks are schistose but these are not prominent.

North of the Mannum - Adelaide road, contact rocks passing along the strike into the granites, comprise felspathised arenaceous rocks and basified schistose rocks.

THE MINOR GRANITIC MASSES.

Outcrops of granitic rock occur sporadically amongst the general country rock both of the hills and the flats. They are invariably of a medium and even grain, but vary in colour from pinks to white types. Many are apparently granodioritic in nature with notable biotite, while others are aplitic and non-biotitic. Parallel structure in most of these masses is absent. A sequence from a schist, to a schistose rock with subordinate granitic bands, to one consisting of half granitic and half biotite-rich schistose bands, to a granitic rock with thin trains of biotite, to a homogeneous type with only occasional clots of biotite, is commonly observed around these masses.

A minor granitic outcrop near the northwest corner of the area and almost adjacent to the main road, was studied in detail. It is a narrow curving band outcropping around the nose of the pitching syncline, and again illustrates the concordance of the granitic rock with the structure of the country rock. It is a handsome white rock, granodioritic in nature and is commonly streaky in appearance, and often contains clots and lenticles of biotite. On either side of this outcrop are saccharoidal quartz-plagioclase-biotite schists with the biotite mainly segregated into layers. These pass outward in stages into the schistose types with no marked biotite folia (Rock Series 31-31D).

THE PEGMATITES.

A variety of rocks of pegmatitic habit occur in the area discussed. These range from simple quartz and quart-microcline types to the more complex ones carrying rare minerals. Graphic types are notable. They vary in size from a fraction of an inch to several yards in width. Grainsize varies from coarse in the complex types, to fine in the aplitic varieties. Grain size may sometimes vary within the one vein from a coarse, highly siliceous central part to a fine-grained margin of granitic character. The colour of the microcline is usually pink, rarely brick red, and occasionally milk-white. Albite is prominent in some pegmatites.

Although no detailed work has been done upon them, it is suggested that there are three different modes of origin.

1. Crystallization of fluids permeating the country rocks, similiar to those active in transforming the sediments to granite. The graphic types in particular are probably of this origin.
2. Replacement types

   A few pegmatites have one or more of the following features which suggest a replacement origin. These are:-

   (1) Retention of schistose "xenoliths" in conformity with the structure of the schists.

(2) A gradation in grain size observed in certain pegmatites from a coarse central vein of quartz-microcline to fine-grained aplitic margins.

(3) Basification of the margins as seen by highly mafic bands of biotite or amphibole, which border the pegmatites (No. 47).

(4) Preservation of traces of the original structure of the metasediments cut through by the pegmatites, such as trains of biotite.

Pegmatites showing these features are not particularly common and occur main-ly near the granitic masses.

3. Rheomorphic types

Certain granitic pegmatites and coarse veins which cut across the granite, may be of rheomorphic origin, representing mobilised material.

Certain of the pegmatites which occur in the Harrison Creek area, half a mile south of the main road, were more complex types and contained notable beryl in association with muscovite, red garnet, tourmaline and chlor-apatite. The felspars included albite in addition to pink microcline. Beryls were obtained as much as six inches in length. Tourmaline up to one foot in length. Tourmaline commonly shows its full trigonal form, but sometimes it occurs as masses of needles. The muscovite is a pale green variety occurring in small books. The red garnet often shows well developed rhombic dodecahedral forms.

QUARTZ REEFS.

Much of the back country beyond Tungkillo, features great ridges and reefs of milky quartz. The ridges rise abruptly at the sides fifty feet or more above the surrounding country and show up prominently as resistant, level-topped masses capped in parts by horizontal Tertiary gravels and fine grits. They have been traced for a mile or so in length and commonly end abruptly.

THE COUNTRY ROCK.

The general country rock of the hills outside the migmatitic zones comprises mainly quartz-felspar-mica schists, granulitic types and amphibolites. When compared with the bedding of the basal grits as delineated by the ilmenitic bands, the schistosity of the country rock is apparently sensibly coincident with the original bedding. Minor granitic rocks outcrop occasionally amongst the country rock and are invariably surrounded by migmatitic rocks. Pegmatites are also common, especially in the western part of the area.

In the crush zone, metasediments and granitic rocks alike have been subjected to crushing and shattering. They are veined and have often suffered metasomatic changes. Silicification of the shatter belt is a feature immediately south of Palmer township where hillocks of massive vein quartz occur with relicts of unreplaced country rock.

The rocks of the flats include metasomatised basal grits, including the anthophyllite schists in which layers of ilmenite may be observed. Veined and contorted composite gneisses with occasional granitic outcrops comprise most of the other varieties. Yellow-green fluorapatites are a feature of the biotite-rich lenses in the contorted gneisses.

PETROGRAPHY.

No. 26 PALMER GRANITE

Location:- Palmer, Mannum 1460/9565

Field relations: The specimen was collected from a boulder of the tor granite occurring approximately one mile west of Palmer township.

The handspecimen is an holocrystalline medium to coarse grained rock, pink in colour and of pleasing aspect. The essential minerals are felspars, quartz and biotite. The most prominent mineral is a pink microcline often of tabular habit, and exhibiting simple twinning on the Carlsbad Law. It has a definite tendency to be porphyritic, crystals reaching up to two centimetres in length.

Granular quartz is abundant, showing its charasteristic vitreous lustre. Plagioclase occurs as white crystals showing fine poly-synthetic twinning and is by no means as prominent as the potash felspar.

Biotite occurs as black lustrous flakes but is not notably abundant and shows no pronounced directional tendencies in this specimen. Golden yellow crystals of leucoxenic sphene are occasionally visible.

Microscopical Description.

In thin section the rock is coarse and holocrystalline. The component minerals are very variable in size and crystal outlines are characteristically absent from them. The texture may be said to resemble the crystalloblastic more than the pyrogenetic. Quartz is abundant as colourless crystals of variable size with irregular outlines. The extinction of the larger individuals is often shadowy showing signs of strain. Lines of fluidal inclusions are shown. Relief is low and positive. Birefringence is weak. The interference figure is uniaxial and positive. Felspars are as equally abundant as quartz. Two varieties are represented.

(1) Microcline occurs as dusty individuals of variable size displaying the typical crosshatched structure. Relief is low

and negative. Peculiar skeletal intergrowths of quartz may be seen in certain crystals of the microcline.

(2) Plagioclase is not notably inferior to the alkali felspar in abundance. It occurs as slightly clouded colourless crystals of low positive relief. Alteration is often most intense ~~within~~ a central kernel, the outer portions of the crystals being clear.

The maximun extinction angle in a plane perpendicular to 010 is 5° which corresponds with an oligoclase near Ab_{80} An_{20}.

Myrmekitic intergrowths of quartz in plagioclase are occasionally seen.

Biotite is not notably abundant. It is an intensely pleochroic variety occurring as irregular plates.

Pleochroism X = yellow

Y = Z = deep brown almost opaque

Extinction is straight.

Ilmenite and Sphene are notable accessory constituents which occur in association with one another. The sphene ~~is~~ leucoxenic, ~~in nature~~ and is apparently derived from the associated ilmenite. It is deep brown in colour and feebly pleochroic. ~~It shows high relief and extreme birefringence.~~

Apatite is a notable accessory constituent. It is colourless, has a moderate relief and weak birefringence.

Mode		
	Quartz :-	39.0%
	Microcline :-	28.4%
	Plagioclase :-	23.8%
	Biotite :-	5.1%
	Ilmenite and Sphene:-	3.6%

The modal proportions indicate that the rock is more of the nature of an adamellite than a granite.

An analysis of a sample of the pink tor granite is appended and differs little from that of W. S. Chapman presented by R. L. Jack in "The Building Stones of South Australia".

Analysis of Pink Granite, Palmer Loc. Analyst J. H. Rattigan		Analysis of Granite, Palmer Analyst W. S. Chapman.	
SiO_2	74.62	SiO	73.96
Al_2O_3	13.91	Al_2O_3	13.67
Fe_2O_3	1.18	Fe_2O_3	1.22
FeO	.92	FeO	1.03
MnO	-	MnO	0.04
MgO	.55	MgO	0.56
CaO	1.61	CaO	1.58
Na_2O	3.15	Na_2O	3.01
K_2O	3.56	K_2O	3.36
$H_2O(-)$	.14	H_2O-	0.04
$H_2O(+)$	.25	H_2O+	0.29
TiO_2	.32	TiO_2	0.37
P_2O_5	.08	P_2O_5	0.16
S	.04	FeS_2	0.25
		CO_2	0.22
	100.36		99.78

Norm:

Quartz	38.40	
Orthoclase	21.13	Salic
Albite	26.72	Group
Anorthite	7.51	95.80%
Corundum	2.04	
Hypersthene	.26	
	$FeSiO_3$	
	$MgSiO_3$	Femic
	1.40	Group
Magnetite	1.62	4.09
Ilmenite	.61	
Apatite	.20	

In THE C.I.P.W. classification the rock is I, 3, 2, 3 . Tehamose.

MICROGRANITE

Rock No. 23

Location 139/954

~~The~~ handspecimen is a fine-grained grey rock, ~~to which numerous small flakes of biotite impart a schistose structure.~~ The rock consists essentially of quartz, felspar and biotite.

In section the rock is seen to consist of a fine evenly granular aggregate of quartz and felspar with subordinate biotite. The ~~predominantly~~ granoblastic texture is modified by the preferred orientation of the biotite flakes.

Quartz is ~~an abundant constituent as~~ rounded or slightly elongated colourless xenoblasts.

Felspar comprises two varieties

(1) Microcline is dominant ~~as dusty~~ xenoblasts displaying the typical crosshatching.
RI < balsam.

(2) Plagioclase ~~is subordinate to the microcline.~~ It occurs as colourless xenoblasts which may not show twinning on the Albite Law.
RI > balsam.
Maximum symmetrical extinction in a plane perpendicular to 010 is 8° which corresponds with an oligoclase near $Ab_{75}An_{25}$.

Biotite is conspicuous but not abundant as small tabular crystals.

Pleochroism ~~is strong~~ X = yellow
Y = Z = deep brown

Extinction is straight.

Accessory constituents include

Titaniferous iron ore - black opaque

Sphene - (Brown grains of extreme relief. Nuclei of ilmenite are seen within some grains).

Epidote - (weakly pleochroic yellow grains of moderate relief).

Orthite

RED GRANITE, KITTICOOLA.

Rock No. 55A.

Location: 152/919.

Field Relations:- a granitic type outcropping on the banks of Reedy Creek, near the Kitticoola Mine.

The handspecimen is a coarsely gneissic red rock consisting essentially of felspars, quartz and biotite. The most prominent constituent is a coarse red microcline which is occasionally porphyritic in habit. Plagioclase, white in colour is subordinate to the potash felspar. Quartz is plentiful.

The most prominent ferromagnesian mineral is a black lustrous biotite which shows directional tendencies. Alteration to a green product is visible in some instances.

Golden metallic grains of pyrite are occasionally visible.

In section the rock is seen to ~~consist of components of~~ variable grainsize. The texture is coarsely granoblastic. The biotite although not abundant shows a preferred orientation and the quartz crystals have a tendency to be elongated in the same direction.

The rock shows signs of alteration in the plagioclase and to a lesser extent in the microcline and mica.

Quartz is abundant as colourless xenoblasts of variable size. It often shows shadowy extinction.

Felspar - two varieties are represented:-

(1) Microcline as dusty crystals showing the typical crosshatched structure, and simple twinning on the Carlsbad Law.
RI < balsam.

(2) Plagioclase as clouded crystals often showing multiple twinning on the Albite Law. Alteration is often intense, plagioclase being represented in some instances by an aggregate of fine micaceous material. Crystals are rarely bent as may be seen from curved twin planes.
RI > balsam.
It is apparently a normal oligoclase.

Myrmekitic intergrowths of quartz in the plagioclase are often seen.

(3) ~~Biotite as intensely pleochroic brown flakes~~ is not notably abundant. Alteration to green chlorite is sometimes observed. Straight extinction.

(4) Green Hornblende is purely accessory.

(5) Sphene, opaque iron ore, epidote and apatite are ~~important accessory~~ constituents.

The rock has apparently felt some of the affects of the metasomatic changes accomplished in the adjacent rocks of the shatter belt.

TALCOSE GRANITE.

Rock No. 55B.

Location:- 153/198.

Field relations: ~~an abnormal granitic rock comprising the country rock of the Kitticoola lode.~~

The hand specimen ~~is~~ a coarse rock with a mottled appearance and consists essentially of red microcline, quartz and a green mineral of micaceous habit. ~~Veining with~~ calcite ~~is visible.~~ Metallic sulphide minerals ~~are occasionally seen.~~

In thin Section the minerals shows signs of severe alteration. The component crystals are in a coarse granoblastic aggregate.

Quartz is abundant as clouded colourless crystals invariably showing shadowy extinction due to strain effects. The clouded effect is apparently due to minute opaque inclusions.

Microcline is often severely sericitized and represented by a fine micaceous aggregate. Elsewhere the alteration is not so severe and the cross hatched structure is in evidence.

Plagioclase is no longer ~~prominent being everywhere profoundly~~ altered. Multiple twinning may be observed ~~on relict~~ patches within a fine aggregate of albite, lime bearing minerals and micaceous material.

~~Talc a~~ Pale green micaceous ~~appearing mineral~~ has apparently replaced ~~biotite~~ and plagioclase. It is weakly pleochroic, ~~shows~~

strong birefringence and straight extinction. Crystals are often bent and occur as sinuous bands. The mineral is probably talcose in nature.

Calcite showing extreme birefringence and a pronounced twinkling effect is prominent.

Accessory constituents ~~are~~ opaque ~~iron ore~~ including haematite, leucoxene and zircon.

This rock is apparently a metasomatic variant ~~of 55A~~.

XENOLITH - GRANITE CONTACT.

Rock No. 50D.

Location: 150/955

The hand specimen shows portion of dark schistose xenolith within a sample of the tor granite. The granite is a coarsely gneissic type in which plagioclase appears to be as abundant as pink microcline. The xenolith is finegrained and dark, due to a relative abundance of dark minerals. Quartz crystals achieve some size within the xenolith.

In section the granitic margin shows a coarsely granoblastic texture in contrast with the finer texture of the xenolith.

1. The granitic margin.

This consists essentially of coarse quartz and felspar which show no trace of crystal outlines.

Quartz is abundant as clear colourless xenoblasts.

Plagioclase - as dusty xenoblasts showing twinning on the albite law.

RI > balsam.

It is apparently an oligoclase near $Ab_{80}An_{20}$

Microcline is notable showing the typical crosshatched structure.

Sphene associated with titaniferous iron ore is an accessory constituent.

2. The xenolithic margin

This shows a prevailing granoblastic aggregate of quartz and felspar to which a directional element is imparted by the preferred orientation of dark minerals. Certain quartz crystals attain large size within the finer matrix.

<u>Quartz</u> is abundant as large and small xenoblasts.

<u>Plagioclase</u> (oligoclase) is next in abundance.

<u>Microcline</u> is not prominent.

<u>Biotite</u> is the most abundant dark mineral.

It is strongly pleochroic.

Extinction is straight.

<u>Hornblende</u> is also notable.

It shows the typical amphibole cleavage at approximately 124 .

Pleochroism is strong X = light green
Y = brownish green
Z = deep green

Titaniferous iron ore is an abundant accessory constituent.

Sphene sometimes occurs in association.

GRANITIC GNEISS.

<u>Rock No. 21.</u>

<u>Location:</u> Palmer 138.953.

<u>Field Relations:</u> A granitic type occurring near the outskirts of the Palmer Outcrop adjacent to contact hornblende granulites.

<u>Macroscopic.</u>

A medium grained pink rock with dark green hornblende in clots or streaks imparting a rude foliation. A narrow band of coarser quartzo-felspathic material traverses the rock. Quartz and felspar are most prominent and sometimes occur as somewhat larger crystals embedded in the finer matrix.

<u>Microscopic.</u>

The texture as seen in thin section is crystalloblastic. The rock consists of a somewhat inequigranular aggregate of interlocking quartz felspar and hornblende.

<u>Mineralogy.</u>

<u>Quartz</u> is most abundant as colourless xenoblasts of all sizes.

Uniaxial positive.

<u>Microcline</u> is prominent as xenoblasts showing incipient alteration.

Low negative relief.

Typical crosshatched structure.

Plagioclase is notable as colourless xenoblasts displaying multiple twinning on the Albite Law.

RI > balsam.

In sections normal to the 010, the maximum extinction angle is 7° which corresponds to an oligoclase near $Ab_{75}An_{25}$.

Hornblende is prominent as green irregular xenoblasts.

Pleochroism is strong X = yellow brown
Y = brownish green
X = deep green

Extinction is inclined as much as 26° in longitudinally sections.

It is sometimes seen passing into biotite.

Biotite is rare as brown pleochroic shreds with straight extinction.

Sphene is a most abundant accessory constituent as feebly pleochroic brown crystals of extreme relief and birefringence.

Biaxial - ve, axial angle low.

Apatite and Titaniferous iron ore are also notable accessories.

Epidote is rare.

FELSPATHISED SANDSTONE.

Rock No. 28A.

Location: Palmer. Mannum Sheet 9669/1366.

Field Relations: Gradational along the strike into leucogranite 28T.

Macrospic.

A finegrained pink sacchariodal rock containing occasional somewhat coarser lenses of quartz and felspar.

Microsoopic.

In thin section the rock is seen to consist of a finegrained equidimensional aggregate of quartz and felspar. The texture is granoblastic.

Mineralogy.

Quartz is abundant as colourless clear rounded xenoblasts.

Relief is low and positive.

A uniaxial positive interference figure is seen.

Felspar is abundant and comprises:-

1. Microcline as small clouded xenoblasts of low negative relief and showing the typical crosshatching.
   In sections normal to Z, the extinction angle is 14°.

2. Plagioclase of low negative relief.
   Maximum extinction angle in sections normal to 001 is –~~[overtyped]~~ 8°, which corresponds with an albite near $Ab_{85}An_{15}$.

Biotite is purely accessory as small pleochroic brown shreds, showing straight extinction.

Muscovite is sparsely distributed as colourless xenoblasts with brilliant polarisation colours and straight extinction.

Iron ore black opaque is distributed very sparingly throughout. It may be of detrital origin.

Mode

Quartz	38.4%
Microcline	31.9%
Plagioclase	29.6%
Accessories	00.1%

LEUCO-GRANITE.

Rock No. 28T.

Location: Palmer, Mannum Sheet 967/138

Field Relations: A granitic type outcropping near the contact of the Palmer body where felspathised sandstones are seen passing into the granite along the line of strike.

In the hand specimen this is a medium grained pink granitic rock consisting almost entirely of quartz and felspar.

In section J ~~the rock~~ is seen to consist of an interlocking aggregate of quartz and felspar. The texture inclines more towards the crystalloblastic than to the pyrogenetic. Crystal outlines are extremely irregular and often sutured. The crystals vary considerably in size and shape but are for the most part of medium grain. Skeletal, arrangements of quartz within and around felspar are a peculiar feature. The implications show a pseudo-eutectic structure.

Quartz is abundant as large and small crystals of irregular outline, often sutured or skeletal. Fluidal inclusions in two directions at right angles are prominent.

Relief is low and positive.

Uniaxial positive.

Felspar is abundant and comprises:-

1. Microcline as turbid crystals of low negative relief and exhibiting the typical crosshatched structure. It carries inclusions of quartz and plagioclase. Simple twinning on the Carlsbad Law is rare.

2. Plagioclase is much subordinate to the microcline. Multiple twinning on the Albite Law. In sections normal to 001. maximum symmetrical extinction is 10 which corresponds to an oligoclase near $Ab_{88}An_{12}$.
Relief balsam.

Accessory constituents are brown pleochroic shreds of biotite, colourless muscovite, and black opaque iron ore sometimes rimmed with leucoxene.

The series of specimens 27 - 27G described below was taken along the strike of a bed, running into the granite.

Location: Mannum 9654/1353.

Quartz - felspar -biotite Schist

Rock No. 27. This is a fine-grained grey schistose rock with biotite and quartz in obvious abundance. Segregation of the biotite is not very noticeable in the hand specimen.

Microscopically this rock displays a granoblastic texture, somewhat modified by the more or less parallel alignment of the biotite. Grain size is of a fine and uniform nature, with the grains averaging about .25 mm. in diameter.

Quartz is very abundant and fairly clear.

Plagioclase - twinning is rare, but it is probably an Oligoclase near Ab_{80}.

RI > balsam.

Untwinned varieties recognised by cleavage and slight turbidity.

Microcline - in small amounts showing typical cross-hatching.

Biotite is very abundant and shows definite directional structure. Strongly pleochroic from very dark brown to light brown.

Muscovite, Apatite and Zircon in accessory amounts only.

Tourmaline - occasional grains.

Ilmenite - a few idioblasts are present.

Bi - mica - quartz - plagioclase Schist.

Rock No. 27A. The only notable difference between this example and the previous one, both in the hand specimen and thin section, is the decided increase in the muscovite content, and which is especially concentrated along a few parallel layers. This imparts a marked schistosity to the rock. In thin section, a slight increase in the tourmaline content is noticed. Microcline is now absent.

Bi - mica - quartz - plagioclase Schist.

Rock No. 27B. Macroscopically this rock is somewhat darker and more compact, with alternating lighter and darker bands. The parallel banding is even better developed here than in 27A.

In thin section, the muscovite layers are seen to be spaced less far apart than in 27A. This mineral is also forming larger and more idioblastic crystals. Biotite is changing slightly in some instances to a chlorite type along the muscovitic layers. Tourmaline is unusually abundant now and as bigger crystals.

Bi - mica - quartz - plagioclase Schist.

Rock 27C. This rock has a somewhat lighter, and slightly coarser appearance than 27B.

In the slide, directional structure is somewhat less marked. Grain size is slightly more variable, and in general the texture is of a coarser nature. Average grain size is .4 mm. diameter.

Plagioclase is more abundant, but it is still commonly untwinned. The twinned varieties give an extinction angle of about 8° .

RI > balsam.

It is therefore an Oligoclase near Ab_{75}.

Muscovite has decreased in amount, but Biotite has increased slightly.

Tourmaline - much less abundant and only a few odd crystals occur.

Rock 27D. This rock shows a decided increase of Biotite which is essentially restricted to a number of slightly contorted bands up to 3 mm. wide. The rest of the rock is of about the same appearance as 27C.

Bi - mica - quartz - plagioclase - Migmatite.

Rock 27E. Macroscopically this is a richly biotitic rock showing some local folding. The strongly biotitic bands show a rough alternation with quartzo-felspathic bands. The grain size has increased considerably and multiple twinning can be seen on some plagioclases with a hand lens. Several small crystals of yellowish-green mineral, (apatite) were also noticed embedded in the biotite rich bands.

In thin section the rock has a medium grained granoblastic texture with average diameter of grains about 1.2 mm. Both Biotite and Muscovite show segregation along lines which are somewhat contorted.

Potash-felspar is still absent but quartz and oligoclase are abundant.

Apatite is a prominent accessory with several basal sections up to $1\frac{1}{2}$ mm. in diameter.

Zircon is still a common accessory as detrital-like grains and also as inclusions in biotite surrounded by pleochroic haloes.

Iron Ore commonly occurs as irregular intergrowths in the muscovite laths, and in slightly increased amounts.

CONTORTED GRANITIC GNEISS.

Rock No. 27F. The hand specimen is a rather weathered pink granitic rock. The directional structure that the biotite assumes shows evidence of residual minor folding. The biotite, however, is much less prominent in this specimen, but the pink potash-felspar is abundant.

Microscopically the rock, which shows a typical crystalloblastic texture, consists essentially of quartz and felspar with smaller amounts of biotite and other accessories. The edges of the quartz crystals are considerably sutured. Inclusions of microcline, biotite and small crystals of tourmaline are common.

Microcline is abundant as slightly turbid xenoblasts ~~crystals~~, showing excellent examples of "gridiron" structure.

Plagioclase is less prominent than microcline and occurs as smaller crystals. Multiple twinning is almost universal here and it is still an Oligoclase of about Ab_{75}.

Biotite - strongly pleochroic and in small amounts only.

Muscovite is almost absent.

Ilmenite occurs as a few large xenoblastic crystals showing slight alteration to leucoxene as evidenced by the whitish surface in reflected light. Other accessories are zircon, apatite, tourmaline and orthite.

Granite.

Rock No. 27G. The rock in the hand specimen is fine grained and somewhat weathered, with biotite distributed evenly throughout it.

In thin section it is essentially similar to 27F, but slightly finer grained.

Leucoxene occurs as an alteration product of ilmenite.

Modes done on thin sections of the above rock series shows the variation in the constituents of the rocks along the strike. An additional discussion of this is given later in the paper.

Constituents	27	27B	27C	27E	27F	27G
Quartz	58.7	53.6	53.3	42.7	43.0	44.4
Plagioclase	10.8	10.0	15.7	23.0	16.0	18.5
Microcline	6.3	-	-	-	35.0	32.6
Biotite	22.7	22.6	23.0	27.5	5.0	4.0
Muscovite	.3	12.1	7.0	5.0	.1	.2
Accessories	1.0	2.1	1.0	2.0	1.0	1.4

GRANITIC GNEISS

9720/1280

Rock No. 33. This rock is a typical example of the aforementioned Rathgen Outcrop.

Macroscopically the rock is coarse grained and very gneissose. The gneissosity is caused by the abundance of biotite in a more or less parallel arrangement. The felspar shows good cleavage with the plagioclase commonly showing multiple twinning. Quartz is very common as greasy greyish crystals. The average size of the quartz and felspar is of about 2 mm. diameter. The biotite is well developed as black shiny flakes and these can be broken off up to 3 mm. in length. Sphene is also notable as glassy brown crystals in association with the biotite. Some, however, is showing alteration to a lighter brown amorphous substance.

In thin section the rock is coarse grained, with a typical crystalloblastic texture with the components of variable size. The gneissosity of the mineral constituents is distinctive. Quartz and felspar are by far the most abundant. Biotite to a lesser extent. Sphene and ilmenite are unusually abundant as accessories.

Quartz shows much variability in size and some suturing of the edges is common. Occurs rarely as a myrmekitic intergrowth in felspar. Quite common as rounded inclusions in felspar.

Felspar is all fairly fresh and also shows some suturing of the edges. Inclusions within it are common.

(a) Plagioclase - multiple twinning is not always seen but is distinguished as a plagioclase by its RI > balsam, and biaxial figure with a very high 2V. Maximum extinction on sections normal to 010 in twinned varieties is 8° and since the RI > balsam, it is an oligoclase of composition Ab_{75}.

(b) Microcline is easily distinguished by its excellent "grid-iron" structure. RI < balsam.

Biotite is strongly pleochroic from nearly black to light brown. Segregation along definite parallel directions is shown. Inclusions of zircon are quite common.

Ilmenite occurs as large black opaque idioblasts, commonly showing slight alteration to leucoxene as evidenced by the whitish surface in reflected light.

Sphene - generally as brown idioblastic, slightly pleochroic crystals which are mainly concentrated in the biotite rich bands. Its unusual abundance is notable and some sections are up to 1 mm. long. Commonly shows alteration to leucoxene.

Apatite - as idioblastic forms also concentrated in the biotite bands, but not as abundant as Sphene.

Zircon in small amounts only.

PETROGRAPHY.

PALMER ADAMELLITE.

A specimen stypical of the tor granite occurring approximately near the main road one mile west ~~xxx~~ of Palmer township was collected for detailed investigation with the following results.

The handspecimen is an holocrystalline medium to coarse-grained pink rock. The most prominent mineral is a pink microcline often of tabular habit. It has a definite tendency to be porphyritic, crystals reaching up to two centimetres in length.

Granular quartz is abundant. Plagioclase is white in colour, and is by no means as prominent as the potash feldspar. Biotite occurs as black lustrous flakes but is not notably abundant and shows no pronounced directional tendencies in this specimen. Golden yellow crystals of sphene are occasionally visible.

In thin section the rock is observed to be coarse and holocrystalline. The component minerals are very variable in size and crystal outlines are characteristically absent from them. The texture may be said to resemble the crystalloblastic more than the pyrogenetic. Quartz is abundnat. Extinction in the larger individuals is often shadowy showing signs of strain. Lines of fluidal inclusions are shown.

Microcline occurs as dusty individuals of variable size displaying the typical cross-hatched structure. Peculiar skeletal intergrowths of quartz may be seen in certain of the mocrocline individuals.

Plagioclase occurs as slightly clouded colourless crystals. Alteration is often most intense in a central zone, surrounded by an outer clear zone. The maximum extinction angle in a plane perpendicular to 010 is 5° indicating an oligoclase near $Ab_{80}An_{20}$. Myrmekitic intergrowths of quartz in plagioclase are occasionally seen.

Biotite is an eintensely pleochroic variety: X = yellow, Y=Z = deep brown almost opaque.

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Biotite is an intensely pleochroic variety: X = yellow, Y=Z = deep brown almost opaque.

Ilmenite and Sphene are notable accessory constituents which occur in association with one another. The sphene is apparently derived from the associated ilmenite. It is deep brown in colour and feebly pleochroic. Colourless apatite is a notable accessory constituent.

A micrometric analysis gave the modal volume proportions of the constituent minerals to be as follows:

Quartz	39%
Microcline	28.4%
Plagioclase	23.8%
Biotite	5.1%
Ilmenite and Sphene	3.6%

The chemical analysis of the pink tor granite was undertaken by one of us. This was found to differ little from W.S. Chapman's analysis and quoted by Dr. Jack (?). These analyses recorded in the table on page . On page ? is stated the norm which indicates 95.50% of salic minerals and only 4.09% of ferric constituents which taken in conjunction with the Mode, clearly demonstrates this rock to be an adamellite. Its C.I.P.W. classification is I, 3, 2, 3 (Tehamose).

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TABLE OF ANALYSES.

ANALYSES.

	I	II	III
SiO_2	74.62	73.96	73.05
Al_2O_3	13.91	13.67	12.81
Fe_2O_3	1.18	1.22	1.54
FeO	0.92	1.03	2.30
MgO	0.55	0.56	0.64
CaO	1.61	1.58	1.74
Na_2O	3.15	3.01	3.42
K_2O	3.56	3.36	3.15
H_2O+	0.25	0.29	0.49
H_2O-	0.14	0.04	0.16
TiO_2	0.32	0.37	0.78
P_2O_5	0.08	0.16	0.10
MnO	—	0.04	tr.
ZrO	—	—	0.09
FeS_2	—	0.25	—
CO_2	—	0.22	—
S	0.04	—	0.05
	100.36	99.78	100.32
Less O for S.	0.01	—	0.01
Total.	100.35	99.78	100.31

NORMS.

	I	III
Quartz	38.40	35.88
Orthoclase	21.13	18.90
Albite	26.72	28.82
Anorthite	7.51	8.06
Corundum	2.04	0.71
Zircon		0.18
Hypersthene Hy	0.26	1.45
En	1.40	1.60
Magnetite	1.62	2.32
Ilmenite	0.61	1.52
Apatite	0.20	0.34
Pyrite		0.12
	99.89	99.90

I. Analysis of the Pink granite (Adamellite) from Palmer ( ), by J.H. Rattigan.

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MnO	—	0.04	tr.
ZrO	—	—	0.09
FeS_2	—	0.25	—
CO_2	—	0.22	—
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II. Analysis of the Pink granite from quarrying operations, by W.S. Chapman, quoted by Dr. Jack.

III. Analysis of the Ruthgen granite (Granodiorite), by C.F. Wegener.

MICROGRANITE (No.) Map Locality 1385/9540. This is a fine-grained grey rock consisting essentially of quartz, feldspar and biotite. The latter mineral as abundant small flakes, exhibits preferred orientation.

In section it is seen to consist of a fine evenly granular aggregate of quartz and feldspar, with subordinate biotite, whose flakes exhibit preferred orientation. It is constituted of the following minerals:

<u>Quartz</u> in rounded or slightly elongated colourless grains. <u>Microcline</u> is the dominant feldspar. <u>Oligoclase</u> (Ab75) also abundant. <u>Biotite</u> is conspicuous but not abundant. Pleochroic: X= yellow, Y = Z = deep brown.

Accessory constituents include black titaniferous iron ore, sphene, in some grains of which ~~needles~~ of ilmenite can be seen, grains of yellow epidote. Some brown brown grains which appear to be orthite.

RED STRESSED GRANITE (5) outcropping on the banks of Reedy Creek, near the Kitticoola Mine. Map location 152/919. The most prominent constituent is a coarse red microcline which is occasionally porphyritic in habit. Plagioclase, white in colour is subordinate to the potash feldspar. Quartz is plentiful. The most prominent ferromagnesian mineral is a black lustrous biotite which shows directional tendencies. Golden metallic grains of pyrite are occasionally visible.

In section the rock is seen to be coarsely granular. The biotite although not abundant shows a preferred orientation and the quartz individuals have a tendency to be elongated in the same direction.

The plagioclase and to a lesser extent in the microcline and mica, show signs of secondary changes.

<u>Quartz</u> is abundant and often shows shadowy extinction. <u>Microcline</u> and <u>oligodase</u> are both present in large amount. The latter is more or less entirely affected by secondary changes resulting in cloudy aggregates. Myrmekitic intergrowths of quartz and plagioclase are not uncommon. There is a small amount of an intensely pleochroic <u>biotite</u> which to some extent has suffered alteration to green chlorite.

In much less quantity than biotite is green hornblende. Other accessories are sphene, opaque iron ore, epidote and apatite.

This rock has apparently felt some of the affects of the metasomatic changes accomplished in the adjacent rock of the Kitticoola shatter belt.

METASOMATIZED GRANITE ( ), the county rock of the Kitticoola lode. Map locality 153/198. In the hand specimen it is observed to be a coarse rock with a mottled appearance and consists essentially of red microcline, quartz and a greenish substance of micaceous habit. Veins of calcite and metallic sulphide minerals are occasionally to be observed.

Viewed in thin section the minerals show signs of severe alteration.

Quartz is abundant as clouded colourless crystals invariably showing shadowy extinction due to strain effects. The clouded effect is apparently due to minute opaque inclusions.

Microcline is often severely sericitized and represented by a fine micaceous aggregate. Elsewhere the alteration is not so severe and the cross hatched structure is in evidence.

The plagioclase has suffered preferred alteration. Relict traces of multiple twinning may be observed in patches within a fine aggregate of albite, lime bearing minerals and micaceous material.

Pale green, piritized, talcose and calcitized areas are prominent, indicating a certain degree of secondary prophylitization ~~of the granite.~~

Accessory constituents including haematite, leucoxene and zircon.

This rock is apparently a more extensively metasomatized form of

XENOLITH ( ) occurring in the tor granite. Map location 150/955. A dark micaceous schistose inclusion within pink sheared adamellite. The xenolith is constituted of an anhedral granular association of abundant quartz, plentiful oligoclase, some microcline and notable amounts of biotite and hornblende, pleochroic from light to dark green. Accessory titaniferous iron ore and some associated sphene are to be noted. The preferred orientation of the ferromagnesian minerals imparts a schistose structure to the rock.

GRANITIC GNEISS ( ). Map location 138/953. A granitic type near the outskirts of the Palmer outcrop adjacent to contact hornblende granulites.

This is a medium grained pink rock with dark green hornblende in clots or streaks imparting a rude foliation. A narrow band of coarser quartzo-feldspathic material traverses the rock. Quartz and feldspar are most prominent and often occur as somewhat larger crystals embedded in the finer matrix.

In section the texture as seen to be a somewhat inequigranular anhedral aggregate of interlocking quartz, feldspar and hornblende. The feldspars are microcline and oligoclase near $Ab_{75}An_{25}$.

Hornblende is prominent, pleochroic in light brown to deep green. Brown biotite is rare.

Of accessories, sphene as feebly pleochroic brown crystals, is abundant. Apatite and titaniferous iron ore are notable. Epidote is rare.

FELDSPATHISED SANDSTONE ( ). Map location 9669/1366. A finegrained pink saccharoidal rock with occasional somewhat coarser lenses of quartz and feldspar. In the field it is gradational along the strike into leucogranite ( ).

In thin section it is seen to consist of a fine-grained equidimensional anhedral aggregate of quartz and feldspar.

The mineral constituents are quartz to the extent of 38.4%, in association with microcline and albite ($Ab_{85}An$~~$_{15}$), 29.6%~~; 31.9%.

Accessories to the extent of 0.1% are brown biotite and muscovite, the latter is the sparser of the two. Also black iron ore distributed very sparingly throughout. This latter may be of detrital origin.

LEUCO-GRANITE (287). Map location 967/138. This is a medium grained pink granitic rock consisting almost entirely of quartz and feldspar, outcropping near the contact of the Palmer body where feldspathised sandstones are seen passing into the granite along the line of strike.

In section it is seen to consist of an interlocking aggregate of quartz and feldspar. The texture inclines more towards the crystalloblastic than to the pyrogenetic. Crystal outlines are extremely irregular and often sutured. The individuals vary considerably in size and shape but are for the most part of medium grain-size. Skeletal, arrangments of quartz within and around feldspar are a peculiar feature. The implications show a pseudo-eutectic structure.

Quartz with fluidal inclusions in two directions at right angles, Microcline as turbid crystals carrying inclusions of quartz and plagioclase. Oligoclase ($Ab_{88}An_{12}$) ~~is~~ much subordinate to the microcline.

Accessory constituents are brown pleochroic shreds of biotite colourless muscovite, and black opaque iron ore, sometimes rimmed with leucoxene.

6. Bimica-quartz-oligoclase-migmatite (27E). Richly biotitic contorted laminae alternate with quartzo-feldspathic bands. The grainsize is larger than that of the less metamorphosed equivalents, namely about 1.2mm. Quartz, oligoclase, biotite and some muscovite are the main constituents. Ilmenite is present to a notable extent and yellowish green apatite is frequently met with in the biotite-rich bands. Tiny zircons are also to be numbered among the accessories.

7. Contorted Granitic Gneiss (No.27F). This is a quartz, microcline, oligoclase, biotite rock in which the disposition of the latter evidences residual minor folding. Pink microcline is abundant.

Microscopically this rock exhibits a typical crystalloblastic texture. The boundaries of the quartzites are considerably sutured. The composition of the plagioclase is about Ab_{75}. Rare flakes of muscovite are present. Ilmenite occurring as a few large xenoblasts. Other accessories are zircon, apatite, tourmaline and orthite.

8. Biotite granite (No.27). Very similar to the foregoing but finer grained and with the evenly distributed biotite.

Progressive mineralogical changes in the passage of a schist band into granite.

A series of six specimens collected progressively along the strike of a schist band (taken to represent a metamatically altered original sedimentary stratum) in its passage into graniti were petrographically investigated with the following result.

1. Quartz-oligoclase-microcline-biotite-schist. This is a fine-grained grey schistose rock in which schistosity is imparted by parallel arrangement of the biotite. As observed in microscope section, the grain-size averages 0.25mm. diameter. The modal mineral composition of the chief constituents is stated in the table herewith on page . Muscovite, apatite and zircon are in accessories only. Tourmaline and ilmenite appear rarely as odd grains.

2. Bimica-quartz-oligoclase-schist. In this there is a decided increase in muscovite and absence of microcline. There is a slight increase in tourmaline.

3. Bimica-quartz-oligoclase-schist. A somewhat darker rock with alternating darker and lighter bands. The muscovite forms larger individuals than the preceding. Tourmaline is abundant and in larger crystals.

4. Bimica-quartz-oligoclase-schist. Somewhat lighter coloured and coarser than the preceding. Average grainsize in section is 0.4mm. The plagioclase is oligoclase near Ab_{75}. Tourmaline less abundant than the preceding.

5. Similar to the preceding but increase in biotite which is mainly restricted to a number of contorted laminae up to 3mm. thick.

6. Bimica-quartz-oligoclase-migmatite. Richly biotitic contorted laminae alternate with quartz felspathic bands. The grainsize in sections is larger, about 1.2mm. ~~diameter~~. Quartz, oligoclase and biotite are the main constituents. Ilmenite is present to the extent of a few comparatively large grains. Other accessories are zircon, apatite, tourmaline and orthite.

~~7.~~ Biotite granite. Very similar to the foregoing but ~~of~~ finer grained grainsize.

Granodioritic Gneiss (No.33). Locality 9720/1280, is a typical example of the Rathgen outcrop. Macroscopically it is coarse grained and exhibits preferred orientation of the biotite to a marked degree. Quartz is abundant as greasy greyish crystals. The average size of the quartz and feldspar is of about 2mm. diameter. Sphene is also observable as glassy brown crystals associated with the biotite. In thin section the preferred orientation of the mineral constituents is cleary demonstrated. Quartz and feldspar are seen to be far the most abundant, of the minerals present. Biotite appears to a lesser extent while sphene and ilmenite are unusually abundant for accessories.

Quartz shows much variability in size and some suturing of the edges is common. It occurs rarely as a myrmekitic intergrowth with feldspar, but quite common as rounded inclusions in feldspar. Feldspar is all fairly fresh and also shows some suturing of the edges. Inclusions within it are common. Plagioclase, where multiple twinning is not clearly seen, is distinguished by its RI > balsam, and biaxial figure with a very high 2V. Maximum extinction on sections normal to 010 in twinned varieties is 8^{o} and it is an oligoclase of composition Ab_{75}. Microcline is ~~xxx~~ crosshatched twinning and RI < balsam. Biotite is strongly pleochroic from nearly opaque to light brown. Inclusions of zircon are quite common. Ilmenite. occurs as large black opaque idioblasts, commonly showing slight alteration to leucoxene. Sphene appears as brown, slightly pleochroic crystals, mainly concentrated in the biotite rich bands. Its unusual abundance is notable and some sections are as much as 1mm. in length. Idiomorphic apatites are also concentrated in the biotite bands, but not as abundant as the sphene. Zircon appears in small amounts only.

The Mode obtained by micrometric volume analysis is as follows:

Quartz	42.8%
Plagioclase	25.8%
Microcline	19.9%
Biotite	6.5%
Ilmenite	2.1%
Sphene	1.5%
Accessories	1.3%

A chemical analysis undertaken by one of us is recorded on the table on page . There also appears the norm which discloses 93.27% of the salic group and only 7.53% of the femic group. The C.I.P.W. classification is I, 3(4), 2, 3(4) (Tehamose).

Veined granitic Gneiss (No.60). Locality 130/961. A fine or medium grained grey granitic rock in which parallel bands of quartzó-feldspathic nature are spaced at regular intervals, with intervening, fine-grained schistose layers.

In thin section a central coarse band is seen traversing a somewhat inequigranular aggregate of quartz, feldspar and dark minerals. The coarse band consists essentially of quartz, oligoclase and microcline. The finer grained bands are constituted of an inequigranular aggregate of quartz and oligoclase to which hornblende and biotite, both with preferred orientation have imparted to the rock a pronounced directional structure.

Plagioclase (Ab_{75}) is the most abundant constituent, Microcline is everywhere subordinate to the plagioclase except in the coarse ~~graines~~ veins. Quartz is abundant. Hornblende, pleochroic in shades of green is less abundant than biotite. Accessory constituents are Sphene, apatite, zircon and zenotime(?).

Oligoclase-Quartz-Microcline-Biotite-Gneiss (No.61). Location 130/961. A coarse grained gneissic rock to which a preferred orientation of the biotite imparts a marked fissility. Quartz and oligoclase are the more abundant of the minerals; the latter as large clear white crystals.

In thin section, the quartz and feldspar of the coarse aggregate is observed to be somewhat elongated. The minerals represented are oligoclase (Ab_{75}), quartz and microcline. Also a little brown biotite. Accessories are titaniferous iron ore, brown sphene, colourless apatites, colourless grains of zircon and red-brown grains of monazite?.

Granitic Gneiss (No.62). Locality 129/962. A medium grained, grey rock in which the quartz and feldspar are segregated into distinct bands separated by layers of biotite in parallel orientation.

In thin section the rock is seen to consist of a rather inequigranular aggregate of quartz and feldspar with subordinate oriented biotite. The quartz and feldspar individuals exhibit sutured outlines and a distinct tendency to be elongated in the one direction.

Feldspar is the most abundant constituent and consists of two varieties:

1. Plagioclase is dominant over potash feldspar. It occurs as slightly dusty xenoblasts of variable size which may or may not show twinning on the Albite Law. RI balsam.

Of minerals present oligoclase (Ab) is the more abundant with turbid xenoblasts of microcline in less amount. Quartz is plentiful with undulatory extinction.as also is brown biotite. Apatite, black iron ore and zircon are sparsely distributed in the section and there are red-brown grains of high relief, biaxial positive with low optic axial angle which appear to be monazite.

Rheomorphic vein in Granite. (to be placed here)

Veined Gneiss (No.10) Locality 133/953. A dark rock with a parallel banded structure imparted by contrasting thin quartzo-feldspathic bands with intervening schistose layers in which dark minerals are conspicuous.

In thin section, abundance of micaceous minerals with preferred orientation imparts a pronounced directional structure to the rock. This is further emphasized by elongation tendency of the quartzes and feldspars. Coarser bands consist mainly of quartz and microcline.

The minerals present are quartz, abundant microcline, subordinate plagioclase, brown biotite and muscovite. The latter exhibits certain features suggestive of a retrograde origin by the change over of sillimanite.

Granodiorite (No.31A). Location 9723/1138. A medium grained rock in which lustrous black flakes of biotite studded through the prevailing white back-ground of quartz and feldspar provide a handsom contrast. In thin section the rock is observed to consist chiefly of an even-grained anhedral aggregate of quartz and plagioclase with subordinate biotite.

The principal minerals present are quartz, oligoclase near Ab_{85}, biotite, pleochroic in yellows and browns. Muscovite is an important accessory and in much less quantity are black iron ore, apatite and zircon.

Quartz-oligoclase-biotite-schist (No.310). Location Palmer 113/978. A schistose rock located in the field some 60 yards distant from the granodioritic rock, 31A.

This is a fine-grained, grey, friable schistose rock composed chiefly of quartz and feldspar with small flakes of black biotite with preferred orientation. The minerals present are quartz, 71.2%, oligoclase (Ab_{75}) to the extent of 18/6%, brown biotite, 10%, and the accessories zircon and apatite totaling 0.2%.

Hornblende Granulite (No.45). Location 9400/1405. This is a fine-grained, light-grey rock essentially composed of quartz, but with some hornblende and biotite segregated in certain folia.

In thin section, the rock appears granular with little evidence of schistosity.

Minerals represented are very abundant quartz, basic oligoclase, a small amount of microcline, fairly plentiful hornblende, strongly pleochroic in green and brown, biotite in small amount and accessories muscovite, epidote, sphene, zircon and apatite.

Amphibole?-Andesine-Schist (Plagioclase Amphibolite).(No.46). Location 9400/1405. A very dark rock consisting mainly of plagioclase and abundant needles of amphibole?. In thin section the rock is seen to consist almost wholly of oriented hornblende, pleochroic in greens and browns andAndesine (Ab_{65}).

Sphene is very abundant as an accessory mostly as rounded forms in which occur inclusions of ~~xxx~~ ilmenite. Other accessories are pyrite, zircon and apatite.

Hornblende-Andesine-Schist (Plagioclase amphibolite). (No.5). Locality 9520/1354. A dark schistose rock consisting essentially of feldspar and amphibole with preferred orientation.

The plagioclase is a normal andesine. The amphibole is a hornblende, pleochroic in light to deep green. Microcline is present in very small amount. Accessories include brown sphene and colourless apatite.

Quartz-microcline-biotite-muscovite-granulite (No.1) Locality 9505/1366. This rock was collected in the aureole just beyond the margin of the granitic outcrop. It is fine-grained and light-grey with no appearance of schistosity.

In thin slide quartz and microcline are observed to be equally abundant. Muscovite and biotite are both moderately abundant. There is present just a little plagioclase. Accessories are sphene, zircon, black iron ore, calcite and tourmaline.

Quartz-plagioclase-anthophyllite schist (No.40). Locality, Palmer, Mannum sheet 172/925. This rock type outcrops on the flats and is associated with layers rich in ilmenite bands. It is believed to be a magnesian metasomatized equivalent of the ilmenitic basal grits which outcrop prominently to the north of Palmer. A rather similar schist has been recorded by Johns in the aureole of the Murray Bridge Granite.

Macroscopically this is a fine-grained, light coloured rock with a pronounced fissility imparted by the preferred orientation of needles of neutral coloured amphibole. The bulk of the rock consists of quartz and feldspar with occasional bands rich in ilmenite running parallel to the schistosity.

In thin section the granoblastic texture of the quartz and feldspar is modified by the parallel orientation of anthophyllite needles.

Minerals present are quartz, plagioclase, anthophyllite and as accessories, ilmenite, rutile, biotite, apatite and zircon.

Quartz-Microcline-Plagioclase-Biotite Schist (No.42). Locality 170/903. A fine-grained quartz, microcline, basic oligoclase (Ab_{70}) biotite schist containing as accessories, rutile, zircon, black iron ore and apatite. Intersecting this is a narrow pegmatitic quartz, microcline oligoclase pegmatitic vein.

A Pegmatitic Vein (No.57) intersecting above Harrison's Creek. Locality, Mannum 102/958. The minerals present are quartz, pale orange microcline, white albite, muscovite with $2V = 28^{\circ}$ and $2E = 74^{\circ}$, black tourmaline, dark red garnet, chlorapatite, $W = 1.635$, white beryl with $W =$ near 1.574.

Fluor-apatite in a contorted composite gneiss (No.54). Locality, Mannum 175/936. The rock is rich in biotite and coarse pink microcline. Small crystals of fluor-apatite and coarse pink microcline. Small crystals of fluor-apatite embedded in the biotite layers have the following properties. Colour, borwn yellow; unaxial negative; we birefringence: W = near 1.6432.

Mode.

	Quartz:-	42.8%
	Plagioclase:-	25.8%
	Microcline:-	19.9%
	Biotite:-	6.5%
	Ilmenite:-	2.1%
	Sphene:-	1.5%
	Other Accessories:-	1.3%

An analysis of the Granitic Gneiss is given below, together with its Norm.

Analysed by C. F. Wegener.

Constituents	%
SiO_2	73.05
Al_2O_3	12.81
Fe_2O_3	1.54
FeO	2.30
MgO	.64
CaO	1.74
Na_2O	3.42
K_2O	3.15
H_2O+	.49
H_2O-	.16
TiO_2	.78
P_2O_5	.10
MnO_2	Tr.
ZrO	.09
S.	.05
TOTAL	100.32

Norm.

Constituents	%	
Quartz	35.88	
Orthoclase	18.90	Salic Group
Albite	28.82	92.37%
Anorthite	8.06	
Corundum	.71	
Zircon	.18	
Hypersthene	1.45	
	1.60	Femic Group 7.53%
Magnetite	2.32	
Ilmenite	1.52	
Apatite	.34	
Pyrites	.12	
TOTAL	99.90	

C.I.P.W. Classification would be I, 3(4), 2, 3(4) - Tehamose.

VEINED GRANITIC GNEISS.

Rock No. 60.

Location: 130/961

~~The hand~~ specimen ~~is~~ a fine or medium grained grey rock of ~~granitic~~ character in which parallel bands of quartzo-felspathic nature are spaced at regular intervals. These are ~~somewhat~~ coarser in texture than ~~the~~ intervening schistose layers.

Microscopical Description.

In thin section a central coarse band is seen traversing a somewhat inequigranular aggregate of quartz, felspar and dark minerals. The coarse band consists essentially of quartz ~~felspar~~ plagioclase and microcline. The ~~general matrix shows~~ an in-equigranular aggregate of quartz and felspar to which hornblende and biotite ~~in parallel~~ orientation have given a pronounced directional structure.

Plagioclase is the most abundant constituent represented. It occurs as colourless, slightly dusty crystals ~~in which~~ twinning on the Albite Law may be observed.

RI > balsam.

Maximum symmetrical extinction measured in the plane normal to 010 is 8° which corresponds with an oligoclase near $Ab_{75}An_{25}$.

Microcline is everywhere subordinate to the plagioclase except in the coarse veins.

Quartz is an abundant ~~constituent~~.

Biotite is the more abundant of the dark minerals.

Pleochroism is intense.

Extinction is straight.

Hornblende is notable as green xenoblasts associated with the biotite.

Pleochroism is strong
X = yellow green
Y = brown green
X = deep green

Extinction is inclined.

Accessory constituents include:-

- Sphene
- Apatite
- Ziron
- Xenotime?

PLAGIOCLASE - QUARTZ - MICROCLINE-BIOTITE-GNEISS.

Rock No. 61.

Location: 130/961.

The hand specimen is a coarse grained gneissic rock to which the parallel orientation of biotite imparts a marked fissile property. Quartz and felspar are abundant, the plagioclase assuming a somewhat porphyritic character as large clear white crystals showing multiple twinning.

In thin section the rock is seen to consist of a prevailingly coarse aggregate of quartz felspar and biotite. The biotite imparts a pronounced directional structure which is accentuated by the tendency for the quartz and felspar to be somewhat elongated.

Felspar is the dominant mineral constituent and comprises two varieties.

Plagioclase appears to be slightly dominant over microcline. It occurs as large and small xenoblasts. Alteration commonly starts at the centre of the crystal to give a kernel of alteration products with relatively clear margins. Multiple twinning is poorly defined or often absent.
RI > balsam.
In sections normal to Z, the extinction angle indicates an oligoclase near $Ab_{75}An_{25}$ in composition.
Inclusions of potash-felspar are seen.
Myrmekitic intergrowths of quartz in plagioclase are often visible.

Microcline is quite abundant as dusty xenoblasts which may or may not show the crosshatched structure.
RI < balsam.

Quartz is an abundant constituent as clear and colourless xenoblasts of irregular outline.

Biotite is prominent as strongly pleochroic brown flakes, which are commonly associated with iron ore, apatite and sphene.

Extinction is straight.

Pleochroic haloes surround zircon inclusions.

Accessory constituents comprise:-

1. titaniferous iron ore - black opaque grains
2. sphene - brown grains of high relief invariably associated with iron ore.
3. apatite - colourless grains of moderate relief.
4. monazite? - red brown grains of high relief.
5. zircon - colourless grains of extreme relief and birefringence.
6. muscovite - is rarely seen as colourless flakes with straight extinction.

GRANITIC GNEISS.

Rock No. 62.

Location: 129/962

The ~~hand~~ specimen is a medium grained grey rock in which the quartz and felspar are segregated into distinct bands separated by layers of biotite in parallel orientation.

In thin section the rock is seen to consist of a rather inequigranular aggregate of quartz and felspar with subordinate biotite ~~in parallel~~ orientation. The quartz and felspar crystals show sutured outlines and ~~have~~ a distinct tendency to be elongated in the one direction.

Felspar is the most abundant constituent and consists of two varieties:-

1. Plagioclase is dominant over potash felspar.

   It occurs as slightly dusty xenoblasts of variable size which may or may not show twinning on the Albite Law.

   RI > balsam.

In sections normal to Z, $X' \wedge 001 = 5°$ which corresponds with an oligoclase near $Ab_{75}An_{25}$.

2. Microcline is prominent as turbid xenoblasts showing the typical crosshatching.

   RI < balsam.

Quartz is abundant as clear colourless xenoblasts of all sizes.

Extinction is shadowy.

Biotite is prominent as small brown laths.

Pleochroism is strong Y = light yellow brown
Y ≅ Z = deep brown

Extinction is straight.

Accessory constituents comprise:-

Apatite colourless grains of moderate relief.

Iron ores black opaque granules.

Monazite ? Deep red grains of high relief have not been positively identified but are provisionally placed as monazite. It appears to be biaxial positive with a low axial angle.

Zircon is sparsely distributed as small rounded grains of extreme relief and birefringence.

RHEOMORPHIC VEIN IN GRANITE.

Rock 51.

Location 140/959

The hand specimen shows a coarse quartzo-felspathic vein traversing a fine grained schistose granitic rock. The vein consists essentially of pink microcline, white plagioclase and greasy brown quartz with occasional biotite flakes.

In thin section the coarse texture of the vein contrasts strongly with the finer granoblastic aggregate of quartz, felspar and biotite which comprises the micro-granite.

1. Rheomaphic Vein

   Quartz large colourless crystals.

   Plagioclase is the most abundant constituent as clouded crystals which may or may not show twinning on the Albite Law.

RI > balsam.

It is apparently an oligoclase near $Ab_{80}An_{20}$.

Microcline displays typical crosshatching.

Iron Ore is an accessory constituent.

2. Micro-Granite.

Quartz as small colourless xenoblasts is abundant.

Microcline is abundant as dusty xenoblasts displaying the typical crosshatched structure.

RI < balsam.

Plagioclase is notable and may show twinning on the Albite Law.

RI > balsam.

Biotite is prominent as highly pleochroic brown laths with no pronouced directional structure in this section. Extinction is straight.

Titaniferous iron showing alteration to leucoxene is a notable accessory.

Muscovite is seen rarely.

VEINED GNEISS. (No 10), Locality 133/953.

Rock No. 10.

Location:- 133 / 953

~~The hand specimen is~~ A dark rock with a parallel banded structure imparted by contrasting thin quartzo-felspathic bands with intervening schistose layers in which dark minerals, ~~of a schistose nature in which both light and dark minerals~~ are conspicuous.

In thin section, abundance of micaceous minerals ~~in~~ with preferred orientation imparts a pronounced directional structure to the rock. This is [illegible] emphasized by ~~the~~ elongation tendency ~~for~~ of the quartz, and felspar, to ~~be elongated in~~ the same ~~general direction.~~ A coarser band is ~~seen to~~ consist mainly of quartz and microcline. The thin wispy nature is a conspicuous feature of the muscovite.

Quartz is abundant as colourless xenoblasts of somewhat elongated habit.

Felspar - The felspar present is chiefly microcline which may or may not display its crosshatched structure.
Plagioclase is subordinate.

Biotite is abundant as brown laths in parallel orientation.

Pleochroism is intense X = light yellow brown, Y = Z = deep brown

Muscovite is an abundant constutuent in thin wispy bands.
It is colourless and shows straight extinction.
Birefringence is extreme.
The form of the muscovite is strongly reminiscent of a retrograde origin. Isolated needles of a length slow character are seen. Bundles of grey fibres of high relief within the muscovite are a feature and may represent original sillimanite relicts.
Intergrowths of quartz with the muscovite are seen in rare instances.
Basal sections show a biaxial negative interference figure 2V is low.
Accessory constituents include notable zircon and apatite.

GRANODIORITE

Rock No. 31A.

Location: 9723/1138.

The hand specimen is a medium grained rock in which lustrous black biotite flakes provide a handsome contrast to the prevailing white back-ground of quartz and felspar. Segregations of biotite in clots are ~~visible~~.

In thin section the texture is seen to be granoblastic. The rock consists chiefly of an even-grained aggregate of quartz and plagioclase with subordinate biotite, the constituent minerals showing little semblance of crystal outlines.

Quartz is abundant as colourless xenoblasts of low positive relief.

Plagioclase occurs as somewhat dusty xenoblasts showing twinning on the Albite, Pericline and Carlsbad Laws.
RI < balsam.

[illegible handwritten note: ... present ... quartz, plagioclase near Ab75, biotite ... yellow and brown. Muscovite is an important accessory ... apatite and zircon.]

Maximum symmetrical extinction observed in sections perpendicular to 010 is 8° which corresponds with an acid oligoclase near $Ab_{85}An_{15}$.

Potash felspar is apparently absent or negligible.

Biotite is notable as small brown flakes.

Pleochroism is intense   X = yellow
                            Y = Z = deep brown

Extinction is straight.

Muscovite is an important accessory constituent. It occurs as colourless, brilliantly polarising flakes. Extinction is straight.

Minor accessories are apatite, iron ore, leucoxene and zircon.

Mode; - Quartz:-

Plagioclase:-

Biotite:-

Muscovite:-

Accessories:-

QUARTZ - ~~PLAGIOCLASE~~ plagioclase - BIOTITE-SCHIST (No. 310), Location Palmer 113/978

Rock No. 310.

Location: Palmer. ~~105~~ 113/978

Field relations: A schistose rock, located in the field some 60 yards distant from the granodioritic type 31A.

~~It~~ This is a fine-grained, grey, friable, schistose rock composed chiefly of quartz, ~~with~~ and felspar ~~and~~ with small flakes of black biotite with preferred orientation.

In thin section the rock is seen to consist essentially of a fine granoblastic aggregate of quartz and felspar. Small ragged xenoblasts of biotite in roughly parallel orientation impart a directional element to the prevailing texture.

Quartz is the most abundant mineral present.

Plagioclase is abundant as colourless rounded xenoblasts. RI > balsam.

In sections normal to 010 the maximum symmetrical extinction is 8° which corresponds with an oligoclase near $Ab_{75}An_{25}$.

Biotite is prominent as irregular xenoblasts in parallel orientation.

Pleochroism is strong X = yellow brown
Y = Z = dark brown

Extinction is straight.

Accessories are:-

Zircon - small rounded grains of high relief and birefringence.

Apatite - colourless grains of moderate relief and weak birefringence.

Mode:-	Quartz:-	71.2%
	Plagioclase:-	18.6%
	Biotite:-	10.0%
	Accessories:-	.2%

HORNBLENDE GRANULITE.

Rock No. 45.

Location:- 9400/1405.

~~In the~~ hand specimen this is a fine-grained, light-grey rock essentially composed of quartz, but with ~~the segregation of~~ some hornblende and biotite ~~into~~ folia.

In thin section, the rock ~~displays a granoblastic texture~~ with little evidence of schistosity.

Quartz ~~is~~ very abundant.

Plagioclase is plentiful but twinning is almost absent.

It is distinguished by its cleavage, turbidity &

RI > balsam.

Possibly a basic oligoclase or andesine.

Microcline - in small amounts showing "crosshatching".

Hornblende is fairly plentiful and strongly pleochroic from deep green to brownish.

Biotite - in small amounts and strongly pleochroic with straight extinction.

Muscovite, epidote, sphene, zircon, and apatite occur in accessory amounts.

~~HORNBLENDE - PLAGIOCLASE~~ - SCHIST. (PLAGIOCLASE AMPHIBOLITE.)

Rock No. 46.

Location: 9400/1405.

~~This is~~ A very dark rock consisting mainly of abundant needles of hornblende, ~~with interspersed felspar~~. Occasional greasy porphyroblasts proved to be much saussuritised plagioclase. Pyrites also occurs as brass-coloured grains. The schistosity of the rock is due to the parallel arrangement of the hornblende needles.

In thin section the rock ~~has a granoblastic texture and~~ consists almost wholly of hornblende and plagioclase. **Hornblende** is strongly pleochroic in greens and ~~brownish greens~~. Cross sections show typical 120° cleavage.

Plagioclase - almost as abundant as hornblende, but very much saussuritised and hence it has a very murky appearance in ordinary light.

It is mostly untwinned.

RI > balsam.

The maximum extinction angle on sections normal to 010 is 18°, hence an Andesine (Ab_{65}.)

Sphene is very abundant as an accessory, mostly in rounded forms, but acute rhombic sections also occur.

High DR and TR.

Some crystals contain inclusions of ilmenite.

Other accessories are pyrite, zircon and apatite.

~~HORNBLENDE - PLAGIOCLASE~~-SCHIST (PLAGIOCLASE AMPHIBOLITE)

Rock No. 5 Loc. 9520/1354

~~This is~~ A dark schistose rock consisting essentially of ~~amphibole and~~ felspar.

The schistose structure is not apparent in thin section due to the transverse orientation of the slice. The section shows a granoblastic aggregate of hornblende and plagioclase.

Hornblende is the most abundant mineral present and typical amphibole cross-sections are seen.

Pleochroism is intense, X = light green
Y = brownish green
Z = deep green

Extinction is inclined as much as 25° .

Plagioclase is quite abundant as colourless clear xenoblasts and twinning on the Albite Law is common, but it is not always shown.

RI > Balsam.

Extinction angles indicate that it is a normal andesine.

Microcline is present in small amounts only and is sericitized.

RI < balsam.

Quartz appears to be absent.

Accessories include a pleochroic brownish sphene and colourless apatite.

The plagioclase is a normal andesine. The amphibole is a hornblende pleochroic in ~~greeny~~ light to deep green. Microcline is present in very small amounts. Accessories include brown sphene and colourless apatite.

MICACEOUS GRANULITE.

Rock No. 1.

Location: 9505/1366.

This rock was collected just outside the contact between ~~the granitic and~~ the country rock. Macroscopically the rock is fine-grained and light-grey ~~in~~ colour with no appearance of ~~visible~~ schistosity. Quartz and felspar seem to be predominant together with lesser amounts of biotite and muscovite.

In the slide the rock has a fine grained granoblastic texture.

Quartz and Microcline are equally abundant.

Plagioclase in small amounts only and twinning is almost absent, but recognised by cleavage.

RI > balsam

Muscovite and Biotite are both fairly abundant.

Epidote - as very pale yellow crystals with a high RI and polarising in bright colours.

Accessories, all of which are fairly abundant are sphene, zircon, calcite, iron ore, and tourmaline.

QUARTZ- PLAGIOCLASE - ANTHOPHYLLITE SCHIST.

Rock No. 40.

Location: Palmer, Mannum Sheet 172/925

Field Relations: The rock type outcrops on the flats and is associated with layers rich in ilmenite bands. It is believed to be ~~un-doubtly an~~ equivalent of ~~to~~ the ilmenitic basal grits which outcrop prominently to the north of Palmer, ~~but has undergone magnesian metasomatism. The almost identical rock types found near~~ Rocky Gully ~~may have a similar derivation.~~

Macroscopically this is a fine grained light coloured rock with a pronounced fissility imparted by the preferred orientation of needles of neutral coloured amphiboles. The bulk of the rock consists of quartz and felspar with occasional bands rich in ilmenite running parallel to the schistosity.

In thin section the granoblastic texture of the quartz and felspar is modified by the parallel orientation of anthophyllite needles. Minerals present are quartz, plagioclase, anthophyllite, and accessory ilmenite, rutile, biotite, apatite & zircon.

Quartz is abundant as small clear xenoblasts of low positive relief. Uniaxial positive.

Plagioclase is subordinate to quartz and consists of twinned and untwinned colourless varieties.

Anthophyllite occurs as neutral coloured needles of moderately high relief.
Amphibole cleavage is seen in sections.
Extinction is straight.

Ilmenite as black opaque granules is an abundant accessory.

Rutile as red brown grains of extreme relief.

Biotite as sparsely distributed small pleochroic brown laths.

Apatite as colourless grains of moderate relief.

Zircon as small rounded grains of extreme relief and birefringence.

QUARTZ - MICROCLINE - PLAGIOCLASE - BIOTITE-SCHIST.

Rock No. 42.

Location: 170/903

The hand specimen shows a pegmatitic vein traversing a fine grained dark schistose rock. The pegmatite veins shows coarse quartz, microcline and muscovite at the centre but the grain size is steadily finer towards the margins where it is equivalent to that of the schistose rock. The schistosity is imparted by flakes of biotite in parellel orientation.

In thin section the coarse pegmatite vein comprises quartz, microcline, and plagioclase. The finer grained margin consists of a granoblastic quartz, microcline plagioclase aggregate and is obviously the felspathised equivalent of the schistose rock. The schistose rock has a prevailingly granoblastic texture modified by shreds of biotite in parallel orientation.

Mineralogy.

Pegmatite Vein

Quartz abundant colourless crystals of large size.

Microcline showing typical crosshatching.

Plagioclase showing multiple twinning on the Albite and Pericline Laws.

RI > balsam.

It is apparently an oligoclase.

Schistose Rock.

Quartz - small xenoblasts with sutured outlines.

Microcline - shows crosshatching.

Plagioclase

RI > balsam.

Maximum symmetrical extinction in the plane perpendicular to 010 is 10° which corresponds to a basic oligoclase or oligoclase-andesine near $Ab_{70}An_{30}$.

Biotite as irregular shreds and flakes.

Extinction is straight.

Rutile is a notable accessory constituent as red brown grains and prisms of extreme relief. Aggregates of small prisms are a feature.

Iron Ore, apatite and zircon are frequent accessory constituents.

Rock No. 57 is a specimen taken from a pegmatite along Harrison's Creek.

Location; Mannum 102/958.

It contains:-

Quartz

Microcline - a pale orange in colour.

Plagioclase - colourless and showing multiple twinning in the hand specimen. It is apparently very near pure albite in composition.

Muscovite - pale green sheets.

$2V = 28°$ (approx.) ($2E = 74°$)

Tourmaline - the black common variety.

Garnet - a dark red variety sometimes showing rhombic dodecahedral faces.

Chlor-Apatite - green in colour.

Uniaxial Negative.

W = 1.635 (approx.)

Beryl is found in the same pegmatite but is not represented in the hand specimen. It is a colourless variety.

Uniaxial Negative.

W is near 1.574.

Albite - clear and white.

Rock No. 54. is a specimen of a contorted composite gneiss.

Location: Marmum. 175/936

The rock is very rich in biotite but coarse pink microcline is abundant.

Small crystals of fluorapatite may be seen in the biotite layers. On examination it is found to have the following properties:-

Colour = lemon yellow.

Uniaxial negative.

Weak Birefringence.

W is near 1.6432.

Fluor-apatite in a contorted composite gneiss (No 54).
Locality: Marmum 175/936. The rock is rich in biotite
and coarse pink microcline. Small crystals of fluor-apatite
~~are~~ embedded in the biotite layers have the following properties:
Colour, lemon yellow; uniaxial negative; weak birefringence;
W near 1.6432.

SUMMARY OF PETROGRAPHIC EVIDENCE

1. The textures and structures of the granitic rocks near Palmer as revealed in thin section tend more to crystalloblastic than the pyrogenetic.
2. In the granitic rocks of the Palmer Outcrop, the ferromagnesian minerals, in particular biotite, although often conspicuous never attain notable abundance, and are sometimes absent.
3. Modal proportions of the minerals in the granitic rocks are not inconsistent with the view that the Palmer granite is derived from an arkosic rock.
4. Sphene is an abundant accessory constituent of the Palmer granite and is often associated with titaniferous iron ore which may form a nucleus within the sphene crystal.
5. Desilication through felspathisation and basification of the contact rocks is indicated at the margins of the granitic outcrops. A graphical study of the modal relations of certain contact rocks is considered in detail later.
6. Petrographic evidence supports the view that the abnormal talcose granite of the shatterbelt is a metasomatic variant of the normal granite.
7. Possible retrograde changes in the schistose rocks of the migmatitic zones may be indicated by the presence of relict sillimanite needles within muscovite. The porphyroblastic development of muscovite in isolated clots as in specimen 31 may represent a similar phenomenon.
8. Magnesian metasomatism is indicated by the presence of anthophyllite in altered ilmenitic basal grits.
9. "Xenoliths" within the granite are of finer grain than the granite and contain the same mineral suite although the proportions of each mineral vary. Ilmenite and sphene appear to be increased in amount as also does biotite.
10. The activity of volatiles is indicated by their fixation

in certain characteristic minerals - fluorine in fluor-apatite, chlorine in chlor-apatite, phosphorus in apatite, boron in toumaline, and sulphur in pyrites in some rocks of the frontal zone (beyond the range of the mineralization of the shatter belt.)

11. Altered rocks associated with definite bands of ilmenite in the field have proved to carry rutile apparently derived at the expense of the titania content of the ilmenite. The presence of rutile may therefore indicate ilmenitic basal beds elsewhere, as in the anthophyllite bearing quartz plagioclase schists of Rocky Gully.

12. Myrmekitic structures and also pseudo-eutectic structures within the granitic rocks may be significant.

THE ORIGIN OF THE PALMER GRANITE AND ASSOCIATED GRANITIC ROCKS.

Certain features which characterize the granitic rocks near Palmer as a whole are recapitulated below.

1. The granitic rocks as a whole are more of the nature of gneisses (or recrystallised arkoses in some instances) than of true granites.
2. The extreme variability of the granitic rocks.
3. The outcrops show a general concordance with the structure of the neighbouring metasediments.
4. Xenolithic material within the granite in general shows a regional orientation.
5. The parallel structure of the granites, the orientation of xenoliths, the margins of the outcrops and the direction of schistosity of the country rock are all essentially parallel.
6. Desilication phenomena, basification in particular being the most significant, characterise the frontal zone around the granitic outcrops. Basification about pegmatitic veins may also be considered here.
7. The textures of the granitic rocks as revealed in thin section resemble more the crystalloblastic than the pyrogenetic.
8. Gradational contacts with surrounding metasediments

In the opinion of the writers these several facts point undeniably to granitisation, or as some would prefer, gneissification as the process whereby the granitic rocks originated. They are convinced that all the features of the Palmer Granite can be explained in terms of granitisation in place. In contrast they can bring forward not one salient point in favour of a magmatic origin.

It has been demonstrated that the source rocks of the Palmer Granite are most likely of sedimentary origin. The sediments which have been granitised must have formed part of the series of schists which Hossfeld has assigned to his Barossa Series.

It will be as well to consider at this point the actual nature of the source sediments transformed to granite. It has been observed that many of the granitic rocks in the Palmer outcrop are almost purely quartzo-felspathic types. In others the ferromagnesian minerals are quite sub-ordinate. The field appearance of these rocks is strongly suggestive of recrystallised arkoses. The substance of these rocks probably largely represents original material although some addition of potash and soda is probable. Further, felspathisation observed in the arenaceous types at the contact is in accordance with the general phenomenon observed in altered psammitic rocks at granite contacts.

Further, microscopic study of the granite reveals an abundance of sphene which is invariably associated with, and apparently derived from ilmenite. Ilmenite often forms a nucleus within sphene crystals. A magnetic analysis of certain basified "xenoliths" revealed a high proportion of ilmenite. In one exceptional case the proportion reached as much as 1.9% by weight. With the sphene content included, the titania content would have been considerable. The large sphene crystals observed in some of the amphibolitic rocks of the migmatitic zone may represent a culmination in TiO_2 through the expulsion of that constituent during the transformation of the sediment.

It is apparent therefore that the source rock was arenaceous, probably arkosic on the one hand and rich in titania (as ilmenite) on the other. The association of quartzose and ilmenitic beds lead the writers to undertake an investigation into the possibility that the Palmer Granite was derived from the ilmenitic basal beds which outcrop prominently to the north of Palmer. While no outright proof of such an origin was revealed, evidence was uncovered which is strongly suggestive.

Hossfeld had considered that the ilmenitic beds apparently ceased south of Palmer. The writers, however, studied the outcrops on the flats below the escarpment and found that certain of the rocks, notably anthophyllite schists contained ilmenite which was often in close parallel bands. These were undoubtedly metasomatised equivalents of the basal beds. At the foot of the scarp in places, kaolinised arkosic rocks with thin ilmenite bands outcrop sporadically and doubtless underly much of the alluvium. The search then turned to the scarp face itself. The metasomatic variant of the granite is not prominent south of the Reedy Creek where it tails out into migmatitic rocks which show signs of shattering. Amongst these rocks, metasediments were found east of Kitticoola near the banks of Reedy Creek which contained bands of ilmenite up to three inches across. These are arkosic in nature and are apparently conformable with the schists to the west corresponding with them in magnitude and direction of the strike and dip. They trend towards the metasomatic variant of the granite some three hundred yards away. Recrystallised quartzose types were seen passing into a granitic type in which ilmenite is prominent.

It must be realised that only the rocks with definite bands of ilmenite have been designated as basal grits on the accompanying map. Hossfeld has pointed out that ilmenite is abundant in restricted areas only, and it is apparent in view of this fact and also the wide extent of the basal beds that many of the metasediments outcropping in the vicinity of the loops of the Reedy Creek may belong to the basal series, their true nature being masked by the changes they have suffered.

It is apparent therefore, the theory that the ilmenitic basal beds are the source rocks of the Palmer Granite should not be disregarded. We therefore assemble the facts for and against the case.

A. In favour of the theory.

1. Evidence favours an arkosic nature for the source sediments.
2. The granite with its xenolithic material is relatively rich in ilmenite and sphene.

3. The proximity of the ilmenitic beds to, and their apparent trend into the granite.

B. Against the theory

The whole evidence which can be marshalled against the theory is Hossfeld's conclusion that the schists are Barossian in age. This is open to doubt. Hossfeld himself admits,

"..no actual junction of the sandstones and the underlying schists was observed."

His whole case appears to rest on the statement,

"Their easterly dip demonstrates they overly the schists to the west."

Against this point, ilmenitic bands have been found outcropping on the scarp face which although in the shear zone, are little affected and are apparently conformable with the schists to the west.

The writers consider a Barossian age not proven for the schist series west of Palmer. Although most probably Pre-Cambrian in age the writers incline to the view that they are later Pre-Cambrian in age possibly corresponding with the Mosquito Series or even the Adelaide System. Should further research indicate this, additional support must be given the theory that the Palmer Granite is derived from the ilmenitic beds.

FAVOURED THEORY AS TO THE ORIGIN OF THE GRANITE.

The series of rocks 27-27G was taken along the strike of a schistose psammitic bed towards the contact of the granite. Some idea of the changes taking place can be gathered from a study of the modal relations of the rocks. The variation diagrams below illustrate to some extent the details of the mineralogical changes in the individual rock types with respect to the parent rock, which is considered to be nearest approached by rock 27.

The rocks at the contact have been desilicated. The most striking change is a basification; a geochemical culmination in the cafemic constituents and also with respect to boron and phosphorus is indicated by the increase in the modal amounts of biotite, plagioclase, tourmaline and apatite. Boron reaches a culmination in rock 27B, and a boron front has apparently proceeded in advance of iron and magnesium .

The granitic end of the series shows a decided increase in potash with a corresponding decrease in the femic constituents as compared with the parent rock (27), shown by the increase and decrease respectively in the modal proportions of microcline and biotite.

Desilication of arkosic beds adjacent to the schistose series above (which may represent greywackes) has taken the form of felspathisation well exhibited in rock 28A. Unfortunately this felspathised series cannot be traced outwards to their unmetasomatised equivalents which are covered by alluvium.

The granite is thought to have originated through the transformation in situ of dominantly arkosic rocks with interbedded alternations of a more basic character (grey wacke). In effect the granitic rocks at Palmer have arisen by a process of ultrametasomatism through the introduction of certain constituents and the removal of others. There has apparently been a considerable influx of potash with the concomitant expulsion of cafemic constituents with titania, phosphorous etc. into the frontal zone. The activity of volatile constituents during the transformation is indicated by their presence in the constitution of distinctive minerals in the frontal zone, boron in tourmaline, sulphur in pyrites, fluorine in fluor apatite, chlorine and phosphorus as chlorapatite.

Emigration of some silica may be indicated by the pseudo-eutectic structures of quartz in alkali felspar since according to Backlund, Geological Magazine 1946, "The emigration of Silica is indicated by the wonderful implications of quartz and potash felspar. These have the appearance of eutectic structures but the proportion of quartz to felspar varies steadily".

The source rocks of the Rathgen gneiss were more basic in nature than those responsible for the Palmer Granite and the transformation to gneiss was accompanied by the emigration of considerable iron, magnesium and titania fixed in the frontal zone as biotite, amphibole and sphene.

In conformity with the granitisation hypothesis the writers explain the several features of the granitic rocks as follows:-

1. THE VARIABILITY OF THE GRANITIC ROCKS.

This is considered to be due to the nature of the source sediments and to the nature and extent of the granitisation suffered by them. The occurrence of quartz-felspathic rocks reminiscent of recrystallised arkoses amongst rocks more aptly termed granites, is no doubt due to the general phenomenon of indifferent susceptibility to granitisation shown by the purer psammitic rocks.

The writers cannot accept the idea of one magma producing the variety of granitic rocks, which, though perhaps not varying much as regards chemical composition have profound textural differences and certain mineralogical differences and yet occur in intimate association.

The dark ellipsoidal "xenoliths" are regarded as basified remnants of the original rocks which have escaped the general transformation to granite. They are notably richer in biotite, ilmenite and sphene than their enclosing granite.

2. THE GNEISSIC STRUCTURE OF THE GRANITIC ROCKS.

It has been shown above that the foliation of the Rathgen gneiss is considered as a residual primary structure, the biotite folia representing the extreme case of the basified layers of the veined gneisses.

In the Palmer Granite and indeed all the foliated granitic rocks the writers believe that the parallel structure is a consequence of primary structures (schistosity) in the transformed rocks. This is supported by the continuity of the foliation into the schistosity of country rock and xenolith alike and also by its essential parallelism with the schistosity of the country rocks. Certain of the contorted structures in the granite undoubtedly represent relicts of original structures (minor folding etc) in the transformed rocks.

Certain of Sederholm's conclusions regarding gneissic granites of Finland are relevant in this respect. He dismisses any dynamo-thermal action as directly responsible for some gneissic structure. In a paper he states "..where they are striped the phenomenon is usually caused by the more or less completely resorbed inclusions of foreign rocks whose femic constituents remain as stripes of mica" and further, "When they are gneissose this is mainly due to the fact that they have absorbed older schistose rock. The parallel texture is probably due to the assimilation of this schistose rock."

The variability in the degree to which the gneissose structure is developed depends on the proportion of initial femic constituents. In many of the granitic rocks at Palmer this was apparently low, some of the rocks showing no biotite whatsoever.

3. THE SHAPE OF THE OUTCROP.

Throughout the transformation the source rocks were predominantly a solid phase and thus the structures and textures of the country rock have been preserved in some degree. There is no question of melting up, as the preservation of the foliation as a residual primary structure ruling this out.

CONCLUSIONS.

An intensive study of the rocks of the Palmer area has convinced the writers that all the features exhibited by the granitic rocks can be explained in terms of granitisation in place. They have considered the possibility that the Palmer Granite has arisen at the expense of the ilmenite bearing basal beds. They are not convinced that the series of schists on the eastern side of the Mt. Lofty Ranges and which Hossfeld has included in his Barossa Series are all of Archaean age. They would prefer further research into their nature and into their structural relations with the beds to the east before a definite position on the stratigraphic sequence is assigned to them. Meanwhile they believe there is as much or more reason to believe that they correspond with the Adelaide System.

As a result of their investigations the writer's attention was attracted to problems further afield, namely to the regional extent of the metamorphism, the fold structure of the ancient mountain range, the widespread pegmatization of the schist series, the sporadic granitization throughout the schist series as shown in the numerous minor granitic outcrops as well as the major Palmer and Tanunda Creek Granites and the tonalitic rocks of the Hundred of Finniss, and to the fluorite-bearing granites to the south east.

The writers are unable to escape the conclusion that these several features are all attendant upon the subsidence of a Pre Cambrian geosynclinal prism of sediments into a high temperature region of the earth's crust. The effects produced in consequence are considered to have originated contemporaneously or penecontemporaneously during one episode of geologic time which may have included several of the divisions ordinarily recognised.

In any event the writers consider that the chronological succession, as proposed by Hossfeld, is no longer acceptable and submit for consideration their preferred version of events affecting the eastern sector of the Mt. Lofty Ranges, with particular emphasis on the Palmer Area.

1. Deposition of Pre Cambrian (Adelaide System?) sediments and their accumulation in a subsiding geosyncline.
2. Time Interval during which subsidence continued to high temperature levels and in which heating of the geosynclinal sediments was proceeding.
3. Period of crumpling and folding, regional metamorphism on a grand scale, granitization, pegmatization and generation and intrusion of magma.

Stresses provoked by crustal expansion initiated folding movements, lateral thrust being in an east-west direction, the axial trends being roughly north-south. Regional metamorphism accompanies on a vast scale and in favourable locations granitization is accomplished. The origin of the transforming fluids and those responsible for the widespread pegmatization possibly lies in the fusion at depth of easily melting portions of the sedimentary prism and the squeezing out of such by the orogenic pressure to areas where they become active. In the meantime the fusion and dissolution of the depressed roots (tectogene) of the sedimentary prism resulted in the generation of magma which was later intruded to higher levels and is now represented as the fluorite-bearing batholith exposed at Murray Bridge and further towards the south east.

The time interval in which these various phenomena were produced is considered as ranging from Late Cambrian through Ordivician times. This speculation is based on the necessity for assuming a long period after deposition before the subsidence and heating up of the sediments could be effective enough to initiate the changes detailed above.

This hypothesis is of course speculative but the writers consider that it is justified as it presents a logical explanation of the several events which were formerly attributed without due reason to separate processes and periods of formation.

4. Faulting with subsequent silicification and mineralization. This is post granitization but may not have been long subsequent. It may be set down as belonging to an early-mid Palaeozoic period.
5. Time Interval marked by peneplanation.
6. Late Tertiary (Kosciuskan) Uplift along old lines.
7. Erosian and deposition of present alluvium.

ECONOMIC GEOLOGY.

The tor granite has been used in the past for building purposes, monumental work and road kerbings. The rock was obtained by splitting with plug and feather work and broke easily along any desired plane.

The Kitticoola Mine, one and three-quarter miles to the south of Palmer, has been of some interest in the past because of its gold content, but copper also proved to be associated in payable quantities. The mine was worked almost continuously from 1890 until about 1936. The copper occurred in the form of sulphides, black oxide, malachite, azurite and also native. The gangue associated with the ore minerals consisted predominantly of quartz and pyrite, together with subordinate amounts of arsenopyrite, micaceous haematite, carbonate minerals etc. Considerable amounts of payable ore were extracted from the lode but operations were, however, somewhat hampered by interference from water at relatively shallow depths.

Road metal has been obtained from several places adjacent to the main road by quarrying into both the more rotten type of granite and into the shattered rocks of the crush zone. Both of these sources yield excellent road metal.

River sands from the Reedy Creek have been used locally for building purposes.

Reasonable supplies of good water were obtained by boring into the fault zone just above the township of Palmer and these have augmented the town's supply.

TERMINOLOGY.

1. In view of the nature of the processes active at Palmer and the difficulty of distinguishing in some instances where alteration of sediments by purely metamorphic processes (as defined by Harker) ends and where metasomatic factors begin to assume importance the writers prefer to use the noncommittal term metasediments. This term embraces all the various rocks which outwardly display obvious signs of a sedimentary origin.
2. The writers do not subscribe to the implications suggested by the terms injection gneiss or "lit-par-lit" gneiss and prefer the term veined gneiss for the characteristically veined rocks.
3. The highly contorted biotite rich rocks with tortuous quartzo-felspathic veins are designated as contorted composite gneisses or ptygmatic migmatites.
4. The term permeation migmatite refers to the fine-grained compact crystalline rocks, the so called granitic schists of H. Y. L. Brown.

The term "Xenolith" as here used, is not in strict accordance with its common use, but for convenience it has been used to indicate the residuals of country rock which have not been completely granitised.

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