THE WEEKEROO AMPHIBOLITE

by

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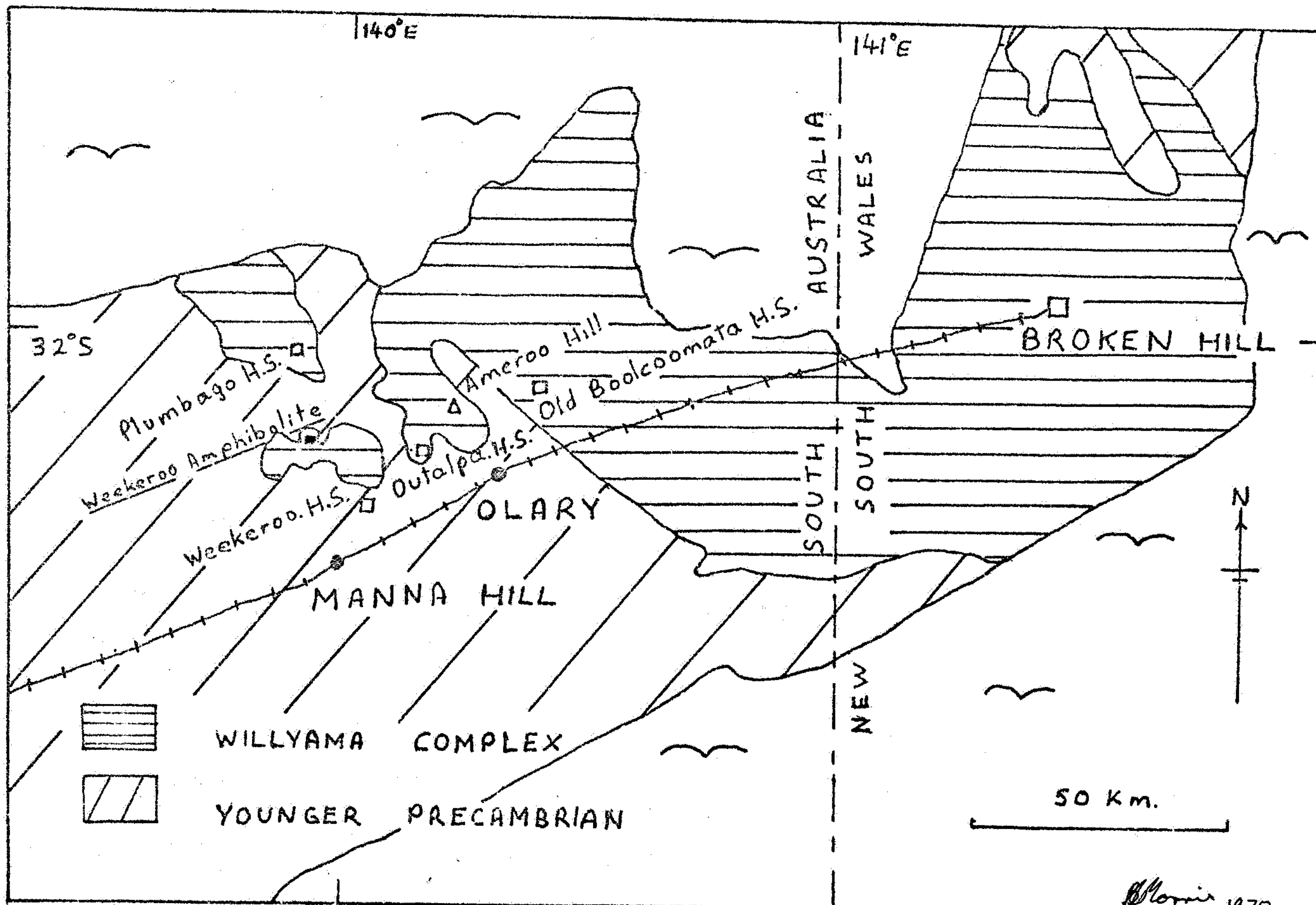
CONTENTS

Locality Map of the Weekeroo Amphibolite.



"A large part of the scientific search is, thus, for things worth naming".

C.I. LEWIS, Mind and the World Order.

ABSTRACT

The Weekeroo Amphibolite is an oval shaped body lying in the Archaean basement complex of high grade schists, gneisses and migmatites, and is overlain unconformably by Proterozoic meta-sediments. A study of field associations, petrology, mineralogy, and chemistry show discordant contacts and relict igneous textures, which indicates a probable igneous origin for the major part of the body. Sodium metasomatism of the body and adjacent sediments is evident.

INTRODUCTION

The Weekeroo amphibolite is situated at the coordinates 32° 12'S, 139° 56'E, and about 8 miles north of the Weekeroo homestead (see locality map opposite). It is about 1½ miles long, ½ mile wide and is one of three such bodies lying about 2 miles apart and alligned in a roughly east-west direction. The body stands out as relatively high, gently rounded hills with the slopes covered with scree (plate 6,A), and is characterised by a general lack of vegetation. The body lies in the Archaean basement complex, that has been deformed at least twice prior to the deposition of the younger Pre-Canabrian sediments. High grade metamorphism with associated pegmatites and granites accompanied the first phase of deformation, and a lower grade of metamorphism appears to have been imposed in the second phase of deformation. The effects of the high grade metamorphism (high epidote-amphibolite facies) and low grade metamorphism (greenschist facies) are evident in the body. The Palaeozoic orogeny accompanying the latter metamorphic phase was also responsible for the megascopic and macroscopic structure found within the body.

Four weeks of field mapping was done in the area, with information being plotted directly on to aerial photographs at a scale of 1 inch represents 4 chains. Altogether 250 samples were collected from the amphibolite body and surrounding rocks, for petrological, mineralogical and chemical analyses. A series of samples was collected from along the length of the body (east-west) with the aim of detecting any trend in the mineralogy or chemical composition of the amphibolite or amphiboles. Also a series of samples was collected from thecontact of the amphibolite out into the metasediments with the aim of finding a trend of variation and extent of Na metasomatism out from the body. In total 150 thin sections were cut and described in detail (Appendix 2).

MAPPING DESCRIPTION

Regional Setting

The Weekeroo Amphibolite body lies within the "Weekeroo Schists" of the Willyama complex, which makes up the Archaean basement in the area. The schistosity runs in a roughly east-west direction and the long axis of the oval shaped body is parallel to the schistosity. The body is about 1½ miles long and ½ mile wide. There are also two similar bodies in the area, one lies about 2 miles to the N.E. and the other about 2 miles to the S.W., both of these were briefly looked at. The three bodies are aligned with their long axes all in the same direction.

Mapping

For the purposes of mapping, the body was divided into two halves, M.A. Cobb doing the western half and myself doing the eastern half. The most striking feature of my half is the albitite around the margins, the albitite layers running north-sough across the body and the large areas of agmatite.

The mapping was done on aerial photographs which were blown up to a scale of, 1 inch represent about 4 chains. The resulting map is shown with the geology, field stations and sample locations. At first the mapping was found to be difficult because the coarse albitite layers occurring in the body could not be followed, even though they had a well defined layering in them. They just occurred as solitary, and apparently discontinuous outcrops (plate 4,C). However, on the discovery of a finer grained "slaty" albitite layer, about 1 foot wide which outcrops just on the surface (plate 4,A) and is often covered by limy soil, the larger outcrops of coarse albitite could be connected, because the "slaty" layers are almost continuous across the body and often closely associated with the coarser albitite rock. The mapping is also made difficult by the large amount of blocky scree that occurs on all the rounded slopes (plate 6,A).

Rock types and their field relationships

The amphibolite itself is a massive fine grained rock with no foliation developed. In outcrop it has a blocky appearance due to several sets of joints. These joints in some areas are developed as three sets almost at right angles. The amphibolite commonly has visible plagioclase laths about 2mm in size giving the rock a porphyroblastic texture. In some areas the amphibolite is slightly coarser grained, but these visible variations in the texture of the rock seem to occur randomly as zones within the body, often over a distance of only a few feet, and with no regular relationship to each other.

Consequently the amphibolite itself was not subdivided into different units. Four samples of amphibolite (342-V, Y, X and W) were selected from along the length of the body (west to east), at about equal intervals, for separation and chemical analyses of the amphibole mineral to be done. A bulk rock chemical analyses was also done on these samples by M.A. Cobb.

A distinction was made between the massive fine grained amphibolite and a coarser "spotted" amphibolite in which the plagioclase occurs as "spots" on the surface and not as laths. Its outcrop appearance is quite different, and is usually deeply weathered on the surface and crumbles easily, unlike the fine grained massive amphibolite. It has a more doleritic looking appearance to it, and it occurs in three small bodies in the Weekeroo Schists just South of the contact, and it also occurs at several positions in the amphibolite body right on the contact, but it does not occur in the centre of the main body. Where it occurs at the contact, it is not albitised like the rest of the body, which suggests this may be a later intrusion and has not suffered any albite metasomatism, though it does appear to have suffered some epidote metasomatism.

Within the body are elongate zones of amphibole-chlorite schists (plate 5,C). These appear to be sheared equivalents of the amphibolite and they are all running in roughly the same direction which is about east-west and parallel to the schistosity in the Weekeroo schists. In the south-east corner of the body is a large fault with a large area of these amphibole-chlorite schists associated with it.

The albitisation is concentrated around the margins of the body, and the sharp contact between the body and the sediments is shown by a marked break in slope (plate 6,C), which shows that the albitite of the body is much more massive and resistant than the albitised sediments. The albitite of the body is massive, with some layering in places, defined mainly by amphibole concentrations. There are two types of albitite here. One is almost pure grey albitite with no amphibole in it, and the other consists of milky white albitite with disorientated amphibole needles (plate 2,BO, which are sometimes accumulated to produce discontinuous layering. The two types of albitite are often intimately mixed. The pure albitite appears to be an earlier phase and it is often brecciated with the, albitite with amphibole needles phase, filling the fractures to produce an albite breccia (plate 1,A). In the metasediments there is a concentration of the pure albitite known as "Mauds Hill" (plate 6,B), and there is some faint layering visible in this. To the western end of this hill is an outcrop of albitite with amphibole needles, and also some amphibole-chlorite schists. It is not clear if this is more strongly albitised sediment or an off-shoot of albite from the body. The layering in the hill is made up of slightly coarser and finer layers of interlocking albite grains, with some layers rich in muscovite and s serecite, which suggests that this albitite may be strongly albitised sediment. However, it seems more likely that the coarse albitite with amphibole needles, and the amphibole-chlorite schists were an off-shoot from the main body.

The albitite also occurs in the centre of the body as coarse albitite with amphibole needles concentrated in layers to produce a well layered rock. The albitite layers are about 6 feet wide and the banding in them consistently dips to the east at about 50° (plate 4,C). Also connected with this coarse albitite is a medium grained albitite with well defined amphibole rich layers. This rock outcrops only at ground level (plate 4,A), is about 1 foot wide with a slaty appearance and is often covered by a limy soil. The layering in this rock also dips to the east. Both types of albitite layers run across the body (north-south) in an arc shape, and in a discontinuous fashion with the layering consistently dipping to the east. Occasionally there is some folding in these layers (plate 5,B) which could represent either flow folding or a tectonic folding, but the plunge of the fold is the same as the regional plunge of the area, which suggests it may be a tectonic fold. The albitite layers in the body could be a result of metasomatic replacement of the amphibolite which has come along points of weakness, such as joints developed during cooling with metamorphic segregation producing the amphibole rich layers. Or it could be that the albitite layers may be original sedimentary layers that have been metamorphosed so that the banding has become a little diffuse. However, at one locality, one of the banded albitite layers can be seen to come to an abrupt halt with the albitite "fingering" into the amphibolite (plate 4,B). This effect tends to support the idea that the albitite layers are the result of some metasomatic replacement effect. The $^{Na}/K$ ratios along the length of the body (Diag. 1,D) show that the amount of albitisation decreases into the body. A sample (341-Z) of the coarse albitite with amphibole needles was taken for chemical analyses of the whole rock and of the amphibole.

The albitisation of the sediments decreases away from the body as a $^{Na}/K$ ratio done by M.A. Cobb, out from the body, shows. But this is also evident in the field where the albitised schists can be divided into albitite (a), albitite plus albitised schist (a + as), albitised schists (as), albitised mica schists (ams), and finally the unaffected mica schists (ms). The albitised sediments are in fact adinoles. The albitite of the sediments shows its well defined layering (plate 3,A) and it also shows evidence of plastic deformation (plate 3,B) adjacent to the contact.

The albitisation of the sediments and amphibolite is quite intense on the northern margin, which is in marked contrast to the southern margin which is only slightly albitised.

There are three types of breccias that occur in the body, an agmatite (plate 1,B), a "granular" breccia (plate 1,C) and a previously mentioned albite breccia. The agmatite occurs over a wide area, as the map shows, the albitic neosome has invaded the amphibolite along fractures where the amphibolite has been previously brecciated. All the paleosome fragments are angular and show no evidence of being disturbed by any magmatic flow. It might be expected that if the veins were liquid then "floating" inclusions would sink, but there is no such tendency, and so the vein material in this case must have been at no time completely liquid, and the vein must have been formed by successive opening, filling and crystallization. This presumably happened in several acts, and inclusions, thus could be supported either by the wall rock or by the crystallizing vein material itself. The petrological study supports this idea. Some of the paleosome shows evidence of replacement and some of the amphibolite fragments have become basified so that they are rich in amphibole and chlorite. In some areas the fragments have been almost completely replaced as plate 2,C shows. The "granular" breccia is unusual in that it contains sub rounded fragments of every rock type in the body. The fragments range in size from less than 1 mm to about 3 feet. It occurs largely in the south eastern part of the body and is closely associated with the large fault in this area, which suggests that it is some type of fault breccia, and the fragments have suffered abrasion to produce their sub rounded form. The albite breccia gives evidence for at least two different phases of albitisation. The brecciated albitite is an earlier form and does not contain amphibole needles. Thus after this albitite was consolidated there has been brecciation and a later phase of albitisation which is coarser and contains amphibole needles.

The magnetite bands (plate 5,A) are about 2 feet wide, quite well laminated and strongly magnetic. They are found around the edge of the body and dip towards the east. No continuous layers are found in the amphibolite itself although there is an odd layer, about 2 feet long in the amphibolite. The magnetite bands strike towards the amphibolite but come to an abrupt halt next to it.

At field station 121 is an outcrop of possible pillow structures similar to plate 2,A. However, their occurrence is very restricted and confined to an area of a few square feet. In this area there is a great deal of epidote rich "veining" and it does appear that the possible pillow structure is just a result of alteration and replacement along joints and fractures.

The schistosity in the Weekeroo Schists strikes at an angle to the body, both on the northern and southern margins, however the effects of the schistosity do not continue into the body. The schistosity is steeply dipping towards the body on both sides. There is some layering in the schists that shows folding with the schistosity being axial plane to it (plate 3,C). The layering also shows some curious large scale trends on the northern side which is at a high angle to the schistosity. However just near the contact the layering and schistosity appear to be parallel, but the layering is obscured altogether next to the contact and it cannot be seen if this layering is conchordant with that in the body. The layering on the southern side is parallel to the schistosity and is almost undetectable.

At the eastern end of the body the Proterozoic basal conglomerate is in direct contact with the body. The conglomerate contains boulders of amphibolite, thus the body must have been in place before the deposition of the Proterozoic. On both sides of the body (north and south) the conglomerate defines two large tight shear folds which run almost the entire length of the body. This could be formed as a result of the rigidity of the amphibolite body and the Proterozoic sediments have been tightly folded around it.

A stero plot of the poles to layering in the body is shown in Diag. 3, and an approximate fold axis results which is plunging in about the same direction as the fold axis of the Proterozoic and Archaean. Which shows that the Proterozoic deformation has affected the amphibolite body. A tentative cross section is drawn across the body (Diag. 4) and this shows an apparent saucer shaped structure, which resembles a layered intrusion with brecciation at the margins.

The amphibolite bodies to the north-east and south-west were visited briefly. The body to the north-east is very rich in albitite with amphibole needles accumulated in layers. There is also quite a lot of agmatite, "granular" breccia, albite breccia, and magnetite layers, but there is very little amphibolite, although the associated features are there. The body to the south-west stands out as large hills and is the biggest body of the three. It consists of amphibolite with albitite around the margins, some agmatite, "granular" breccia and some magnetite bands. Thus its features are very similar to the Weekeroo Amphibolite.

A STUDY OF THE AMPHIBOLES

Occurrence and properties of the amphiboles

Amphiboles occur in most of the rock types found in and around the Weekeroo Amphibolite body. They occur in, the fine grained massive amphibolite, the coarser grained "spotted" amphibolite, the three types of breccias, the massive albitite around the contact, and also in the albitite layers across the body. From a study of thin sections, it was found that amphiboles make up about 51% (as determined from a model analyses, see table 2) of the massive fine grained amphibolite. They occur typically as small prismatic grains 0.2mm in size with jagged terminations. They are generally strongly poikiloblastic (plate 10,B) with respect to, plagioclase, biotite, opaques (often rimmed with sphene), epidote, occasional quartz and zircon with pleochroic haloes. The prismatic crystals rarely show any preferred orientation but they are often altered and appear to be being replaced by biotite (plate 10,D), epidote (plate 10,C), and fine grained hematite along cleavages and edges. Some of the amphibole crystals show simple twinning. Some are zoned, particularly those that occur within the possible pillow structures. These are quite strongly zoned with a more intense pleochroism around the rims and sometimes in the centre (plate 10,A). The amphiboles are strongly pleochroic, X = pale brown, Y = grass green, Z = blue green, with 2V = 84^o, biaxial -ve, and Z^C ranges from 16^o to 23^o. Thus the optical properties are suggestive of a hornblende. The chemical analyses (table 1,A) are also suggestive of hornblende.

The amphiboles of the coarser grained "spotted" amphibolite make up about 50% of the rock and they occur as prismatic grains with jagged terminations and 0.5mm in size. They are not as poikiloblastic as those above, but they do have inclusions of plagioclase, quartz and opaques. They tend to be more strongly altered to biotite and fine grained hematite along cleavage partings. They are biaxial -ve, 2V = 70^o and Z^C about 17^o. They tend to be more strongly pleochroic X = brown, Y = green, Z = deep blue green. There are also odd patches of amphibole in spherulitic array. Thus this amphibole also appears to be a hornblende, and its stronger pleochroism could be because it is more Fe rich, and in fact this coarse amphibolite rock is richer in opaques than the fine grained massive amphibolite.

The amphiboles of the albitite rock occur as large disorientated needles (plate 2,B), that make up 21.7% of the rock. They are prismatic crystals and stand out as prophyroblasts, that are weakly pleochroic; X = pale yellow-green, Y = pale green, Z = pale blue-green, and contain some opaque inclusions. The edges of the crystals are often irregular and appear to be absorbed or replaced by plagioclase. The crystals are up to 2mm in size with 2V = 77^o, Z^C = 10^o - 14^o and biaxial -ve. The chemical analyses of this amphibole (341-Z table 1,A) shows it to be MgO rich and Al_2O_3 deficient. Thus the optics and chemical composition suggests it is an actinolite. A powder photograph done on this sample also suggests that it is actinolite. Also occurring in this rock are fine needles of amphibole (plate 10,E) 0.1mm long and 0.01mm wide, these are very weakly pleochroic to colourless and too fine grained to get an optical figure of them. It appears to be a secondary amphibole to the porphyroblastic actinolite. Some of these needles are arranged in a spherulitic array, with a large prismatic amphibole as a nucleus (plate 8,B). The amphibole needles are themselves partly altered to chlorite.

In the agmatite amphiboles occur both in the neosome and the paleosome. The paleosome pieces are made up of 90% amphibole crystals that occur as porphyroblasts. They are prismatic in form (1mm) and have many minute opaque inclusions. They show alteration along the cleavages and edges to fine grained hematite. They are weakly pleochroic: X = pale brown, Y = pale green, Z = blue-green, and show some zoning with a less intense pleochroic rim, suggesting that the rim is Fe deficient. The crystals are biaxial -ve, $Z\hat{}C = 18^{\circ}$ and $2V = 85^{\circ}$. Thus the amphibole appears to be hornblende. There are also some fine needles (0.1mm long) of pale green amphibole that appears to be secondary to the hornblende, and this is scattered through out the paleosome but tends to be more concentrated at the contact between the paleosome and neosome. The neosome does not contain any large prismatic crystals of hornblende but there are some pale green fine needles of hornblende.

<u>Analytical Procedures on Amphiboles</u>

For chemical analyses to be done on the amphiboles, they had to be separated from the rock. This was achieved with some difficulty. Because the amphibole grains are only about 0.2mm long and 0.1mm wide, the rock had to be crushed to such a size that the grains were fine enough to be completely homogeneous and yet coarse enough to be satisfactorily separated on the Franz Isodynamic Magnetic Separator. By trial and error it was found that the rock powder fraction between 260 and 224 seive size was the most satisfactory. The amphiboles from the albitite rock (341-Z) were separated with at least 99% purity on the magnetic separator alone after several runs. This was because the amphibole had a lower magnetic susceptibility than the biotite in the rock. However, this was not the case for the amphibole samples, 341-X, Y, V and W, because here the biotites and the amphiboles were of almost identical magnetic susceptibility and were impossible to separate by this method. Thus heavy liquid separation was employed for these samples, using methelene iodide diluted with acetone to give an S.G. of 3.147. This method produced an amphibole concentrate of about 97% purity, with impurities of biotite and epidote. The amphibole concentrate of these samples was eventually brought up to at least 99% purity by hand picking. Fusion buttons were made with the amphibole concentrates and a chemical analyses of all major elements except Na_2O were done on the X. R.F. machine. The Na_2O analyses was done on the flame photometer after dissolving the samples by HF digestion. Cr and Ni were also analysed for by atomic absorption.

<u>Chemistry of amphiboles</u>

The results of the chemical analyses, for all major elements plus Ni and Cr, of the amphiboles and their corresponding amphibolite rocks (total rock analyses by M.A. Cobb) are shown in table 1, A, B and C. The amphibolite analyses 342-V, Y, X and W are similar to the ortho-amphibolites of the Broken Hill Basin (A.B. Edwards, 1957, Table 3). The amphibole analyses 341-V, Y, X and W are similar to the hornblendes found at Broken Hill (A.B. Edwards, 1957 Table 2) but are even more like the hornblendes found in amphibolites of epidote-amphibolite facies at Black Hills, South Dakota (A.E.J. Engel and C.G. Engel, 1962, Table 8). The amphibole (341-Z) from the albitite zone is MgO rich, Al_2O_3 deficient and is of an actinolite composition. The formula for the amphiboles from the amphibolite and from the albitite rock were calculated and found to differ. The amphibole from the amphibolite gave the formula $Ca_2\ (Mg_2Fe_3)\ (Si_6Al_2)O_{22}\ (OH)_2$ with minor amounts of Mn, Na, K, P and Ti, which together add up to only 0.279 formula units. Thus this amphibole appears to be an hornblende. The amphibolite from the albitite rock gave a formula $Ca_2\ (Mg_4\ Fe)\ (Si\ Al)_8\ O_{22}\ (OH)_2$ with minor Mn, Na, K, P and Ti which together amount to only 0.054 formula units. Thus this amphibole appears to be actinolite.

Diagrams 1 and 2 show the variation of chemical parameters along the length of the body (west to east) for amphiboles and their corresponding amphibolite rocks. As can be seen the amphibole follows closely the trend of variation of the amphibolite rock, and shows that hornblende is a responsive "sponge" to changes in rock composition. The variation of the chemical parameters always shows a maximum or a minimum at sample 341-X which is at about the centre of the body. This can be explained if the body were originally an intrusive one, because the centre of the body would be the hottest for a longer period, since the edges would cool the quicker. A.E.J. Engel and C.G. Engel (1962) have said that in metamorphic hornblendes Al can replace successively larger amounts of Si in the tetrahedral positions of hornblendes with increasing temperature, and the excess Al spills over into the Mg positions. Thus Diag.2 shows Al increasing to position 341-X and then decreasing again. Diag. 1,A shows the $\frac{Fe}{Mg}$ ratio increasing to a maximum at position 341-X, and this could be because Mg is being replaced by Al. The decrease of $\frac{Fe}{Mg}$ in the total rock may be as a result of the Mg migrating from the amphibole into the rock. Further evidence that position 341-X may have been a position of higher temperature is shown by the Ni and Cr curves which also reach a maximum at position 341-X. It has been shown by A.E.J. Engel and C.G. Engel (1962 Table 8) that the amount of Ni and Cr increases with temperature in amphiboles. The Diag. 1,D, which has a minimum of $\frac{Na}{K}$ at the centre of the body for the amphibolite, and increases towards the edge. This shows the concentration of Na metasomatism at the margins and how it decreases towards the centre. The hornblende being a responsive "sponge" to changes in rock composition actually reflects this decrease of Na metasomatism towards the centre in its chemistry.

Density

The density of the hornblendes was found to be approximately 3.211. This was determined during the heavy liquid separation of the amphiboles. The density of amphiboles is dependant on the Ti, Na + K and $\frac{Fe}{Mg}$ values. The hornblendes from, South Dakota of epidote-amphibolite facies (400°C, TiO_2 = 0.43), South Dakota of almandine-amphibolite facies (500°C TiO_2 = 0.56)

Emeryville of almandine-amphibolite facies (525°C TiO_2 = 1.32) and Colton of hornblende-granulite facies (625°C, TiO_2 = 2.39) (Engel and Engel 1962, Table 8) have densities of 3.19, 3.20, 3.26 and 3.28 respectively. The hornblendes from the Weekeroo Amphibolite have a density of 3.21 and TiO_2 = 0.82, which suggests that these hornblendes formed in the Almandine-amphibolite facies of metamorphism at about 510°C. However, the Weekeroo hornblendes are more Fe rich than those above and this does increase the density significantly, and also, there is no garnet in the amphibolite which would suggest that these hornblendes were subjected to a metamorphism just below the almandine-amphibolite facies.

Reactions of amphiboles

The hornblende is probably formed from pyroxene, however no remnant pyroxene has been detected which could suggest there has been complete conversion from pyroxene to hornblende. There is however evidence of remnant ophitic texture (plate 7,B) which was presumably between the pyroxene and plagioclase but now is between amphibole and plagioclase. Hornblende can form by a reaction between pyroxene and the anorthite component of plagioclase with epidote and chlorite also being formed. This reaction does seem reasonable since there is only an albite rich plagioclase within the amphibolite and chlorite and epidote are common. The conversion of pyroxene to amphibolite also involves the loss of Fe which would be precipitated as magnetite, hematite or ilmenite, and this could account for the large number of opaques in the hornblende grains and also for the chemistry of the hornblendes being Fe rich. Many of the hornblendes are zoned (plate 10,A) with a more intense pleochroism in the outer rim, and also occasionally in the centre. The zoning could be due to Fe rich rims, from the migration of Fe towards the edge of the crystal. E. Wm. Heinrich (1965) says that in intrusive rocks hornblende may be replaced by biotite and this does occur in these hornblendes (plate 10,D). The poikiloblastic texture of the hornblendes is evidence of its alteration to epidote and magnetite and also occasional quartz. The hornblende also shows alteration to chlorite and magnetite. Sphene is often developed in and around the amphibole crystals as xenoblastic granules. Often it has opaque inclusions suggesting it has formed from the alteration of ilmenite, but occasionally it does not contain inclusions. This could mean that ilmenite has completely altered to sphene, or it could be a product of the reaction of brown hornblende converting to blue-green hornblende under a retrograde reaction, with Ti being exsolved from solid solution. This brown hornblende would have been primary, and converted to blue-green hornblende at the same time as the pyroxene did.

Thus the amphiboles reflect changes in the composition of the amphibolite and they also show evidence of metamorphism at just below the almandine-amphibolite facies (450°C). There has also been a later greenschist facies of metamorphism which is reflected in the amphiboles by the development of chlorite and the alteration of ilmenite to sphene. The amphiboles also give some indication as to the origin of the body. The hornblende is not the type of amphibole expected from a metamorphosed sediment and the regular variation of composition along the length of the body, its ophitic texture and the evidence for its origin from pyroxene, suggest that the amphibolite was originally an intrusive basic igneous body. However, the amphibole in the albitite is an Mg rich actinolite type and is less stable at higher temperatures than the Fe rich hornblende, which suggests that this actinolite is a later lower temperature type of amphibole and may have been derived from the metamorphism of sediments, or formed during a phase of the albite metasomatism.

PETROGRAPHY

For a petrological study of the amphibolite and its surrounding rocks, samples were collected fairly evenly from over the body (see field location map). Seventy three thin sections were cut and described. Nine polished sections were also described.

The massive fine grained amphibolite that makes up most of the body consists of approximately 51% amphibole, 42% plagioclase, 3% biotite, 4% opaques with minor sphene and epidote. Zircon and to a lesser extent tourmaline are usually present as is also some carbonate. The amphibole is hornblende and it occurs as prismatic, poikiloblastic crystals with no preferred orientation. The plagioclase is generally as elongate sub-idioblastic laths that are arranged in a doleritic looking texture (plate 7,A). The plagioclase is often in an ophitic or sub-ophitic arrangement with the amphibole (plate 7,B). The plagioclase laths also give the rock a porphyroblastic texture. The plagioclase shows simple, Carlsbad-albite, albite and some pericline twinning. However, the twinning is not always common and it is often diffuse. The plagioclase seems to be both +ve and -ve with a 2V of about 75° and often higher. Its composition by optical methods ranges from Ab_{85} to Ab_{95}, but from an R.I. determination the composition was found to be Ab_{84} with $\alpha = 1.5377$, $\beta = 1.5431$, $\gamma = 1.5468$ which means that the plagioclase is in the low oligoclase range. The plagioclase is often serecitised and with minute inclusions of opaque and amphibole. Its edges are also often indented by amphibole and the two minerals seem to be intimately related. The opaques make up approximately 4% of the rock. They occur as small (0.1mm) sub-idioblastic crystals within amphibole and scattered through-out the rock. From a study of the polished sections, the opaques are magnetite, with hematite and ilmenite exsolving along the (111) cleavage. The opaques are often surrounded by small granules of sphene and in this case the opaques have lost their cubic form and tend to be irregular in shape. In some cases the sphene has almost completely replaced the opaques, to the stage where there is only a few inclusions left within the sphene (plate 9,E). The sphene is strongly pleochroic pink to buff coloured and shows alteration to leucoxene. The sphene replacing the opaques represents a retrograde reaction and gives evidence for the later greenschist facies of metamorphism after the earlier amphibolite grade. Epidote is also present in the amphibolite, but appears to be secondary. It occurs as alteration of amphiboles (plate 10,C) and also of plagioclase. The epidote often occurs in cracks and veins along with plagioclase, and has an xenoblastic form. Carbonate also occurs as a minor constituent in the amphibolite as xenoblastic interstitial grains. This also tends to form along fractures and may just be a secondary mineral from the affect of weathering. Zircon and tourmaline are nearly always minor accessories with the zircon usually within amphibole crystals and producing pleochroic haloes. The zircon grains are usually xenoblastic sub-rounded grains. Tourmaline occurs interstitially as small sub-idioblastic grains. None of the minerals in the amphibolite have any real preferred orientation.

A slide was cut from the centre of a possible pillow structure, and also from the edge, showing the contact between the amphibolite and the epidote rich "vein". There is a great deal of veining in the area and the vein consists of about 80% xenoblastic interlocking epidote grains with 10% of fine grained interlocking granules of plagioclase and some minor quartz. Within the vein is a layer of coarse xenoblastic tourmaline grains running parallel to the contact. There is also about 5% of opaques often surrounded by sphene. The contact with the "pillow" is not an abrupt one but there is a transition zone, consisting of about 37% of large idioblastic and strongly zoned amphibole crystals (plate 10,A). There are also some fine needles of green hornblende. The plagioclase (50%) makes up a fine grained groundmass of interlocking xenoblastic grains. Epidote makes up about 2%, as also does sphene. Biotite makes up 1% and increases towards the amphibolite. Thus towards the amphibolite of the possible pillow structure the amount of epidote decreases, plagioclase increases, opaques decreases and amphibole increases. The amphibolite in the "pillow" adjacent to the contact contains 40% amphibole that is finer grained and has less zoning than in the transition zone and has a general preferred orientation perpendicular to the contact. The amount of sphene epidote, opaques and biotite all become more abundant in the amphibolite than in the transition zone. At the centre of the "pillow" structure the amount of amphiboles is only about 25% and greatly altered to biotite. The biotite and opaques make up about 12% each and sphene about 5%. The plagioclase makes up a fine grained groundmass (0.1mm) but there are also a few remnant porphyroblasts (3mm) that show irregular absorbed edges with amphibole. There is a lack of these porphyroblasts at the margins of the structure and this could possibly represent a chilled margin as J.B. Jones, J.L. Talbot and E. Maud. McBriar (1961) have suggested. Thus the structures may be genuine pillow structures or possibly they have formed this shape as a result of alteration and replacement along joint planes.

The coarse grained "spotted" amphibolite differs from the fine grained massive amphibolite in that it is coarser, contains more opaques, biotite and also some quartz in myrmekitic intergrowth with plagioclase (plate 9,D). It also has an odd spherulitic structure of amphibole which suggests fast cooling just below the surface. The field relationships also suggest that this amphibole is quite different to the massive fine grained amphibolite, its weathered surface is crumbly and quite different to the massive amphibolite. The field relationships show that this may be a later intrusion to the main amphibolite body.

The agmatite consists of angular pieces of amphibolite which have been basified to the stage where they consist of about 85% blue green hornblende with a prismatic form and some zoning. There is also fine needles of green hornblende which appears to be forming from the large prismatic crystals, which are set in a fine grained groundmass of plagioclase with minor biotite, epidote, chlorite and opaques. Pink sphene with opaque inclusions is quite common and tends to be concentrated near the edge of the amphibolite fragments. The contact of the paleosome with the neosome is somewhat diffuse on the micro scale with needles of amphibole and chlorite forming out into the crystalloblastic neosome.

The neosome is made up of about 98% coarse interlocking crystals of plagioclase with no preferred orientation, but at the edges of the paleosome the plagioclase crystals are perpendicular to the contact (plate 7,F). Thus there is no evidence of flow in the neosome, though there are some strain shadows and bent plagioclase crystals (plate 9,C), which suggests the vein material was at no time completely liquid, but the vein must have formed by successive opening, filling and crystallization during the albite metasomatic stage. This type of agmatite is usually found along intrusive contacts.

The albitite is made up of about 20% actinolite porphyroblasts in a granoblastic groundmass of interlocking xenoblastic grains that show Carlsbad-albite twinning. By optical methods the composition of the plagioclase is Ab_{96} but from an R.I. determination it was found to be Ab_{86} with $\alpha = 1.5363$, $\beta = 1.5412$ and $\gamma = 1.5453$ which is slightly more albitic than the plagioclase in the amphibolite. Opaques surrounded by sphene make up about 7% of some samples while zircon, biotite, tourmaline and apatite are common accessories. Some of the albitite shows layering, defined often by biotite or opaque rich layers. Also some layers are made up of fine grained xenoblastic interlocking plagioclase grains, while the next is made up of coarse idioblastic crystals lying perpendicular to the layering (plate 7,D). This may be connected with recrystallization along original sedimentary layering. The porphyroblastic amphibole crystals are also often concentrated in crude layers which could just represent metamorphic segregation, producing the layers or alternatively, partly destroying an original sedimentary layering. Quartz is often associated as intergrowth with the plagioclase groundmass. Some of the amphiboles in the albitite layers across the body are arranged in a spherulitic array (plate 8,B), which does not suggest a metamorphosed and metasomatised sediment. The plagioclase often has opaque inclusions and plate 9,B shows the inclusions concentrated along one particular twin.

At various positions within the body are amphibole-chlorite schist zones which all have their schistosity roughly in the same direction. They consist of 20% hornblende which has a preferred orientation and shows alteration to biotite, 25% biotite which also has a preferred orientation, 5% chlorite needles with some showing a spherulitic texture, 50% plagioclase which makes up a groundmass of interlocking xenoblastic grains, 1% epidote and minor opaques and zircon. Sheared amphibolites are transformed to calcite + chlorite + hornblende + epidote + albite (Deer W.A., Howie R.A., and Zussman J. 1966). Thus these schist zones appear to be sheared equivalents of the amphibolite.

Also occurring in the body, in parts, is a layer 3 inches wide of black fine grained rock which breaks into cleavage fragments. The thin section shows it consists of 98% very fine grained tourmaline "droplets" in association with plagioclase and epidote. The chemical analyses of the rock (table 1,B, sample 341-129) also suggests it consists predominately of tourmaline.

The magnetite layers are made up of about 50% xenoblastic amphibole crystals with a rough preferred orientation parallel to the layering, and has many inclusions of feldspar, opaques and sphene. Plagioclase (40%) makes up a groundmass of interlocking sub-rounded grains with inclusions of cubic magnetite. The plagioclase is fine grained and layers are defined by slightly coarser and finer layers, and by magnetite rich and poor layers. The magnetite has a partly cubic form and occurs in layers with a resemblance to graded bedding (plate 7,E), which may be metamorphic segregation or an original sedimentary structure. Associated with some of the magnetite bands are similar well laminated rocks, not rich in magnetite, and these show purple layers in the hand specimen, which in thin section, are layers of sub-rounded plagioclase grains, with fine grained hematite precipitated in the core of the grains and none around the rim.

Running across the body are some thin albitite layers 1 - 2 feet wide and thinly laminated with green and milky white layers, and the rock has a slaty appearance in outcrop. The green layers are amphibole rich, with the porphyroblastic amphiboles being strongly poikiloblastic and with irregular absorbed edges. The groundmass is made up of an intergrowth of xenoblastic plagioclase (showing very little albite twinning) and quartz, with plagioclase being the most common. Epidote makes up 10% with chlorite, zircon, tourmaline and serecite as accessories.

The petrological study of the amphibolite and associated rocks shows that the amphibolite has definite igneous textures and the agmatite also suggests an intrusive origin, but the albitite and magnetite layers show possible evidence of a sedimentary origin. There appears to have been albite metasomatism around the margins of the body which has become less intense towards the centre, however epidote metasomatism along joint planes and fractures is quite common in the centre of the body.

CONCLUSIONS

In the Broken Hill and Olary region there are amphibolitic formations which show variations in composition, mode of occurrence and origin. They have been generally described as igneous dykes, plugs or sills, that have intruded both the meta-sediments and the granitic rocks of the crystalline basement. Some recent investigations in the Broken Hill region have shown that some amphibolites are derived from calcareous sediments into which they often grade, though amphibolitic rocks of intrusive character also occur, and it is often difficult to distinguish between the para and ortho-amphibolites. The difficulty in distinguishing between the two is because there is often no general field criteria, the uncertainty of their age and petrological characteristics, thus no detailed subdivision of the two rock types in the Olary region has been attempted in the past.

The Weekeroo Amphibolite body which is in the Olary region has some volcanic, intrusive and sedimentary characteristics, and at least four possible explanations can be used to explain its origin. These are:-

1) A volcanic sequence
2) A series of sills with interlayered sediments
3) Metamorphosed calcareous sediments
4) A basic igneous intrusion.

1) A volcanic sequence is suggested by the massive basaltic appearance of the amphibolite and the occurrence of possible pillow structures. The body as definite spilitic affinities and together with the albite rich layers it may represent a spilitic-keratophyre assemblage. Adinoles often occur at the contact of such as assemblage (T.G. Vallance, 1960) which is in fact the case here. However if the albite rich layers are keratophyres then it would be expected that they would be wider and more continuous across the body than what they are. Also it would be expected that the layering would be along the long axis of the body rather than the short axis, because as it is now, it represents a thickness of lavas and keratophyres about 1½ miles thick and only ½ mile wide. Also the volcanic equivalents do not seem to be present, and the suggested temperature high at the centre of the body, does not fit in with a volcanic origin. Thus I think it unlikely that the body represents a spilite-keratophyre assemblage.

2) A series of sills with interlayered sediments represents another possibility, with the sills being of doleritic composition interlayered with sediments which have been metamorphosed and recrystallised to produce the albite rich layers. If this were the case I would expect the layers again to run along the length of the body rather than across it, and the layers to be somewhat more continuous than they are. It might also be expected that there would be some evidence of chilled margins of the sills with the sediment, though this could have been obliterated with metamorphism. The amphibole in the albite rich layers is a Mg rich variety, which can form from the metamorphism of sediments. The temperature high at the centre of the body cannot be explained by this model.

3) The metamorphism of calcareous sediments to produce a para-amphibolite has been used to explain many amphibolites in the Broken Hill, Olary region. However most of the para-amphibolites occur as thin layers 1 or 2 feet thick in a sedimentary sequence, and they are not usually as massive as this particular body. The para-amphibolites are typically conformable with the rest of the sequence in which they occur, and they show diffuse boundaries with a grandual change from sediment to amphibolite. At Weekeroo the amphibolite has sharp contacts and is unconformable with the surrounding rocks. The schistosity of the surrounding schists strikes the contact at an angle as also does the layering in the schists. The layering on the northern margin seems to roughly correspond to the layering in the body, but even if this is so, the contact of the amphibolite is at a high angle to the layering and not parallel to it as you would expect for para-amphibolite. The petrological study shows definite igneous textures and the chemical analyses of the whole rock and of the amphibole strongly suggest an ortho-amphibolite.

4) A basic igneous intrusion is suggested by the igneous texture found during the petrological study. The sharp disconformable contact of the body is also suggestive of an ortho-amphibolite. The possible temperature high at the centre of the body found from a study of the amphiboles suggests that the amphibolite formed as one massive body rather than a series of flows or sills. The albitite rich layers across the body which all dip the same way appear to be metasomatic with the banding produced by metamorphic differentiation. Since they all dip the same way, there must have been some common controlling factor such as joint planes formed by cooling, or they may represent original sedimentary layering that has been caught up in the intrusion. The magnetic layers seem to be of sedimentary origin which explains why they only occur as continuous layers in the albitite zone around the margins and come to an abrupt halt at the amphibolite, and only occur within the amphibolite as small fragments (2 feet) which may have been caught up in the intrusion. It seems possible then that the body may have originally been a dolerite plug that has suffered fairly low grade amphibolite facies metamorphism and then a later greenschist grade of

metamorphism. The bodies to the north-east and south-west and the Weekeroo one may have all originally been one large intrusion that has been boudinaged and the three bodies drawn apart. The trend of the layering in the Weekeroo schists suggest that the body has moved from the east to the west with the most westerly body being the largest, and consisting of massive amphibolite with not as much albitisation as the Weekeroo amphibolite. The easterly body is just about all albitite with very little amphibolite. The fact that the ends of the amphibolite bodies are jagged, which contrasts with the straight well defined contact along the sides, supports the idea that the bodies have been pulled apart. The movement may have caused the brecciation around the margins of the amphibolite and the earlier phase of albitisation. The later phase of albitisation would have occurred after the movement and permiated into the fractures and crystallised to produce the agmatite and albite breccia, as well as produce the adinoles in the Weekeroo schists. The stresses of this east-west movement may also have been responsible for the amphibole-chlorite schist zones within the body. Thus this last explanation seems to be the most feasible, on the evidence of petrology, chemistry and field relationships that is available.

I feel that further detailed work on this and the surrounding amphibolites, and associated albitisation, is necessary before any really positive conclusions can be drawn.

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Table 1

Chemical Analyses of amphiboles and the corresponding amphibolite rock

Amphiboles — A

Sample	SiO_2	Al_2O_3	K_2O	Na_2O	CaO	Total Fe as Fe_2O_3	TiO_2	MnO	P_2O_5	MgO	Total
341-V	46.37	10.11	0.39	0.56	10.07	20.67	1.06	0.24	0.05	10.12	100.24
341-Y	44.57	12.41	0.43	0.39	10.93	19.91	0.72	0.27	0.05	10.06	99.74
341-X	44.58	13.39	0.46	0.36	10.92	20.61	0.56	0.20	0.04	7.22	98.34
341-W	45.47	11.57	0.32	0.35	11.40	19.69	0.96	0.23	0.06	10.43	100.48
341-Z	53.49	3.40	0.03	0.06	12.19	11.26	0.09	0.17	0.05	18.91	99.65

Amphibolite — B

Sample	SiO_2	Al_2O_3	K_2O	Na_2O	CaO	Total Fe as Fe_2O_3	TiO_2	MnO	P_2O_5	MgO	Total
342-V	52.15	12.93	0.35	3.92	7.84	14.40	2.07	0.20	0.05	5.03	99.41
342-Y	52.74	14.74	1.03	3.50	7.54	13.43	1.43	0.18	0.03	6.27	101.60
342-X	50.03	15.80	0.92	3.27	8.13	14.20	1.21	0.15	0.05	6.92	99.80
342-W	50.45	14.48	0.25	3.73	8.25	13.47	1.27	0.14	0.03	5.48	98.60
342-Z	65.64	16.10	0.002	7.88	3.61	2.79	0.62	0.04	0.06	4.19	100.91
341-129	36.07	28.95	0.13	0.55	1.42	12.78	0.61	0.02	0.01	6.95	89.92

C

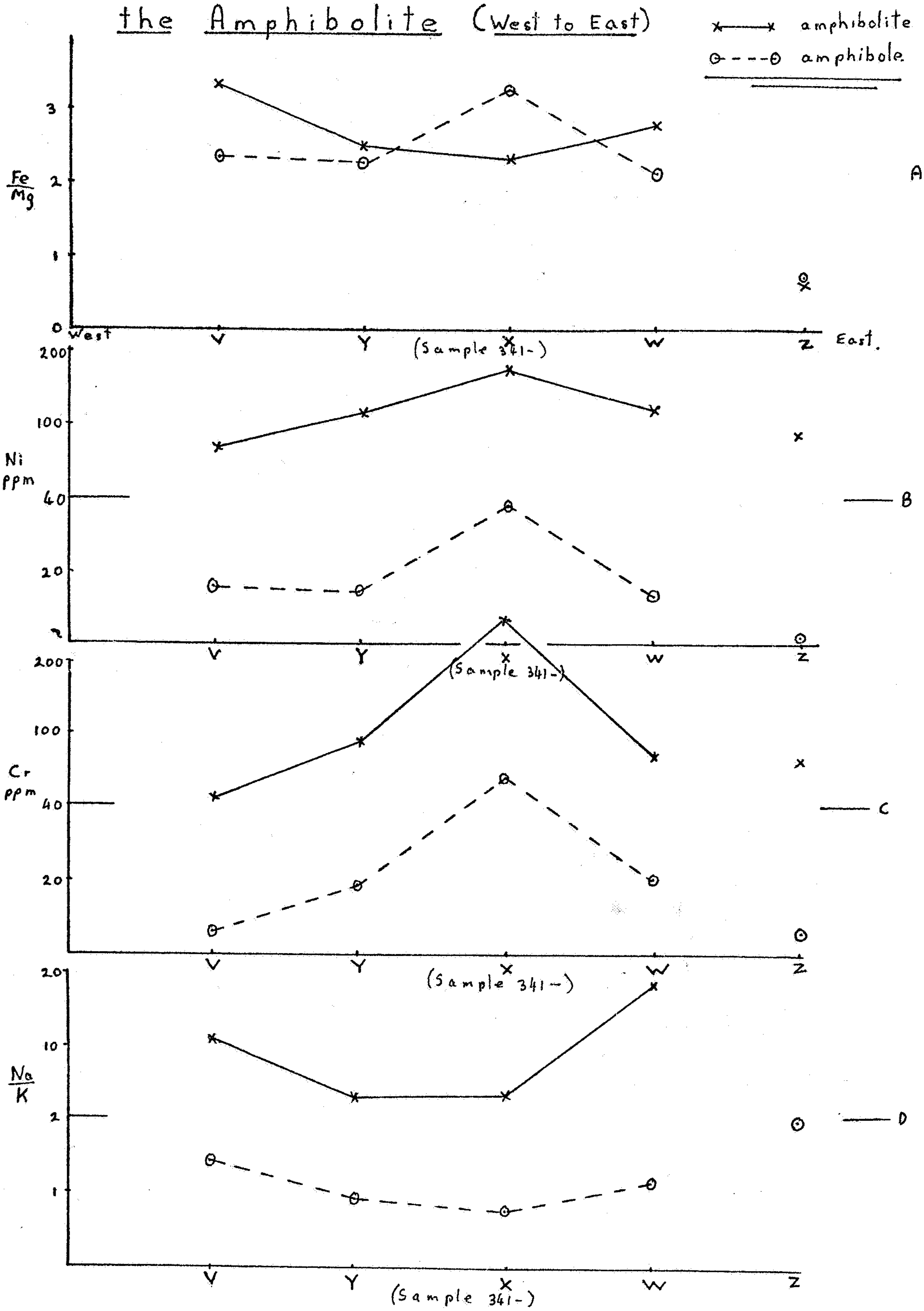
Sample	Fe/Mg	Ni (ppm)	Cr (ppm)	Na_2O/K_2O
amphiboles				
341-V	2.37	15.52	6.0	1.44
341-Y	2.29	14.16	18.8	0.91
341-X	3.32	39.42	49.6	0.78
341-W	2.19	13.71	21.0	1.10
341-Z	0.69	1.77	6.20	2.00
amphibolite				
342-V	3.30	67.6	9.9	11.2
342-Y	2.49	118.9	83.9	3.41
342-X	2.39	170.1	260.2	3.51
342-W	2.83	115.1	69.4	18.4
342-Z	0.67	82.6	65.7	3990

341-X, Y, V, W :- amphibolite and the corresponding amphibole.

341-Z :- albitite and the corresponding amphibole

341-129 :- black fine grained tourmaline rich rock

Variation of Chemical Parameters Across the Amphibolite (West to East)



Diag 2

Variation of Al_2O_3 across the Amphibolite
(West to East)

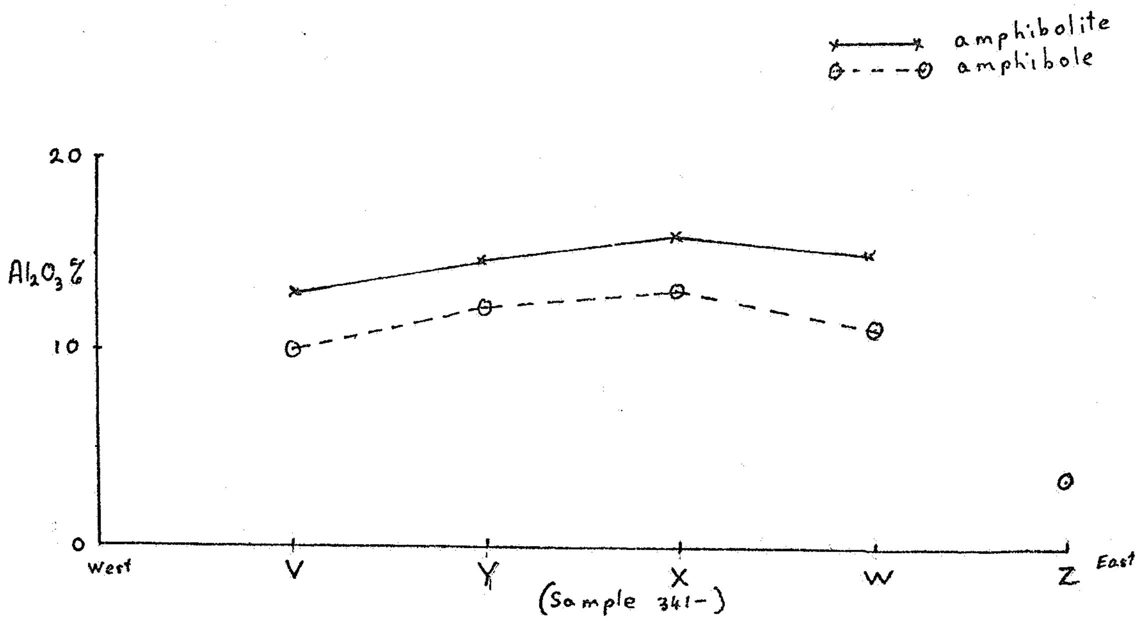


Table 2

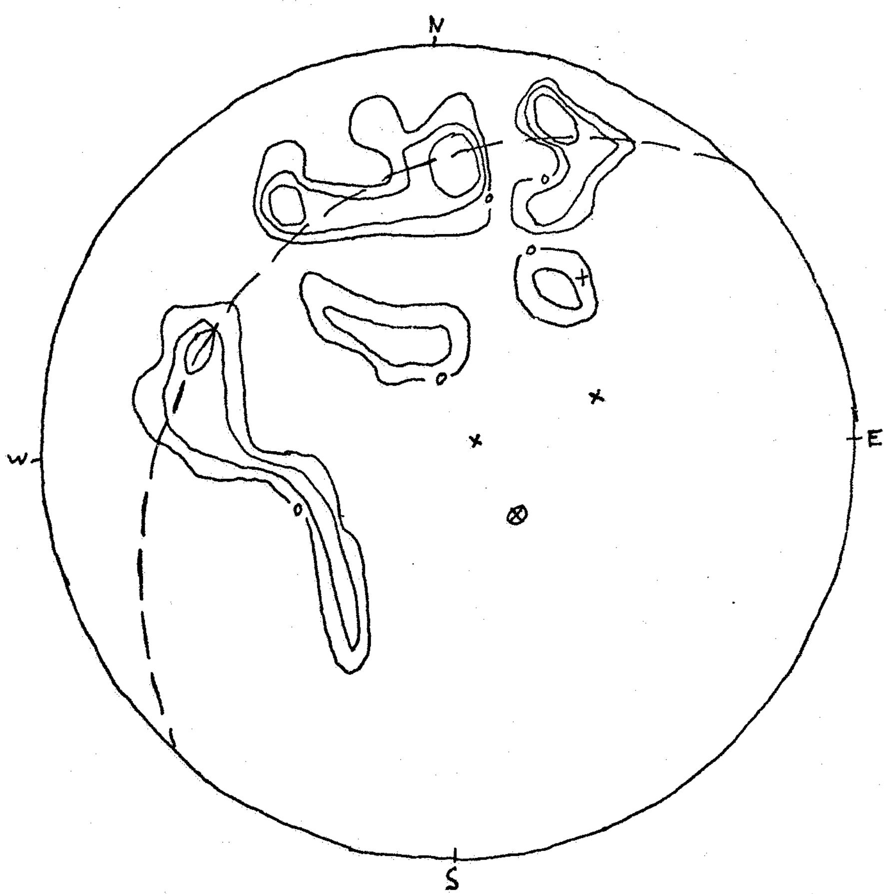
Modal Analyses of Amphibolite

Mineral	342 - V	342 - Y	342 - X	342 - W	342 - Z
amphibole	54·6	51·7	50·2	51·7	21·7
plagioclase	38·1	42·8	37·9	41·1	70·5
opaque	5·2	3·1	4·4	4·9	5·7
biotite	1·9	2·4	7·5	1·5	1·0
sphene	0·2	—	—	0·3	—
epidote	—	—	—	0·5	—
chlorite	—	—	—	—	1·1

amphibolite :- 342 - V, Y, X, W

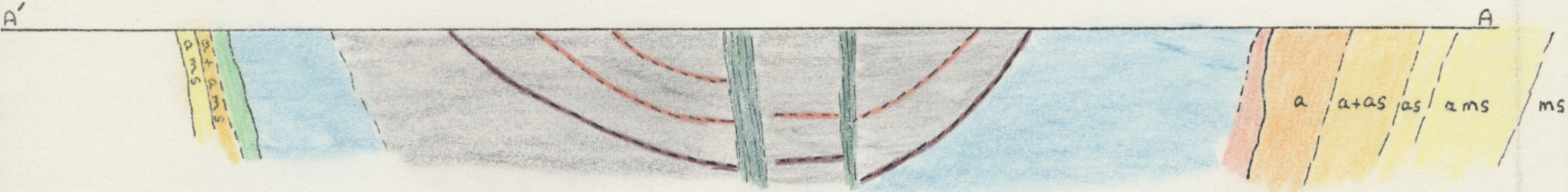
Plot of Poles to Layering

× plunges of minor folds
⊗ fold axis of plot



Diag. 4.

Cross Section (A A') of Weekeroo Amphibolite



See Map for Legend.

1970

BIBLIOGRAPHY

CAMPANA B. and KING D. (1958): Regional Geology and Mineral resources of the Olary Province.
GEOL. SURVEY. S. AUST. BULL. 34.

CHAPMAN C.A. (1962): Diabase-granite composition dikes with pillow like structures, Mt. Desert. Is. Maine.
J. GEOL. V.70, p539-564.

DEER W.A., HOWIE R.A. and ZUSSMAN J. (1966): An introduction to the rock forming mineral.
A LONGMANS PUBLICATION.

EDWARDS A.B. (1957): Amphibolites from the Broken Hill District.
JOUR. of the GEOL. SOC. of AUST. V.5.

ELLIOTT R.B. (1966): The association of amphibolite and albite, Kragero South Norway.
GEOL. MAG. V.103 p1-7.

ENGEL A.E.S. and ENGELL C.G. (1962): Hornblendes formed during progressive metamorphism of amphibolites.
GEOL. SOC. Am BULL V.73 p1499-1514.

GAZZI P. (1963): On the microscopic determination of the amphiboles in grains.
Am. Min. V.48. p422-429.

GLAESSNER M.F. and PARKIN L.W. (Edited) (1957-60): The Geology of South Australia.
GEOL. SOC. of AUST. V.5-6

GOOD SPEED G.E. (1953): Rheomorphic breccias.
Am. J. Sci. V.251 p453-469.

HEINRICH E.Wm (1965): Microscopic identification of Minerals.
McGRAW-HILL PUBLICATION

JONES J.B., TALBOT J.L. and McBRIAR E. MAUD (1961): A suite of volcanic rocks with Spilitic Affinities from the Archaean of South Australia.
AUST. JOUR. SCI. V.29 p354.

KOSTYUK E.A. and SOBOLEV V.S. (1969): Paragenetic types of calciferous amphiboles of metamorphic rocks.
LITHOS V.2 p67-82.

LEAKE B.E. 1964): The chemical distinction between ortho and para-amphibolites.
JOUR OF PETROLOGY. V.5 p238-254.

MUELLER R.F. (1967): Mobility of the elements in metamorphism
JOUR. GEOL. V.75 p565-582.

NOBLE J.A. (1952): Evaluation of criteria for the forcible intrusion of magma.
JOUR. GEOL. V.60 p34-57.

REYNOLDS D. (1954): Fluidization as a Geological process and its bearing on the problem of intrusive granites.
Am. JOUR. SCI. V.252, p577-614.

RIVALINTI and SIGHINALFI (1969): Geochemical study of Greywacks as a possible starting material of Para-amphibolites.
CONTRIB. TO MINERALOGY AND PETROLOGY V.23 No.3.

SNELLING N.J. A note on the possible Sedimentary origin of some amphibolites from the Cooma Area. N.S.W.
JOUR. ROY. SOC. N.S.W. V.92, Pt.2 p43-46.

TURNER F.J. (1968): Metamorphic Petrology.
McGRAW-HILL PUBLICATION.

TALBOT J.L. (1967): Subdivision and structure of the Pre-Cambrian, Weekeroo, South Australia.
TRANS. ROY. SOC. S. AUST. V.91, p45.

VALLANCE T.G. (1960): Concerning Spilites.
PROC. LINNEAN. SOC. N.S.W. V.85 p8-52.

WALKER, JOPLIN, LOVERING and GREEN (1960): Metamorphic and metasomatic covergence of basic igneous rocks and lime-magnesia sediments of the Pre-Cambrian of N.W. Queensland.
JOUR. GEOL. SOC. AUST. V.6 p149-178.

WILLIAMS H., TURNER F.J. and GILBERT C.M. (1954): Petrography.
W.J. FREEMAN AND CO. PUBLISHERS.

GEOLOGY OF THE WEEKEROO AMPHIBOLITE :

REGIONAL GEOLOGY :

The Weekeroo Amphibolite lies within an early Pre-Cambrian (Archean?) basement complex of schists and gneisses generally referred to as the Willyama Complex (Mawson 1912). The basement is unconformably overlain by later Pre-Cambrian sediments of the Burra Group and the Umberatana Group : it is generally accepted that the Umberatana Group (Sturtian) is essentially a glacial sequence.

The basement had been subjected to at least two deformations with associated Metamorphism before the onset of deposition of the Burra Group sediments. Granite and pegmatite intrusions are characteristic of the earlier tectonic phase. Subsequent to the sediment deposition a further deformation and metamorphism to the biotite grade affected both the basement and the sediments.

The amphibolite is contained within the Weekeroo Schists a silky well-laminated and very fissile biotite-muscovite schist, the long axis of the amphibolite body paralleling the schistosity of the schists. About two miles east of the Weekeroo Amphibolite there lies another relatively large body and similarly about two miles to its west a third large amphibolite can be found. All three bodies are intimately associated with the Weekeroo Schist.

The Weekeroo Amphibolite is a lensoid body about one mile long and a half mile wide, disappearing under alluvium to the west. A small (quarter mile) outlyer of amphibolite is found out from the southwest corner of the main body.

PREVIOUS INVESTIGATIONS :

No intensive investigation of the larger amphibolites within the Olary-Plumbage region has been undertaken in the past. However, regional geological investigations have been numerous, the first of any importance being undertaken by D. Mawson (1912) followed by later work, with special reference to economic mineralization, by geologists of the South Australian Department of Mines (Whittle 1948, Campana and King 1958 etc.). For the Weekeroo area a more detailed geological and structural analysis was presented by Talbot (1962, 1967). A brief survey of the Weekeroo Amphibolite was undertaken by J.B. Jones, J.L. Talbot, and E. Maud McBriar in 1962. A preliminary investigation of the Weekeroo area was made by the author during an undergraduate field camp.

MAPPING PROCEDURE :

This particular investigation was undertaken as a joint project by the author and Mr. B.J. Morris. For field mapping purposes the amphibolite was divided into two roughly equal areas with an approximate north-south dividing line, the author mapping the western portion. A total of four weeks were spent in the field early in 1970 for mapping purposes. Field data was plotted directly onto aerial photographs prepared by the South Australian Lands Department to an approximate scale of one inch represents four chains. Over one hundred rock specimens were collected from the western half for possible petrological analysis, a total of seventy-five thin-sections being prepared by the author. Additional samples were chosen over the whole body for total rock analyses, and a series of schists were collected out from the body for an analysis of the extent of metasomatism of the adjoining Weekeroo Schists.

The resultant geological map (in pocket at back of report) shows the mapped distribution of rock types as deduced by field mapping. However, it should be emphasised that each rock subdivision shown on the map contains variations, some quite marked, which occur on a scale preventing their delineation as separate mappable units. In fact primary mapping itself was difficult due to the widespread scree cover on the gentle to moderately dipping slopes (Plate 6A) and the lack of continuity of recognisable outcrop types.

One of the most notable features of the amphibolite body is the development of narrow to quite broad zones of very leucocratic rock, in places showing quite distinct banding (Plate 4C). Unfortunately it occurs in rather limited (over tens of feet) separate outcrops which are of little help in determining the structure of the body. During mapping a very similar rock type was found that exhibited a very slaty nature and low relief outcrop (Plate 4A) which, however, had a much greater lateral extent permitting its delineation over most of the bodies width.

One of the interesting features brought out during mapping was the broad irregular zonal distribution of these leucocratic rocks in the western half compared to the rather more regular layer-like outcrops in the east. Again it should be emphasised that the leucocratic zones are not of constant appearance, varying from an almost pure plagioclase rock to a well banded amphibole-plagioclase rock and in general showing diffuse contacts with the surrounding amphibolite. The use of the term albitite is somewhat of a misnomer since the plagioclase found in these rocks varies from sodic to calcic oligoclase.

The bulk of the body consists of a very dark non-foliated generally fresh amphibolite that shows a patchy aerial distribution of grain sizes. Unfortunately these gradations in grain size manifest themselves on the scale of feet to tens of feet making separate mapping impossible. Outcrop is generally quite good and shows a blocky nature due to intersecting joint planes. Thin to coarse leucocratic veining is a common feature. Hornblende is the predominant mineral (greater than 50% in all grain sizes) with plagioclase generally making up the rest of the rock. The plagioclase in the medium-grained samples often exhibits a distinct porphyritic texture, the larger laths showing a random orientation in a dark groundmass. A general coarsening in grain size and increase in modal plagioclase is suggested with approach to the bodies margin.

An interesting feature of this rock type, particularly at one locality (88), is the existence of what has been called "pillow" structures (Plate 2A) by Jones et.al.(1961). These are generally spheroidal to ovoid "pillow" shaped structures, say two feet across, with leucocratic plagioclase-epidote-hornblende-tourmaline "interpillow" material. This "interpillow" material closely resembles the much more extensive leucocratic zones and banding found within the amphibolite body. Although these structures resemble closely pillow structures found in lava flows elsewhere in the world, several features characteristic of this occurrence tend to suggest a different origin. The known outcrops of structures which could be called pillows are very limited, only two or three being found. Also the lateral extent of each outcrop is very limited, to a maximum of about twenty-five feet. The rock grades either way into "normal" massive amphibolite with or without random leucocratic veining of the type found between the "pillows". It is suggested that a possible explanation for their formation could be alteration and metasomatism along fractures resulting in the fortuitous pillow shaped structures. The finer grained borders of the "pillows" which exist in a few structures could be due to an aspect of this metasomatism.

A similar rock type to the "normal" amphibolite is that designated as a "spotted" amphibolite which is characterised by spotty accumulations of plagioclase and epidote. Its extent in the western half is relatively limited and seems restricted to marginal zones.

Fine to medium grained dark green chlorite-amphibole (hornblende) schists (Plate 5C) which are common features of the main body are interpreted as being strongly sheared equivilents of the "normal" amphibolite. They form low, long and narrow outcrops but it is in most cases impossible to detect any movement along these features due to very similar rock types on either side or to very limited solid outcrop. Their schistosities in the eastern half tend to parallel the country rock schistosity, whereas this trend is less definately developed in the west. Odd schist zones are associated with quartz reefs; movement on these particular schists can often be demonstrated.

Leucocratic plagioclase rich rocks within and adjacent to the amphibolite body are one of its most striking aspects. These rocks are considered as metasomatic in origin. The amphibolite body is rimmed, particularly on its northern side, by a zone of massive essentially clean white to cream plagioclase rock (the term albitite is somewhat misleading as the plagioclase is generally an oligoclase), which leads to a distinct break in slope against the country rock schists (Plate 6C). The plagioclase - rock outlyer to the north-east of the main body (Plate 6B) is identical to this and in all probability represents a high in metasomatic activity within the country rock schists. Its inner margins grade into a similar rock type containing increasingly abundant dark green prismatic amphibole crystals (actinolite-hornblende?) generally in a random orientation (Plate 2B). Both rock types often show evidence of brecciation (Plate 1A). This latter rock type is also found within the main body as well defined bands and as irregular zones extending in a general north-south direction (Plate 4C). Commonly an alignment and banding of the amphiboles is shown, with a consistent dip east of the order of 50° being characteristic. Some small scale folding of these bands is evident (Plate 5B), their orientation and the dip of the bands being consistent with the regional plunge of the last deformation of the basement and metasediments.

A similar type of banding exists within the body parallel to the coarse banded "albitite" but exhibiting a much finer banding and a well developed slaty appearance breaking along the banding planes. Its outcrop is hard to find being exposed for only a few inches above the ground surfaces (Plate 4A). However, it is the most continuous banding present in the body and by far the most useful in deducing the structure present within the amphibolite.

The origin of these zones and bands pose quite considerable problems. Metasomatism is no doubt responsible for their present leucocratic nature, but what exactly has been metasomatised ? Their constant orientation suggests either amphibolite alteration related to fractures along which the metasomatising "fluids" could readily permeate, or to relict sedimentary features which again provided a pathway for the metasomatising "fluids". The banding is no doubt a metamorphic differentiation product possibly combined with some primary sedimentary layering if this hypothesis is accepted.

Irregular zones of leucocratic plagioclase rock are also found within the body, being of limited aerial extent (Plate 4B). The field appearance of this type of zone suggests possible plastic state intrusion of the leucocratic material into the amphibolite.

Schlieren of basic material (amphibole rich) within a leucocratic neosome were found at one point close to the bodies margin (Field Station 138, Plate 2C). The country rock is the fine grained "normal" amphibolite showing veining of leucocratic material.

This occurrence is suggested by the author to be a modification of the agmatite (Mehnert 1968) found within the body ; a more plastic state for the paleosome (amphibolite) is evident compared with the angular fragments of paleosome in the agmatite. The agmatite (breccia) is by far the most common type of breccia contained within the body and is predominant within the eastern half (Geology Map, Plate 1B).

The agmatite appears to be a tectonic breccia with metasomatic "fluids" entering along the fine breccia cracks, separating the angular fragments to give the appearance shown in Plate 1B. The presence of this breccia is one of the strongest indications of an intrusive origin for the amphibolite.

Brecciation of the boundary "albitites" is also evident (Plate 1A) where fragments of pre-existing plagioclase-rock are contained within the later amphibole "albitites". Such a feature strongly suggests at least two phases of metasomatism where the earlier plagioclase-rock had been brecciated tectonically or by the second metasomatic phase itself.

A third type, or granular breccia, is shown in Plate 1C and contains fragments of most rock types found within the body in an essentially fine grained amphibole rich groundmass. Their common association with amphibole-chlorite schists and their very nature suggests an origin as a fault breccia. In the western half of the body their most common occurrence is in the outlier in the south-west corner of the main body. This particular outlier also contains many amphibole-chlorite schists and shows the abundant development of cleavage and joints.

The outer portions of the amphibolite body are characterised by thin (1-2 ft.) magnetite rich bands generally discontinuous in outcrop (Plate 5A). Their strike generally follows the margin of the body and only infrequently strike into the body to disappear in a relatively short distance. They commonly show small to medium scale banding with quartz (sample 128), the lamellae commonly showing fine undulations to extreme contortions. These bands are commonly associated with a light grey amphibole plagioclase rock resembling the border "albitite". A sedimentary origin is suggested for these bands. A very well banded amphibole-plagioclase rock (Sample 342-61) is also suggestive of a sedimentary origin for itself and for its enclosing rocks.

The amphibolite body is contained within quartz mica Weekeroo Schists which show the effects of Na - metasomatism to varying degrees outwards from the contact. Their well developed schistosity (Plate 3c) dips into the body on both the north and south sides. A fine banding at a high angle to the schistosity is found in many outcrops (Plate 3C). This banding has suffered the effects of metasomatism and folding with the schistosity as an axial-plane schistosity. It is suggested by the author that these fine bands are a reflection of the original sedimentary structure of the rock. Unfortunately this banding disappears on approach to the body and further out into the schists; near the body the plagioclase rich bands and the schistosity approach parallelism and parallel the contact.

The degree of the metasomatism falls off quite rapidly out from the body (see section on Chemistry). The massive "albitite" is found at the contact and grades out into albitised schists with distinct more massive plagioclase bands parallel to the schistosity (a + as), then albitised schists (as) commonly showing fine banding (Plate 3C) grading out into "albite" mica schists (ams) until finally the unaffected (or weakly affected) Weekeroo mica schists are reached (ms). This sequence of schists from the amphibolite body outwards is found to varying degrees around the body.

A slight variation is found on the southern side of the body where a very well banded "albitite" is found (Plate 3A). The bands which are commonly one half to two inches wide are essentially green amphibole in a white to cream plagioclase rock, the banding paralleling the country rock schistosity. An interesting feature of this unit is the tectonically produced boudins found at one locality (Plate 3B). It is suggested that this particular rock type (metasediment) is equivalent to the (a + as) unit described on the northern boundary with, however, significant amounts of amphibolite being originally contained with the sediments or schists prior to metasomatism and shearing. The banding is commonly seen to strike into the contact of the schists with the body indicating a non-conformable contact relative to the schistosity.

It should be noted that the amphibolite body is bounded on its northern and southern sides by quite intense shearing, the Proterozoic basal conglomerate stretching almost the whole length of the main body (see Geology map especially outlier).

The rock types and field associations of the Weekeroo Amphibolite supply indefinite and often conflicting evidence as to its origin. From the field evidence the author believes that the bulk of the amphibolite is made up of basic igneous rock(s), probably of an intrusive nature, which has been metasomatised either along fractures or along included sedimentary "rafts". Some metasomatism of an intrusive nature is suggested. It is further suggested that two (or more) metasomatic phases have affected the rocks. A possible sedimentary sequence (magnetite bands etc.) is indicated along the northern and western margins of the body.

PETROLOGY OF THE WEEKEROO AMPHIBOLITE

General :

From rock samples collected during field mapping a total of seventy-five (75) thin-sections were prepared and described by the author (Appendix II). The distribution of the samples collected is shown on the field stations/sample location map (back pocket). Samples were chosen so as to provide a representative selection of each rock type mapped, to study variations within these "units" and to investigate any unusual rock types met during mapping. For descriptive purposes the following section will consider the petrology of the individual rock types and then the characteristics of the individual minerals encountered.

The determination of plagioclase compositions was generally made by the method of Michel-Levy where maximum extinction angles of albite twins are measured in sections normal to (010) (Heinrich 1965). Some compositions were measured normal to a where these sections were encountered. Standard curves for converting appropriate measurements to composition were consulted in Henrich (1965). 2V angles were estimated from the curvature of isogyres in optic-axis figures.

Petrology of the rock types :

The field characteristics and associations of the rock types mapped (map in back pocket) have been described in the section on mapping procedure.

The "normal" amphibolite is generally fine to medium grained and commonly shows a distinct relict doleritic texture (Plate 7A). One slide (342-93) shows variolitic textures in the groundmass. The average mineral proportions are amphibole 50-55%, plagioclase 40-45% with minor biotite, opaques, epidote and sphene. Plagioclase exists as cloudy, xenoblastic to subideoblastic lath shaped crystals in random orientation, somewhat porphyroblastic. Compositions are in the range Ab_{75-80}, the sign is generally (-) although some are (+) and twinning commonly occurs as a few broad, diffuse laminae. The intergranular positions contain amphibole, biotite, opaques and sphene. Commonly a relict sub-ophitic texture is exhibited by plagioclase and amphibole (Plate 7B). No relict pyroxene or olivine was found.

On approach to the margins of the body it is possible sometimes to detect a coarsening in grain size eg. 342-117 which is commonly associated with an increase in modal plagioclase (up to 75%). Minor calcite is then a common accessory.

So called "Pillow" structures were found in a few places within the massive amphibolite; general spheroidal masses of dark amphibolite with intervening veins of leucocratic epidote -plagioclase rock. The veining material is medium grained and has as its main constituent epidote (80%), plagioclase (10%), tourmaline (5%) and opaques (5%). The tourmaline tends to be concentrated in a layer parallel to the contact of the "pillow" with the veining material. The transistion from the vein to the "pillow" leads to an increase in amphibole, plagioclase and biotite with the other minerals decreasing. The amphiboles are markedly zoned (Plate 10A) possibly with iron rich margins. The outer rim of the "pillow" consists of amphibole (40%), plagioclase (50%) with epidote (5%), sphene (6%), biotite (5%) and opaques (1%) in a relict doleritic texture. The core is characterised by amphibole (20-30%) going to biotite (10%), plagioclase (50%), opaques (10-15%) with sphene (5%) and minor epidote. The plagioclase in the core also exists as lath shaped porphyroblasts, these being absent near the rim (interpreted by Jones et-al as a chilled margin).

The "spotted" amphibolite is very restricted in its occurrence in the western half. Roughly circular accumulations of epidote are commonly characteristic e.g. 342-84.

The dark green schists found within the body consists of hornblende (20%), biotite (25%), and chlorite (5%) all showing a preferred orientation, set in a fine grained mosaic of xenoblastic plagioclase with minor epidote and opaques. Deer, Howie and Zussman (1966) consider such schists to be sheared equivilents of amphibolite.

The so called "albitite" consists essentially of plagioclase and amphibole, the amphibole commonly as porphyroblasts set in an interlocking groundmass of xenoblastic plagioclase (average about 80%). Two grain sizes of plagioclase are common ; medium lath shaped crystals and a fine grained "welded" groundmass, the latter probably formed by a combination of cataclasis and metasomatism. Banding in the "albitite is due to layering of amphibole, biotite or opaque present. These layers could be a product of metamorphic differentiation, metamorphic recrystallisation of primary sedimentary layering or a combination of both. However, in the layered plagioclase rich rock spherulitic arrangements of amphibole have been found (Plate 8B) which possibly favours the metamorphic differentiation idea. The amphibole "albitite" just in from the contact is characterised by dark green randomly oriented actinolite set in a fine grained granoblastic plagioclase groundmass.

The thinner slaty plagioclase rich bands are characterised by thin lamellae of green amphibole and white plagioclase. The amphiboles tend to be porphyroblastic but very irregular in form and strongly poikiloblastic. The groundmass is essentially xenoblastic plagioclase and quartz with some epidote, chlorite and tourmaline.

Agmatite is relatively rare in the western half being most extensive in the portion mapped by B.J. Morris. A thin-section was not prepared by the author; for a petrological description of the agmatite reference can be made to Brian Morris's section on petrology (B.J.M. 16).

The magnetite layers are not, as expected, excessively rich in magnetite, about 10% being the norm. Xenoblastic amphibole is the dominant mineral and shows a preferred orientation parallel to the banding. Plagioclase (40%) or quartz (45-50%) is the other important mineral, the latter generally being more common. The layers are commonly defined by amphibole poor and rich zones, the amphibole generally exhibiting a porphyroblastic nature. The opaques commonly pass through these as layers (Plate 8C).

A tourmaline-quartz band was found (342-5B) which possibly shows relict graded bedding. Similar relict bedding has possibly been found by B.J. Morris (pers. comm.) in his specimen 341-27B (Plate 7B). Possible relict bedding is shown in a very well banded green amphibole-white plagioclase rock in the western half (342-61). The rocks that possibly show relict bedding are restricted to the marginal zones of the amphibolite.

The schists out from the body tend to be somewhat variable in their mineral content. Those further out (a + as) eg. 342-12 consist essentially of untwinned xenoblastic plagioclase with minor biotite, chlorite, and opaques. Some banding of plagioclase and quartz may occur (eg. 342-12B) on approach to the contact. The quartz commonly has inclusion filled cores with clear edges indicating a possible sedimentary origin. Biotite is still an accessory. Position 342-14 is unusual in that "spot - like" accumulations of muscovite occur (see Chemistry, Na_2O : K_2O). Biotite is still common (up to 5%) with more diverse accessories coming in e.g. amphibole, sphene, apatite etc. Muscovite is still common closer to the contact but does not occur in patches. Instead its fine prismatic form alligns to give a preferred orientation. Tectonic stressing of the schists is shown by the common elongation and parallel alignment of otherwise equidimensional quartz and plagioclase grains. The elongation parallels the schistosity but bears no relationship to the banding. Any micaceous minerals allign themselves with this elongation.

The well banded amphibole "albitite" on the south of the body consists of about 10-20% prismatic amphibole, intergranular to a quartz-plagioclase (60%) mosaic. Since in this unit twinning is rare the distinguishing of quartz from plagioclase is very difficult. The quartz is characterised by inclusions in the cores i.e. originally sedimentary quartz. Many accessory minerals are present in this unit e.g. biotite, chlorite, opaques, apatite etc.

MINERALOGY :

Plagioclase feldspar and amphibole (hornblende and actinolite) are by far the two most abundant minerals making up the rock types found in the amphibolite. The various rock types are mere modal and spatial variations of these two minerals. Other minerals, especially epidote, may achieve local significance but nowhere near as extensive as the two main minerals. Certain accessory minerals are ubiquitous and some are spasmodic in occurrence.

The amphiboles have been dealt with in detail by B.J. Morris (B.J.M. 7- B.J.M. 13) and hence only a brief discussion of their characteristics will follow :-

Amphiboles : Amphibole commonly exceeds plagioclase except in the leucocratic rocks. Two crystal habits are found, either irregular prisms with jagged ends or fine elongate prisms (Plate 10E). Most amphiboles are green to blue-green with darker edges (Fe enrichment probably), pleochroic = straw, = green, = blue-green, some are zoned (Plate 10A) and some are twinned. Most are moderate to strongly poikiloblastic (Plate 10B) with inclusions of commonly opaques, quartz, plagioclase, sphene and epidote. Probably altering to biotite, sphene and chlorite due to the green schists facies retrograde metamorphism. (Plate 10C, 10D). The amphibole is generally hornblende except in the "albitite" where actinolite is the characteristic amphibole. It is concluded that the amphibole is formed from pyroxene during metamorphism to the epidote - amphibolite facies.

Plagioclase : The plagioclase in the rocks occurs in several different forms, being good indicators of the primary, metamorphic and metasomatic history of the amphibolite and associated rocks. The larger, generally lath shaped crystals which are common to the rocks showing a relict doleritic texture (Plate 7A) are considered as relict primary plagioclase. These laths commonly show crenulated edges where resorption during metamorphism has taken place. Twinning, where present, is commonly a few broad lamellae. Many inclusions are common. Both Biaxial (+) and (-), the former appearing dominant, and is generally associated with untwinned crystals.

Groundmass plagioclase again is generally lath shaped but may be xenoblastic equidimensional. They commonly give the appearance of welding due to very patchy and irregular extinction (possibly a product of cataclasis with annealing or a metasomatic effect).

Twinning in general is not common except in some of the outlying schists and some of the leucocratic rocks. This lack of twinning is characteristic of metamorphic rocks (Turner 1951). When twinning does occur it takes the form of a few lamellae generally following one twin law (albite predominant), again characteristic of metamorphic plagioclases. Some relict carlsbad-albite twinning can be found in the laths in the relict dolerite texture. Where multiple lamellae occur they can often be shown to be secondary polysynthetic twinning (according to the criterion of Vance 1961) on the albite law. Bent lamellae are also found (Plate 9C) suggesting twinning and deformation due to tectonic stresses, not primary growth. It was noticed that fine lamellar twinning was rarer in equigranular plagioclase mosaics than in the more inequigranular (porphyroblastic) textures.

A further type of twinning found within the amphibolite was the so-called chequerboard twinning (Plate 9A). Its occurrence is restricted to within several hundred feet of the margins of the amphibolite, or close to leucocratic zones within the bulk of the body. Considerable debate exists as to the primary or secondary nature of this type of twinning. Metasomatic replacement of potash feldspar has been proposed by several workers (as discussed in Starkey 1959) with patchy grains being the transitional stages. A primary origin in the form of welding together of individual albite laths has also been proposed (Cattey 1955 p.106). Metasomatic processes are obviously involved in the formation of chequerboard "albite" in the Weekeroo Amphibolite because of the intimate spatial arrangement of its occurrence and the zones of metasomatism.

The plagioclase compositions measured by optical methods almost invariably gives the plagioclase to be an oligoclase. Brian Morris (pers. comm.) made two composition determinations by refractive indices : in the so called "albitite" the average composition was Ab_{86} whilst in the "normal" amphibolite its average composition was Ab_{84}.

__Epidote__ : Epidote is essentially ubiquitous in all rocks and varies from an accessory to a major component (80%) of the rock e.g. 342-101. Most grains are xenoblastic and equidimensional and are characteristically a pale yellow colour and may exhibit weak pleochroism.

Common association with amphibole (Plate 10C) and plagioclase feldspar suggests the hornblende and plagioclase are altering to the epidote, probably in sympathy with the retrograde green-schist facies metamorphism (the Ca content of plagioclase decreases with decreasing metamorphic grade).

__Biotite__ : Biotite is a common accessory in many of the rock samples studied especially in the border zones and schists and in the internal schists zones. It shows its characteristic strong, brown pleochroism. Its common intimate association with hornblende reflects the retrogression of the amphibolite in the green-schist metamorphism (Plate 10D). A good crystal outline is rarely found.

__Muscovite__ : Muscovite is restricted to the schists outside the body, not being recorded from any rock within the body. It exists as fine disseminated grains or in elongate knots, (fine grained) with their long axes parallel to the schistosity

<u>Sphene and Opaques</u> : In nearly all thin-sections opaque rimmed by sphene was found, (Plate 9E). It varies in amount from a mere accessory to quite an important component of the rock type. The sphene is forming from the opaques (ilmenite of titanomagnetite) in response to the green-schist metamorphism which has affected the amphibolite body. Its occurrence also reflects the relatively high titania content of most of the amphibolite. The sphene commonly forms granular aggregates, is pale pink and sometimes exhibits pleochroism. Skeletal opaques (Plate 9F) are found in some rocks suggesting a possible igneous origin.

<u>Chlorite</u> : Chlorite is common as an alteration product of amphibole (Plate 8B), commonly forming spherulitic arrays (Plate 8A) and exhibiting marked pleochroism in shades of green. Its low interference colours and fibrous nature are characteristic.

<u>Carbonate</u> : Carbonate is a rare accessory and appears to be restricted to rocks close to the amphibolite/schists contact. Probably a secondary weathering product. Mostly calcite though some scapolite could be present.

<u>Tourmaline</u> : Tourmaline is restricted to marginal rocks in the north and west and probably reflects either boron metasomatism or initial boron in the sediments. Some veining of tourmaline can be found e.g. 342-121A indicating a metasomatic effect. It is distinguished from amphibole by the darker colour (pink-brown) and the position of its maximum absorption (perpendicular to the polarizer). Some granular tourmaline is often associated with amphibole within the main body (Plate 7C).

<u>Quartz</u> : As an accessory in the amphibolite but attains importance in the magnetite bands and the metasediments. It is commonly strained (undulose extinction). In the schists inclusions rich cores probably indicate original sedimentary quartz which has been subjected to metamorphism and metasomatism.

Minor accessories encountered include apatite both as long very thin prisms or as equant grains, and zircons probably although small size makes identification difficult.

The petrology of the Weekeroo Amphibolite suggests a basic igneous body which has been metasomatised in selected areas with the effects of this metasomatism falling off rapidly into the massive fine grained doleritic looking rock. A sedimentary sequence for the northern and western borders is suggested.

CHEMISTRY OF THE WEEKEROO AMPHIBOLITE

General :

During field mapping eleven rocks were selected for total rock and trace elements (Ni, Cr) analyses with a later decision to also analyse for Cu and Co. At each locality a fresh sample was selected, rocks showing secondary veining or weathering being ignored. For a description of the analytical methods employed see Appendix III. The results of the analyses are shown in Table 3. Calculated Niggli values are shown in Table 4. (ref. Johannsen 1931).

Because of the often incomplete or conflicting field evidence, the major and trace elements contents of amphibolites have been studied by many workers with a view to distinguishing between ortho-amphibolites (i.e. amphibolites derived from igneous rocks) and para-amphibolites (i.e. amphibolites derived from sedimentary rocks). The data obtained in this investigation was analysed with this view in mind.

Major Elements :

The total rock analyses as determined by the author are shown in Table 3. The average of these analyses is compared with Nockold's averages for the three main basaltic types in Table 5. The only sediments having a primary concentration near that of amphibolites are calcareous or dolomitic shales and hence para-amphibolites can only be metamorphic equivilents of these, ignoring of course any regional metasomatism.

Initial work on the chemical distinction of para - and ortho - amphibolites was based on looking for differences in abundance of selective elements between the two groups. This approach was obviously invalid because of the similarity in concentrations of the major elements between the amphibolite groups in most cases. A more profitable approach is based on the trends of variation of the major elements within the amphibolites and by their comparison with well documented igneous and sedimentary trends (Leake 1964). However, intense regional metasomatism may prevent the classification of any particular

TABLE 3.

TOTAL ROCK ANALYSES

	341-129	341-U	341-II	341-Z	342-X	342-125	342-T	342-V	342-117	341-W	342-190	341-163
SiO_2	36.07	5015	52.82	65.64	50.05	52.74	50.10	52.15	53.00	50.45	54.95	49.71
Al_2O_3	28.95	13.05	13.31	16.10	15.80	14.74	13.06	12.93	13.60	14.48	14.92	14.81
Fe_2O_3 (Total Fe) 1	12.78	16.79	13.32	2.79	14.20	13.43	16.51	14.40	14.50	13.47	11.46	13.42
MgO	6.95	5.90	4.84	4.19	6.92	6.27	6.44	5.03	5.50	5.48	4.37	7.67
CaO	1.42	9.88	8.42	3.61	8.13	7.54	8.32	7.84	5.95	8.25,	5.78	8.95
Na_2O	0.55	1.95	4.44	7.88	3.27	3.50	3.17	3.92	5.14	3.73	5.80	2.68
K_2O	0.13	0.28	0.06	0.002	0.92	1.03	0.01	0.35	0.17	0.25	0.04	1.20
TiO_2	0.61	2.25	2.04	0.62	1.21	1.43	2.16	2.07	1.73	1.27	2.34	1.40
P205	0.01	0.04	0.07	0.06	0.05	0.03	0.04	0.05	0.04	0.03	0.06	0.14
MnO	0.02	0.26	0.15	0.04	0.15	0.18	0.21	0.20	0.14	0.14	0.17	0.30
Ni ppm		105	115	85	170	119	139	68	101	115	109	125
Cr		66	40	66	260	84	134	10	16	69	50	161
Cu		183	80		68	327	210	32	66	163	12	141
Co		92	76		92	87	107	110	123	80	87	107
Wt.loss		0.53	0.74	0.71	0.89	0.79	0.60	0.53	1.425	0.84	0.49	1.09
TOTAL	89.92	100.98	100.06	100.91	99.80	101.60	100.37	99.41	100.94	98.60	100.14	101.10

TABLE 4

NIGGLI VALUES FOR TOTAL ROCK ANALYSIS OF WEEKEROO AMPHIBOLE

	341-129	U	II	Z	X	125	T	V	117	W	190	163
si	92.2	119.6	136.7	223.8	116.5	130.5	119.7	135.2	136.96	127.5	152.8	114.4
al	43.6	18.3	20.4	32.4	21.7	21.5	18.4	19.8	20.7	21.5	24.4	20.1
fm	51	51.6	44.9	28.5	49.2	48.6	53.1	48	49.7	46.6	42.6	50.1
c	3.84	25.2	23.3	13.1	20.3	19.9	21.2	21.8	16.5	22.3	17.2	22.1
alk	1.5	4.9	11.4	26	8.8	10	7.3	10.4	13.2	9.6	15.7	7.7
ti	1.23	4.01	4.04	1.64	2.1	2.67	3.87	4.05	3.42	2.43	4.85	2.49
mg	0.52	0.41	0.42	0.75	0.49	0.48	0.43	0.41	0.42	0.44	0.43	0.53

Total Fe taken as Fe_2O_3

TABLE 5.

AVERAGE COMPOSITION OF WEEKEROO AMPHIBOLITE, NORMAL THOLEIITE, NORMAL ALKALI BASALT, CENTRAL BASALT AND 200 AMPHIBOLITE

	WEEKEROO AMPHIBOLITE	THOLEIITE	ALKALI BASALT	CENTRAL BASALT	AVERAGE OF 200 AMPHIBOLITE
SiO_2	51.61	51.33	46.14	51.56	50.3
Al_2O_3	14.07	14.21	14.75	18.12	15.7
TiO_2	1.79	2.05	2.65	1.10	1.6
Total Fe_2O_3	14.15	12.0	11.98	9.15	11.4
MgO	5.84	6.40	9.46	6.04	7.0
CaO	7.91	10.52	10.82	10.12	9.5
Na_2O	3.76	2.25	2.65	2.27	2.9
K_2O	0.43	0.83	0.96	0.82	1.1
MnO	0.19	0.18	0.20	0.16	0.2
P_2O_5	0.06	0.23	0.39	0.16	0.3
	99.85	100.00	100.00	100.00	100.00

TABLE 5. (Cont.)

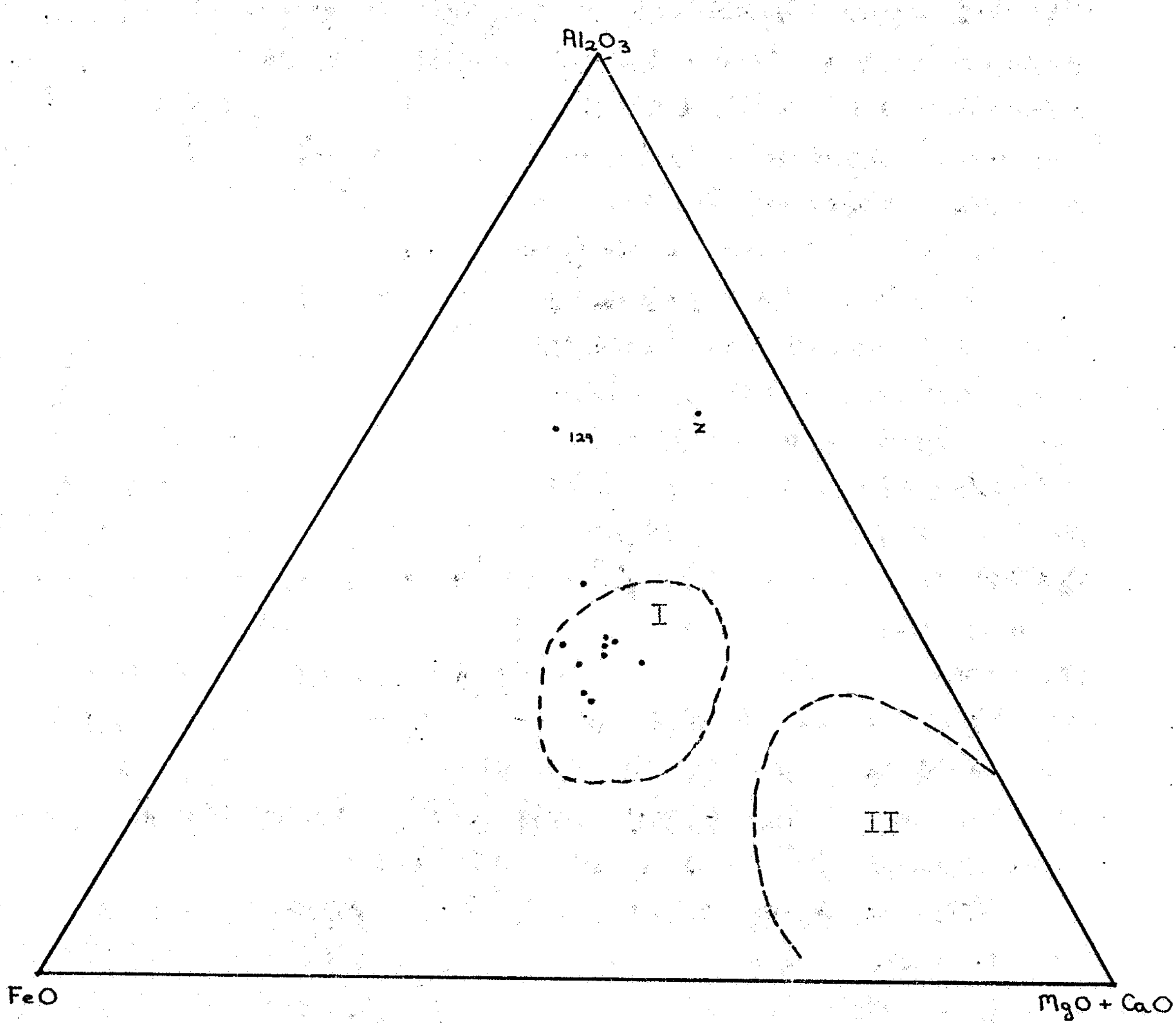
NIGGLI NUMBERS

	WEEKEROO AMPHIBOLITE	THOLEIITE	ALKALI BASALT	CENTRAL BASALT	AVERAGE OF 200 AMPHIBOLITE
Si	129	123	97	126	118
al	20.7	20	18.5	26	21.5
fm	48.4	46.5	50.5	40.5	46.5
c	21	27	24.5	26.5	24
alk	9.9	6.5	6.5	7	8
ti	3.39	3.67	4.18	2.03	2.18
k	0.08	0.20	0.19	0.19	0.20
mg	0.46	0.49	0.59	0.55	0.53

REFERENCES : Average amphibolite from Poldervaart (1955, p.136)
Basalt averages from Nockolds (1954, p. 1021)

DIAGRAM 5 : Al_2O_3 - FeO - (MgO + CaO).

(after Edwards 1958)



I = Igneous Field.

II = Sedimentary Field.

M.A.C. '70.

amphibolite(s) since under these conditions, convergence of igneous and sedimentary trends has been noted (Walker et.al. 1959).

Orville (1969) considers that any rock composed chiefly of hornblende and plagioclase will approximate to a basaltic composition on major elements since the composition field for the two phase assemblage hornblende-plagioclase closely follows that of basic igneous rocks. However, the author considers that trends in composition of a particular amphibolite would generally differentiate between it being an ortho - or para - amphibolite even if its average composition fell within the field of basic igneous rocks.

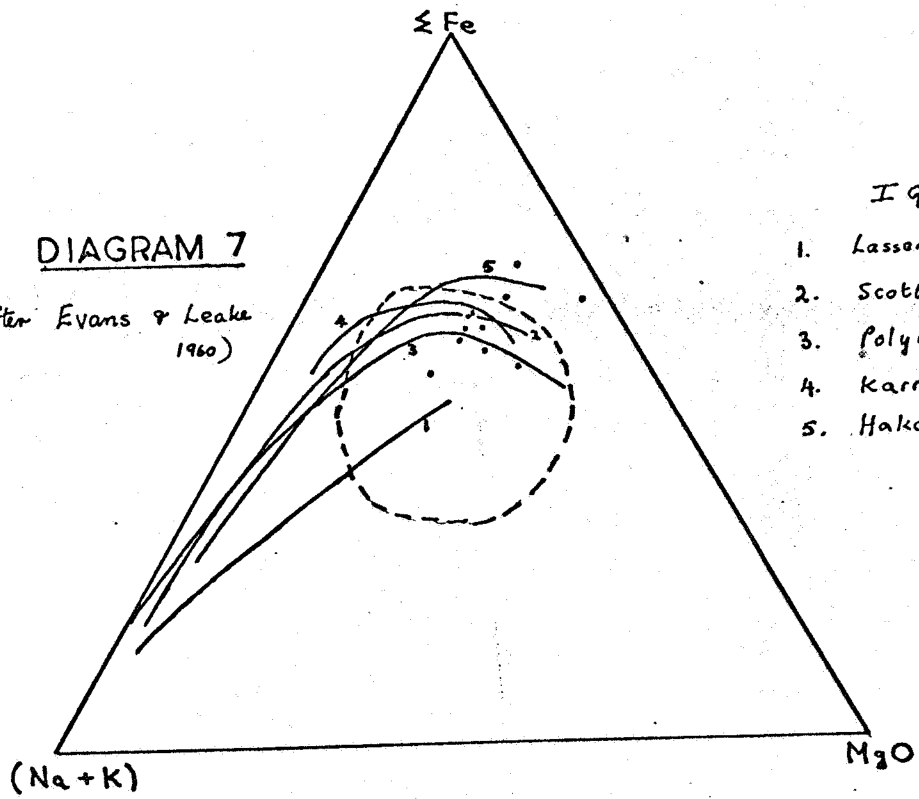
No matter what compositional diagram is used, the total rock analyses of the Weekeroo Amphibolite fall within the field characterised by basic igneous rocks. The Al_2O_3, (CaO + MgO), and total iron oxide (as FeO) contents of the analyses are plotted in Diagram 5 (after Edwards 1958). All of the "normal" amphibolites fall in the field occupied by Broken Hill Basin amphibolites (Edwards 1958) and average basalts and dolerites (from Daly:Igneous Rocks). (The two analyses that fall well outside of either field shown are both metasomatically produced rocks, sample 341-129 being a tourmaline rich band within the amphibolite (B.J.M. pers. comm.) and 341-Z being an amphibole "albitite". These two analyses have been plotted (if at all) for interest.

This diagram, however, does not consider the TiO_2 content of the rocks : the analyses of the amphibolite (Table 3) show a TiO_2 content of from 1.2% to 2.3% compared with the analyses in the sedimentary field where TiO_2 content is generally less than 1%. In fact use has been made of the TiO_2 content of amphibolites and the associated sediments in any one area to attempt to determine the origin of the amphibolite(s) because basic igneous rocks in general have TiO_2 contents greater than most sediments (about 1% being the dividing line).

Plotting of the MgO-CaO-FeO (total iron as FeO) contents

DIAGRAM 7

(after Evans & Leake 1960)



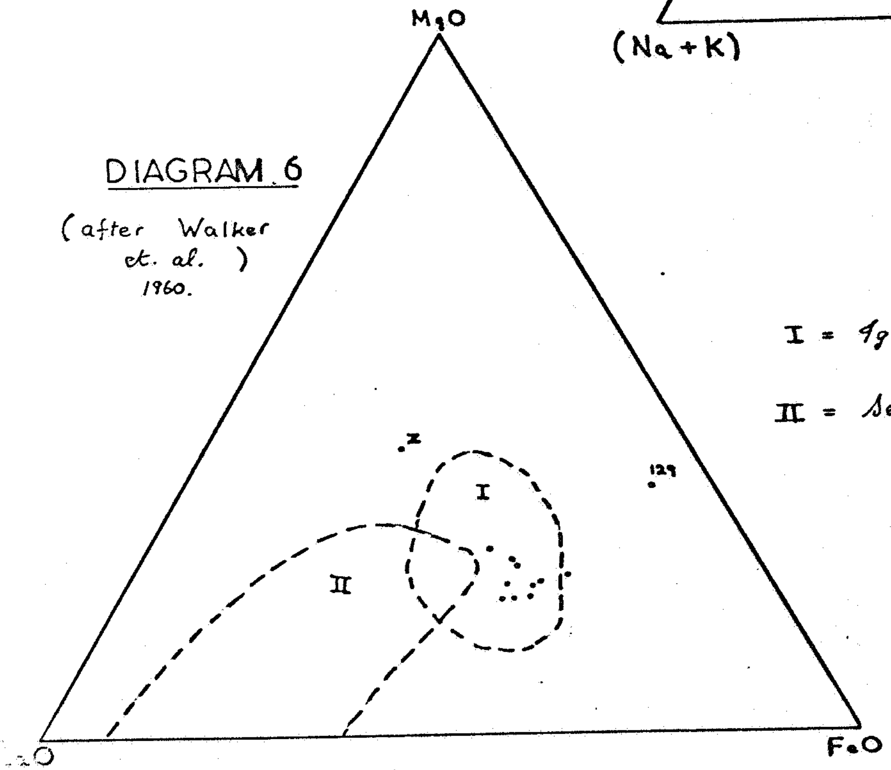
IGNEOUS ROCK SERIES:

1. Lassen Peak lavas (calc-alkaline).
2. Scottish alkali basalt – trachyte trend.
3. Polynesian alkali basalt – trachyte trend.
4. Karroo dolerites (main trend)
5. Hakone P lavas (tholeiitic).

– – – Field of Spilites (Vallance 1960, Battey 1956.).

DIAGRAM 6

(after Walker et. al. 1960.)

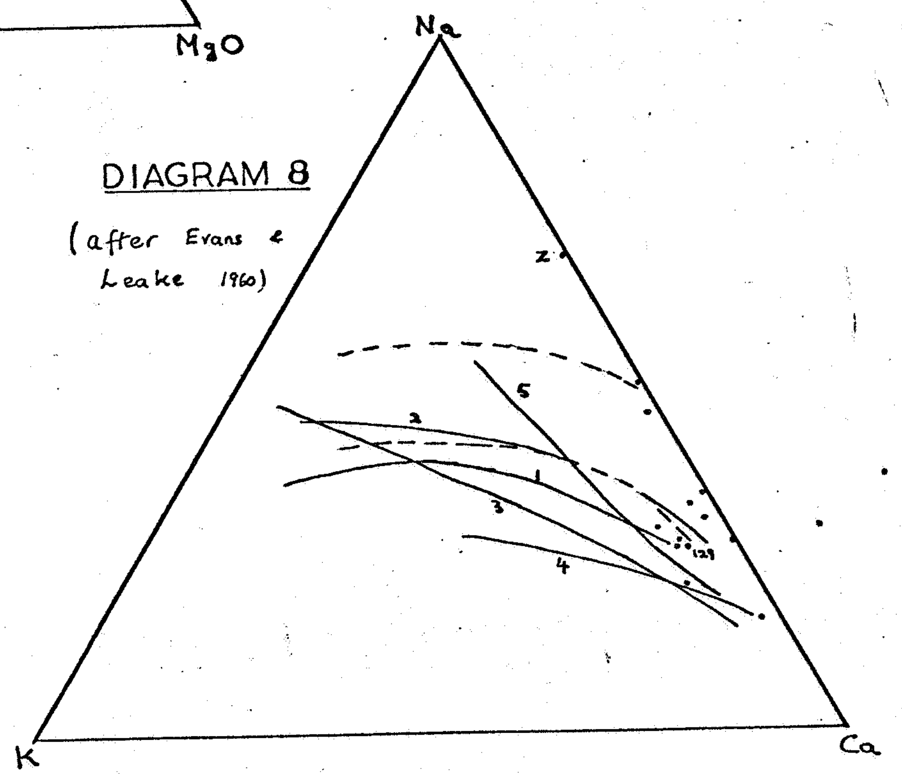


I = Igneous Field.

II = Sedimentary Field.

DIAGRAM 8

(after Evans & Leake 1960)



M.A.C. 1970

of the analyses gives the distribution shown in Diagram 6 (after Walker et.al. 1959, Meier 1962), all of the analyses falling within or very close to the field of basic igneous rocks. On these elements alone there is very little variation between the individual amphibolite analyses.

The scatter of points in the FeO:MgO:Alk Plot (Diagram 7) is probably due to the combined effect of metamorphic differentiation and alkali movement (metasomatism is probably an important cause). The few analyses plotted cannot be related with any certainty to any of the igneous - rock series shown. Most of the points plotted lie within the field of spilite compositions as given by Vallance (1960) and hence the analysed rock may have affinities closer to the spilites than to the alkali basalts.

This affinity with spilites could again be demonstrated with the Na : Ca ; K plot (Diagram 8). The very low potash content of the rocks is markedly shown in this diagram where all of the analyses plot very close to the Na-Ca join. All but four analyses plot in a small group, the variations being due to secondary alteration of the rocks in question. In the case of 341-U, which was obtained from a small outlying body on the southern side of the amphibolite, secondary enrichment in carbonate (Ca) is expected through weathering processes. Obtaining a reasonably fresh sample of this rock was plagued by difficulties. The trend of 342-117, 342-190 and 341-Z towards the Na end member is attributed by the author to be due to Na-metasomatism, these three rock samples occurring close to or on the amphibolite - sediment boundary.

To attempt distinction between ortho - and para - amphibolites from triangular diagrams is, according to Orville (1969) fraught with uncertainty since an amphibole - plagioclase mineral assemblage has essentially the same composition as basic igneous rocks. Since sedimentary "trends" should readily be distinguishable from igneous trends, profitable use can often be made of variation diagrams to distinguish between

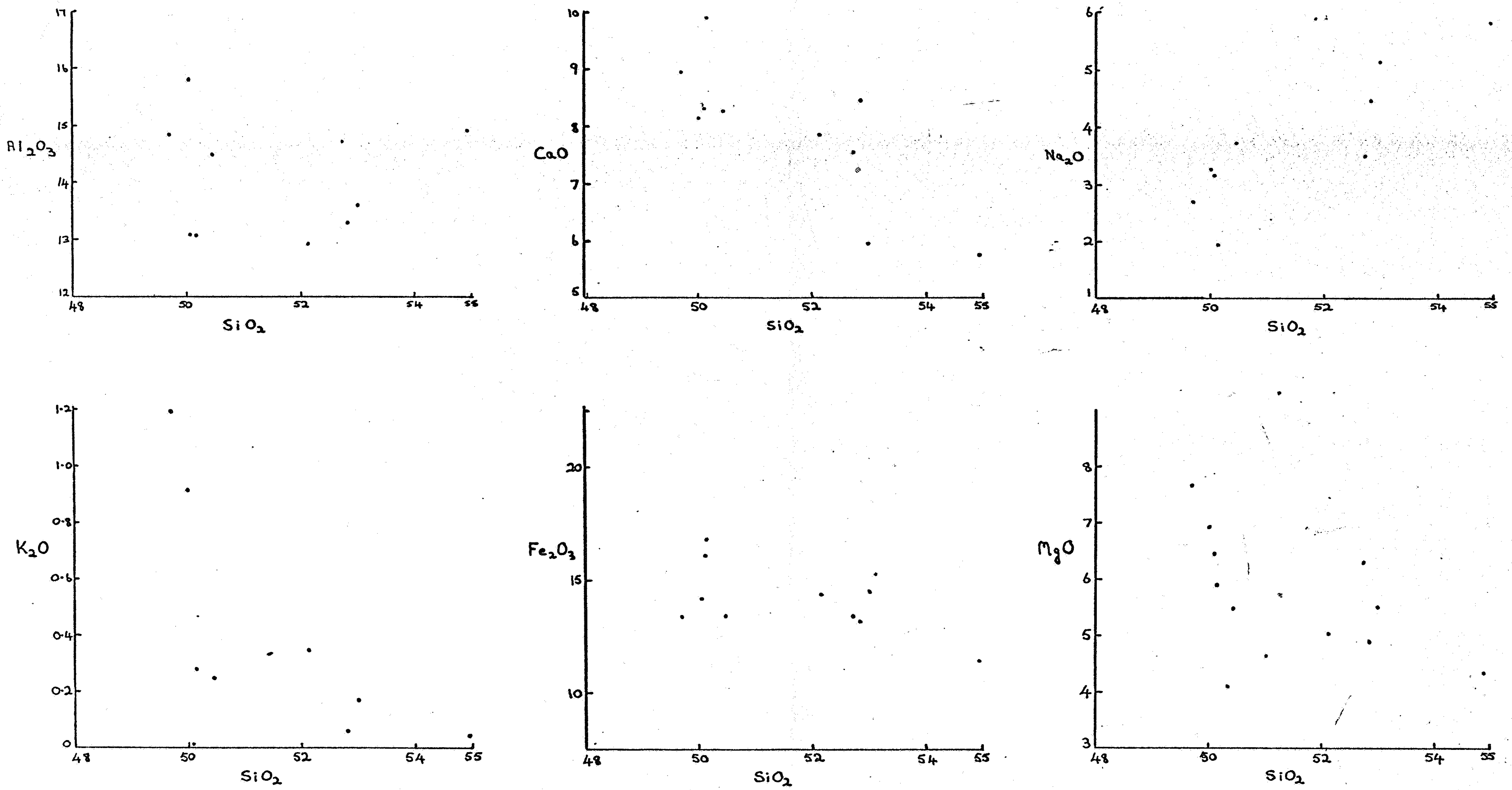


DIAGRAM 9

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DIAGRAM 10
(after Falkum 1969)

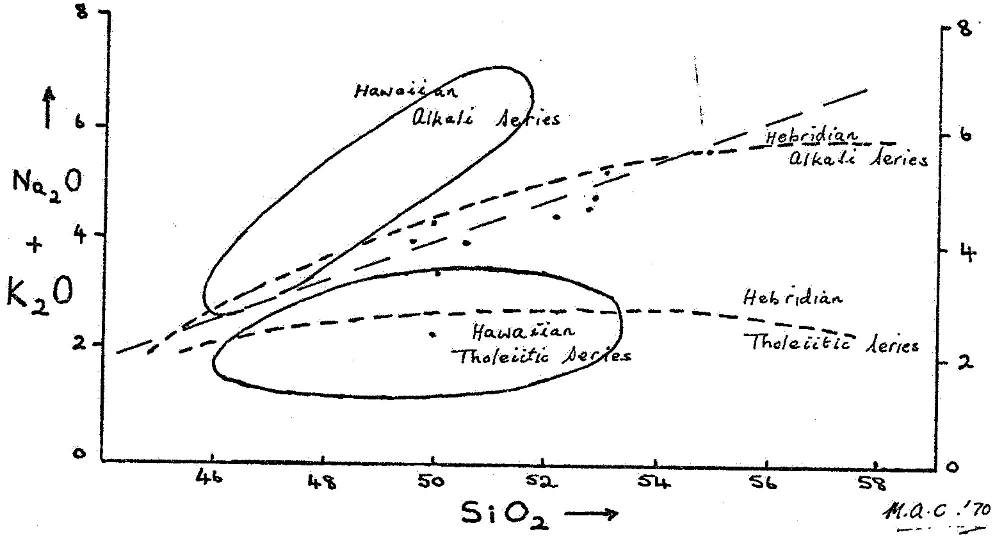
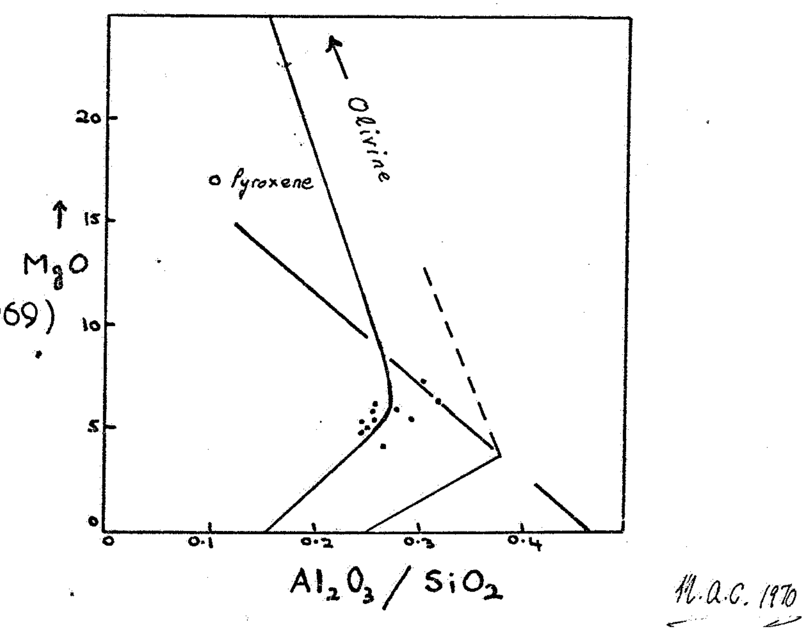


DIAGRAM 11
(after Falkum 1969)



amphibolite origins.

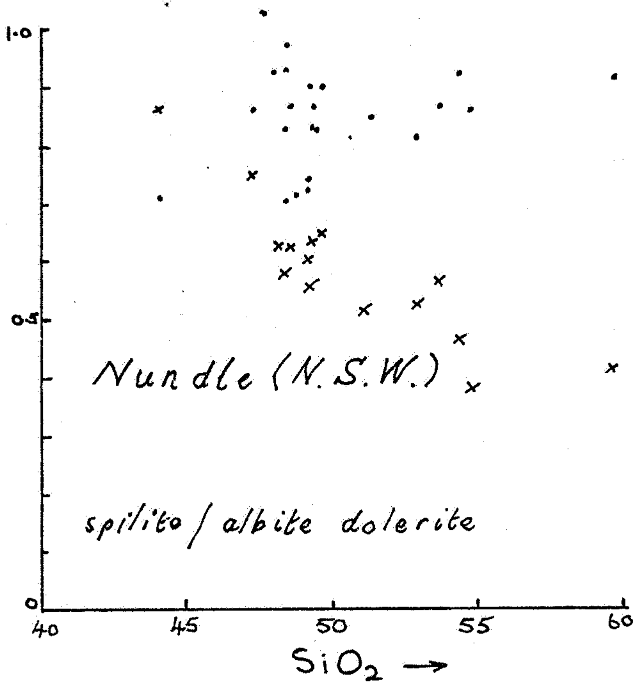
The variation of the weight percentages of the major oxides with silica content of the rock is shown in Diagram 9 (A-F). It should be emphasised that only ten analyses are represented and hence any conclusions drawn should be regarded as tentative since this is hardly a sufficient number of plots to reveal trends with definition. However, a few generalisations can be made on the plots obtained. Each plot except Al_2O_3 vs. SiO_2 (Diagram 9A) seems to show a definite systematic variation of the respective oxide with silica content : CaO K_2O, Fe_2O_3 and MgO show a negative relationship (slope) and Na_2O a positive relationship with SiO_2. Each of these relation ships except K_2O vs. SiO_2 is that expected from differentiation of a basic magma (Krauskopf 1967).

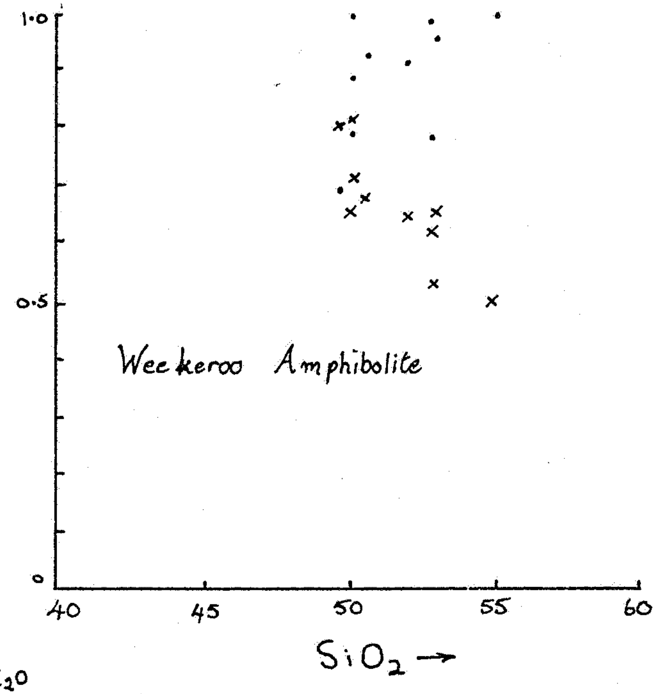
The trend of total alkalis ($Na_2O + K_2O$) with silica content is compared with the two magmatic series from Hawaii and the British Hebridies in Diagram 10 (after Falkum 1969). The trend obtained does not fit exactly either the alkali or the tholeiitic basalt series but comes somewhere between them. The diagram also indicates that the calcim-rich (alkali poor generally) samples were the earlier differentiates. Comparison with Diagram 11 (after Falkum 1969) shows that the analyses plot closer to the tholeiite differentiation scheme than to the alkali series, although a few plots are ambiguous.

Diagram 12 is quite interesting in that the variation in both Na_2O : $Na_2O + K_2O$ and CaO : CaO + Na_2O + K_2O with SiO_2 for the Weekeroo Amphibolite corresponds remarkably with that for a spilite/albite dolerite at Bundle in N.S.W. (Vallance 1960).

The Niggli values corresponding to the total rock analyses are given in Table 4 where total iron has been calculated as Fe_2O_3 (FeO analyses not being available). Niggle values have been demonstrated to show systematic variation with magmatic differentiation, whereas no single major element shows a variation in abundance that is uniquely associated with either magmatic differentiation or sedimentary variations.

DIAGRAM 12. (after Vallance 1960).





• = $Na_2O / Na_2O + K_2O$

x = $CaO / CaO + Na_2O + K_2O$

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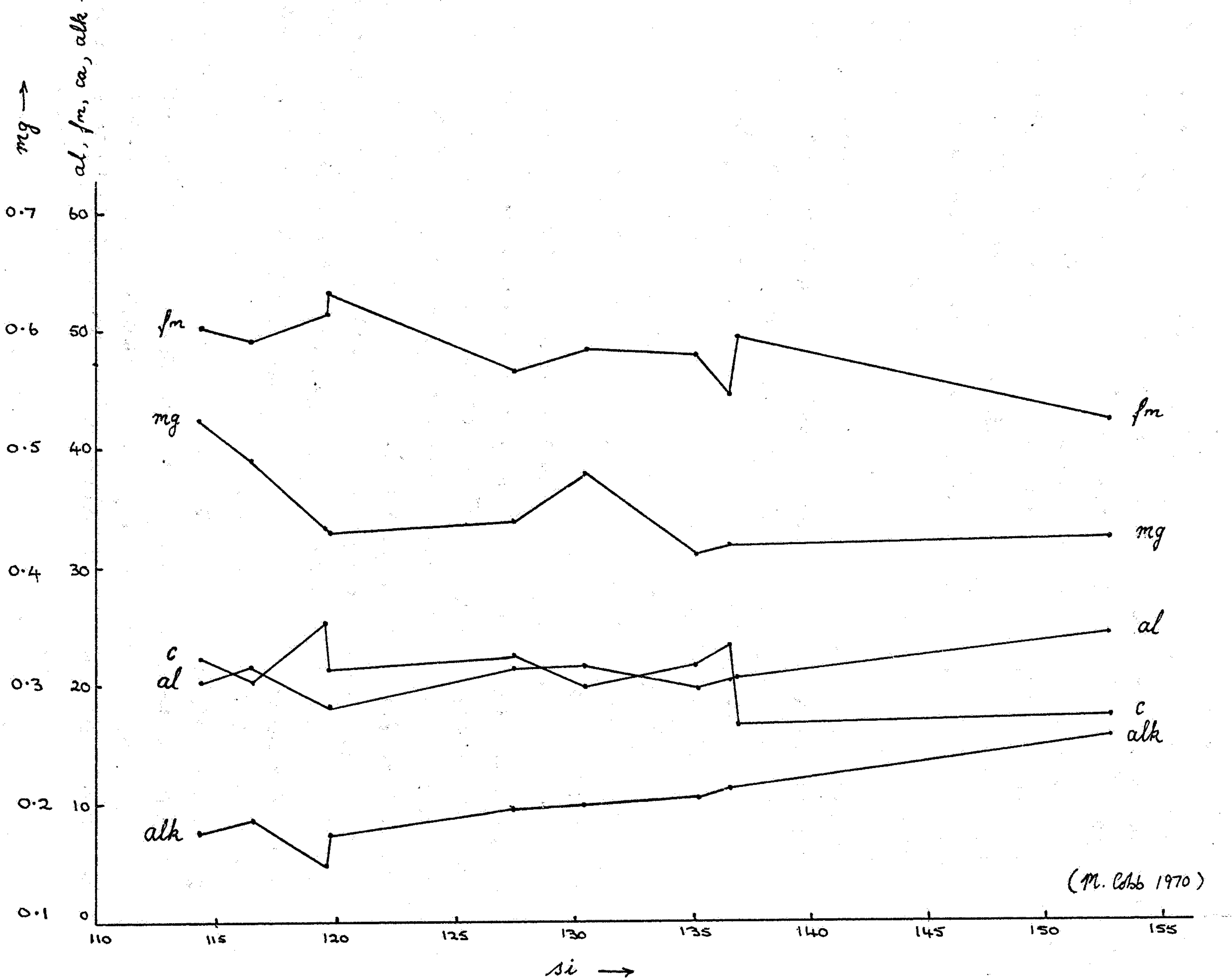
DIAGRAM 13 : Niggli al, fm, ca, alk, mg, against si.



The variation of Niggli fm, mg, al, c and alk with si is shown in Diagram 13. The curves are far from smooth but it is suggested that a variation is still recognisable with fm, mg and to a lesser degree c showing a decrease and alk and to a lesser degree al showing an increase with increasing si. These trends are identical to those shown by the Karroo Dolerites even if they are developed to a much lesser extent. Evans and Leake (1960) consider that these trends can result from Na-metasomation except the fall of mg with increasing si which is essentially a product of magmatic differentiation. It should be noted that metasomatism is quite evident in the Weekeroo Amphibolite. Leake (1964) considered that mixtures of suitable sediments would produce similar trends and quotes as example that "if a pelite with an mg of 0.35, fm of 40, and c of 5 were mixed with various amounts of dolomite (mg 1.00, fm 50, c 50) a systematic increase in mg with decrease in si, alk and al would result, though the corresponding change in fm would be slight".

To overcome this difficulty Leake (1964) plotted c against mg and compared the trends obtained with those of the Karroo dolerites and those expected from mixing of sediments. The latter would involve a marked increase in c with increase in mg whereas for basic igneous rocks the relationship changes as crystallization proceeds. The analyses for the Weekeroo Amphibolite are plotted on Diagram 14. The author considers that the spread of points is too gread to draw any reasonable conclusions except to make the observation that the points group around the Karroo dolerites trend. Since the sedimentary "trend" is approximately perpendicular to the igneous trend then if sufficient analyses were available it should be possibl to determine the trend followed by the amphibolite in question.

The variation of al-alk with c can also be useful in determining any trends shown by amphibolite analyses. However, caution is needed since both al-alk and c vary strongly with the modal composition of the rock analysed (Evans and Leake 1960).

DIAGRAM 14 : Niggli mg against c plot.

$$c = \frac{100.Ca}{Ca+Mg+Al+Fe} \qquad mg = \frac{MgO}{FeO+MnO+2Fe_2O_3+MgO}$$

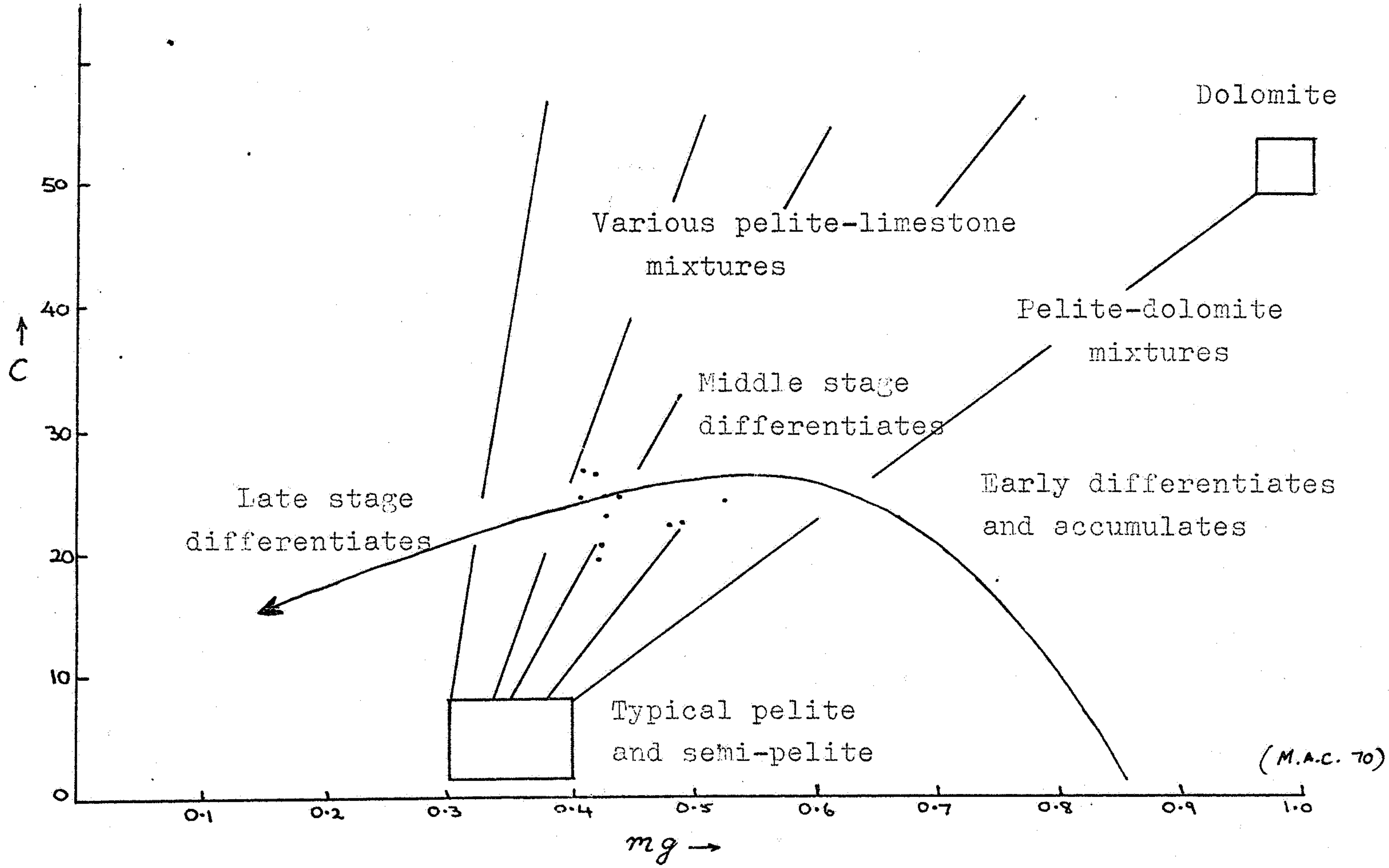


DIAGRAM 15 : Niggli al-alk against c.

(after Evans and Leake 1960).

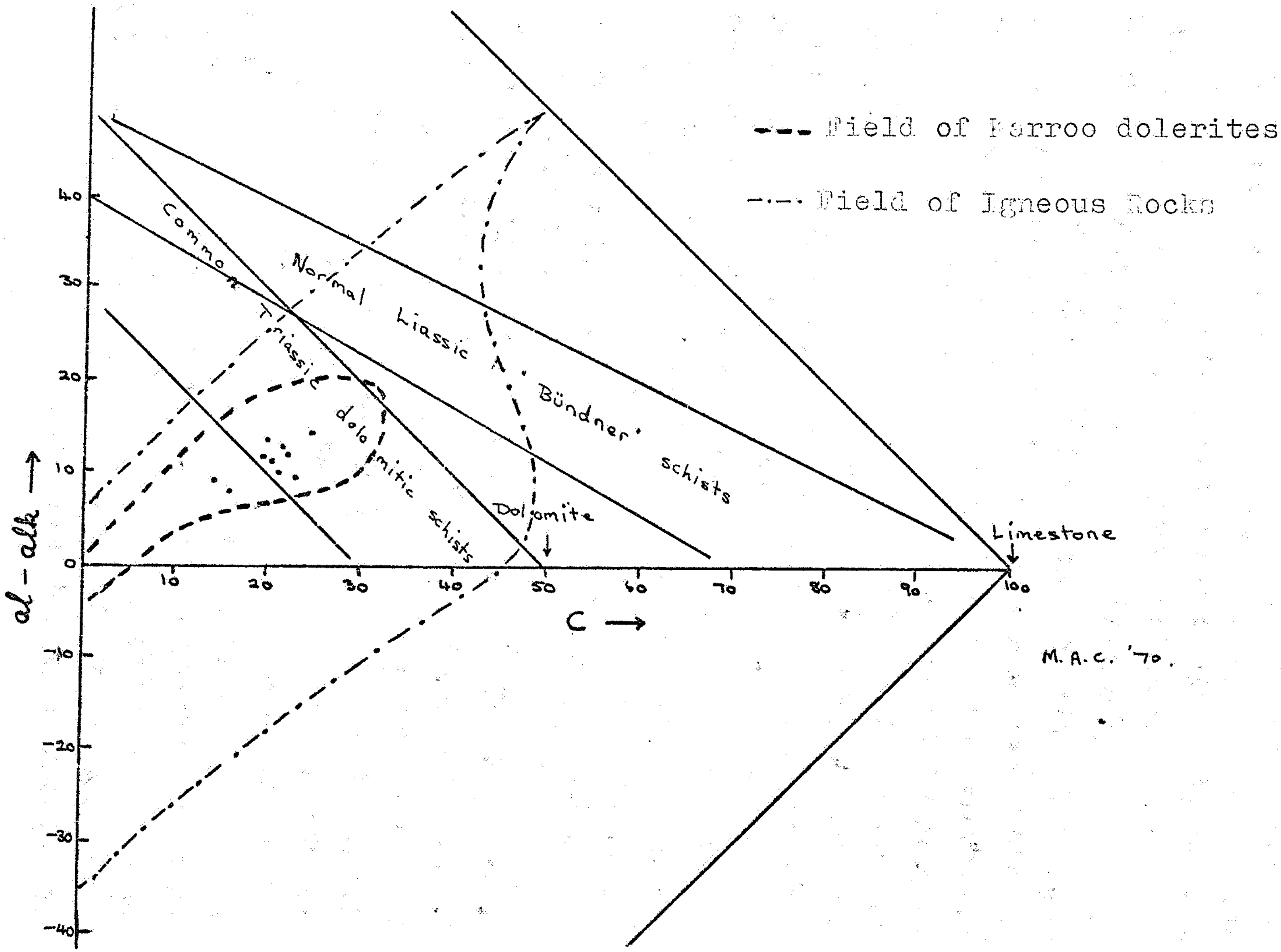


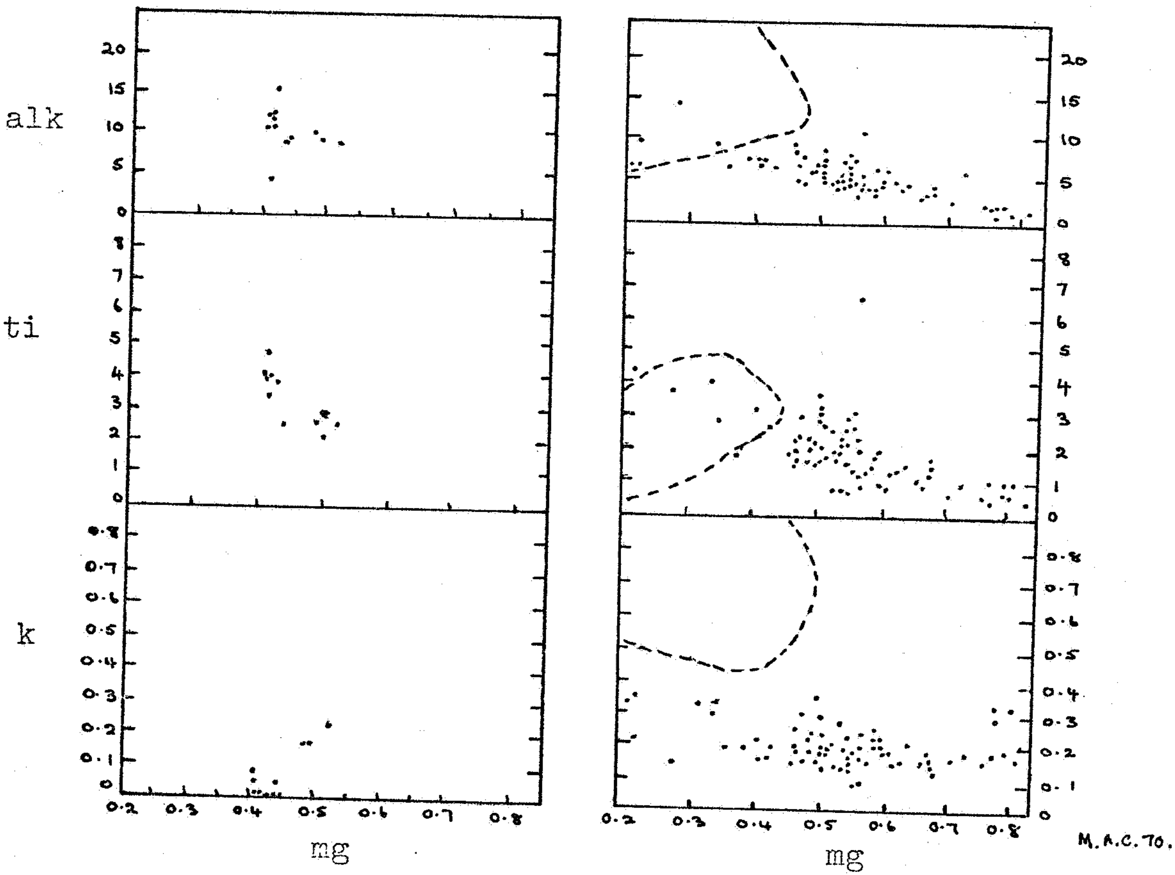
Diagram 15 shows a definite trend of the Weekeroo Amphibolite analyses approximately perpendicular to the tabulated sedimentary "trends". All of the analyses fall within the field delineated by the Karroo dolerites.

It was mentioned earlier that the fall of mg with increasing si is essentially a product of magmatic differentiation, being difficult to reproduce by consideration of metasomatic or other processes. Hence it is constructive to consider the variation of certain Niggli values with changes in mg ; Diagram 16 (after Leake 1964) shows such variations of alk, ti, and k with mg for both the Weekeroo Amphibolite (Diagram 16A) and the Karroo dolerites (Diagram 16B). The field of the Littleton pelites and the Connemara pelites is shown.

The most obvious feature of these plots is that for both alk and ti the points obtained from the Weekeroo Amphibolite lie on or near the boundary between the Karroo dolerites and the pelites region. The values for k, however, fall well away from the region where the pelites plot. Hence on absolute values little can be deduced. The author considers, however, that the ti plot shows a rise in ti with a decrease in mg, to be expected during the process of differentiation. The spread in points for the alk plot is probably a product of metasomatism. There is a strong suggestion of an increase in k with an increase in mg, the exact opposite of a differentiation scheme but what would be expected from the gradual addition of a pelite to a dolomite. However, the author thinks that the very low k values involved are of primary importance (all 0.2 whereas some 0.6 in clays). With the variation of k deduced being due to alkali metasomatism and possibly sericitisation, both evident in the amphibolite.

DIAGRAM 16 : alk, ti, k, against mg.

(after Leake 1964)



Weekeroo Amphibolite

Karroo dolerites & Connemara and Littleton pelites, (enclosed area).

TABLE 6.

	WEKGROO AMPHIBOLITE		IGNEOUS			SEDIMENTARY			BLACK
	RANGE	AVERAGE	ULTRA	MAFIC	FELSIC	LIMESTONE	S.STONE	SHALE	SHALE
Ni	67.6-170.1	116	1200	160	8	3-10	2-10	20-100	20-300
Cr	9.9-260.2	89	2000	300	25	5	10-100	100-400	10-500
Cu	12.2-327	128	80	140	30	5-20	10-40	30-150	20-300
Co	76.1-125.3	96	200	45	5	0.2-2	1-10	10-50	5-50

Igneous and Sedimentary Data after Hawkes and Webb (1962)

TRACE ELEMENTS:

In additiontto major oxides the rock samples of the Wookeroo Amphibolite were analysed for the trace elements Ni, Cu, Co, and Cr (Table 3). The range of values obtained for each element and their averages are compared with the expected values for different rock types (from Hawkes and Webb 1962) in Table 6. Both Ni and Co compare best with mafic igneous rocks, Cu and Cr with either mafic igneous rocks or shales, although the range recorded for the amphibolite tends to be large.

Leake (1964) considers that amphibolites rich in Cr, Ni and Ti with low k values "are almost certainly igneous in origin", whilst amphibolites low in Cr, Ni, and Ti with high k values can be of either origin. It is possible that the rather wide range seen for each element is indicative of a sedimentary origin since sediments are notoriously inhomogeneous in their trace element distribution. However, it could just as easily be due to sampling or even to the amphibolite being originally a layered intrusion (e.g. a series of sills).

During magmatic differentiation a decrease in Ni and Cr with the decrease in mg is well documented and in comparison with the sedimentary "trend" where on mixing of pelite and limestone Cr and Ni increase with decreasing mg. Hence seperation of ortho- from para-amphibolites should be relatively easy on the correlation of these two trace elements with mg. The variation in Cr and Ni with mg is shown in Diagram 17 for the Wookeroo Amphibolite and a comparison with the Karroo dolerites is made. In this diagram the plots of the Connemara and Littleton pelites are enclosed by the ringed areas.

The Karroo dolerites show strong positive correlation of Ni and Cr with mg whereas the pelites show little, if any, systematic variation. Co shows little variation with mg. The Wookeroo Amphibolite shows a positive correlation between Cr, and possibly Ni, and mg although the number of analyses makes the interpretation somewhat uncertain. For Ni and Cr

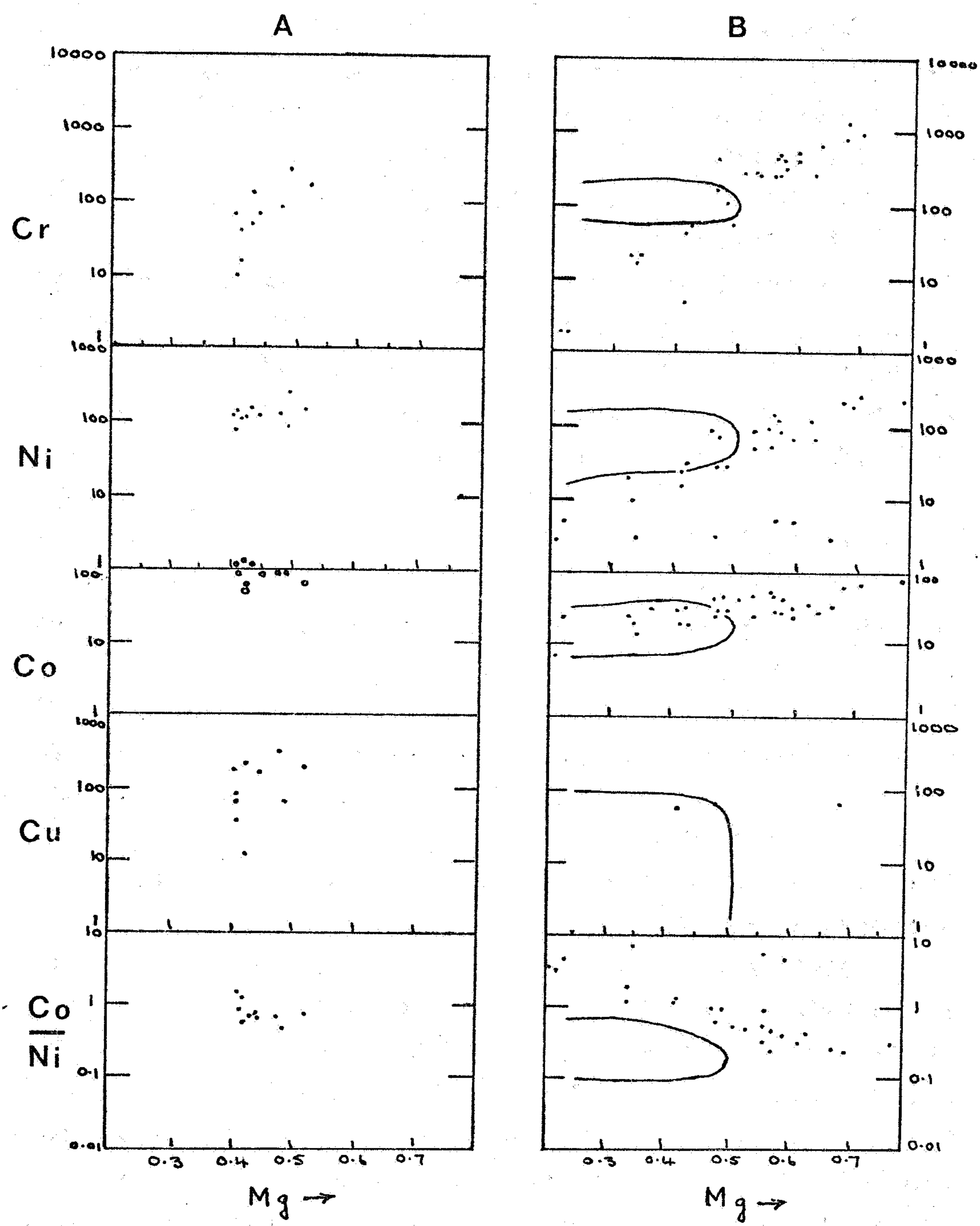


DIAGRAM 17 : (after Leake 1964)

there exists overlap between the analyses plots and the field for the pelites. However, this is fortuitous, the trend of the plots still being at an angle to the sedimentary "trends". Again Co shows little variation with mg (it does not vary with differentiation so much as Cr and Ni), and it lies well above the field for the pelites.

The trend for Co:Ni against mg is again uncertain but suggests a decreasing ratio with increasing mg, the trend shown by the Karroo dolerites. The absolute values lie just above the field characterised by pelites. Again it should be emphasised that the few analyses available combined with their rather limited range in compositions allows only suggestions to be made about trends present (if any), not decisions.

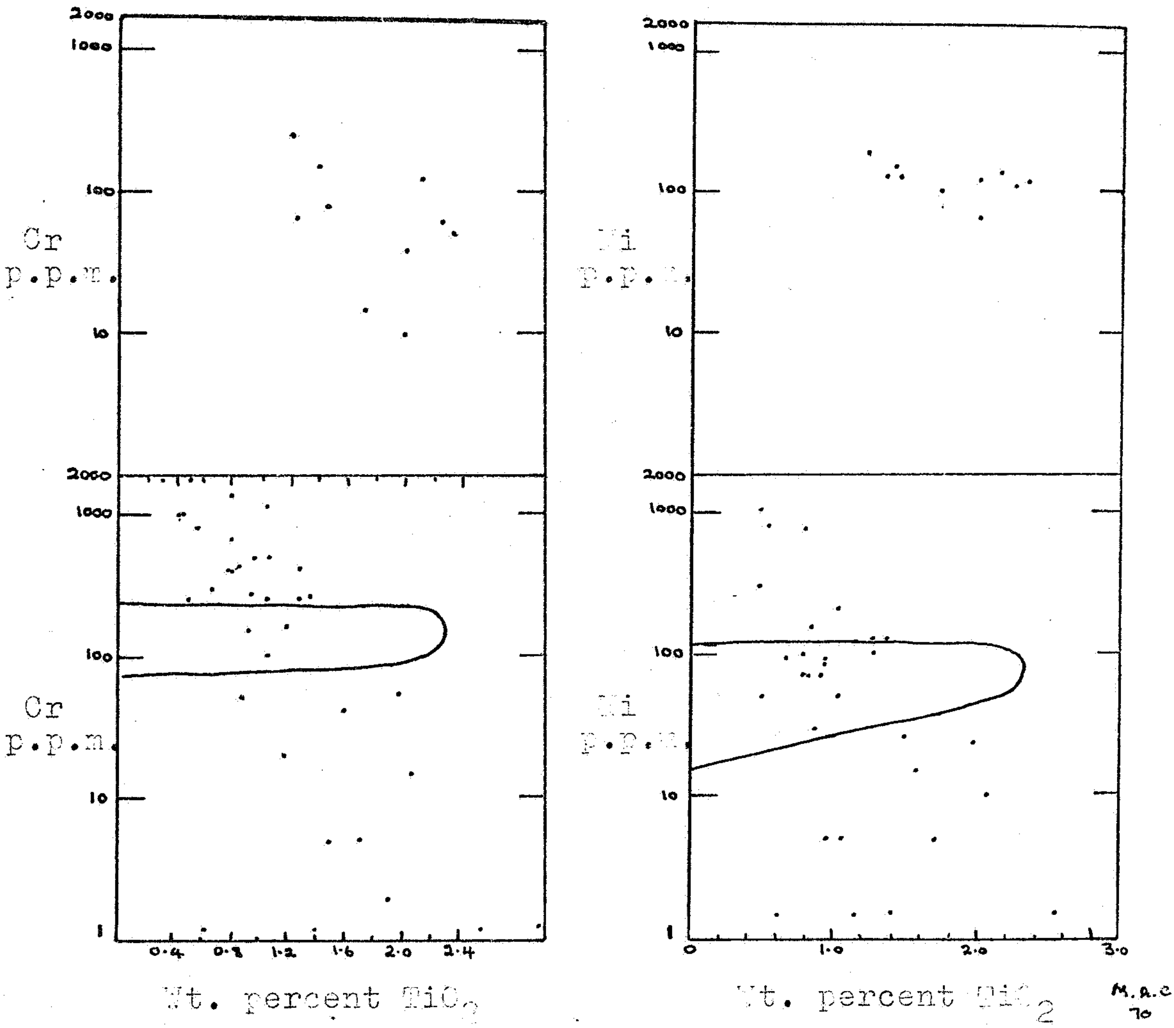
The use of Cu as an indicator of differentiation has been called into question by several workers including Heier (1962) who considers that its distribution is too erratic and that it is readily redistributed by metamorphism, hence negating its use. No trend is obvious in the plot for the Weekeroo Amphibolite (Diagram 17A) except possibly a rapid increase in Cu with little change in mg, although this is open to doubt. As for Ni and Cr, several of the analyses fall within the field characterised by pelites.

Since Ti, Cr, and Ni vary systematically with mg during differentiation of a basic magma then a relationship should exist between Cr and Ni, and Ni and Ti, and Cr and Ti. A negative correlation for the latter two is expected (Leake 1964). Comparison of the values obtained for the Weekeroo Amphibolite with that shown by the Karroo dolerites and the Connemara and Littleton pelites can be made in Diagram 18, the pelites plotting within the enclosed field.

Diagram 18A is a TiO_2 against Cr plot. Even though the spread in points is quite large a negative correlation is suggested, the rocks plotting in the same region as the Karroo dolerites. However, the TiO_2 against Ni diagram (18B) is even less convincing; the trend, if any, seeming essentially

Diagram 18 : TiO_2 wt. percent plotted against Ni, Cr.

Pelites enclosed in ringed area.
(after Leake 1964)



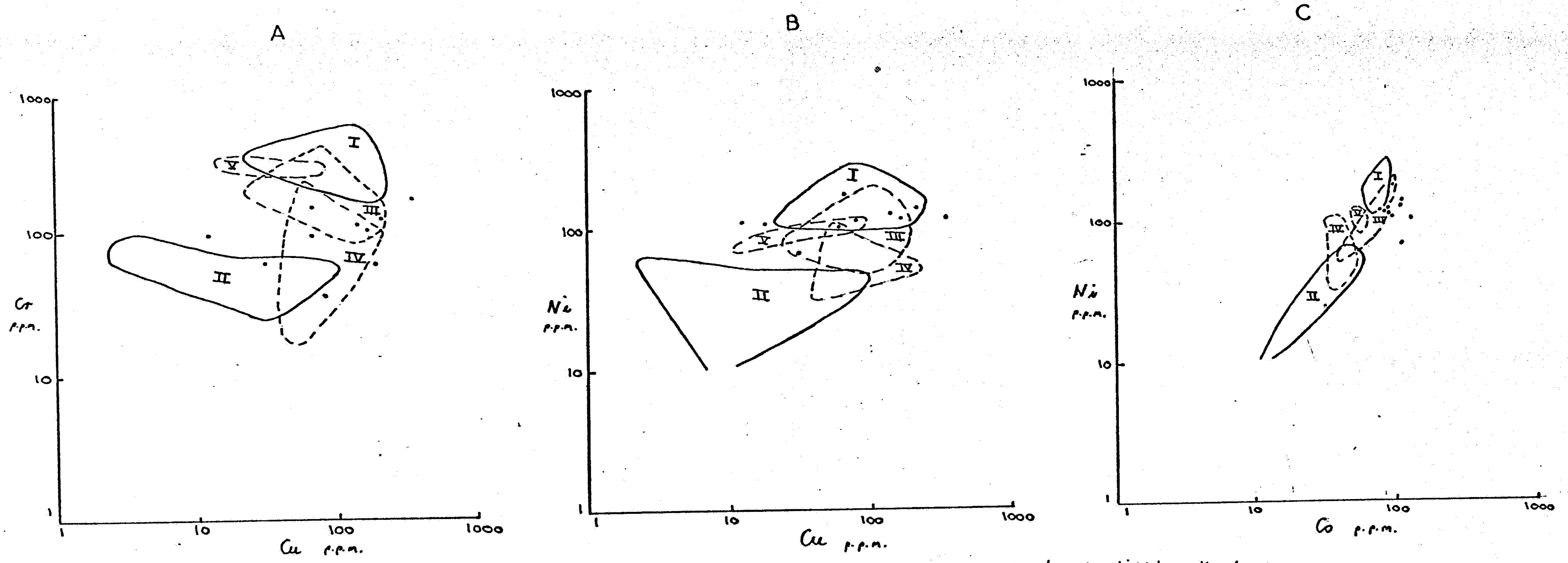


DIAGRAM 19

I = unaltered and slightly altered basic magmatic rocks.

II = para-amphibolites of low to moderate grade alteration, including metasomatism.

III = metamorphosed basic magmatic rocks (metadolerites and metabasalts)

IV = ortho-amphibolites, intensely metasomatised

V = para-amphibolites, intensely metasomatised.

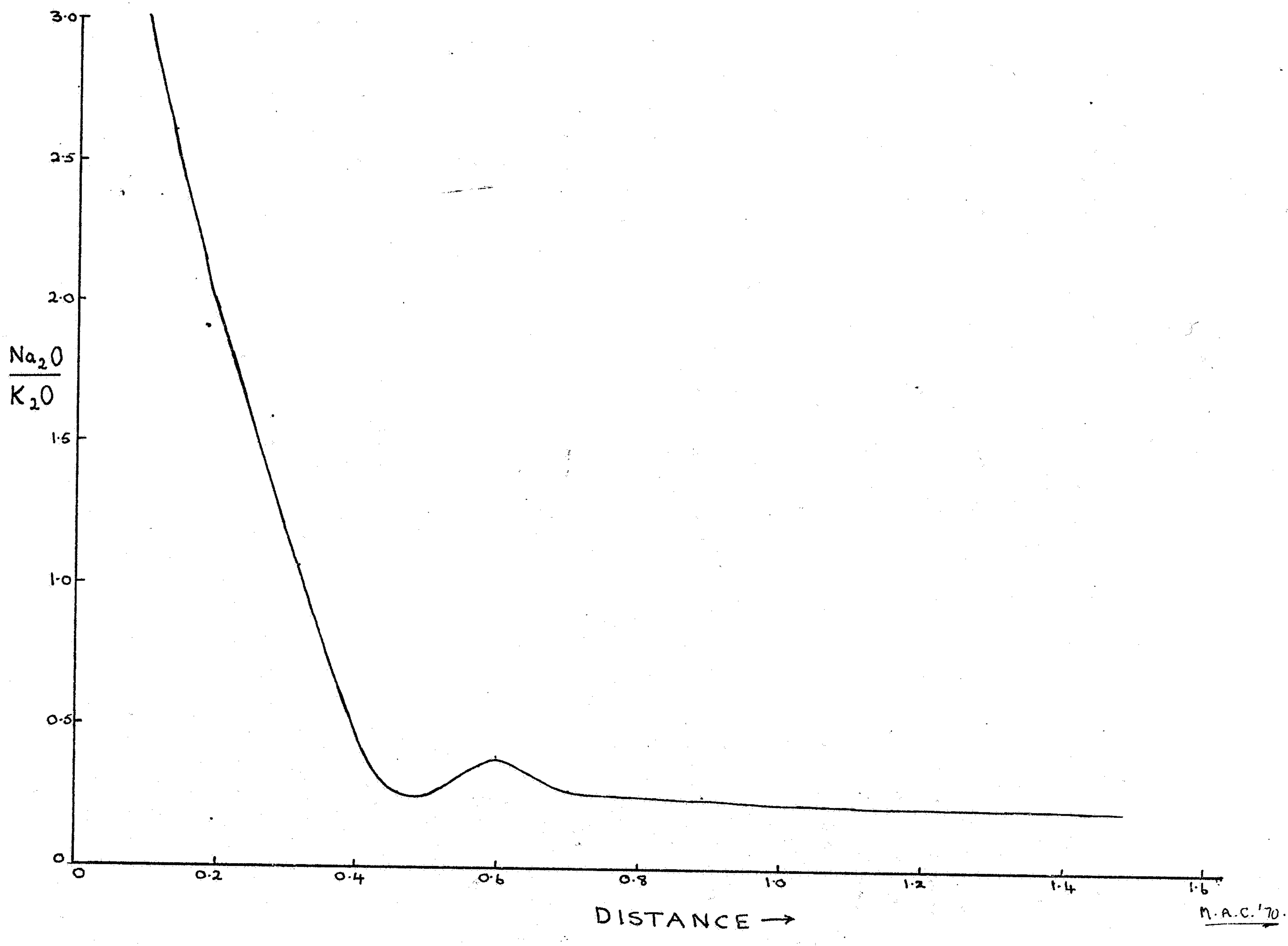
(M.a.c 1970)

horizontal mimicing a sedimentary trend but with a higher total content. The results obtained from these particular variations are inconclusive.

Walker et. al. (1960) used logarithmic plots of Ni-Cr, Ni-Co, and Cr-Cu to attempt a destinction between ortho- and para-amphibolites. The corresponding plots for the Weekeroo Amphibolite are shown in Diagram 19. From analyses of known rocks Walker et. al. determined fields for the various rock types (I - V in Diagram 19) related to amphibolites. Metamorphism and metasomatism tend to bring together the original unaltered basic igneous rock field and slightly altered (metamorphosed and metasomatised) para-amphibolite field. In general they found that metamorphism and metasomatism caused convergence of the fields of each rock type, the degree depending on the intensity of the process. As was mentioned earlier Cu is easily activated during metamorphism and hence would then bear no relation to the original content of the rock or to any differentiation process acting. Consequently Diagrams 19A and 19B may have little significance since the Weekeroo Amphibolite has been obviously quite strongly metamorphosed and metasomatised. For Cr vs. Cu and Ni vs. Co the bulk of the plots seem associated with fields I and III and for the Ni vs. Cu with fields I, III, and IV. Very rarely do any of the points plot within fields II and V. Hence even though the plots are rather erratic in their distribution they tend to suggest basic rock affinities albeit metamorphosed and metasomatised.

The chemistry of the Weekeroo Amphibolite is far from conclusive in uniquely determining its origin. However, the variation diagrams for major oxides and their Niggli values strongly suggest a basic igneous origin; triangular diagrams (Orville 1969) and trace element variations are less conclusive The author considers the weight of evidence to lie on the side of a basic igneous rock origin (ortho-amphibolite).

DIAGRAM 20 : Na_2O / K_2O in schists.



Leake (1964) suggested that the spatial distribution of such factors as Niggli mg can often be used to determine the orientation and structural relationships of any particular amphibolite. Considering the Weekeroo Amphibolite the highest values for mg are congregated in the centre moving out into lower values. This would tend to indicate the early differentiates exist in the centre provided the body is a single unit. Brian Morris (pers. comm.) in his study of amphiboles considers the centre of the body to have been a region of higher temperature, possibly corresponding to initial differentiates. Many more analyses are required, however, to confirm the distribution of values such as mg.

<u>METASOMATISM - Na_2O : K_2O Ratio</u> :

During field mapping a series of schists were collected outwards from the amphibolite-schist contact. These were later analysed for Na_2O and K_2O (Appendix III). The resultant plot of Na_2O : K_2O against distance out from the contact is given in Diagram 20.

Sodium metasomatism is evident both in the field and in the petrological study of thin-sections. Diagram 19 shows the variation in Na_2O : K_2O along the length of the body. A similar diagram can be prepared for a north-south traverse. Hence the effects of the metasomatism appear to decrease towards the centre, as to be expected.

Diagram 20 shows the rapid decrease in Na_2O : K_2O with distance from the contact into the schists (note that the value of Na_2O : K_2O obtained for the sample 341-Z, a massive albitite on the contact, was 3940 and hence has not been plotted It is suggested by the author that at least two phases of metasomatism have occurred, the second more extensive and forming the veining in the agmatite and the groundmass in the "albitite" breccia. The bulk of the metasomatism is restricted to the contact of the amphibolite and schists and to a short distance either side. Brecciation of the amphibolite and shearing of the schists with the associated increase in permeability probably provided the pathway for the rising metasomatising solutions.

An interesting feature of Diagram 20 is the rise in Na_2O : K_2O at a distance out from the body. This peak probably coincides with the hill of massive "albitite" in the schists in the north-east corner of the amphibolite. Since the schists on the north are quite strongly sheared it is possible that the Na enrichment in this zone is due to excessive shearing.

The variation in the Na_2O : K_2O ratio out from the body can be correlated with the change in schist type starting from a massive albitite and grading out through albite schists with albite bands (a+as), albite schists (as), albite mica schists (ams), and finally the weakly to unaffected mica schists (Weekeroo Schists). The use of the term albite is somewhat of a misnomer as the plagioclase is generally oligoclase.

Close to the amphibolite-schist boundary a few of the schists show a spotting effect with essentially muscovite being concentrated in patches (e.g. 542-14, 542-63). Agrell (1939) considers a similar feature at Dinas Head as being due to a thermal effect by heat from an intrusive dolerite and being attributed to "the active nature of the water contained in the rock". The author considers that later metasomatism has all but obliterated this effect since it is only seen where Na-metasomatism is least extensive.

It is considered that at least two phases of Na-metasomatism have occurred the second of increased intensity, with brecciation of the amphibolite and earlier metasomatic plagioclase rock preceeding the second phase. The brecciation increased the extent to which the metasomatising fluid could penetrate the amphibolite. It is possible that hydrothermal post-magmatic processes are responsible for the Na-bearing solutions (Mehnert 1968 p. 153).

CONCLUSIONS :

From a consideration of the data obtained during this study several conclusions can be reached as to the origin and post-formational history of the Weekeroo Amphibolite.

1) That most of the body is of a basic igneous origin.
   a) The field relationships are inconclusive, the metasomatism evident being essentially a contact effect and hence obliterating the amphibolite / schist contact. The contact appears to be non-concordant, however, since the country rock schistosity and banding strikes into the body on both the north and south sides. The approach to parallelism at the contact is essentially a shearing effect. The agmatite is probably an intrusive breccia. The north-south layers tend to indicate a layered sequence of intrusives.
   b) Thin-section studies indicate distinct relict doleritic textures. Metasomatism of the main bulk of the amphibolite ("normal" amphibolite) is uncommon being restricted to border zones and irregular north-south banding.
   c) The total rock and trace element chemistry gives strong evidence for differentiation in a basic igneous body.

2) That a possible sedimentary origin may be proposed for the northern and western portions out from the magnetite bands. The possibility of graded bedding is the main evidence for this.

3) That the Weekeroo Amphibolite is intimately associated with the amphibolite to the east and the amphibolite to the west. Both show strong contact metasomatism, agmatite

formation and magnetite bands. Tectonism in the form of intense shearing in an east-west direction and boudinaging on a regional scale has resulted in their present forms and distribution. The small outlier of the Weekeroo Amphibolite is interpreted as a sheared off fragment.

4) That the most probable form of the body at emplacement was a series of essentially flat-lying sills (layered intrusion?) with sedimentary 'rafts' being incorporated along 'inter-layer' boundaries. The present form of the latter is due to metasomatism and metamorphic differentiation, and their present orientation to regional tectonics.

5) That the amphibolite has suffered at least two phases of metamorphism, the earlier phase to the epidote-amphibolite facies of regional metamorphism resulting in the amphibole-intermediate to sodic plagioclase-epidote assemblage (from the earlier mineralogy of pyroxene and calcic plagioclase), the later phase to the upper greenschist facies. This latter metamorphism is responsible for amphibole going to chlorite and biotite, opaque (ilmenite or titanomagnetite) going to sphene and the formation of the amphibole-chlorite schists in the main body.

6) That the amphibolite has suffered two phases of Na-metasomatism, the later of greater intensity and extent. The metasomatism is essentially a contact effect, in itself evidence for an intrusive origin. Metasomatism is only extensive within the body along north-south bands, probably relict sedimentary rafts.

FUTURE WORK :

This project has collected together a certain ammount of data that allows tentative suggestions to be made about the history of the Weekeroo Amphibolite. In any future work it would be wise to include a study of the two other large amphibolite bodies. More intensive mapping is suggested particularly of contact relationships. A petrological analysis of the plagioclase feldspars should supply general information on plagioclase in a metamorphic environment, particularly of the so called chequerboard albite. More detailed chemistry is essential to delineate accurately any trends present and this study in particular should be carried to the other bodies. Geophysics in the form of ground magnetics or low aeromagnetics would be very useful as an aid in deducing the shape and structure of the body (a previous survey by S.A. Dept. of Mines with wide flight line spacing indicated a strong anomaly over the body).

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BIBLIOGRAPHY.

Battey, M.H. (1955), "Alkali Metasomatism and the Petrology of some Keratophyres." GEOL. MAG. xcii (2) : 104-126.

Campana, B. & King, D.(1958), "Regional Geology and Mineral Resources of the Olary Province." S.A. Dept. of Mines Bulletin No.34.

Deer, W.A., Howie, R.A., & Zussman, J. (1966), "An introduction to the rock forming minerals." A LONGMANS PUBLICATION. (also seperate volumes).

Edwards, A.B. (1958), "Amphibolites from the Broken Hill District." JOUR. GEOL. SOC. AUST., 5(1) : 1 - 32.

Evans, B.W., & Leake, B.E., (1960), "The Composition and Origin of the Striped Amphibolite of Connemara, Ireland" JOUR. PET. 1 : 337 - 363.

Falkum, T. (1969), " A Deformed Agglomerate in the Pre-Cambrian Migmatites of Southern Norway." N.G.T. 49 : 367 - 386.

Hawkes, H.E., & Webb, J.S. (1962), "Geochemistry in mineral exploration." HARPER INTERNATIONAL.

Heier, K.S. (1962), "The possible origins of amphibolites in an area of high metamorphic grade." N.G.T. 42 : 157-165.

Johannsen, A. (1931), "A descriptive petrography of the igneous rocks." UNIV. of CHICAGO PRESS.

Jones, J.B., Talbot, J.L., and McBriar, E.M., (1962), "A suite of volcanic rocks with spilitic affinities from the Archean of South Australia." AUST. JOUR. SCI. 29 : 356.

Krauskopf, K.B., (1967), "Introduction to Geochemistry." Mc.Graw Hill Book Company.

Leake, B.E., (1964) "The Chemical Distinction between Ortho- and Para-Amphibolites." JOUR. PET. 5(2) : 238-254.

Mawson, D. (1912), "Geological Investigations in the Broken Hill Area." MEM. ROY. SOC. S. AUST., II (3).

Mehnert, K.R. (1968), "Migmatites and the Origin of Granitic Rocks." ELSEVIER PUBLISHING Co.

Orville, P.M. (1969), "A model for metamorphic differentiation origin of thin-layered amphibolites." AM. JOUR. SCI. 267 : 64 - 86.

Starkey, J. (1959), "Chessboard albite from New Brunswick, Canada." Geol. Mag. 96 : 141 - 145.

Talbot, J.L., (1962) "A study of the structural and metamorphic relationships between Older and Younger Pre-Cambrian rocks in the Mt. Lofty - Olary Arc, South Australia." UNPUB. THESIS, UNIV. of ADELAIDE, 171 pp.

__________, (1967) "Subdivision and structure of the Pre-Cambrian (Willyama Complex and Adelaide System), Weekeroo, South Australia." TRANS. ROY. SOC. S. AUST. (1967) 91 : 45 - 57.

Vallance, T.G., (1960), "Concerning Spilites." Presidential Address, PROC. LINNEAN SOC. N. S. W. 85 : 8 - 46.

Walker, K.R., Joplin, G.A., Lovering, J.F., Green, R. (1959), "Metamorphic and Metasomatic Convergence of Basic Igneous Rocks and Lime-Magnesia Sediments of the Pre-Cambrian of North-Western Queensland." JOUR. GEOL. SOC. AUST. 6(2) : 149 -178.

Whittle, A.W.G., (1948), "The Geology of the Boolcoomata Granite." TRANS. ROY. SOC. S. AUST. LXXII (2):228-243.

APPENDIX I

Plates 1 - 10

Plate 1

A. Albite breccia showing albitite pieces with albitite with amphibole needles around it.

B. Agmatite, with albite rich neosome veining the paleosome of amphibolite.

C. "Granular" breccia, showing sub rounded fragments of albitite, amphibolite and magnetite rich layers.

PLATE 1

A

B

C

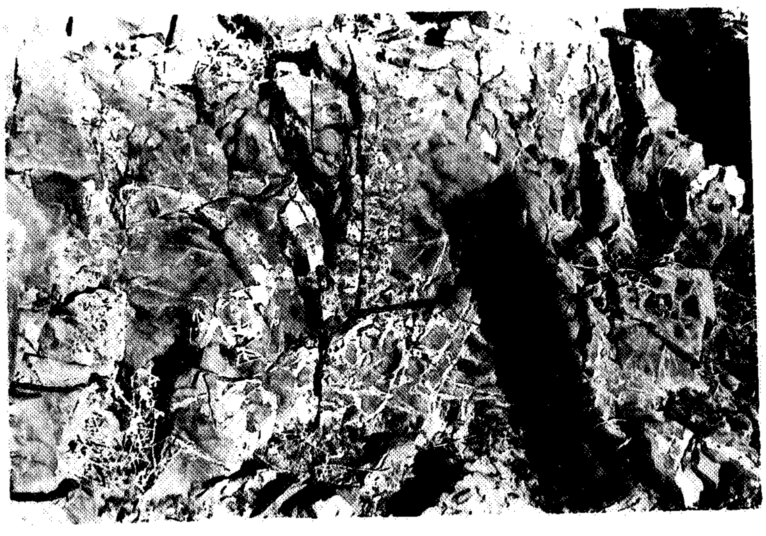


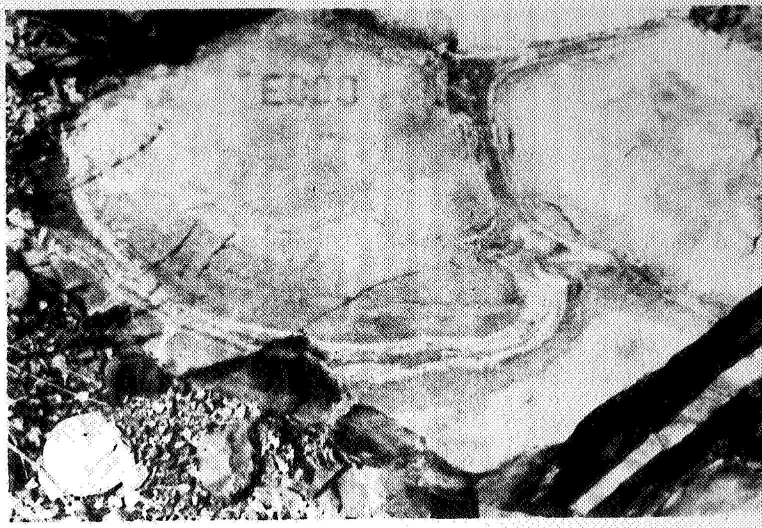
Plate 2

A. Possible pillow structures in amphibolite.

B. Albitite with amphibole needles.

C. Agmatite with partly replaced paleosome.

PLATE 2



A

B

C

Plate 3

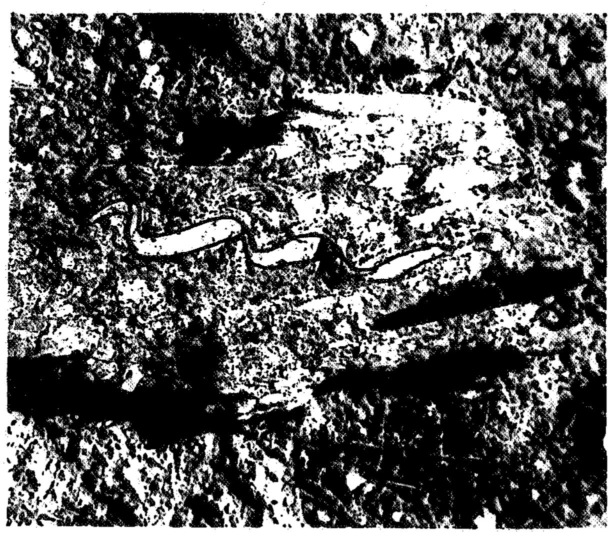
A. Albitised meta-sediments adjacent to the body.

B. Plastic deformation of albitised meta-sediments adjacent to body.

C. Folding of layering in the Weekeroo schists with axial plane schistosity.

PLATE 3

A



B

C

Plate 4

A. Outcrop of "slaty" albitite with amphibole rich layers that occurs within the body.

B. An albitite layer with amphibole rich bands within the body, terminating and "fingering" into the amphibolite.

C. Outcrop of albitite layer with amphibole rich bands, showing the dip of the layer.

PLATE 4

A

B

C

Plate 5

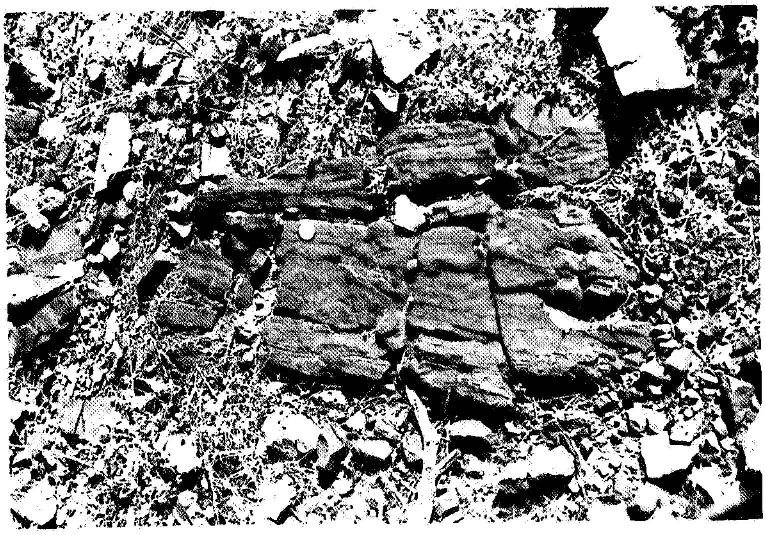
A. Outcrop of magnetite rich layer.

B. Fold of albitite rich layer within the amphibolite.

C. Outcrop of an amphibole-chlorite schist zone.

PLATE 5

A



B

C

Plate 6

A. General view of amphibolite body showing the gently rounded hills and scree coverd slopes.

B. "Mauds Hill". A concentration of albitite in the Weekeroo schists. With the amphibolite in the background and a pegmatite zone in the fore ground.

C. A view showing the break in slope between the albitite of the body and the albitised schists.

PLATE 6

A

B

C

Plate 7

A. General section of the amphibolite showing it's doleritic texture. Plagioclase (p1), amphibole (am) and opaques (op) are the predominate minerals, (crossed nicols).

B. Ophitic texture of amphibolite, showing plagioclase laths within an amphibole crystal. (crossed nicols).

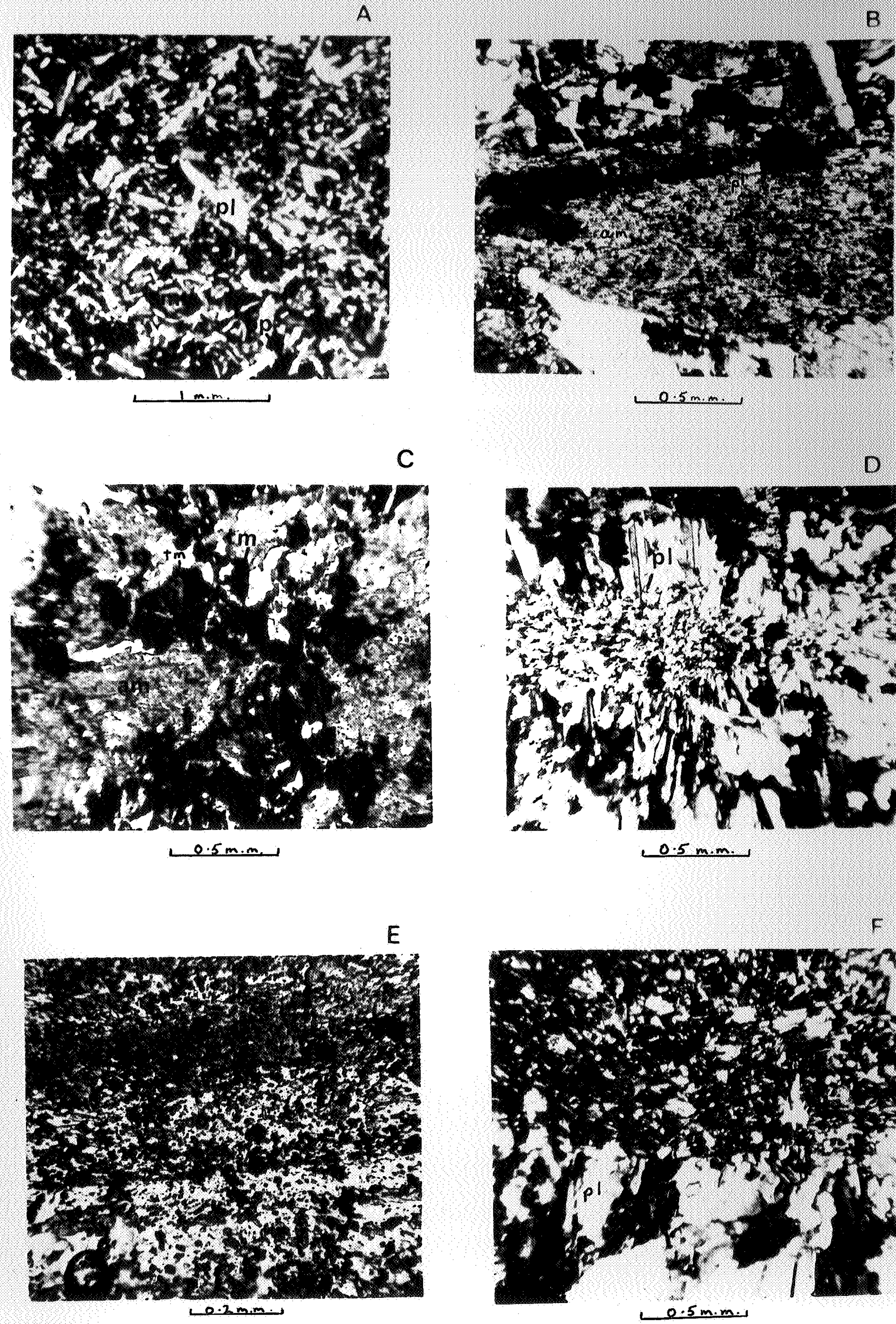
C. Granular tourmaline associated with poikiloblastic amphibole (plane polarized light).

D. Plagioclase crystals perpendicular to layering of interlocking xenoblastic plagioclase grains. (crossed nicols)

E. "Graded" bedding of magnetite grains in a plagioclase groundmass (plane polarized light).

F. Plagioclase crystals perpendicular to the contact of an amphibolite fragment in agmatite (crossed nicols).

PLATE 7



<u>Plate 8</u>

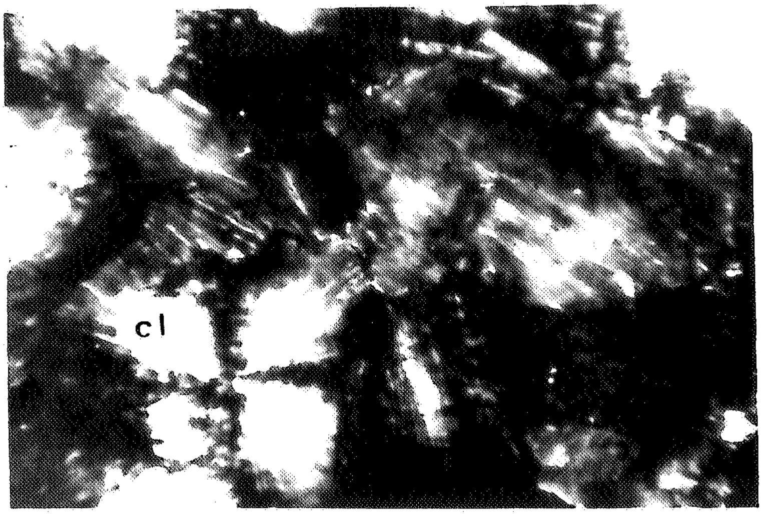
A. Spherulitic arrangement of fibrous chlorite. (crossed nicols)

B. Prismatic amphibole crystals surrounded by needles of amphibole in spherulitic array. Amphibole needles partially altered to chlorite. (crossed nicols)

C. Prismatic amphibole crystals cutting across layering of plagioclase, biotite and opaques. (plane polarised light)

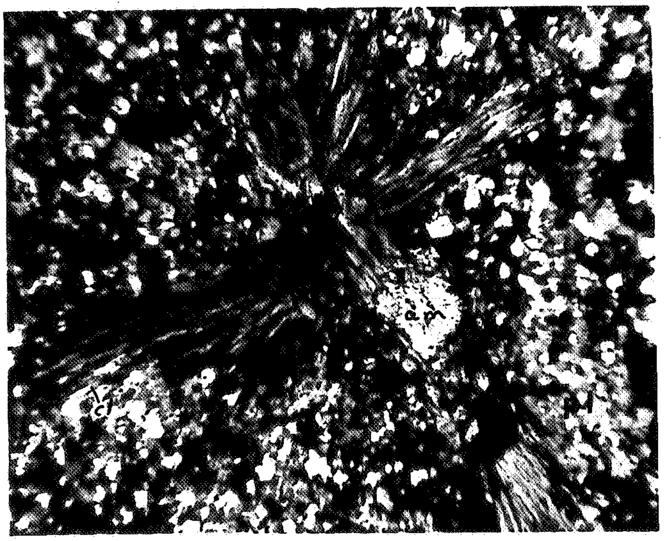
PLATE 8

A



0·2 m.m.

B



0·5 m.m.

C

0·5 m.m.

Plate 9

A. Chequerboard albite
(crossed nicols)

B. Opaques concentrated in one twin of a plagioclase crystal. (crossed nicols)

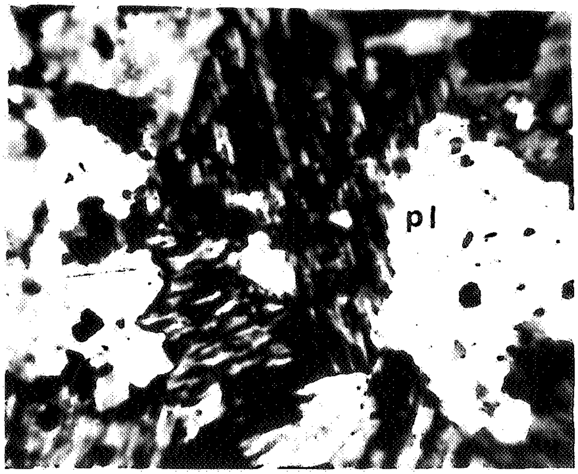
C. Bent twin lamellae in plagioclase.
(crossed nicols)

D. Myrmekite in amphibolite rock.
(crossed nicols)

E. Sphene with opaque inclusions and alteration to leucoxene on the surface.
(plane polarised light)

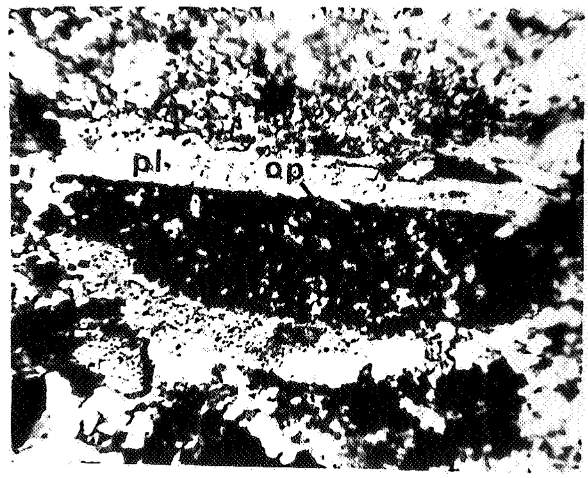
F. Skeletal magnetite.
(plane polarised light)

PLATE 9



0·1 m.m.

A



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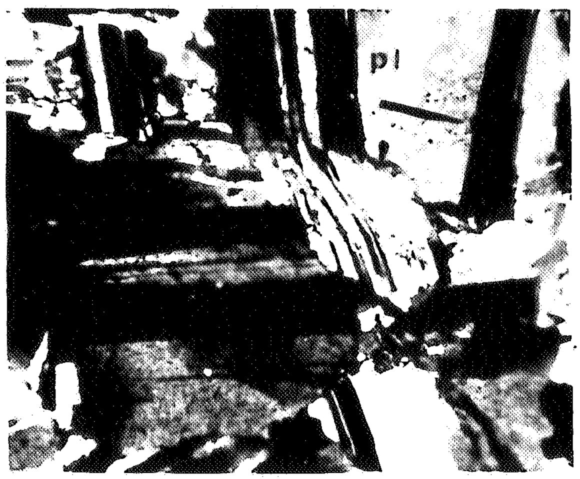
B

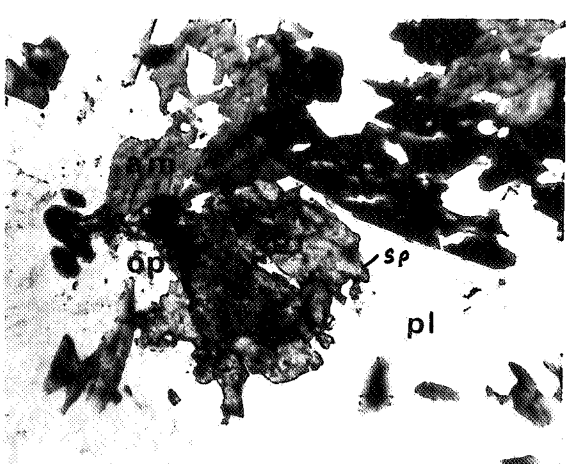


0·2 m.m.

C

0·2 m.m.

D



0·2 m.m.

E

0·2 m.m.

F

Plate 10

A. Zoned amphibole crystal.
(plane polarized light)

B. Poikiloblastic amphibole crystal with respect to opaques and plagioclase.
(plane polarized light)

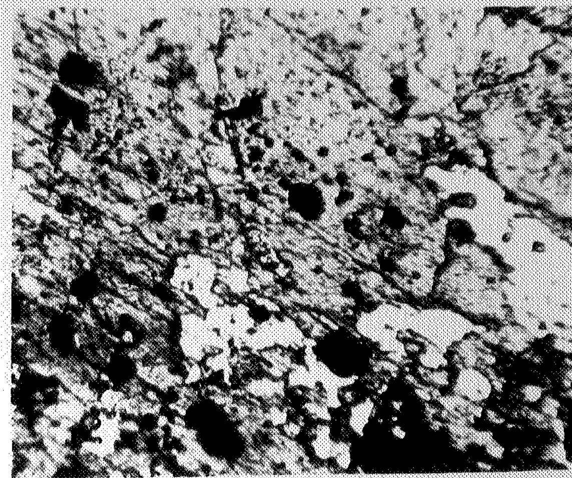
C. Epidote replacing amphibole
(plane polarized light)

D. Biotite replacing amphibole
(plane polarized light)

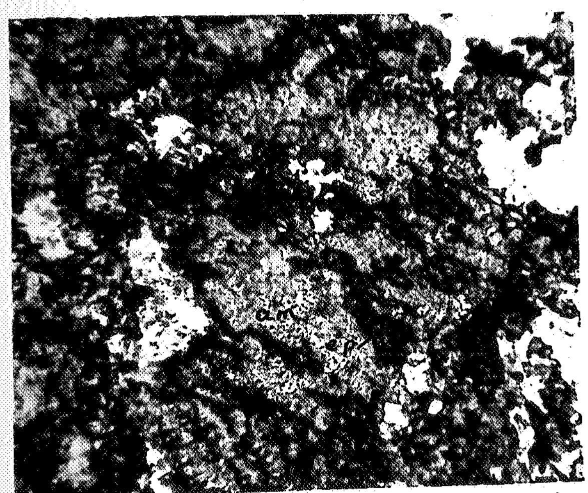
E. Prismatic amphibole crystal with fibrous amphibole.

PLATE 10

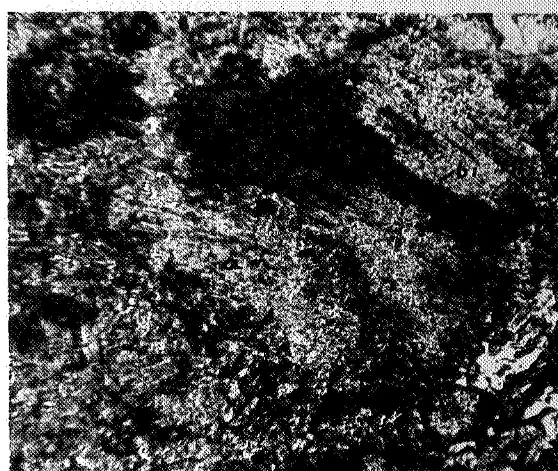
0·2 m.m. A



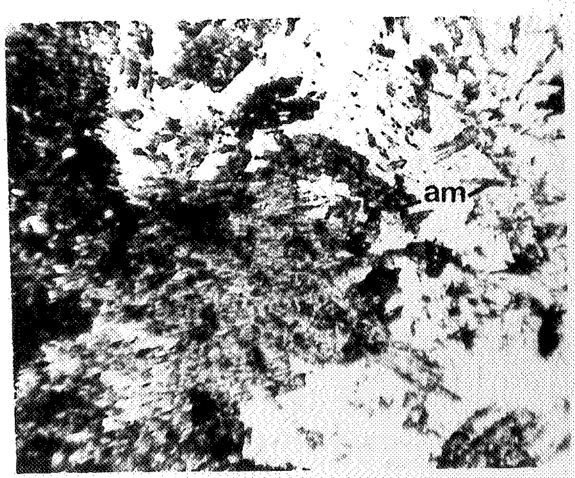
0·5 m.m. B



0·5 m.m. C



0·2 m.m. D



0·5 m.m. E

APPENDIX II

Thin section descriptions

M.A.Cobb, (342-) 75 sections

B.J.Morris, (341-) 73 sections

+9 polished sections

341 - 1a

Macro: Fine to medium grained massive albite rich rock. Made up of white areas up to 1 inch in size and surrounded by a darker grey albitite, giving the rock an albite breccia appearance.

Micro: Feldspar (75%): xenoblastic interlocking grains, size 0.1mm and have undulose extinction. Show albite and Carlsbad-albite twinning.

Ab_{85}, biax -ve, 2V = 63°

Grains with no twinning, inclusions in the core, size 1mm, Ab_{73}, biax +ve, 2V = 70 and makes up 30% of all feldspar.

Serecite (20%): highly birefringent needle like crystals showing straight extinction. Occur as accumulations between feldspar grains and no preferred orientation 0.15mm.

Quartz (3%): xenoblastic interlocking grains (0.15mm) with inclusions.

Minor: zircon, sphene, tourmaline.

341 - 2

Macro: Basal conglomerate containing sub-rounded grains up to 1 inch of albitite, quartz, quartzite, amphibolite with a fine to medium grained dark matrix of mica and amphibole.

Micro: Matrix

mica (80%): prismatic crystals 0.5 - 0.1mm with a rough preferred orientation and altered to opaques (1%) in part.

Rest of matrix made up of quartz and feldspar grains. Sub angular 0.1mm. Matrix is draped around the larger grains.

Large grains

Feldspar (70%): Sub angular grains (1mm - 5mm) with many inclusions and serecitised with altered edges. Ab_{72}.

Quartz (5%): Sub rounded grains (2mm) with many inclusions.

quartz-feldspathic rock (15%): granoblastic mozaic of interlocking crystals (0.1mm).

slate or shale (5%).

341 - 7b

Macro: Medium to course grained holocrystalline albitite with disorientated green amphibole needles.

Micro: Plagioclase (75%):: xenoblastic interlocking grains, twinning is not common, inclusions and undulose extinction. 0.1 - 0.4mm, Ab_{85}.

Amphibole (15%): Idioblastic form with absorbed edges, partly poikiloblastic. $\hat{ZC} = 22^\circ$, biax -ve, $2V = 70^\circ$, weakly pleochroic, light green-pale blue green. Inclusions of zircon, sphere albite.

Opaques (5%): Probably magnetite and associated with amphibole, has cubic habit.

Sphene (5%): xenoblastic grains with opaque inclusions. Pleochroic, light pink - colourless.

Minor: zircon

341 - 8

Macro: A fine to medium grained albite-mica schist, with thin layers defined by albite rich areas.

Micro: Mica (60%): Gives a lepidoblastic texture. Idioblastic grains 1mm long. biax -ve, pleochroic X = golden brown Y = Z = dark brown.

Plagioclase (30%): Very fine grained and difficult to do any more.

minor: opaques, tourmaline, zircon.

341 - 9

Macro: Medium grained albite rock with some layering and amphibole crystals having some preferred orientation.

Micro: Plagioclase (70 - 80%): Idioblastic grains (1mm) with preferred orientation and occur in layers with crystals lined up perpendicular to the layering. Layers 2mm thick. All show pericline or Carlsbad-albite twinning Ab_{84}. Also have layers consisting of fine grained (0.2mm) xenoblastic interlocking grains with very little twinning.

Amphibole (10 - 15%): Once well developed crystals are mostly replaced by albite. Size 1mm. Weakly pleochroic pale brown - pale green - blue green. $Z \wedge C = 15^\circ$, biax -ve, $2V = 65^\circ$.

Apatite (5%): xenoblastic grains, high R.I. and low birefringence, 0.1mm in size.

mica (1%): Prismatic flakes scattered through out the rock. Size 0.2mm.

<u>341 - 10</u>

Macro: A medium grained albitite with epidote and dark green course amphibole needles.

Micro: <u>Plagioclase</u> (80%): A granoblastic groundmass of interlocking xenoblastic grains (0.3mm) with no preferred orientation. About half the grains are twinned (Carlsbad-albite and pericline) Ab_{84}.

<u>Amphibole</u> (15%): Xenoblastic porphyroblasts with no preferred orientation 1.5mm. Poikiloblastic with plagioclase and opaque inclusions. Altered along edges to biotite.
Weakly pleochroic pale green - pale olive green.
$Z \hat{} C = 19^{\circ}$, $2V = 80^{\circ}$, biax -ve.

<u>Chlorite</u> (3%): idioblastic needles (0.1mm), biax +ve.

<u>Opaques</u> (4%): Poikiloblastic cubic grains of size 0.1mm - 0.6mm.

<u>Accessories</u>: Tourmaline, zircon, apatite, sphere.

341 - 13

Macro: An agmatite consisting of angular to sub-rounded recrystallized magnetic amphibolite with the neosome being medium grained albite which appears finer grained adjacent to the paleosome.

Micro: **Paleosome**

amphibole (85%): Poikiloblastic prismatic crystals 0.6mm in size with inclusions of zircon, sphere and opaques. Strongly pleochroic X = pale brown, Y = pale green, Z = blue green. biax -ve, 2V = 83° $\hat{ZC}$ = 20°.

Some zoning suggesting an Fe rich core. Altered to biotite and iddingsite along edges.

opaques (10%): Size 0.3mm with a roughly cubic form and closely associated with amphibole.

biotite (1%): Closely associated with amphibole.

plagioclase (1-2%): fine grained with very little twinning.

accessories: zircon, sphere, rutite, chlorite (near edges).

NEOSOME : Near edges of xenoliths it consists of fine grained albite (0.05mm) and fine needles of hornblende and chlorite. Carlsbad - albite twinning is common in the plagioclase. Fine cubic opaque grains are also in this zone. This zone consists of 70% albite, 15% hornblende, 5% chlorite, 5% magnetite.

The courser neosome is almost all interlocking idioblastic crystals (1mm) Ab_{82} with minor amphibole, chlorite and opaques.

341 - 15

Macro: A course grained albite - amphibolite rock with large accumulations of each. The amphibole is coursely crystalline.

Micro:

amphibole (47%): Poikiloblastic prismatic crystals (1mm - 5mm). Medium pleochroism. Inclusions of plagioclase and opaques and altered to biotite at edges.
biax -ve, 2V = 75° $Z\hat{}C$ = 18°.

plagioclase (45%): A groundmass of interlocking xenoblastic grains (0.2mm) with irregular boundaries and minute inclusions and serecitised.
biax -ve, 2V = 60° Ab_{80}.

sphene (2%): xenoblastic grains (0.4mm) with opaque inclusions and also surrounds some opaques as a rim. Pleochoroic pale pink - buff.

opaques (1-2%): Generally has a cubic form (0.1mm).

accessories: zircon, tourmaline, quartze, K-feldspar.

341 - 19

Macro: Coursely grained holocrystalline "spotted" amphibolite rich in epidote.

Micro: amphibole (30%): xenoblastic, prismatic grains giving a porphyroblastic texture to the rock. Altered and replaced with irregular edges. Biotite epidote and sphene are closely associated.

$Z \hat{} C = 14^{\circ}$ biax -ve, $2V = 70^{\circ}$.

Pleochroic X = pale brown Y = green Z = blue green.

Epidote (40%): xenoblastic grains (0.2mm) with a mortar structure. Closely associated with sphene and amphibole. biax -ve, $2V = 70^{\circ}$ pleochroic, pale yellow green - colourless - yellow green.

sphene (7%): xenoblastic grains (0.3mm) with pleochroism light pink - colourless.

biotite (3%): xenoblastic grains (0.3mm) and seem to be alteration of amphibole. Pleochroic, X = straw yellow Y = dark green brown.

plagioclase (20%): Groundmass of interlocking xenoblastic grains (0.1mm). Very little twinning and some graphic intergrowth with quartz.

accessories: tourmaline, rutile, opaques, zircon.

341 - 21b

Macro: A fine grained homogeneous rock with some fine banding.

Micro: plagioclase (30%): granoblastic, interlocking xenoblastic grains (0.1mm) uniacial +ve. Some layers finer frained. Some faint strain shadows.

Muscovite (20%): Elongate flakes (0.05mm) ligned up parallel to the bedding.

Rutile (2%): Sub idioblastic crystals 0.01mm up to 0.1mm in size and concentrated in the courser layers.

accessories: tourmaline, zircon, opaque, sphene, serecite, chlorite.

341 - 27a

Macro:

Granular breccia with feldspar as course granules 10mm in size and less with a medium grained matrix of amphibole and plagioclase.

Micro:

amphibole (30%): xenoblastic grains (0.2mm) with inclusions of biotite, opaques and sphene. Pleochroic colourless - light green - blue green. $Z \hat{} C = 15^{\circ}$ biax -ve 2V = 85.

opaques (15%): As idioblastic cubic grains replacing amphibole or surrounding it. (0.2mm). Very fine grained when it covers one half of a feldspar twin. Itself is altered to sphene.

plagioclase (45%): Occurs as large grains 1mm and shown Carlsbad-albite twinning and as minute inclusions, edges are absorbed.
Ab_{96} biax -ve $2V = 50^{\circ}$.
The matrix is a fine grained (.1mm - 0.05mm) interlocking mozaic of plagioclase and quartz.

quartz (3%): as xenoblastic grains 1mm and also in the matrix where it is fine grained .1mm or less.

spinel (1%): occurs associated with magnetite.

biotite (1%): as alteration product of amphitole.

accessories: zircon, sphene.

341 - 27b

Macro: A fine grained thinly laminated rock. Layers 1mm wide and some are very rich in magnetite while others are feldspathic.

Micro: Shows graded bedding.

amphibole (50%): Xenoblastic elongate interlocking grains which tend to bepparallel to the layering. Edges and cleavages are altered to red iddingsite. Inclusion of plagioclase, opaques and sphene. biax -ve, 2V = 70° $Z \hat{} C$ = 17° size .1mm - 1.5mm. Pleochroic pale grey green - pale green - pale blue green thus Fe deficient.

Plagioclase (40%): Xenoblastic interlocking sub rounded grains with inclusions of magnetite. size 0.07mm. Sone show Carlsbad - albite twins. Ab_{90}.

Magnetite (7%): As cubic grains (0.1mm) as solitary grains and as inclusions in amphibole and feldspar and rimmed with sphere. They define some graded bedding?

Sphene (1%): Xenoblastic grains and surrounds magnetite. Pleochroic pale pink - colourless.

accessories: zircon, tourmaline, biotite.

341 - 30

Macro: A medium grained albitite rock with layers 2mm wide defined by amphibole rich and deficient layers.

Micro: Granoblastic generally with amphibole producing a porphyrablastic texture.

Amphibole (35%): Prismatic crystals (1mm) tending to be porphyroblasts. Grains are absorbed and altered with inclusions of epidote and plagioclase and sphene giving a poikiloblastic look.
Biax -ve, $2V = 73^{\circ}$, $Z\hat{}C = 18^{\circ}$.
Pleochroic dark olive green - blue green - pale brown thus is fairly Fe rich.

plagioclase (55%): A mozaic of interlocking xenoblastic grains (0.3mm) with irregular edges. Some twinning Ab_{95}. Grains elongate and show a preferred orientation parallel to the layering.

epidote (2%): xenoblastic grains (0.2mm) showing a mortar structur.

sphene (1%): Sub-idioblastic form and pleochroic pink - colourless. Size 0.1mm.

accessories: biotite, opaques, zircon, quartz.

341-33

Macro: Course grained albitite with porphyroblasts of amphibole in a random array.

Micro: amphibole (30%): Xenoblastic porphyroblasts up to 5mm. Altered and replaced at edges and cleavages to sphene, plagioclase, and opaques.

$Z \hat{} C = 12^{\circ}$ biax -ve $2V = 70^{\circ}$.

strongly pleochroic thus Fe rich.

plagioclase (63%): As granoblastic groundmass of interlocking xenoblastic grains (0.02mm) and show very little twinning. Have strain shadows. Tend to get courser crystals around amphibole grains that show Carlsbad - albite twinning. Ab_{96}. Sericitesed and have small inclusions.

sphene (2%): xenoblastic grains (0.1mm) and generally surrounds opaques.

accessories: biotite, opaques, zircon and rutile.

341 - 34

Macro: Medium to course grained albitite rock, layered with amphibale rich and deficient layers.

Micro: Amphibole (45%): xenoblastic crystals with irregular edges and with inclusions of feldspar and opaques and also altered to biotite in part. Zoned with Fe rich rims. Pleochroic blue green - pale green - pale brown. $Z \hat{} C = 21^{\circ}$, biaxial -ve, $2V = 80^{\circ}$ size 0.5mm.

Plagioclase (45%): As granoblastic groundmass of xenoblastic interlocking grains (0.05mm) with quartz also associated. Some grains show Carlsbad - albite twinning. Ab_{92}.

Opaques (10%): Sub idioblastic cubic form (0.2mm) associated with both feldspar and amphibole.

quartz (5%): Mostly xenoblastic grains associated with the plagioclase of size 0.05mm. Also occurs in courser clumps 0.5mm.

accessories: biotite, zircon, sphene.

<u>341 - 43</u>

Macro: A course grained holocrystalline albitite rock with areas of course green amphibole.

Micro: granoblastic texture

<u>Amphibole</u> (35%): xenoblastic interlocking grains (0.7mm) and weakly pleochroic thus Fe deficient $\hat{ZC} = 19^{\circ}$, biax -ve, $2V = 80^{\circ}$.

<u>Plagioclase</u> (60%): xenoblastic interlocking grains (0.5mm) with Carlsbad - albite twinning is common. Many minute inclusions. Ab_{96}, biax -ve, $2V = 50^{\circ}$.

<u>sphene</u> (1-2%): xenoblastic grains (0.2mm) associated with amphibole and altered to leucoxene.

<u>epidote</u> (0.5%): xenoblastic grains (0.1mm)

<u>accessories</u>: opaques, tourmaline, zircon, biotite.

341 - 50a

Macro: A finely crystalline albite rich rock showing some sort of foliation.

Micro: plagioclase (85%): xenoblastic groundmass of irregular interlocking grains 0.02mm.

amphibole (5%): xenoblastic droplets (0.03mm)

chlorite (5%): xenoblastic grains (0.02mm)

biotite (1%): xenoblastic falkes (0.01mm)

opaques (3%): xenoblastic grains (0.01mm)

some veins of courser interlocking plagioclase grains.

341 - 50b

Macro: A medium to course grained rock with irregular patches of milky plagioclase and porphyroblasts of green amphibole needles.

Micro: amphibole (40%): Sub-idioblastic porphyroblasts, of prismatic form with jagged terminations. Size 0.7mm. $Z\hat{}C = 16^{\circ}$, biax -ve, $2V = 85^{\circ}$ weakly pleochroic thus Fe deficient.

plagioclase (55%): xenoblastic irregularly shaped interlocking grains (0.1mm) which tend to be courser near the amphibole grains. Grains show albite and Carlsbad - albite twinning, Ab_{93}, biax -ve, 2V = 82. Also many minute inclusions.

sphene (2%): Sub-idioblastic and poikiloblastic grains (0.5mm). Small opaque inclusions and strongly pleochroic, flesh pink - buff.

biotite (1%): Sub-idioblastic flakes occuring around amphibole grains.

accessories: opaque, zircon, tourmaline.

<u>341 - 52</u>

Macro: A course grained granular breccia with variability of grain size, particles sub rounded.

Micro:

<u>amphibole</u> (10%): Sub-idioblastic grains (1mm) which are weakly pleochroic.
Some grains (1-2mm) made up of fine grained amphibole and plagioclase.

<u>albitite</u> (1-2%): grains (1mm) made up of interlocking plagioclase grains (0.05mm).

<u>plagioclase</u> (70%): Makes up a groundmass of xenoblastic interlocking irregularly shaped grains (0.2mm). Shows albite twinning Ab_{95}.

<u>quartz</u> (2%): xenoblastic grains (0.4mm).

<u>chlorite</u> (2%): fine needles 0.2mm long.

<u>opaque</u> (15%): Sub-idioblastic cubic form (0.4mm) and after rimmed with sphene.

<u>sphene</u> (2%): xenoblastic grains (0.1mm) often surrounds opaques.

341 - 55

Macro: Course grained "spotted" amphibolite made up of amphibole, albite and epidote giving a granoblastic holocrystalline looking rock.

Micro: Amphibole (30%): Prismatic grains with jagged terminations and many minute inclusions (2mm). Some twinning. Strongly pleochroic, blue green - green - pale brown. $Z\hat{}C = 20^{\circ}$, biax -ve, $2V = 85^{\circ}$.

plagioclase (50%): Interlocking xenoblastic grains (0.1mm) making up a groundmass. Albite twinning Ab_{93}. Minute inclusions, biax -ve, $2V = 82^{\circ}$.

epidote (10%): xenoblastic grains (0.3mm) and intimately replacing amphibole.

sphene (4%): xenoblastic grains up to 0.5mm in size and often surrounding and replacing opaques.

opaques (3%): Sub-idioblastic form (0.2mm), but when surrounded by sphene grains tend to be irregular.

chlorite (1%): Fine green needles (0.1mm).

accessories: zircon, tourmaline.

341 - 56

Macro: A strongly foliated amphibole rich rock, which is weathered and enriched in biotite and chlorite with a preferred orientation.

Micro: amphibole (20%): Sub idioblastic prismatic grains with a rough preferred orientation and altered in part to biolite. Size 0.1 - 0.2mm.
$2V = 85^{\circ}$, biax -ve, $Z\hat{}C = 20^{\circ}$.

plagioclase (50%): Small interlocking xenoblastic grains 0.1mm and no twinning.

biotite (25%): Flakes have a preferred orientation (0.1mm) and often replacing amphibole.

epidote (1%): xenoblastic grains 0.2 mm in size.

chlorite (5%): Needle like crystals 0.05mm in size and making up veins in which they have a spherulitie texture and anomalous pleochroism.

accessories: opaques and zircon.

341 - 57

Macro: Medium to fine grained solid amphibolite with granoblastic texture.

Micro: amphibole (80%): Sub idioblastic prismatic grains with jagged terminations, size is 0.4mm. Medium pleochroism blue green - pale green - olive green. There is a rough preferred orientation. Grains have simple twins and inclusions of plagioclase and opaques.
$Z\hat{}C = 12^{\circ}$, biax -ve, $2V = 75^{\circ}$.

plagioclase (15%): Tends to be finer groundmass of xenoblastic interlocking grains (0.5 - 1mm) that show simple twinning and are serecitised and full of inclusions. Ab_{97}, biax -ve, $2V = 60^{\circ}$.

quartz (1-2%): xenoblastic grains 0.2mm associated with the plagioclase.

opaques (7%): xenoblastic grains mostly as inclusions in amphibole.

sphene (1%): as alteration around opaques.

accessories: biotite, serecite, tourmaline.

<u>341 - 58</u>

Macro: Fine to medium grained massive amphibolite with plagioclase laths (1mm).

Micro: <u>amphibole</u> (65%): xenoblastic grains up to .4mm in size with absorbed edges. Inclusions of plagioclase opaques, sphene and zircon.
Strongly pleochroic, thus Fe rich.
biax -ve, 2V = 75.

<u>plagioclase</u> (30%): xenoblastic grains (0.5mm) which shows Carlsbad - albite twinning, Ab_{97} biax -ve, 2V = 89°.

<u>opaques</u> (4%): often cubic form (0.1mm).

<u>biotite</u> (1%): Associated with plagioclase.

<u>quartz</u> (1%): xenoblastic grains.

<u>accessories</u>: zircon, sphene, tourmaline.

341 - 59a

Macro: Medium grained amphibole rich schist.

Micro: amphibole (40%): Prismatic grains with jagged terminations, size 1.2mm. Give a porphyroblastic texture to rock and grains are also poikiloblastic and some preferred orientation.
biax -ve, 2V = 85°, $Z\hat{}C = 15°$.

plagioclase (20%): xenoblastic interlocking grains 0.2mm in size. Some albite twinning Ab_{95}.
2V = 85° biax +ve and -ve.

epidote (30%): xenoblastic grains mainly in amphibole. Size. 0.2mm

opaques (5%): Sub-idioblastic form. 0.2mm.

accessories: sphene, zircon, serecite.

341 - 59b

Macro: Medium to course grained albitite with some crude layering defined by amphibole rich areas.

Micro: amphibole (30%): xenoblastic grains, strongly poikiloblastic and prismatic. Size 1mm. Also tend to be porphyroblastic.
$Z \hat{} C = 17^{o}$, biax +ve, $2V = 85^{o}$.

plagioclase (65%): xenoblastic, interlocking grains with irregular edges. Some twinning. Ab_{93}.

opaques (3%): Sub-idioblastic form (0.1mm) and often altered to sphene.

sphene (1%): Mainly as alteration of opaques.

accessories: zircon, serecite.

341 - 60

Macro: Medium grained "spotted" amphibolite, rich in albite and showing a rough foliation.

Micro:

amphibole (45%): Prismatic grains (0.3mm) with jagged terminations. $Z \hat{} C = 20^\circ$, biax -ve, $2V = 75^\circ$.

plagioclase (35%): Groundmass of xenoblastic intergrowth of grains 0.1mm with some idioblastic grains 0.7mm. Albite twinning present Ab_{97}. Biax +ve and $2V = 60^\circ$.

epidote (15%): Sub-idioblastic grains (0.15mm), biax -ve, $2V = 70^\circ$.

sphene (7%): Granular xenoblastic grains in and around amphibole, with opaque inclusions and weakly pleochroic.

opaques (3%): xenoblastic grains mainly associated with amphibole.

accessories: biotite, quartz, zircon, chlorite.

341 - 61a

Macro: Medium grained albite-amphibolite rock with some layering.

Micro: Amphibolite in slide.

amphibole (45%): Prismatic grains with jagged terminations and poikiloblastic (0.5mm). Some zoning with an Fe rich rim.
$Z \hat{} C = 14^{\circ}$, biax -ve, $2V = 80^{\circ}$.

plagioclase (43%): Interlocking xenoblastic grains 0.1mm twinning rare. biax -ve, $2V = 75^{\circ}$, Ab_{95}.

opaques (7%): cubic form 0.3mm

sphene (2%): surrounds the opaques.

minor zircon

Layered Part

plagioclase (75%): xenoblastic interlocking grains 0.03mm

epidote (15%): xenoblastic grains replacing amphibole.

amphibole (3%): Prismatic grains 0.2mm and more iron rich than above.

biotite (1%): small flakes 0.05mm.

opaques (4%): some have cubic form (0.05mm)

sphene (2%): as rims around opaque

chlorite (1%): as spherulites.

341 - 64

Macro: Medium to course grained albitite with layering 1-5mm wide defined by amphibole rich and deficient layers.

Micro:

amphibole (35%): Prismatic grains with jagged terminations and poikiloblastic. Strong pleochroism with Fe rich rims.
$Z\hat{}C = 17^{\circ}$ biax -ve $2V = 84^{\circ}$
Altered along cleavages to biotite.
Stand out as porphyroblasts (2mm)

plagioclase (55%): groundmass of xenoblastic interlocking grains (0.05mm), showing albite twinning Ab_{95}.

opaques (3%): xenoblastic grains (0.1mm) often in amphibole.

sphene (5%): xenoblastic granules (0.3mm).

biotite (1%): as alteration of amphibole

341 - 66

Macro: Medium to course grained albitite rock with amphibole in it producing a rough layering.

Micro: amphibole (25%): Prismatic grains with jagged terminations and weakly pleochroic. Size 1mm. Stand out as porphyroblasts with some opaque inclusions

$Z\hat{}C = 14^{\circ}$ biax -ve $2V = 85^{\circ}$

plagioclase (75%): xenoblastic interlocking grains with irregular edges. Complex twinning common.

Ab_{95}, size 0.1mm, biax -ve, $2V = 80^{\circ}$.

opaques (3%): Sub-idioblastic and often surrounded by deep red material producing a hexagonal arrangement, could be hematite.

sphene (3%): xenoblastic grains (0.1mm) with opaque inclusions and altered to leucoxene.

hematite (1%): Surrounds opaques in hexagonal form.

rutile (1%): Small grains (0.05mm) of amber and yellow colour.

341 - 67

Macro: Granular breccia with sub-rounded irregular sorted particles of albitite, amphibolite, magnetite rich rock, with a dark matrix of mainly amphibole.

Micro: opaques (25%): Sub-idioblastic grains (0.8mm), some is hematite or rutile showing good growth zoning.
amphibole (30%): Prismatic grains with jagged terminations and weakly pleochroic, but showing some zoning to give an Fe rich rim.
biax -ve, 2V = 70°.
plagioclase (40%): xenoblastic interlocking grains, with variable grain size 3mm - 0.05mm. Albite twinning present Ab_{87}.
sphene (2%): Small grains (0.3mm) replacing opaques.

341 - 68

Macro: Agmatite which is holocrystalline, with a neosome of medium to course plagioclase crystals with angular fragments (2") of palaeosome which is recrystallised amphibolite.

Micro: Neosome

plagioclase (98%): Sub idioblastic interlocking crystals (1.5mm) with no preferred orientation but at edges of xenoliths crystals tend to be perpendicular to the edge of contact. Some strain shadows and albite, Carlsbad-albite twinning common.

Ab_{95}, biax +ve, 2V = 75^{o}

Also near edge get fine amphibole and chlorite needles penetrating into the groundmass.

Palaeosome

amphibole (70%): Prismatic with absorbed edges altered to plagioclase and sphene. $Z\hat{}C = 18^{o}$, biax -ve, 2V = 75^{o} size 0.8mm. Also interstitial fine light green coloured needles 0.5mm long and 0.01mm wide, could be chlorite.

plagioclase (24%): Interlocking groundmass of xenoblastic grains 0.4mm. Some minute inclusions and diffuse twinning.

sphene (5%): Sub idioblastic, pleochroic grains 0.1mm. Generally associated with amphibole but also occurs as a rim around the margins of the xenoliths and usually contain opaque inclusions.

accessories: epidote, biotite, chlorite, zircon.

341 - 69

Macro: Fine to medium grained albitised "sediments", with sugary texture and amphibole needles and a well defined layering.

Micro: amphibole (10%): Prismatic crystals with jagged terminations. Poikiloblastic and porphyroblasts. Medium pleochroism and inclusions of opaques, sphene, zircon giving pleochroic haloes. Some preferred orientation parallel to layering.
size 0.7mm, $Z\hat{}C = 21^{\circ}$, $2V = 83^{\circ}$.
plagioclase (80%): Interlocking xenoblastic grains with irregular edges. Size is 0.3mm in course layer and 0.05mm in finer layer. biax -ve, $2V = 72^{\circ}$.
opaques (2%): Sub idioblastic grains (0.1mm) that are strung out parallel to the layering.
sphene (5%): xenoblastic grains (0.08mm), strongly pleochroic - pink - colourless. Most common in fine grained layer and with opaque inclusions.
accessories: zircon, quartz.

341 - 70

Macro: Medium grained amphibolite, granoblastic with a spotted appearance with plagioclase.

Micro: amphibole (35%): Prismatic grains (0.3mm) with some preferred orientation and medium pleochroism. Altered along edges and cleavages to red iddingsite. $Z\hat{}C = 17^\circ$, $2V = 70^\circ$, biax -ve.

plagioclase (50%): Groundmass of sub-idioblastic grains 0.2mm and often with myrmekite texture with quartz. Albite twinning rare Ab_{90}.

biotite (7%): Small flakes and blebs 0.1mm

opaques (3%): Some with cubic form and surrounded by sphene. Size 0.05mm.

sphene (3%): Grains (0.05mm) surround opaques and accumulations of grains have opaque inclusions.

chlorite (2%): Small needles 0.05mm.

quartze (3%): As intergrowth with plagioclase is a myrmekite texture.

341 - 71b

Macro: Weathered spotted amphibolite, dolerite looking.

Micro: amphibole (60%): Prismatic crystals with jagged terminations and some twinning. Strongly pleochroic, blue green - green - pale brown. Inclusions of plagioclase and opaques and altered to biotite in part. Also an odd spherulitic structure.

Size 0.3mm, $Z \hat{} C = 13^\circ$, biax -ve, $2V = 70^\circ$.

plagioclase (20%): As interstitial granules around amphibole grains. 0.2mm.

biotite (10%): Flakes formed on amphibole grains Size, 0.2mm.

opaques (10%): 7% occurs as partly cubic masses rest is as inclusions in amphibole.

accessories: sphene, rutile, parovskite, zircon, quartz.

<u>341 - 72</u>

Macro: Medium grained, "spotted" amphibolite which is dolerite looking.

Micro: amphibole (55%): Prismatic crystals with jagged terminations and stand out as poikiloblastic porphyroblasts. Fairly strongly pleochroic $Z \hat{} C = 18^{\circ}$, $2V = 75^{\circ}$, biax -ve. Some simple twinning.

plagioclase (25%): Groundmass of interlocking xenoblastic grains 0.1mm. Some large remnant idioblastic grains 0.5mm. Ab_{88} myrmekite texture with quartz is common.

quartz (5%): xenoblastic grains intergrown with plagioclase to give myrmekitic texture.

biotite (6%): Prismatic flakes (0.05mm).

opaques (7%): irregular grains (0.1mm) rimmed with sphene. 1% are as inclusions in amphibole.

accessories: sphene, chlorite, zircon.

341 - 75

Macro: Medium grained "slaty" albitite with layers 2mm wide defined by amphibole rich and deficient layers.

Micro: amphibole (30%): Prismatic, poikiloblastic porphyroblasts (2mm). Weakly pleochroic, thus Fe deficient.
$Z\hat{}C = 10^\circ$, $2V = 85^\circ$, biax -ve.
Inclusions of plagioclase, zircon, quartz, opaques.
Plagioclase (55%): interlocking xenoblastic grains (0.3mm) and some show albite twinning. Some layers are finer grained (0.05mm). Ab_{93}.
quartz (3%): xenoblastic interlocking grains (0.2mm).
opaques (4%): Often cubic form (0.1mm) and surrounded by hematite? and sphene.
sphene (5%): Surrounds opaques and also occurs as accumulations with opaque inclusions.
biotite (1%): Prismatic flakes 0.05mm.
accessories: chlorite in spherulites, zercon.

<u>341 - 77a</u>

Macro: Medium grained massive amphibolite.

Micro: <u>Amphibole</u> (27%): xenoblastic grains (0.2mm) with minute inclusions, weakly pleochroic, thus Fe deficient.

$Z\hat{}C = 22^{\circ}$, biax -ve, $2V = 70^{\circ}$.

<u>biotite</u> (20%): Stubby prismatic flakes replacing amphibole and some preferred orientation (0.2mm).

<u>epidote</u> (10%): xenoblastic grains associated with amphibole (0.1mm).

<u>plagioclase</u> (30%): Irregular xenoblastic interlocking grains (0.1mm) with diffuse twinning, inclusions and serecitised.

<u>quartz</u> (5%): Interlocking xenoblastic grains intergrown with plagioclase.

<u>sphene</u> (2%): xenoblastic grains (0.1mm) with opaque inclusions.

<u>opaques</u> (1%): Irregular grains (0.1mm) and in sphene.

<u>accessories</u>: chlorite, serecite, zircon, carbonate.

341 - 77b

Macro: Massive fine grained albitite with remnant layering.

Micro: plagioclase (90%): xenoblastic interlocking grains (0.02mm) diffuse twinning Ab_{97}. Could be some quartz but too fine grained to be sure.

biotite (5%): small prismatic flakes (0.03mm) with a preferred orientation parallel to the layering.

accessories: opaque, amphibole, chlorite, rutile, zircon, sphene.

341 - 80

Macro: Course grained granoblastic albitite rock with a quartzite looking appearance.

Micro: plagioclase (89%): Sub-idioblastic interlocking grains with Carlsbad-albite twinning, Ab_{94} biax -ve, 2V = 85°. Size 1.3mm

Get fine grained patches of plagioclase (0.2mm), opaques and amphibole, appears to be a product of a reaction amphibole - plagioclase topaque.

amphibole (4%): Prismatic remnant crystals, greatly poikiloblastic with plagioclase, opaques and sphene. Weakly pleochroic thus Fe deficient.

$Z \hat{} C$ = 16°, biax -ve, 2V = 80°.

opaques (3%): Often cubic form and 0.1mm in size.

sphene (2%): xenoblastic grains (0.1mm) with opaque inclusions.

accessories: chlorite, zircon, quartz.

341 - 81

Macro: Massive course grained holocrystalline "spotted" amphibolite with amphibole needles as porphyroblasts.

Micro:

amphibole (45%): Prismatic prophyroblasts tending to poikiloblastic with opaque and epidote inclusions. Strongly pleochroic.
$Z \hat{} C = 21^{\circ}$, biax -ve, $2V = 80^{\circ}$, size 2.5mm.

epidote (15%): xenoblastic grains with irregular edges, 0.2mm in size.

opaques (5%): xenoblastic grains 0.1mm in size and surrounded by sphene. Often as inclusions in amphibole.

plagioclase (35%): xenoblastic intergrown grains, showing undulose extinction and bent twins, and twinning rather diffuse. Size 0.2mm.

sphene (1%): Surrounds opaques.

accessories: chlorite, zircon.

341 - 83

Macro: Medium grained albitite with crude porphyroblastic amphibole rich layers.

Micro: amphibole (30%): Porphyroblastic, poikiloblastic, ophitic, and partly absorbed prismatic grains with a preferred orientation parallel to the layering. Weakly pleochroic, thus Fe deficient.
$Z \hat{} C$ = 21°, biax -ve, 2V = 80°, size 1mm.
plagioclase (60%): A granoblastic groundmass of xenoblastic interlocking grains (0.2mm). Albite twinning is common. Ab_{86}, biax +ve, 2V = 80°.
opaque (4%): Sub-idioblastic form (0.1mm). Some layers are rich in fine grained opaques (0.001mm).
sphene (3%): xenoblastic grains (0.1mm) around opaques. Pleochroic - flesh pink - buff - colourless.
accessories: zircon, biotite, iddingsite, tourmaline.

341 - 85

Macro: Course grained amphibolite with disorientated plagioclase laths.

Micro: plagioclase (45%): Idioblastic crystals (1mm) with a rough preferred orientation and some Carlsbad - albite twinning. Ab_{95}, biax +ve, $2V = 83^{\circ}$.

Many minute inclusions and serecitised.

amphibole (40%): xenoblastic grains, sub-ophitic and greatly absorbed edges but some retain their prismatic habit. Some twinning and zoning with an Fe rich rim. Altered along cleavage to biotite and iddingsite.

Size 1mm, $Z\hat{}C = 19^{\circ}$, biax -ve, $2V = 80^{\circ}$.

opaques (10%): xenoblastic grains associated with amphibole (0.7mm).

sphene (1%): as rims around opaques.

accessories: epidote, zircon, tourmaline, quartz, serecite.

341 - 86

Macro: Massive fine grained albitite with remnant layering.

Micro: plagioclase: Interlocking xenoblastic grains (.02mm) Some diffuse twinning and could also be some quartz intergrown.
Some layers 1mm wide of courser material (0.03mm) and richer in serecite or muscovite.

<u>341 - 87</u>

Macro: Course holocrystalline amphibolite with some foliation and albite veining.

Micro: <u>amphibole</u> (47%): Prismatic grains showing a rough preferred orientation giving a platty structure. Poikiloblastic and strongly pleochroic.

Z = blue green Y = grassy green X = pale brown.

$Z\hat{}C = 17^{\circ}$, biax -ve, $2V = 97^{\circ}$ size 0.7mm.

<u>plagioclase</u> (45%): Idioblastic grains (1mm) with inclusions and diffuse twinning.

<u>opaque</u> (3%): grains surrounded by sphene and often in amphibole (0.05mm).

<u>sphene</u> (5%): Mostly surrounds amphibole.

341 - 90

Macro: Massive fine grained amphibolite.

Micro: amphibole (50%): Prismatic grains with jagged terminations (0.5mm) and poikiloblastic in part. Weakly pleochroic, thus Fe deficient and greatly altered to biotite.

$Z\hat{}C = 15^{\circ}$, $2V = 85^{\circ}$, biax -ve.

plagioclase (30%): Groundmass of idioblastic grains with minute inclusions and intergrown with quartz in part. $2V = 70^{\circ}$, biax +ve, size 0.1mm.

biotite (10%): flakes altering on amphibole (0.05mm).

opaque (6%): Sub-idioblastic grains (0.05mm) associated with amphibole.

epidote (1%): xenoblastic grains (0.05mm).

accessories: sphene, quartz, tourmaline, zircon.

341 - 93

Macro: Milky albitite with irregular patches of porphyroblastic amphibole.

Micro: amphibole (20%): Prismatic, poikiloblastic, porphyroblasts. Grains greatly altered to iddingsite.
Weakly pleochroic.
$Z \hat{} C = 12^{\circ}$, biax -ve, $2V = 73^{\circ}$, size = 1mm.
plagioclase (75%): Interlocking xenoblastic grains (0.1mm). With albite and Carlsbad-albite twinning, minute inclusions and weathered. Ab_{87}.
opaque (1%): Mostly as inclusions in amphibole (0.2mm).
sphene (1%): Surrounds opaques and is altered to leucoxene.
accessories: rutile, tourmaline, serecite, iddingsite and quartz.

341 - 94

Macro: Fine grained milky albitite with porphyroblasts of amphibole which have a rough preferrred orientation.

Micro: amphibole (15%): Prismatic, poikiloblastic, porphyroblasts. Medium pleochroism. Size 1.5mm, $Z\hat{}C = 14^{\circ}$, $2V = 73^{\circ}$ biax -ve.
plagioclase (75%): Interlocking xenoblastic grains (0.02mm) twinning rare.
opaques (5%): xenoblastic grains (0.2mm)
accessories: sphene, quartz, serecite.

341 - 97

Macro: Massive medium grained "spotted" amphibolite with round areas of milky plagioclase.

Micro: amphibole (45%): Interlocking prismatic crystals with jagged terminations (0.4mm). Many inclusions and alteration to iddingsite along cleavages. Medium pleochroism - pale green - pale blue green - pale brown. Some zoning with Fe rich rim. $Z \hat{} C = 23^{\circ}$, biax -ve, $2V = 85^{\circ}$.

plagioclase (40%): Intergrown xenoblastic grains (0.2mm) with Carlsbad-albite twinning and small inclusions. Ab_{95}.

opaques (7%): Sub-idioblastic 0.1mm.

epidote (3%): xenoblastic grains, biax -ve, 0.05mm.

biotite (2%): alteration product of amphibole 0.05mm.

iddingsite (2%): alteration product of amphibole.

accessories: sphene, tourmaline, zircon.

341 - 98

Macro: Fine grained massive amphibolite with small plagioclase laths.

Micro: amphibole (50%): Prismatic, poikiloblastic, sub ophilic grains 0.2mm. Strongly pleochroic, thus Fe rich, also some zoning with an Fe rich rim.
$Z\hat{}C = 20^{\circ}$, biax -ve, $2V = 90^{\circ}$. Some opaque inclusions.
plagioclase (40%): Idioblastic laths arranged in an igneous texture and weathered. (0.5mm).
biax -ve, $2V = 80^{\circ}$, Ab_{90}.
opaques (2%): Sub-idioblastic grains 0.1mm.
epidote (5%): xenoblastic grains 0.1mm.
serecite (5%): small flakes on feldspar.
carbonate (2%): xenoblastic grains.
biotite (1%): small flakes 0.1mm
accessories: zircon, tourmaline

341 - 99

Macro: Massive medium grained amphibolite with high amount of plagioclase.

Micro: amphibole (25%): Prismatic crystals with medium pleochroism and small inclusions of opaque and sphene.
$Z\hat{}C = 10^{\circ}$. biax -ve, 2V = 80°, size 0.2mm.
plagioclase (65%): Sub-idioblastic interlocking grains. Show Carlsbad-albite twinning Ab_{88}, biax -ve 2V = 75.
biotite (3%): prismatic flakes (0.1mm) associated with amphibole.
chlorite (1%): small needles 0.1mm long.
opaques (1%): 0.1mm in size and rimmed with sphene.
sphene (2%): granules (0.1mm) with opaque inclusions and surrounding opaque. Altered to leucoxene.
accessories: epidote, zircon, serecite, leucoxene.

341 - 100

Macro: Massive fine grained amphibolite showing a foliation and has a weathered surface of white calcareous material.

Micro: amphibole (70%): Prismatic crystals showing a preferred orientation to give a platty texture. Weakly pleochroic, minute inclusions, and some spherulitic texture. Size 0.2mm.

opaque (10%): Sub idioblastic grains (0.2mm).

sphene (6%): xenoblastic grains (0.1mm), altered to leucoxene.

plagioclase (10%): xenoblastic grains with indistinct twinning (0.1mm).

accessories: epidote, zircon, leucoxene.

341 - 104

Macro: Medium grained albitite with amphibole rich and deficient layers. Layers 3mm wide.

Micro: amphibole (20%): Porphyroblastic, prismatic grains (o.2mm).

Weakly pleochroic thus Fe deficient. Some zoning to give an Fe rich rim. Altered along cleavage to iddingsite.

plagioclase (70%): Groundmass of xenoblastic interlocking grains. Size 01. - 0.01mm. Some show albite and Carlsband-albite twinning. Ab_{90}.

opaque (1%): xenoblastic grains rimmed with sphene. Size 0.1mm.

sphene (2%): xenoblastic grains (0.2mm) altered to leucoxene and minute opaque inclusions.

chlorite (3%): pale green needles 0.3mm long.

quartz (3%): as interlocking xenoblastic grains with plagioclase but true amount not known because it is indistinguishable from plag.

accessories: zircon, leucoxene, iddingsite, biotite.

341 - 111

Macro: Massive fine grained amphibolite.

Micro: amphibole (45%): xenoblastic poikiloblastic grains (0.1mm).
A few opaque and plagioclase inclusions and weakly pleochroic.
$Z\hat{}C = 15^{\circ}$, biax +ve, $2V = 80^{\circ}$.
plagioclase (45%): Sub-idioblastic laths arranged in a platty ingneous texture, show albite twinning.
Ab_{89}, biax +ve, $2V = 80^{\circ}$, size 0.5mm.
opaques (10%): xenoblastic grains 0.05mm.
biotite (1-2%): Stubby prismatic flakes 0.07mm.
accessories: sphene, zircon, serecite.

341 - 113

Macro: Weathered and sheared amphibolite rich in albite, medium grained with albite veins.

Micro: amphibole (33%): Prismatic grains (0.2mm) with jagged terminations. Some inclusions of opaques and plagioclase. Weakly pleochroic - pale green - pale-blue green - pale brown. Some zoning with an Fe rich rim.

$Z \hat{} C = 14^{\circ}$, biax +ve, $2V = 80^{\circ}$.

plagioclase (60%): Sub idioblastic interlocking grains showing albite twinning, many minute inclusions.

Size 0.5mm, $2V = 85^{\circ}$, biax +ve.

opaques (3%): xenoblastic grains (0.1mm) and altered to sphene.

biotite (5%): Stubby prismatic flakes (0.2mm) with no preferred orientation.

accessories: sphene, zircon.

341 - 117

Macro: Medium grained layered albitite with amphibole rich and deficient layers.

Micro: amphibole (35%): xenoblastic, poikiloblastic porphyroblasts (2mm). Medium pleochroism and shows zoning with an Fe rich rim and appears to be being replaced by epidote and plagioclase. biax -ve, $2V = 80^{\circ}$, $\hat{ZC} = 17^{\circ}$

epidote (15%): xenoblastic grains (0.3mm) replacing amphibole and contains minute inclusions of opaque.

sphene (3%): xenoblastic grains closely associated with amphibole.

plagioclase + quartz (45%): Intergrowth of xenoblastic grains (0.1mm). Twinning not common, quartz makes up about 5%. Ab_{95}.

accessories: Chlorite, zircon, tourmaline, serecite.

341 - 118

Macro: Massive milky albitite, fine grained with amphibole porphyroblasts in spherulitic array.

Micro: amphibole (23%): As needle shaped porphyroblasts in spherulitic array. Size 2mm. Weakly pleochroic thus Fe deficient. Spherulites tend to be a secondary thing and radiate from amphibole grains

$Z \hat{} C = 16^{\circ}$, biax -ve, $2V = 85^{\circ}$.

plagioclase (65%): Intergrown xenoblastic grains Size 0.05mm, Ab_{88}.

quartz (10%): intergrown xenoblastic grains with plagioclase.

accessories: opaques, sphene, serecite, iddingsite.

341 - 120

Macro: Fine grained massive amphibolite.

Micro: amphibole (30%): xenoblastic, poikiloblastic grains (0.1mm). Strongly pleochroic with opaque inclusions.
$Z \hat{} C = 15^{o}$, biax -ve, $2V = 80^{o}$.
plagioclase (45%): Sub-idioblastic porphyroblasts (0.3mm) albite twinning is common. Ab_{91}.
biax -ve, 2V = 85. Many minute inclusions.
opaque (10%): Sub-idioblastic and associated with amphibole. size 0.05mm.
sphene (5%): xenoblastic grains surrounding opaques.
biotite (10%): Stubby prismatic crystals (0.2mm) associated with amphibole.
epidote (1%): xenoblastic grains 0.1mm
carbonate (2%): Accumulations of xenoblastic grains 0.2mm. A product of weathering.
accessories: serecite, tourmaline, zircon, kaolinite.

341 - 121a

Macro: Part of a supposed "pillow" of epidote rich vein showing the contact between the amphibolite and the vein.

Micro: Composition of Vein

epidote (80%): xenoblastic interlocking granules (2mm). Some alteration along grain boundaries.

plagioclase (10%): xenoblastic interlocking granules (0.03mm) may also be some quartz.

Tourmaline (5%): Layer of xenoblastic tourmaline running parallel to contact up to 3mm in size.

opaque (5%): Grains 0.5mm with cubic form.

accessories: sphene, amphibole.

Composition of Transition Zone

amphibole (35%): Idioblastic zoned crystals (0.5mm) $Z \hat{} C = 20^{\circ}$, biax -ve, $2V = 85^{\circ}$, many inclusions.

plagioclase (50%): xenoblastic interlocking grains (0.05mm) with altered boundaries.

epidote (1%): xenoblastic grains (0.2mm).

sphene (2%): xenoblastic grains occur between plagioclase grains.

biotite (1%): prismatic flakes (0.2mm).

opaques: rare

Thus towards amphibolite

epidote - decreases
plagioclase - increases
opaques - decreases
amphibole - increases
chlorite needles - fairly constant.

<u>Composition of Amphibolite</u>

<u>amphibole</u> (40%): Prismatic grains with jagged terminations, some zoning and weakly pleochroic.
Oriented perpendicular to contact.
Size = 0.08mm, $Z \hat{} C = 16^{\circ}$, biax -ve, $2V = 80^{\circ}$.

<u>plagioclase</u> (50%): Interlocking groundmass of xenoblastic grains (0.05mm). Many minute inclusions and cloudy appearance, twinning rare.
biax -ve, $2V = 75^{\circ}$.

<u>sphene</u> (5%): xenoblastic grains (0.1mm) with opaque inclusions.

<u>epidote</u> (5%): xenoblastic grains (0.3mm).

<u>opaque</u> (1%): Sub-idioblastic grains (0.2mm) accumulated near the contact.

<u>biotite</u> (5%): Stubby prismatic flakes more common nearest contact.

341 - 121b

Macro: Massive fine grained amphibolite from centre of a supposed "pillow" structure.

Micro: amphibole (25%): Prismatic grains with jagged terminations. (0.1mm). Some preferred orientation, strongly altered to biotite, and Fe deficient

$Z\hat{}C = 17^{o}$, biax -ve, $2V = 80^{o}$.

plagioclase (50%): Groundmass of interlocking xenoblastic grains. (0.1mm). Many minute inclusions, and serecitised. Some large remnant prophyroblasts (3mm).

Ab_{93}.

biotite (10%): Prismatic stubby crystals replacing amphibole and have some preferred orientation.

opaques (12%): Idioblastic grains (0.1mm) rimmed with sphene.

sphene (5%): Accumulations of small granules making up areas 0.2mm in size with opaque inclusions.

epidote (1-2%): xenoblastic grains occurs in small veins (0.2mm).

341 - 126

Macro: Fine grained milky albitite with amphibole needles enclosing a finely laminated albitite-amphibole rich rock.

Micro: amphibole (10%): Poikiloblastic, porphyroblasts with inclusions of sphene and plagioclase. Altered to iddingsite at edges.

$\hat{ZC} = 8^{\circ}$, biax -ve, $2V = 83^{\circ}$, size 0.7mm.

plagioclase (70%): Groundmass of xenoblastic intergrown grains (0.05mm). Some albite twinning layers about 2mm wide.

quartz (10%): xenoblastic grains (0.05mm) in interlocking association with plagioclase.

opaques (5%): Cubic form (0.1mm) and richer in some layers than others.

sphene (2%): xenoblastic grains 0.05mm.

accessories: rutile, zircon, serecite, iddingsite

341-127

Macro: Fine grained milky albitite with a random arrangement of amphibole porphyroblasts with a typical needle form.

Micro: amphibole (22%): Prismatic prophyroblasts (1.5mm) with opaque inclusions and weakly pleochroic. $Z\hat{}C = 20^{o}$, biax -ve, $2V = 77^{o}$.

plagioclase (71%): Groundmass of interlocking xenoblastic grains (0.2mm). Has Carlsbad-albite twinning Ab_{96}. Tends to have layers of fine and course plagioclase.

opaques (6%): xenoblastic grains up to 2mm in size and often poikiloblastic.

sphene (1%): Mainly as alteration of opaques.

accessories: chlorite, zircon, biotite, tourmaline.

341 - 128

Macro: Course grained "spotted" amphibolite, rich in epidote.

Micro: amphibole (35%): Prismatic grains (2mm) with ophitic texture, and inclusions of opaque, epidote, and plagioclase. Strongly pleochroic.
X - pale brown, Y - green, Z - blue green.
$Z \hat{} C = 10^{\circ}$, biax -ve, $2V = 85^{\circ}$.
epidote (30%): xenoblastic grains replacing amphibole in part. 0.5mm.
plagioclase (25%): Groundmass of sub-idioblastic grains (1mm). Carlsbad-albite twinning is common. Ab_{95}.
opaque (1%): xenoblastic grains up to 1mm in size.
sphene (2%): xenoblastic grains with opaque inclusions and surrounding opaques.

341 - 129

Macro: Very fine grained black rock with some plagioclase veins. Rock tends to show a 120° cleavage and smooth surfaces.

Micro: Tourmaline (98%): Mass of xenoblastic droplets (0.05mm). Too fine grained to get a sign and figure. Has greatest absorption perpendicular to the polarizer direction.
Pleochroism: smoky grey - deep green.
accessories: plagioclase, epidote, amphibole.
Some veins running through the rock are made up of 80% coarse plagioclase (0.2mm, Ab_{90}), with epidote (15%), and odd opaques.

341 - 130

Macro: Agmatite with albite neosome and a recrystallized amphibolite palaeosome, with altered edges.

Micro: Composition of Palaeosome

amphibole (90%): Prismatic porphyroblasts (1mm), with many inclusions and some zoning to give Fe rich edges, but weakly pleochroic. Altered along cleavage to iddingsite.

$Z\hat{}C = 18^{\circ}$, biax -ve, $2V = 85^{\circ}$.

plagioclase (7%): xenoblastic groundmass, with some grains showing simple twinning Ab_{93}. Size 0.02mm.

chlorite (3%): fine needles 0.1mm long.

accessories: opaques, iddingsite, sphene, zircon.

Transition Zone (4.5mm wide)

Boundary between amphibolite and neosome is marked by a concentration of chlorite at the boundary and course plagioclase (0.4mm, Ab_{90}).

0.5mm away from the boundary get idioblastic chlorite showing hexagonal outline 0.3mm in size, also have course plagioclase here (0.15mm) which gets finer grained further out to 0.05mm with chlorite needles (0.2mm).

Then you get slightly courser xenoblastic plagioclase grains (0.2mm) with diffuse twinning (Ab_{90}) and less chlorite needles.

/2

Composition of Neosome

The neosome is made up of interlocking xenoblastic grains with multiple twinning, many minute inclusions concentrated near the centre of the grains. Chlorite not as abundant here.

Plagioclase :- Ab_{92}, size 1mm, biax -ve, $2V = 50^{\circ}$.

Chlorite appears to be coming from the breakdown of amphibole.

341 - 132

Macro: Course holocrystalline albitite with amphibole rich layers. Also some purple layers of hematite? Layers 4mm wide.

Micro: amphibole (55%): Poikiloblastic porphyroblasts with inclusions of epidote and plagioclase. Amphibole richer in some layers than others. Weakly pleochroic. Size 1.5mm. $Z \hat{} C = 14^{\circ}$, biax -ve, $2V = 83^{\circ}$.

epidote (7%): Poikiloblastic xenoblastic grains (0.5mm).

sphene (1%): xenoblastic, poikiloblastic grains (0.3mm).

plagioclase (35%): Groundmass of interlocking sub angular xenoblastic grains. The purple layers are 1mm wide and due to masses of fine grained opaque inclusions in the core of the plagioclase grains. Some Carlsbad - albite twinning Ab_{90}.

chlorite (1%): Small needles.

opaque (3%): As fine grained inclusions in plagioclase amphibole and sphene and also as angular grains 0.1mm in size.

accessories: zircon, toumaline, quartz.

341 - 125

Macro: Medium grained amphibolite with plagioclase laths which stand out as porphyroblasts.

Micro: amphibole (52%): Prismatic poikiloblastic grains with some preferred orientation, strongly pleochroic thus Fe rich.

X - pale brown, Y- green, Z - blue green.

size 0.5mm, $Z \hat{} C = 13^{\circ}$, $2V = 80^{\circ}$, biaxial -ve.

plagioclase (43%): Idioblastic, porphyroblasts of plagioclase laths in an igneous texture. Only simple twinning present. Many small inclusions. Size 2mm, biax +ve, $2V = 50^{\circ}$.

opaques (3%): Partly cubic form and 0.1mm in size and surrounded by small droplets of sphene.

biotite (2.5%): Stubby flakes scattered over feldspar.

epidote (1%): Small xenoblastic grains.

accessories: chlorite, sphene, zircon, serecite

341 - X

Macro: Fine to medium grained massive amphibolite with small plagioclase laths.

Micro: amphibole (51%): Prismatic grains with jagged terminations, and poikiloblastic. Inclusions of plagioclase and opaques, and altering to biotite in part. Weakly pleochroic thus Fe deficient and some grains are twinned.
Size 1.5mm, $Z \hat{} C = 16^{o}$, biax +ve, $2V = 85^{o}$.
plagioclase (38%): Idioblastic plexus of plagioclase in a typical igneous texture. Show simple twinning and serecitised. Show sub-ophitic texture with amphibole. biax +ve, Ab_{85}, 1.2mm.
opaque (3.2%): xenoblastic grains 0.05mm in size and much in amphibole as small inclusions.
biotite (7%): Stubby flakes 0.05mm in size.
accessories: zircon, rutile, serecite.

341 - N

Macro: Massive fine grained amphibolite.

Micro: amphibole (53%): Sub-idioblastic prismatic grains which are partly poikiloblastic. Medium pleochroism: X - pale brown, Y - grass green, Z - blue green. Size 0.2mm, $Z\hat{}C = 16^{\circ}$, biax -ve, $2V = 85^{\circ}$.

plagioclase (42%): Idioblastic porphyroblasts (1mm), with many inclusions and serecitised. Ab_{90}, biax -ve, 2V = 50.

biotite (2%): Stubby prisms (0.02mm) on surface of plagioclase and amphibole.

opaque (5%): Sub-idioblastic form (0.2mm) and also occurs in amphibole grains.

sphene (1%): xenoblastic grains as rims around opaques.

accessories: epidote, zircon, serecite.

341 - V

Macro: Massive fine grained amphibolite.

Micro: amphibole (50%): Prismatic poikiloblastic grains (0.2mm), with strong pleochroism, thus Fe rich.
X - pale brown, Y - grass green, Z - blue green.
Some grains show twinning. $Z\hat{}C = 16^{o}$
biax -ve, $2V = 87^{o}$.

plagioclase (35%): Idioblastic porphyroblasts (1mm), with a sub-ophitic texture with amphibole. The plexus show an igneous texture, and simple and albite twinning (Ab_{88}) with some serecitisation and minute inclusions.

biotite (2%): Stubby flakes (0.01mm) as alteration of biotite.

opaque (5%): Generally associated with amphibole, and size up to 0.2mm.

sphene (1%): xenoblastic grains with opaque inclusions.

accessories: zircon, serecite, tourmaline.

Opaques in Polished Sections

341 - 27b

Opaque is magnetite (10%), a light grey-white colour with no crystal form or texture except inclusions of feldspar and sphene.

342 - 5D

Opaque is magnetite with exsollution of hematite along the (111) direction. The magnetite has a brownish tint suggesting it is rich in Ti. Could also be some exsolution of ilmenite.

341 - 67

Sub-idioblastic opaques made up mostly of haematite from exsolution of magnetite and very little magnetite left.

342 - 5B

Minor magnetite in idioblastic form with inclusions of feldspar and sphene.

341 - W

Magnetite with a brownish tint and has exsolution of haematite and/or ilmenite along (111) of magnetite.

341 - 128

Rock is brecciated with most of the opaques interstitial. Opaque is magnetite with exsolution of hematite and/or ilmenite. The opaques are concentrated in layers.

341 - V

Opaques are xenoblastic grains of hematite with inclusions of feldspar and sphene. Some magnetite also.

341 - X

Opaques are irregular shaped grains of hematite and magnetite with inclusions of feldspar and sphene.

341 - 125

Opaques are irregular shaped grains of hematite and magnetite with inclusions of feldspar and sphene.

342-I

MACRO : A fine to medium grained, banded albite amphibolite. Patchy development of feldspar also evident. Approximately 65% amphibole and 35% feldspar. Grain size average 1-2 mm.

MICRO : Granoblastic to nematoblastic moderately banded rock with sub-parallel alignment of mafic minerals : Medium grained with banding on the scale of 1-3 mm.

PLAGIOCLASE : 65-70%, size 0.1-1.5 mm xenoblastic. Twinning veins from distinct multiple, irregular to very poorly developed. Untwinned grains exhibit patchy extinction (welding of small grains or an expression of zoning?) Biaxial (-) Ab_{70} - Ab_{65} (Oligoclase - Andesine). Inclusions common, some grains being choked.

AMPHIBOLE : 25-30%. Xenoblastic prismatic with ragged terminations. Biaxial (-) 2v 75^{o}- 80^{o}. $Z \hat{} c = 23^{o}$. Markedly poikiloblastic (plagioclase etc.). Pleochroic with α = straw, β = grass green, γ = pale blue green. Alteration to a golden brown mineral along cleavages and grain boundaries.

ACCESSORIES :

Opaques - 1% Average size 0.2mm. Xenoblastic to idioblastic.

Epidote - 1%, Biaxial (-) generally xenoblastic high relief.

Sphene - 3%, Biaxial (+) though a poor figure, high relief, weakly pleochroic, colourless/ pale pink. Contain opaque cores (ilmenite or titanomagnetite ?).

342-5A

MACRO : A fine grained dark grey-green quartz feldspar mica schistose rock with irregular patches of leucocratic minerals. Some thin cross-cutting quartz-feldspar veinlets showing deformation. Odd large (say 2m x 1.5mm) feldspar porphyroblasts.

MICRO : A fine grained quartz, plagioclase, amphibole, mica rock with a well defined schistosity. Thin quartz-plagioclase bands are folded possibly with the schistosity as axial plane. The schistosity bends around quartz-feldspar patches.

QUARTZ : 45% xenoblastic, interlocking mosaic-like grains, average size 0.05 - 0.1mm. Uniaxial (+) but some grains show a small 2v (strain). May reach 0.5mm in patches.

PLAGIOCLASE : 10% xenoblastic as two grain sizes i.e. small (0.1mm) grains interlocked with quartz and large crystals choked with inclusions (biotite, sphene, apatite ?). Twinning of the smaller grains is very rare (separation from quartz difficult) whereas odd larger grain gives extinction parallel to twinning. Both Biaxial (+) and (-).

BIOTITE : 35%, average size 0.1 x 0.05 mm. Strongly pleochroic straw - olive green. Mottling near extinction. Elongate crystals with parallel extinction.

SPHENE : 5-10% as xenoblastic granular clumps but with odd idioblastic crystals . High relief, colourless, moderate birefringence.

OPAQUES : An accessory - deep red at edges. Range in regularity of form.

342-5B

MACRO : A coarse, well banded quartz, plagioclase, amphibole tourmaline rock. Contact between dark mafic band and white quartz-plagioclase band exist for 1mm.

MICRO : Thin-section divided in half i.e. a dark mafic section and a colourless-white half. Contact characterised by a coarser grained leucocratic zone and a very dark mafic zone. Each side shows distinct banding suggestive of graded bedding.

QUARTZ : 70% (90% in light half and 20% in dark half). As two distinct sizes - in a fine grained mosaic (0.02 - 0.05mm) and in a coarse layer (0.15 - 0.25mm). Xenoblastic, mosaic-like with inclusive common (amphibole ? sphene, opaques)

TOURMALINE : 10%-15% Average size 0.01mm. Concentrated in dark half. Slightly elongate xenoblastic to idioblastic crystals showing maximum absorption perpendicular to the polarizer. Pleochroic light pink to dark green.

CARBONATE : 10% - 15% Average size 0.2 - 0.5 mm. Exhibits a small 2v (poor figure). Rhombehedral cleavage in some grains. High relief. Calcite.

PLAGIOCLASE : 2-3% Very hard to distinguish from quartz.

BIOTITE: Accessory, restricted to light half, some alteration to chlorite.

OPAQUES: Accessory.

342-5C

MACRO : Extremely fine grained dark grey-black amphibolite consisting essentially of dark green-black mineral (amphibole ?).

MICRO : A very fine grained "mossy" looking rock with, however, a strong preferred orientation of elongate needle-like minerals (length slow) possibly an amphibole. All grains are strongly poikiloblastic with very fine mineral and bubble inclusions.

AMPHIBOLE : Possibly 40-50% as probable larger crystals now strongly resorbed, corroded and full of inclusions.

TOURMALINE : reasonably common, strongly pleochroic, length fast.

PLAGIOCLASE : About 40%, originally larger crystals now inclusion riddled and with poorly defined edges. Biaxial (+).

EPIDOTE : 5% as grains and inclusions.

BIOTITE : Moderately common.

ACCESSORIES :

Carbonate (scapatite?), sphene.

342-5D

MACRO : Medium approximately granoblastic massive rock with randomly oriented plagioclase laths (indistinct) and amphibole with accessory opaques.

MICRO : A fine grained feldspar-amphibole-chlorite-biotite rock showing a relict doleritic texture (somewhat "ophitic"). Plagioclase laths show a random orientation.

PLAGIOCLASE : 40-50% size 0.5 - 0.8mm. Xenoblastic elongate commonly containing many inclusions (too small to identify). Multiple twinning common. Ab_{80} approximately.

AMPHIBOLE : 20% Xenoblastic, commonly "ophitic" with plagioclase, or partially resorbed. Biaxial (-), $2v = 60^{o}$, $Z \hat{} c\ 17^{o}$. Pleochroic scheme α = straw, β = light green, γ = dark green (blue).

CHLORITE : 15% - 20% Fibrous and radiating (may reach 0.8 - 1.0 mm. long). Very low (appears isatrepic) to low birefringence, slightly pleochroic light green or colourless to medium green-blue. Associated with amphibole. Biaxial (+).

OPAQUES : About 5%, xenoblastic.

ACCESSORIES :

Sphene - about 0.5 - 1mm, xenoblastic fractured grains.

Carbonate - probably calcite.

342-12

MACRO : A fine to medium grained (banded). Very leucocratic granoblastic plagioclase rich rock with minor mica between grains.

MICRO : A fine to medium grained rock consisting essentially of an interlocking mosaic of plagioclase grains. A coarser grained zone (sizes about 0.4mm) and a finer grained zone (sizes about 0.1mm) are recognisable, the latter showing aligned elongate grains (shearing?

PLAGIOCLASE : About 90%, characteristically untwinned (differentiation from quartz difficult). Biaxial (+) and (-) $2v = 85^{o} - 90^{o}$. Xenoblastic grains, commonly inclusion filled. Possibly Ab_{70}.

BIOTITE : 1% elongate prismatic and tabular, strongly pleochroic, light to dark brown. Mottling at extinction.

CHLORITE : Accessory associated with biotite, fibrous commonly in radiating arrangements. Very weakly pleochroic, colourless to pale green.

OPAQUES : An accessory along with rutile ? (golden brown xenoblastic, weakly pleochroic).

342-12B

MACRO : A fine grained plagioclase rich rock with probable fine and coarser bands (separated by a thin biotite? rich band). Minor opaques and mica. A schistosity exists at a steep angle to the banding.

MICRO : A fine grained granoblastic rock showing a very strong preferred orientation. Essentially a plagioclase rich rock (probably since twinning rare). A banding of non-included and included grains is evident.

PLAGIOCLASE : About 70% Xenoblastic elongate grains showing a parallel alignment. Figures obtained poor but in all probability Biaxial (-). Twinning is rare and exists as broad lamellae or as very fine lamellae (high magnification). Generally Oligoclase i.e. Ab_{70-75}. Odd inclusions

QUARTZ : About 25% based on slight difference in R.I., lack of twinning, strain extinction etc. Inclusion rich cores with clear rims i.e. originally sedimentary quartz grains with authigenic rims. These grains are restricted to two zones with a clear quartz-feldspar band in between.

BIOTITE : About 2-4% intergranular to felsic minerals, strongly pleochroic. Associated with a light green-grey pleochroic flaky mineral (chlorite?). About 8%.

RUTILE ? : Accessory, golden brown, xenoblastic.

342-13

MACRO : A leucocratic fine to medium grained plagioclase rich rock showing a weak banding. Moderately well developed plagioclase laths in a fine grained plagioclase matrix. A greenish mineral appears to be infilling cracks (biotite ?).

MICRO : Microporphyroblastic rock with fine to medium grained plagioclase laths (approx. 1mm) and fine grained plagioclase mosaic (approx. 0.1 - 0.2mm) showing banding. Some thin cracks infilled by golden-yellow chlorite/biotite ?.

PLAGIOCLASE : About 95%. The coarse grained crystal show well developed multiple twinning commongly bent and displaced. Fine inclusions common. Biaxial (-) Twinning gives Ab_{64-70} (Michel - Levy) whereas one determination on a section ⊥ a gave Ab_{93}. The finer grained mosaic contains very xenoblastic grains (amoeboid), finely twinned at times and Biaxial (-). Some chequer-board "albite" is developed.

RUTILE : About 1-2%. Golden brown, small granules or subidiomorphic prisms.

CHLORITES : About 1-2%. low birefringence (anomolous blue-violet interference colours), slightly pleochroic (pale green and pale brown) commonly associated with the rutile.

ACCESSORIES :

Sphene, Zircon ? (elongate, subidioblastic)

342-14

MACRO : A fine grained leucocratic schist containing plagioclase and mica showing distinct patches of a particular mineral, generally ovoid with dark (biotite ?) edges. Schistosity at an angle to a weak to moderate banding.

MICRO : A fine grained quartz ? - plagioclase-mica schist with distinct elongate ovoid patches of predominantly muscovite.

PLAGIOCLASE : About 80% - 85%, fine grained (less than 0.2mm), xenoblastic, mosaic-like and very irregular outlines. Small inclusions common (bubbles, amphibole, zircon ? etc.)

BIOTITE : About 5%, average size 0.1mm - 0.2mm. Xenoblastic to subidiomorphic, appears flaky. Pleochroic in shades of brown. Medium to high birefringence. Some alteration to muscovite and chlorite.

MUSCOVITE : About 5-8%. As diseminated grains throughout the rock and as patchy concentrations. High birefringence, high relief, colourless. A general concentration of biotite around the patches (with a finer grained plagioclase).

ACCESSORIES :

Amphibole - elongate thin prisms slightly pleochroic.

Sphene - subidiomorphic, pale pink.

Apatite - Very thin needles.

Opaques - Associated with sphene.

Zircon ? - Small, xenoblastic, high relief.

342-14B

MACRO : A very fine grained, light grey schistose and weakly banded rock. A mineral lineation is evident on the schistosity planes. Essentially plagioclase and mica.

MICRO : A fine grained plagioclase, biotite, muscovite schist with elongate (acicular) micas in a fine-grained plagioclase mosaic. A strong preferred orientation is evident. A patchy concentration of micas. Veinlets contain amphibole or medium grained plagioclase.

PLAGIOCLASE : About 75-80%, average 0.05 - 0.15mm, xenoblastic, mosaic-like texture. Twinning rare. Inclusions common - quartz ?, opaques, bubbles.

MUSCOVITE : About 10-15% as thin prisms (say 0.08 x 0.01mm). Moderate preferred orientation. Moderate to high birefringence.

BIOTITE : About 2-3% strongly pleochroic in shades of brown, moderate birefringence.

AMPHIBOLE : About 5-8%. Pleochroic in shades of green.

ACCESSORIES :

Opaque - equidimensional or elongate prisms commonly parallel to or along mica cleavages. Some alteration to sphene.

Tourmaline - Pleochroic in green, maximum absorption amphibole and polarizer.

Chlorite - Commonly along cracks, strongly pleochroic in green, low birefringence.

342-15

MARCO : A fine grained, grey, banded plagioclase rich rock with fine and coarse plagioclase bands. A weak to moderate schistosity.

MICRO : A fine grained essentially granoblastic plagioclase rich rock in a mosaic-like arrangement. (0.1 - 0.2mm Two sub-parallel bands cut across the slide where the grains are about 1-1.8mm in size.

PLAGIOCLASE : About 95%-98%, small xenoblastic interlocking grains. Multiple twinning rare (some possibly quartz). Biaxial (-). Odd areas where grains coarser (up to 2mm). Generally full of inclusions often crystallographically oriented along twin directions (biotite flakes). Some simple and multiple twinning. Composition about Ab_{80}. Some chequerboard twinning developed.

BIOTITE : About 1-2%, moderately pleochroic light green - olive green. Mottling near extinction

RUTILE : About 1% subidioblastic prismatic or equidimensional golden brown, high relief.

SPHENE : Accessory, pale pink, high relief, xenoblastic to subidioblastic; commonly associated with biotite.

342-20

MACRO : A medium grained porphyroblastic amphibole, plagioclase rock showing distinct banding of amphibole porphyroblasts. Random orientation of amphibole on banding faces.

MICRO : Porphyroblasts of strongly "resorbed" (Poikiloblastic amphibole set in a fine grained matrix of mosaic-like feldspar and quartz (rare).

AMPHIBOLE : About 35% - 40%, size range 0.2 - 2.0mm Very irregular in outline, quite poikiloblastic containing plagioclase grains (xenoblastic). Biaxial (-), 2v = 75° - 80°. Pleochroic, β = light green, γ = olive green.

PLAGIOCLASE : About 50% - 55%. A mosaic of fine (0.05 - 0.2 mm) Xenoblastic interlocking grains. Inclusions are common especially in the larger grains. Twinning moderately common generally as fine lamellae. Low extinction angles, possibly Ab_{80}.

QUARTZ : About 2-3% xenoblastic, interlocking with plagioclase. Weak undulose extinction,

ACCESSORIES :

Sphene - pink, xenoblastic fractured grains, opaque cores.

Opaques - irregular outline.

Rutile - odd grain

Biotite - golden brown, associated with amphibole, altering to chlorite (fibrous, yellow-yellow green). Also some chlorite with amphibole.

342-22

MACRO : A medium grained grey-green rock of epidate, amphibole and a light coloured mineral. Random orientation of elongate amphiboles which have irregular outlines.

MICRO : A fine to medium grained rock with an "ophitic" relationship between strongly poikiloblastic quartz, resorbed amphiboles and amphibole needles.

QUARTZ : About 45%, size o.2 - 1.0 mm, colourless; Uniaxial (+) but most show a small anomalous 2v (up to 10^{o}) due to strain. Generally filled with inclusions e.g. amphibole, sphene, bubbles etc. Xenoblastic, undulose extinction, cracking present (mortar structure ?)

AMPHIBOLE : About 25% - 30%. As inclusions in quartz, as needles and as larger resorbed grains giving a needle-like appearance. Biaxial (-). Strongly pleochroic α = straw, β = light yellow-green, γ = blue-green. Frequently cracked with orange-brown alteration product.

EPIDOTE : About 25% - 30%, xenoblastic colourless to pale yellow (weakly pleochroic). Moderate birefringence (patchy colours), moderate to high relief. Biaxial (-), 2v = 60^{o}.

SPHENE : About 1-2%, subidioblastic elongate grains, pale pink (slight to moderate pleochroism). About 0.02mm - 0.05mm with infrequent larger grains. Opaque cores and inclusions common.

ACCESSORIES :

Opaque - xenoblastic

Apatite - very elongate needles (20 x width) colourless, moderate relief.

342-25

MACRO : A porphyroblastic amphibole - plagioclase rock with large (up to 20 mm) dark green amphibole in a fine white plagioclase groundmass.

MICRO : Porphyroblasts of amphibole in a mosaic of feldspar and finer amphibole, epidate and sphene. Suggestion of a lineation of mosaic minerals and some amphiboles An "ophitic" relationship between the larger amphiboles and plagioclase/opaques.

AMPHIBOLE : About 35-40% as two sizes i.e. a large (up to 4-5 mm) grain size, xenoblastic frequently partially resorbed, and smaller grains and needles (0.05 - 0.1mm). Some of the larger grains show pleochroic haloes. Pleochroic in shades of green. Edges commonly darker and show stronger pleochroism. Biaxial (-) 2v = 80°.

PLAGIOCLASE : About 50%, sizes 0.2mm - 1.5mm, xenoblastic. Some show fine multiple lamellae, giving about Ab_{70}. Biaxial (-) 2v + 80°.

ACCESSORIES :

Sphene - 3-5%, pleochroic light to dark pink, xenoblastic to idioblastic, 0.05 - 0.5mm.

Biotite - 1-2%, size up to 0.2mm, tabular flakes strongly pleochroic light brown to olive brown.

Epidate - 2%, granular, pleochroic light to dark yellow, occurs in concentrations.

Quartz, Opaques, Apatite, Zircon ?

342-26

MACRO : A grey-green fine grained strongly schistose rock with prismatic dark green amphibole as a major constituent.

MICRO : Xenoblastic aggregate of fibrous, irregular, highly strained amphibole (prismatic with ragged terminations). A preferred orientation is noticeable.

AMPHIBOLE : About 95% as ragged prisms, irregularly terminated. Sizes 0.5 - 1.5mm. Moderately pleochroic in shades of green and brown. Evidence of strain shadows i.e. a single crystal extinguishes irregularly and patchily. Some zoning effect with grain edges generally darker and exhibit stronger pleochroism. Pleochroic haloes also present. Biaxial (-), 2v = 80° - 85°.

BIOTITE : About 2-3%, average size 0.2mm. Interstitial to amphibole (replacing such ?). Moderate birefringence, strongly pleochroic light brown green to dark olive green. Mottling near extinction. Low extinction angle Also occurs as infilling of small cracks.

342-28

MACRO : A grey-green fine grained rock with elongate pale pink plagioclase (sub-oriented), amphibole and opaque.

MICRO : A fine to medium grained rock with a "sub-ophitic" type of relationship between amphiboles, opaques and larger feldspar laths. A probable relict dolerite texture.

AMPHIBOLE - About 40%, size 0.01 - 0.2mm Xenoblastic granular or elongate prismatic. Strongly pleochroic α = straw, β = medium green, γ = blue-green. Invariably has golden-brown rims (biotite? Inclusions include opaques, plagioclase, Biaxial (-).

PLAGIOCLASE : About 50%, size 0.05 - 0.8mm, Xenoblastic, lath shaped to roughly equidimensional. Inclusions common e.g. amphibole, bubble etc. Commonly cracked and infilled by golden brown material. Biaxial (-) 2v = 85°.

ACCESSORIES :

Opaques - 2-3% Commonly subidioblastic to ideoblastic either as cores in sphene or as moderately idioblastic crystals, 0.02 - 0.1mm.

Sphene - 1-2% As rims around opaques or as individual grains (0.01 - 0.06 mm).

Zircon ?

342-31B

MACRO : A fine to medium grained dark green amphibole - plagioclase rock with patches and veinlets of plagioclase, the latter intersecting any banding.

MICRO : Medium to coarse grained crystalloblastic rock consisting of plagioclase, amphibole, sphene, epidote and opaques. All of the crystals are xenoblastic and arranged decussate. Poikiloblastic feldspar and amphibole.

PLAGIOCLASE : About 55%, size 0.2 - 1.8mm, xenoblastic. Many crystals show twinning to varying degrees. Irregular extinction is common, grains cracked and strained probably though could be interpreted as irregular zoning (leads to irregular twinning). Inclusions are amphibole, opaques, bubbles etc., and where numerous grains become cloudy; Biaxial (-) and about Ab_{65-70}.

AMPHIBOLE : About 30% as large xenoblastic ragged crystals or thin elongate prisms. Strongly pleochroic light yellow-green to blue-green, frequently with darker edges. Small inclusions commonly oriented. Biaxial (-) $2v = 75^{o} - 80^{o}$.

SPHENE : About 3% xenoblastic to subideoblastic, strongly pleochroic in shades of pink, opaque inclusions.

EPIDOTE : About 10%, pleochroic colourless-yellow, granular, moderate birefringence.

OPAQUES : About 1% granular grains or with sphene

MACRO : A leucocratic fine to medium grained banded amphibole plagioclase rock. Note banding appears to be cut by other banding - could be a secondary veining.

MICRO : A weakly banded rock with alternating fine grained mosaic-like bands of quartz-plagioclase, amphibole, opaque and their coarse grained equivalents.

AMPHIBOLE - About 15%. Prismatic with ragged terminations, irregular, some moderately poikiloblastic. Pleochroism generally weak, light to medium green. Some alteration along edges, cleavages and cracks to a golden-brown mineral. Biaxial (-), $2v = 75^{o} - 80^{o}$.

PLAGIOCLASE : About 60%. Multiple twinning, chequerboard twinning and mosaic plagioclase essentially. Biaxial (-) low extinction angles - oligoclase.

QUARTZ - About 20%. Size 0.02 - 0.08 mm, interlocking with plagioclase. Commonly strained - small 2v. Uniaxial (+). Inclusions of amphibole, opaque etc.

OPAQUES : About 5%, subidioblastic to idioblastic from small granules to grains about 0.5mm.

ACCESSORIES :

Rutile ? - golden brown

Sphene - pink

342-34

MACRO : A medium grained epidote amphibole rock with dark green amphibole, pale green epidote, the latter also filling small veins.

MICRO : Medium grained rock with xenoblastic, decussate, poikiloblastic amphiboles some as prisms with ragged terminations interlocking with xenoblastic epidote, sphene etc.

AMPHIBOLE : About 30%, size 1.5mm. Pleochroic α = straw, β = light green γ = medium green/ blue green. Generally poikiloblastic containing plagioclase etc. Irregular extinction due to strain. Biaxial (-).

EPIDOTE : About 60%, size 0.1 - 0.2 mm. Xenoblastic Slightly pleochroic from colourless to pale yellow, moderate to (high) birefringence. Biaxial (-).

PLAGIOCLASE : Small inclusions in amphibole.

SPHENE : About 5% in irregular groups, pale pink, moderate to high birefringence. Associated with amphiboles and opaques.

OPAQUES : Accessory, some idioblastic, deep red-black.

342-35

MACRO : A medium grained amphibole plagioclase rock with a weak schistosity developed. Both minerals show poorly developed form.

MICRO : A fine to medium grained rock consisting of diffuse-looking xenoblastic plagioclase, xenoblastic amphibole altering to chlorite, biotite, some quartz and skeletal opaque. A probable preferred orientation.

PLAGIOCLASE : About 50-60%, size up to 1-1.5mm. Chequerboard twinning common and grains showing irregular extinction (forerunner of former ?). Commonly included. Deformation seems probable Biaxial (-).

CHLORITE : About 30%, size 0.2 - 1.0mm. Xenoblastic crystals showing very low birefringence i.e. dark brown-black interference colours (little or no extinction changes). Some fan-shaped arrangements. Pleochroic colourless to medium blue-green. Fibrous to a felted arrangement.

BIOTITE : About 10%, size 0.2 - 0.3mm. Pleochroic pale pink to medium olive brown. Reasonable preferred orientation. Some opaques parallel to length.

ACCESSORIES :

Opaque - commonly skeletal and associated with amphibole (may reach 1-2%)

Rutile ? - golden brown

342-37

MACRO : A dark grey-black fine grained, finely laminated opaque rich rock with thin (~1mm) white bands. Odd larger quartz? grains. Some secondary leucocratic crosscutting veins.

MICRO : A fine-grained moderate to strongly foliated quartz-plagioclase-amphibole-opaque rock, grains being elongate, arranged in a parallel manner and commonly showing signs of pronounced strain.

AMPHIBOLE : About 25%-30%, size 0.1-0.5mm. Xenoblastic, prismatic with ragged terminations, moderately strongly poikiloblastic making some grains appear granular, to small elongate prisms. Pleochroic α = colourless, β = light green, γ = blue green. Some colour patching especially darker edges. Inclusions include opaques, plagioclase etc. Some of the thinner needle-like amphiboles lie across feldspar grain boundaries and appear to be crystallographically oriented (approx 70^{o} to twinning). Biaxial (-), 2v = 75^{o} - 80^{o}. Some alteration along cracks, cleavages etc. to a brown mineral.

PLAGIOCLASES : About 40-45%, size 0.05 - 0.5mm. Xenoblastic mosaic-like texture with quartz. Multiple twinning present but coarse, irregular and often shows physical displacement along cracks (cleavages ?). Also irregular extinction shows has been subjected to strain (or zoning?). Small extinction angle (7^{o}) giving $Ab_{75-80^{o}}$. Biaxial (-). Inclusions common.

QUARTZ : About 5%. Xenoblastic cracked grains showing undulose extinction, mosaic-like texture with plagioclase. Small anomolous 2v.

OPAQUES : About 30% - 35%. Xenoblastic to idioblastic from granules to well formed crystals (0.1mm). In reflected light gives a bluish tinge which shows a sort of pleochroism. Occurs as separate grains or in poorly defined zones (opaque rich) or as inclusions in other minerals. Alters to sphene. Some zones appear sheared.

SPHENE : Accessory as granules around magnetite, pink and slightly pleochroic, high relief.

ACCESSORIES :

Biotite, Rutile ?

342-38

MACRO : A dark grey-green finely laminated (schistosity?) rock similar to 342-37 i.e. white fine laminae (1mm) in a dark groundmass. Also some fine cross-cutting laminae and patches.

MICRO : A fine to medium grained amphibole-plagioclase-biotite rock showing a distinct preferred orientation i.e. moderately schistose.

AMPHIBOLE : About 35-40%. Xenoblastic stumpy prisms with ragged terminations or as six-sided sections showing cleavage, as felted masses with biotite. Pleochroic light yellow green to medium green blue low interference colours, felted nature (0.01 - 0.02mm). The larger elongate prisms show higher interference colours, pleochroic, low extinction angles, length slow. Biaxial (-) $2v = 80^{\circ}$

BIOTITE : About 40% size 0.2 mm. Small xenoblastic to partially idioblastic grains. Strongly pleochroic in brown. Preferred orientation. Biaxial (-). Basal section non-pleochroic and gives nearly uniaxial figure.

PLAGIOCLASE : About 20% Xenoblastic, twinning rare and where present is multiple. Biaxial (-) and (+). Inclusions include bubbles, amphibole etc. Some mosaic textures with quartz.

SPHENE : Less than 1% especially along cracks etc. Pleochroic in pink, associated with biotite, high relief.

342-43

MACRO : A fine grained dark grey-black massive rock with some distinct plagioclase laths (about 1mm long) in random orientation.

MICRO : A microporphyroblastic plagioclase-amphibole rock with minor calcite, opaque, epidote and biotite, i.e. cloudy laths of plagioclase with an intergranular matrix of small plagioclase laths, calcite etc. A relict dolerite texture.

PLAGIOCLASE : About 50%. As large blasts approximately 1.0 - 1.5mm and as smaller laths 0.1 - 0.4mm. Nearly all lath shaped, xenoblastic corroded crystals. Twinning on a relatively large scale as few broad lamellae or as fine multiple and some irregular showing non-uniform extinction. Twinning absent on many larger grains Biaxial (+) and (-) the former generally untwinned Full of groundmass inclusions (amphibole, calcite, sphene, quartz, opaques etc.) Possibly Ab_{85}.

AMPHIBOLES : About 45%. As large (o.4 - 0.5mm) xenoblastic strongly poikiloblastic crystals, as finer grained (0.1-0.2mm) elongate xenoblastic to subidioblastic prisms and as minute granules. Pleochroic α = straw, β = green, γ = blue green. Markedly poikiloblastic with plagioclase (Ab_{80}), calcite, sphene etc. inclusions.

OPAQUES : Less than 1%. Alterting to orange red probably isatropic limonite?

ACCESSORIES :

Chlorite, epidote, sphene, biotite, quartz.

342-47

MACRO : A fine to medium grained massive, grey green plagioclase amphibole rock, the amphibole being some-what porphyroblastic.

MICRO : Microporphyroblasts of amphibole set in a fine grained feldspar and minor quartz mosaic with small amphiboles and epidotes. Random orientation.

AMPHIBOLE : About 65% as large (up to 1.2mm) xenoblastic prismatic crystals commonly altering to a light green chlorite along cleavages strongly pleochroic α = straw, β = green, γ = blue green with patchy colour zonation. Also alters to golden brown along cracks etc. Biaxial (-), $Z \wedge c = 17^{\circ}$. Some fine needle-like crystals in the groundmass.

PLAGIOCLASE : About 30%, size 0.05mm. Xenoblastic interlocking mosaic. Twinning rare and where it does occur as fine often truncated twins. Small inclusions of amphibole, bubbles etc. common.

QUARTZ : About 2% xenoblastic, slight undulose extinction (small 2v)

EPIDOTE : About 2%. Generally fine grained (0.01 - 0.04mm), high relief, moderate birefringence, slightly pleochroic colourless to pale yellow. Xenoblastic. Commonly contains minute inclusions.

OPAQUE : About 1%; Xenoblastic grains and thin rod-like grains. Commonly associated with amphibole.

342-48

MACRO : A medium grained crystalloblastic plagioclase-amphibole opaque rock, the plagioclase existing as quite distinct laths (one 10mm x 0.6mm) in random orientation in a plagioclase (equidimensional), amphibole (dark green) and opaque groundmass.

MICRO : A medium to coarse grained plagioclase rich rock with finer grained intergranular amphibole and opaque (with granular sphene) in approximately equal proportions.

PLAGIOCLASE : About 75%. Xenoblastic lath shaped crystals, coarse grained (1-6mm) with irregular crystal edges. Many inclusions are common. Twinning is common with rather broad lamellae. Composition Ab_{75-85}. Biaxial (-) and (+). Some chequerboard twinning is present.

AMPHIBOLE : About 10% size 0.2mm. Xenoblastic prisms with ragged terminations. Pleochroic α = straw, β = pale green, γ = blue green. Biaxial (-) $Z \wedge c = 11^{\circ}$? (possibly actinolite). Inclusions are common especially opaques. Twinning is found in many amphiboles.

OPAQUES : About 10% size 0.2mm. Xenoblastic to idiomorphic. Alters to sphene. Commonly associated with amphibole. Frequently engulfs inclusions of feldspar etc.

SPHENE : About 5%. All xenoblastic as small granules associated with opaques. Pale pink to pale brown.

MACRO : A medium to coarse grained plagioclase-amphibole-epidote rock. The plagioclase appears reasonably ideoblastic. The amphibole is dark green, the epidote is pale green and appears to be replacing felspar.

MICRO : A medium to coarse grained amphibole-epidote-felspar rock with remnant strongly resorbed amphibole.

AMPHIBOLE : About 40%. Very irregular and resorbed ragged crystals. Pleochroic α = straw, β = green γ = blue green. Bent lamellae and irregular extinction characterises some crystals. Some inclusions especially plagioclase and opaques. Patchiness of colour is common. Biaxial (-) $2v = 75^\circ - 80^\circ$ $Z \hat{} c = 16^\circ$ with dispersion weak.

PLAGIOCLASE : About 20%. Very irregular in outline. Size 0.5 - 2.0mm. Commonly choked with alteration products (clay ?). Also as a fine grained mosaic with a welded appearance (very irregular extinction) or even looks myrmekitic. Biaxial (-), $2v = 85^\circ - 90^\circ$.

EPIDOTE : About 35%. Xenoblastic to subidioblastic, moderate birefringence, intimately associated with amphibole and sphene. Pale yellow to colourless, moderate relief.

OPAQUE : About 1-2%. altering to sphene (pink, granular) or goethite-haematite ? (red) the latter rare.

342-50

MACRO : A fine to medium grained grey-green somewhat porphyroblastic amphibole plagioclase rock showing evidence of deformation (cataclasis).

MICRO : Porphyroblasts of irregular amphiboles set in a finer grained groundmass of amphibole fragments, plagioclase, epidote and biotite. Suggestion of cataclasis in the larger grains.

AMPHIBOLE : About 55% - 60% size range 1-6mm as porphyroblasts showing a very irregular nature (resorbed?) and cataclasis of their edges. Fragments form a finer grained groundmass. Pleochroic α = straw to a pale green, β = grass green, γ = blue green. Patchy colours and darker edges are common Biaxial (-), 2v = 85^{o} , Z $^\wedge$ c = 19^{o}. Alteration along cracks, cleavages etc. to a golden brown mineral. A secondary quartz-plagioclase veinlet cuts some large crystal

PLAGIOCLASE : About 25-30% as a mass of welded grains twinning very rare, frequently cracked, inclusions common. Biaxial (-). Some grains Biaxial (+) with a low 2v are possibly quartz.

SPHENE : About 2-3%. Small xenoblastic grains, deep orange brown commonly associated with opaques (1-2%).

BIOTITE : About 5% size 0.05 - 0.1mm, xenoblastic to subidioblastic probably an alteration product of amphibole. Strongly pleochroic. Straw to olive brown.

ACCESSORIES :

Epidote - moderate relief, pale yellow
Apatite - very elongate colourless needles.
Zircon ?

342-54A

MACRO : A medium grained plagioclase rich rock with minor amphibole.

MICRO : A medium grained plagioclase rich rock interspersed with both larger grained and finer grained amphibole.

PLAGIOCLASE : About 80-85%, size 0.1 - 0.8mm. Xenoblastic, interlocking mosaic. Twinning is common but is generally very irregular and patchy and is often dislocated somewhat. Extinction angles are very low giving the plagioclase as an oligoclase (probably Ab_{85}). Irregular extinction and twinning dislocation suggests strain. Inclusions are common especially amphibole needles apatite needles, opaques, quartz, bubbles etc.

AMPHIBOLE : About 15% as xenoblastic stumpy prisms with ragged terminations or thin elongate prisms. The larger crystals (up to 1mm) have been broken up into smaller xenoblastic crystals which have been separated (all extinguish together). Biaxial (-), $Z \wedge c = 18^{\circ}$. Pleochroic α = light green, β = medium green, γ = blue green with common colour patching and zoning. Alteration to brown biotite and a chlorite.

ACCESSORIES :

Opaques - xenoblastic commonly altering to sphene.
Apatite - colourless thin needles.
Chlorite - green-brown, low birefringence.
Biotite - alteration product of amphibole with chlorite.

342-54B

MACRO : A medium grained green and white speckled amphibole plagioclase rock showing signs of deformation. The rock is commonly cracked.

MICRO : A fine grained biotite, amphibole, plagioclase rock with a moderately well developed preferred orientation. Most of the amphiboles appear approximately perpendicular to the biotites in the slide.

AMPHIBOLE : About 15%. Xenoblastic to subidioblastic elongate prisms or stumpy prisms with ragged terminations. Strongly pleochroic α = straw, β = green, γ = blue green. Biaxial (-), $Z \hat{} c = 19^{\circ}$.

BIOTITE : About 60%. Xenoblastic to subidioblastic elongate prisms. Strongly pleochroic pale brown to dark brown. Has relict amphibole along cleavages especially in larger biotites.

PLAGIOCLASE : About 20%. As small xenoblastic grains in groundmass. Twinning is rare and irregular where it occurs. Biaxial (-).

CHLORITE : About 1%. Green, fibrous to platy and often in radial arrangements. Biaxial (+), low birefringence and 2v.

EPIDOTE : About 1%. Xenoblastic as large crystals or as granular groups. High relief, pleochroic in pale yellow.

SPHENE AND OPAQUES : About 1-2%. May reach 0.5mm or as fine aggregates with sphene.

342-56

MACRO : A medium to coarse grained granular, plagioclase (pink-white) amphibole rock, the latter commonly occuring as very thin elongate (acicular) crystals in a random orientation.

MICRO : A coarse grained plagioclase rich rock with minor amounts of fine to medium grained amphibole, opaques and sphene (intergranular).

PLAGIOCLASE : About 70%, size 0.5 - 2mm, xenoblastic to subidioblastic. Twinning is not common. Both Biaxial (+) (⊥ a section gave Ab_{93}) and (-), the latter more common and shows better twinning (which commonly ends abruptly within the crystal). Some poorly developed chequerboard twinning. Some alteration along cleavages etc. to a golden brown mineral.

AMPHIBOLE : About 10-12%. Small xenoblastic prismatic to acicular crystals. Pleochroism weak, colourless to pale green. Commonly altered along cleavages to golden brown biotite. Biaxial (-) odd grain recorded Biaxial (+).

SPHENE : About 8%. Up to 0.5mm. Granular, pink. Associated with opaques.

OPAQUES : About 8%. Commonly subidioblastic, may reach 1mm. Tending to a skeletal arrangement. Commonly associated with the amphibole.

CHLORITE : Accessory after amphibole, fibrous.

342-58

MACRO : A weakly banded amphibole plagioclase rock, the green amphibole being fine grained and as porphyroblasts and set in a white granular plagioclase groundmass.

MICRO : Porphyroblastic amphibole and plagioclase set in a very fine grained "welded" mosaic of xenoblastic plagioclase and quartz. Some suggestion of a weak banding in places.

AMPHIBOLE : About 15-20% size 0.2-2mm. Prismatic with ragged terminations. Veins from weak to moderage pleochroism α = straw, β = medium green, γ = blue green. Patchiness of colour is evident. Also occurs as odd single elongate-acicular crystals with length say 10 x width. Biaxial (-), 2v = 70^{o}- 75^{o}, $Z \wedge c = 16^{o}$.

PLAGIOCLASE : About 75%. Occurs as two distinct grain sizes, as medium to coarse grained xenoblastic crystals and in a very fine grained interlocking groundmass.of xenoblastic plagioclase and quartz. The former (0.5 - 1.2mm) commonly shows multiple twinning (Ab_{68}) and usually has indistinct edges which grade between grains. Strain extinction is not rare. Some grains Biaxial (+) with 2v = 90^{o} whereas most biaxial (-) with 2v = 75^{o}. The (+) grains generally show little if any twinning. Some inclusions. The fine grained matrix (0.01 - 0.03 mm) consists essentially of plagioclase some showing fine twinning, and quartz.

QUARTZ : About 5% in a fine grained matrix, xenoblastic commonly shows strain extinction.

SPHENE : About 5% size 0.1 - 0.5mm, xenoblastic to subidioblastic, colourless to pink (weakly pleochroic). Medium to high relief, generally with opaque cores.

OPAQUE : About 2-3% as cores in sphene or as independent grains (0.3mm max.) whose edges are commonly going to sphene.

342-60

MACRO : A fine to medium grained porphyroblastic amphibole-plagioclase rock, porphyroblasts of these minerals being set in a fine grained groundmass of these and accessory minerals.

MICRO : Strongly resorbed porphyroblasts of amphibole and plagioclase set in a fine grained mosaic of plagioclase, quartz, sphene and zircon ?

AMPHIBOLE : About 25-30%. Prismatic with ragged terminations (grading to fibrous). Strongly resorbed and some quite poikiloblastic (feldspar, epidote, opaques). Pleochroic α = straw, β = pale green, γ = medium blue green. Biaxial (-), $Z \wedge c = 16^{\circ} - 18^{\circ}$. Associated with opaques and sphene and altering to epidote ?

PLAGIOCLASE : About 65%. As porphyroblasts or a fine grained matrix. Porphyroblasts commonly show a chequer effect to varying degrees. Up to 1mm, xenoblastic, Biaxial (-). Inclusions not uncommon. Matrix consists of fine grained xenoblastic plagioclase, quartz etc., some plagioclase showing fine twinning.

EPIDOTE : About 8% xenoblastic, after amphibole. Pale yellow.

ACCESSORIES :

Sphene, Opaques, Apatite, Zircon ?

342-61

MACRO : A very well banded (alternating green and white bands) Amphibole-plagioclase rock. Generally fine grained. Banding on the scale of 2-3mm.

MICRO : A medium grained distinctly banded rock with alternating amphibole rich and plagioclase rich layers, on the scale of 2-4mm.

AMPHIBOLE : About 25% size 0.1 - 0.8mm. Prismatic with ragged terminations. Diverse orientation within the bands. Pleochroic with α = straw, β = medium green γ = blue-green. Frequently shows colour patching, especially darker green edges. Some inclusions of plagioclase, opaques and sphene. Biaxial (-), 2v = 80-85°, $Z \wedge c$ = 16°.

PLAGIOCLASE : About 70% size 0.1-2mm. Between amphibole rich bands and within them xenoblastic, commonly showing multiple twinning giving composition Ab_{68} (Biaxial (-). Twinning varies from chequerboard type, normal multiple twinning to patchy extinction and about 80% of the grains show some twinning. The patchy extinction could be a zoning effect or chequeboard twinning cut subparallel to (010) (Starkey 19). In crystals showing irregular polysynthetic twinning, the twins frequently do not extend over the width of the crystal (compositional zonation ?) Untwinned varieties are generally Biaxial (+) - Oligoclase? Inclusions of amphibole, sphene after opaque etc. not common.

ACCESSORIES :

Sphene (after opaque), Zircon ? Opaque

342-62

MACRO : A fine to medium grained dark grey-black granoblastic amphibole-plagioclase-opaque rock. Secondary white veinlets cut the rock. Cleavage is quite well developed. A moderate suggestion of a preferred orientation.

MICRO : A medium grained granoblastic, lepidoblastic amphibole, plagioclase, opaque rich rock with a weakly defined preferred orientation.

AMPHIBOLE : About 50%, size 0.4-0.8mm. Xenoblastic platy, some quite poikiloblastic (plagioclase, opaques) to moderately resorbed. Pleochroic α = straw, β = green, γ = blue-green. Biaxial (-), 2v = 80°, $Z\hat{}c$ = 17°. Some colour zoning, generally darker edges. Commonly altered along cleavages and cracks to a golden-brown mineral.

PLAGIOCLASE : About 40%, size 0.1-0.5 mm. Xenoblastic interlocking grains. 50-60% show twinning, some multiple and distinct, some diffuse. The former are generally Biaxial (-) the latter (+). Low extinction angles (oligoclase). Commonly full of inclusions (sphene etc.)

OPAQUES : About 8-10%. Small xenoblastic to idioblastic crystals more commonly associated with the plagioclase than with the amphibole. Alteration to sphene (1-2%) is not uncommon with some approaching idioblastic rhombohedra . High relief colourless to pink.

ACCESSORIES :

Biotite (grains and alteration of amphibole), Zircon ?

MACRO : A fine grained quartz feldspar-mica schist characterised by very distinct pink lensoids (about 1cm wide) of a mica probably.

MICRO : A muscotie, biotite, quartz, feldspar schist where the muscotie is congregated in elongate patches with their long axis parallel to the schistosity. The preferred orientation of the muscovite in the patches is much stronger than the orientation of the micas outside the patches.

MUSCOVITE : About 35%, very fine grained (0.05-0.15 mm), elongate prismatic. Colourless, moderate relief, moderate birefringence, length slow. Mottling near extinction.

BIOTITE : About 15%, size 0.05-0.15mm, subidioblastic but odd larger porphyroblasts with no relationship to schistosity. Strongly pleochroic α = straw, β = olive green, γ = grey brown. Moderate birefringence. Restricted to zones between muscovite lenses whereas muscotie is spread throughout the rock.

FELDSPAR : About 30-35% size about 0.05mm. Xenoblastic, interlocking grains. Little or no twinning. Biaxial (-). Few inclusions (species) but not uncommon, mostly opaques and appear to be concentrated near edges.

QUARTZ : About 10%, xenoblastic, colourless, interlocking grains. Uniaxial (+), some grains showing anomolous 2v and strain shadows.

ACCESSORIES :

Opaques (1%) preferentially concentrated in biotite rich zones. Amphibole as odd large grains and sphene, associated with opaques.

342-64

MACRO : A medium to coarse grained dark green amphibole - plagioclase-epidote rock with an apparent granoblastic texture.

MICRO : A medium to coarse grained rock showing extreme alteration of minerals (weathering ?)

AMPHIBOLE : About 20%. Relict amphibole up to 1-2mm showing alteration to chlorite, biotite (golden-brown) and epidote where it abuts plagioclase. Strongly pleochroic in shades of green. Biaxial (-), $Z \hat{} c = 19^{o}$.

CHLORITE : About 10-15%. Alteration product of amphibole. A fibrous, felted appearance commonly in fan shapes, radial and spherulitic textures. Low birefringence, pleochroic in green.

PLAGIOCLASE : About 50%. Xenoblastic commonly choked with inclusions, commonly the cores. The main inclusion is epidote. Twinning gives a composition about Ab_{82}. Other inclusions are amphibole and possible zircon. Biaxial (-).

EPIDOTE : About 15-20% as inclusions in feldspar and as independent grains. Xenoblastic to subidioblastic, granular, colourless to pale yellow. Moderate relief and birefringence.

ACCESSORIES :

Sphene, zircon ?

342-68

MACRO : A coarse grained green and white speckled amphibole-plagioclase-epidote rock, the plagioclase occuring as distinct laths. Thin, white veinlets are common.

MICRO : A coarse grained plagioclase, amphibole, epidote rock showing quite moderate alteration (weathering?)

AMPHIBOLE : About 45%, size 0.8 - 2.3mm prismatic with ragged terminations. An "ophitic" relationship with plagioclase. Pleochroic α = straw, β = medium to dark green, γ = deep blue-green. Biaxial (-), 2v = 80-85°, Z ^ c = 16°. Inclusions are common and include plagioclase, zircon ?, opaques and sphene. Alteration to green chlorite, biotite etc.

PLAGIOCLASE : About 40%, size 0.4-1.3mm. xenoblastic equidimensional to lath shaped. Twinning when present varies from distinct (Biaxial (-)) to very diffuse or absent (Biaxial (+)). Gives Ab_{80}. Inclusions common and numerous, some crystals being choked - amphibole, epidote, sericite ?

EPIDOTE : About 10%. Mostly as inclusions within plagioclase. Weakly pleochroic colourless to yellow.

SPHENE : Alteration product of opaques, pink granular.

OPAQUES : Relict cores in sphene, needle-like inclusions in amphibole or subidioblastic (about 1mm) crystals.

ACCESSORIES :

Biotite (from amphibole), chlorite (green, fibrous)

MACRO : A quartz, feldspar mica schist showing a distinct schistosity which has been quite strongly crenulated in parts. Possible presence of original bedding or a plagioclase rich band.

MICRO : A quartz feldspar muscovite biotite schist showing a strong foliation which has been markedly crenulated (strain slip or false cleavage) associated with strain shadows in the quartz and feldspar.

QUARTZ : About 50-55%. Xenoblastic, colourless. Uniaxial (+) except where shows strain shadows (Undulose extinction) and has a small 2v . Some inclusions.

MUSCOVITE : About 30%. Subidioblastic to idioblastic, elongate prisms defining a pronounced foliation which has been markedly crenulated. Moderate birefringence, colourless, length slow, Biaxial (-). Mottled near extinction.

BIOTITE : About 5-10%. Similar to muscovite except brown and strongly pleochroic. Commonly cuts the schistosity.

ACCESSORIES :

Feldspar - Biaxial (-), no twinning.

Amphibole - strongly pleochroic in green, elongate prisms. Probably altering to chlorite.

Opaque - commonly with amphibole, generally elongate prisms.

342-78

MACRO : A fine grained light grey probably quartz-plagioclase rock with minor green amphibole porphyroblasts. Carbonate is present probably in significant amounts.

MICRO : A fine grained quartz plagioclase with intergranular carbonate. Two distinct grain sizes - a coarse quartz - plagioclase - carbonate mosaic (0.05 mm) with finer grained patches of quartz-feldspar (0.05mm).

QUARTZ : About 30-40%. Size average 0.05mm. Xenoblastic with some inclusions. Uniaxial (+) Cataclasis of some grains evident.

PLAGIOCLASE : About 40%, size average 0.05mm. Colourless, xenoblastic. Biaxial (-). Twinning in some grains gives Ab_{86-80} (Oligoclase).

CARBONATE : About 10-15%. As large grains (0.06 - 0.1mm) and as fine intergranular infilling colourless, twinkling effect on rotation. Secondary ?

ACCESSORIES :

Sphene - opaque cores commonly, high relief, pink
Biotite - pleochroic in brown
amphibole - slightly pleochroic in green

342 - 79

MACRO : A fine to medium grained white-green amphibole - plagioclase - quartz rock showing weak to moderate banding, and patchy concentrations of felsic minerals. Some aphibole porphyroblasts.

MICRO : A quartz plagioclase amphibole rock where the quartz and plagioclase is concentrated in distinct zones from ovoid to linear bands. The amphibole is coarser grained and has a preferred orientation. Opaques and sphene common.

AMPHIBOLE : About 35%, size 0.5-1mm, prismatic with ragged terminations. Moderately pleochroic α = very pale green, β = dark green, γ = light blue green. Colour patching is common with also an odd zoned grain the centre being ideoblastic (rhombehedral) with a xenoblastic rim. The centre also shows pleochroic haloes. Inclusions of angular plagioclase where amphibole is "bleached" at contact. Biaxial (-), 2v = 80°, $Z \wedge c$ = 17°.

PLAGIOCLASE : About 50%, size 0.05-0.2mm with odd larger crystals 0.8-1.5mm. The smaller xeno-blastic crystals are in a fine grained mosaic with quartz and are found in ovoid patches and in crude banding - the grains are elongate (shearing?). Biaxial (-) with multiple twinning in many grains. Some odd Biaxial (+) giving Ab_{90} (Michel-Levy) and Ab_{91} ($\perp$ a). Some of the larger crystals show a marked chequer effect.

QUARTZ : About 10%. Xenoblastic interlocking in the plagioclase. Uniaxial (+), some showing strain extinction.

OPAQUE : About 1-2%, size 0.1-0.8mm generally altering to sphene especially around the margins.

MACRO : A fine to medium grained leucocratic "sugary" rock consisting essentially of plagioclase with minor altered amphibole.

MICRO : A medium grained plagioclase rich rock with minor amphibole going to chlorite associated with sphene and rutile. A crack infilled with quartz is present in the slide.

PLAGIOCLASE : About 90%. Size 0.5-2mm. Xenoblastic interlocking grains, equigranular to lath shaped, decussate. About 90% are twinned and it is not uncommon for twinning to show dislocation. Strain shadows not uncommon. All contain inclusions as many very small grains (Unidentifiable), bubbles and odd larger amphibole. Biaxial (-), twinning gives Ab_{84}.

QUARTZ : About 5%. Xenoblastic, strain shadows in some grains leading to a small 2v.

AMPHIBOLE : Pleochroic straw- pale green most altered to a green Chlorite (2%) which is pleochroic, fibrous and has low birefringence. Intergranular.

SPHENE AND RUTILE : About 2%, intergranular. Sphene is xenoblastic, shows high relief and pleochroism in pink and is associated with golden brown Rutile which is irregularly to conchoidally fractured, is weakly pleochroic yellow brown - red brown and shows straight extinction.

342-82A

MACRO : A fine to medium grained coarsely banded amphibole, chlorite, felsics rock with crosscutting amphibole patches.

MICRO : A medium to coarse grained coarsely banded rock with alternating amphibole rich and quartz-feldspar-epidote rich bands.

AMPHIBOLE : About 55%. Two grain sizes i.e. large crystals up to 6mm across and smaller acicular prisms 0.3-0.4mm long generally restricted to the felsic bands. The larger grains are quite poikiloblastic with feldspar, epidote, sphene, other amphibole, zircons ? (pleochroic haloes) all being xenoblastic. Pleochroic α = straw, β = medium green, γ = blue green. Biaxial (-), 2v = 75^{o}, z $\hat{}$ c = 16^{o}. Altering along cracks to biotite. Cleavages evident.

EPIDOTE : Form a distinct band within the felsic band against the amphibole band. Xenoblastic granular (0.2m). Pale yellow, slightly pleochroic, high relief, moderate birefringence.

FELDSPAR : Xenoblastic interlocking (amoeboid) mosaic giving appearance of welding (undulose extinction strong). Twinning moderately rare, where exists as broken or bent multiple or as chequerboard type. Inclusions common. Biaxial (-

ACCESSORIES :

Sphene - in amphibole surrounded by darker areas.
Biotite - alteration ? of amphibole
Quartz - Uniaxial (+) some with anomolous 2v . In feldspar rich band and as inclusions in amphibole.

342-82B

MACRO : A fine to medium grained granoblastic dark grey-green amphibole plagioclase rock with minor secondary white veinlets.

MICRO : A medium grained granoblastic amphibole plagioclase opaque rich rock. Random orientation of elongate crystals.

AMPHIBOLE : About 40%, size 0.4 - 0.6mm. Xenoblasti[c] embayed outline. At best prismatic with ragged terminations. Moderately poikiloblastic with opaque, sphene etc. inclusions. Pleochroic α = pale green, β = green, γ = blue green, with some colour patching. Biaxial (-), 2v = 75-80°, $Z \wedge c$ = 18°.

PLAGIOCLASE : About 45-50%, size 0.4-1mm. Xenoblastic, interlobate to amoeboid. Twinning present and veins from good multiple to chequer-board type giving very irregular extinction. Generally Biaxial (-) and Ab_{68-70}. Untwinned Biaxial (+) grains probably Oligoclase. Inclusion of amphibole, quartz, zircon ? etc. common.

QUARTZ : About 5%, xenoblastic interlobate, some as inclusions in amphibole. Uniaxial (+) some with small 2v (strained). Inclusions common and numerous.

OPAQUES : About 2-3%, 0.1 - 0.8mm xenoblastic, with amphibole. Alteration to sphene along edges not uncommon.

BIOTITE : About 1-2% xenoblastic, individual or wit[h] amphibole. Strongly pleochroic straw brown - dar[k] grey brown.

ACCESSORIES :

Epidote - pale yellow (slightly pleochroic)

342- 84

MACRO : A medium grained "spotted" epidote amphibole plagioclase rich rock, light green patches of epidote set in a dark green amphibole plagioclase rock.

MICRO : A fine to medium grained amphibole, epidote, plagioclase rich rock with the plagioclase forming a somewhat finer grained mosaic-like interstitial groundmass.

AMPHIBOLE : About 50%. Xenoblastic, prismatic with ragged terminations. Pleochroic α = pale yellow, β = green, γ = blue green with some colour patching, quite distinct in many grains, Biaxial (-), $Z \hat{} c = 17^{o}$.

PLAGIOCLASE : About 20%. As xenoblastic laths up to 0.4mm and as a fine grained mosaic with quartz (resembles myrmekite). Larger crystals show multiple twinning to chequerboard twinning, Biaxial (-) and Ab_{70}. One large (0.1mm) crystal is Biaxial (+) and has no inclusions except at its edges.

EPIDOTE : About 25% may reach 1.2mm. Xenoblastic (elongate crystals - cleavage fragments (001) are largest). Arranged in distinct patches and disseminated in rock. Biaxial (-), 2v = 80°. Pale yellow pleochroism, moderate relief; Fine inclusions common.

SPHENE : About 2-5%. As rims around irregular opaque cores. Generally associated with amphibole Pink and granular, weakly pleochroic.

ACCESSORIES :

Quartz - Uniaxial (+) xenoblastic, amoeboid.

342-85

MACRO : Medium grained crystalloblastic plagioclase amphibole rock, the plagioclase commonly existing as fine laths.

MICRO : Fine to medium grained plagioclase rich rock with fine grained amphibole and opaques occupying intergranular positions.

PLAGIOCLASE : About 65-70%, size 0.5 - 1.5 mm, xenoblastic to subidioblastic, commonly lath shaped srystals showing simple to fine multiple twinning, odd crystals showing bent lamellae. Extinction angles give Ab_{68}, Biaxial (-). Some untwinned. Biaxial (+). Intergranular positions often show intense twinning, chequerboard commonly frequently with small epidote inclusions (and opaques, zircons ?, dust, bubbles.)

AMPHIBOLE : About 25-30%, size 0.1 - 0.4mm Xenoblastic, embayed crystals, some granular. Strongly pleochroic α = straw to pale green, β = green, γ = blue green. Biaxial (-), $Z \hat{} c = 17^{o}$. Some alteration to chlorite (chloritoid ?) quite strongly pleochroic, fibrous, low birefringence.

OPAQUES : About 2-5%, size 0.2 - 0.4mm Xenoblastic to subidioblastic, associated with amphibole. Some grains altering to sphene at edges and some altering to red limonite/goethite ?

ACCESSORIES :

Epidote - generally as small inclusions.

MACRO : A fine grained indurate blue-grey weakly laminated plagioclase - amphibole rock with secondary irregular patchy veins of amphibole. Some odd large grains of opaques are visible.

MICRO : A very fine grained amphibole-plagioclase opaque rich rock, cut by irregular veins of fine to medium grained amphibole. A preferred orientation of the groundmass amphiboles is evident.

AMPHIBOLE : In groundmass about 30% (veinlets almost pure amphibole). Occurs as very fine subideoblastic to ideoblastic elongate prisms (microlites ?), about 0.06 - 0.08 mm long. Pale green, slightly pleochroic. Length slow, $Z \wedge c = 17^{\circ} - 20^{\circ}$. Cannot obtain a sign. In irregular veinlets as larger xenoblastic granular to stumpy prismatic with ragged terminations. Pleochroic α = colourless to straw, β = green, γ = bluish green. Biaxial (-), $2v = 85^{\circ}$, $Z \wedge c + 19^{\circ}$.

FELDSPAR : About 65%, very fine grained groundmass 0.02 - 0.07mm. Xenoblastic, strain shadows common. Generally too small to get a sign - some could quite easily be quartz since on a larger grains got Biaxial (+). Contain a few zircon ? and bubble-like inclusions.

OPAQUES : About 2%. Subidioblastic to ideoblastic, 0.01 - 0.1mm. Commonly altering to sphene around edges. Also some deep red grading to orange around edges which appears isatropic.

SPHENE : About 2%. As rims around opaques or small granular aggregates. High relief, colourless to pale pink. Associated with or altering to orange red mineral (leucoxene, limonite ?)

342-88

MACRO : A fine grained dark grey black plagioclase amphibole rock, the plagioclase existing as randomly oriented lath shaped crystals in a very dark intergranular groundmass. Odd secondary veinlets.

MICRO : A porphyroblastic plagioclase amphibole opaque rich rock showing a relict doleritic texture i.e. cloudy porphyroblastic plagioclase laths (random orientation with an intergranular matrix of plagioclase amphibole, opaques and biotite.

PLAGIOCLASE : About 45%. As large porphyroblasts about 1mm long but may reach 2mm, and as fine intergranular laths and xenoblastic grains. The porphyroblasts are xenoblastic to subideoblastic lath shaped crystals with crenulated margins commonly containing many inclusions (mainly amphibole, also biotite, zircon ?, bubbles, quartz and opaques). Biaxial (-), twinned and Ab_{73-75}. Some untwinned Biaxial (+). Finer groundmass crystals generally untwinned and contain inclusions. Some irregular extinction from the centre outwards could indicate zoning. Possibility of some quartz (some figures unobtainable).

AMPHIBOLE : About 50%. Xenoblastic aggregate of fine grains (interstitial). Strongly pleochroic α = straw, β = green, γ = blue green. Biaxial (-), $2v = 80^{\circ}$ $Z \hat{} c = 19^{\circ}$.

BIOTITE : About 1-2% Xenoblastic, associated with amphibole. Strongly pleochroic in shades of brown.

OPAQUES : About 1-2% Xenoblastic, interlobate in groundmass. Appears to be altering to sphene along edges.

MACRO : Fragmental, irregular amphibole porphyroblasts set in a grey, weak to moderately banded amphibole plagioclase rock.

MICRO : A fine grained plagioclase rich rock with relict medium to coarse grained amphibole (fragments approx. 0.5mm). Occurs both as disseminated grains and in rough layers.

PLAGIOCLASE : About 65-70% fine grained granoblastic interlobate mosaic most commonly showing chequer-board type twinning. Multiple twinning also present - extinction angles give Ab_{70-73} (or Ab_{85-87} cannot tell). Biaxial (-) for chequer-board type. Untwinned crystals are Biaxial (+) $2v = 85^{\circ} - 90^{\circ}$. (one is 90°). Probably some interstitial quartz grains, inclusions common, especially in cores - detrital origin ?

AMPHIBOLE : About 30%. Generally as medium to large crystals which are now parallel fragments that extinguish together (resorbed and replaced). Inclusions of plagioclase (chequerboard) Biaxial (-), $2v = 75^{\circ} - 90^{\circ}$, $Z \wedge c = 16^{\circ}$, Length slow. Pleochroic α = light green, β = green, γ = green to blue green. Darker pleochroic haloes are quite common. Some alteration to biotite.

ACCESSORIES :

Opaques - about 1% xenoblastic granular to odd ideoblastic.

Sphene - alteration of opaques, granular, high relief, pinkish.

Biotite - probably as alteration product of amphibole.

Zircon ? - in plagioclase, xenoblastic, high relief.

MACRO : A medium grained amphibole plagioclase, dark green rock which grades into a fine grained pale green epidote rich rock (the thin-section is in this part) Boundary irregular.

MICRO : A fine grained epidote, biotite, sphene, amphibole rich rock.

EPIDOTE : About 80%. Xenoblastic granular, pale yellow (slightly pleochroic) moderate relief, moderate birefringence (bright interference colours). Commonly full of inclusions, e.g. biotite. Biaxial (-), 2v = 80° - 85°.

BIOTITE : About 2-3%. Xenoblastic irregular crystals, strongly pleochroic straw to olive green. Basal section very low 2v and is yellow green. (non pleochroic).

AMPHIBOLE : About 5% xenoblastic prismatic with ragged terminations. Pleochroic in shades of green α = yellow green, β = green, γ = blue green. Colour patching especially darker edges and cleavages. Biaxial (-). Some alteration to green brown biotite along cleavages and cracks. Also some alteration to chlorite - green, pleochroic, low birefringence.

OPAQUES AND SPHENE : About 1-2%. Xenoblastic to subideoblastic opaque cores in a granular border of sphene the latter being pale pink, moderate to high relief, moderate birefringence.

FELDSPAR ? : Biaxial (+), no twinning, strain shadows, too high a 2v for quartz. Probably Oligoclase.

MACRO : A fine grained dark grey amphibole plagioclase rock, the plagioclase as small laths in random orientation i.e. relict doleritic.

MICRO : A porphyroblastic plagioclase amphibole and opaque rich rock with a relict doleritic texture - decussate plagioclase laths and amphiboles with intergranular finer grained generally granular plagioclase, amphibole and opaques in a radial and felted texture.

PLAGIOCLASE : About 50%. As large (0.8 - 1.5mm) subideoblastic laths with crenulated edges and as finer (0.1mm) xenoblastic laths in the groundmass as felted, radial or randomly oriented crystals. Larger laths commonly show twinning to varying degrees, generally only two broad lamellae. Both Biaxial (+) and (-), the former appears predominand, the latter showing more distinct twinning. The finer grained plagioclase (groundmass) forms radial and sheaf-like arrangements. Probably Biaxial (-) but twinning rarer. Inclusions are common in all grains commonly amphibole, opaque, biotite, sphene, bubbles, dust etc. About Ab_{73}.

AMPHIBOLE : About 40%. As larger xenoblastic to subideoblastic prisms with ragged terminations (0.3 - 0.5mm) and as finer (0.02mm) granular to subideoblastic groundmass crystals. Biaxial (-) $2v = 80^{\circ} - 85^{\circ}$, $Z \wedge c = 21^{\circ}$. Strongly pleochroic α = straw, β = green, γ = blue green. Some associated (altered to ?) with biotite.

OPAQUES : About 5-10% fine grained generally xenoblastic granular or rod-like crystals congregated in groundmass. Alteration to sphene.

342-95

MACRO : Fine to medium grained amphibole epidote plagioclase rock, the larger grains having indistinct form. A probable patchy nature for epidote. Odd opaque grains (approx. 1mm) within rock.

MICRO : A fine grained crystalloblastic amphibole epidote plagioclase rock showing a distinct fragmental nature for the mafics.

PLAGIOCLASE : About 60-65%, size about 0.8mm. Xenoblastic interlobate commonly showing chequer-board twinning Biaxial (-).

AMPHIBOLE : About 25-30%, size 0.2 - 0.3mm. Xenoblastic, prismatic with ragged terminations to fragmental. Biaxial (-) $Z \wedge c = 18^{\circ}$. Strongly pleochroic α = straw, β = green, γ = blue green.

EPIDOTE : About 2-3%. Colourless to pale yellow. Biaxial (-). Xenoblastic granular, high relief, fractured, moderate birefringence.

OPAQUES: About 2-3%. Xenoblastic to subidioblastic, commonly altering to sphene.

ACCESSORIES :

Sphene - 1%. Small pinkish granules, high relief, associated with opaques and epidote.

Biotite - 1-2%, small subidioblastic crystals, brown, commonly associated with epidote.

Muscovite - colourless, xenoblastic, moderate birefringence.

Carbonate - high relief, Uniaxial (-).

342 - 98

MACRO : A fine to medium grained apparently granoblastic, patchy amphibole, plagioclase rock.

MICRO : Fine to medium grained amphibole prisms set in a fine grained granoblastic plagioclase groundmass. The amphiboles show no preferred orientation. Opaques and associated sphene are common subsidiaries.

AMPHIBOLE : About 45-50%. size 0.2 - 0.8 mm. Xenoblastic, prismatic with ragged terminations, elongate prismatic to resorbed and granulated crystals. Pleochroism strong α = straw, β = green, γ = blue green. Some brown pleochroic haloes. Biaxial (-). $Z \wedge c = 18^{\circ}$. (length slow) Some are moderately poikiloblastic containing inclusions of opaque, sphene, zircon ? etc. All of relatively low birefringence.

PLAGIOCLASE : About 45-50%. Xenoblastic interlobate some with appearance of welding together of smaller grains. Biaxial (-) and shows multiple twinning Ab_{69}. Some untwinned or broadly twinned and Biaxial (+) with quartz blebs (myrmekite ?). Some quartz also along intergranular boundaries. Inclusions of amphibole, epidote, sphene and zircon ?

OPAQUES : About 5%. Xenoblastic to subidioblastic, very fine grained (0.1mm), associated with amphibole and plagioclase - altering to sphene.

EPIDOTE : Small pale yellow granules of moderate birefringence.

MACRO : A medium to coarse grained dark green rock consisting essentially of amphibole with intergranular plagioclase and epidote. A preferred orientation is evident.

MICRO : A fine to medium grained crystalloblastic inequigranular rock of felted amphiboles with intergranular epidote, plagioclase (and quartz ?). A weak preferred orientation of the amphibole is evident.

AMPHIBOLE : About 80-85%, size 0.4 - 2mm xenoblastic prismatic with ragged terminations. Strongly pleochroic α = straw to pale green, β = medium to dark green, γ = blue green with some colour patchiness especially darker edges. Quite strongly poikiloblastic with inclusions of epidote, platioclase, zircon ? rutile ? and fine opaques. Biaxial (-), 2v = 80°, $Z \wedge c$ = 19°. Some alteration to biotite along cleavages, inter granular positions etc. Some lamellar twinning present.

EPIDOTE : About 5-8%, very fine (less than 0.2mm) Xenoblastic granular, colourless, high relief, irregularly fractured. Biaxial (-). Generally concentrated in intergranular positions with quartz and plagioclase or as inclusions in amphibole.

PLAGIOCLASE : About 2-3%, Xenoblastic, intergranular, twinning rare or absent. Biaxial (-). Inclusions common especially zircon, amphibole, bubbles, dust etc. Some water clear with no twinning, Biaxial (-).

QUARTZ : About 3-5%. Colourless, xenoblastic, appears like welding of smaller grains, little inclusions. Uniaxial (+).

OPAQUES : Less than 1%. Xenoblastic, appears granulated, some alteration to sphene along edges.

342-101

MACRO : A fine grained grey-pale green granoblastic epidote amphibole rock. Minor opaques are evident.

MICRO : A fine grained essentially granoblastic epidote - amphibole rock with minor amounts of sphene and opaques

EPIDOTE : About 60%, size 0.08 - 0.4mm. Xenoblastic, approximately equidimensional granular grains, colourless to pale yellow-green, moderate to high relief, moderate birefringence (bright interference colours). Uniaxial (-).

AMPHIBOLE : About 35-40% fine grained xenoblastic to subidioblastic crystals commonly prismatic with ragged terminations. Pleochroic α = straw, β = green, γ = blue green, with patchy colour. Biaxial (-), $Z \hat{} c = 18^{\circ}$. Some inclusions e.g. opaques going to sphene, zircons etc. Alteration to golden brown biotite along cracks.

OPAQUES : About 1%. Xenoblastic granular cores in sphene.

SPHENE : About 1-2%. As rims to opaque cores or as granular masses. High relief, pinkish, moderate birefringence.

ZIRCON : Accessory, Uniaxial (+), high relief, low to moderate birefringence.

342-102

MACRO : A very fine grained pale green grey epidote rich rock with small zones of medium grained dark green amphibole. A cleavage is moderately well developed.

MICRO : A very fine grained epidote rich rock with patches of quartz grains and amphibole.

EPIDOTE : About 60%, size 0.05 - 0.1 mm. Xenoblastic interlocking crystals, irregular cracking and many inclusions. (zircon, sphene, quartz)

QUARTZ : About 35%, size 0.2 - 0.4mm. Zenoblastic mosaic like, concentrated in patches. Uniaxial (+), cracking of grains very common. Some smaller grains within epidote rich areas.

AMPHIBOLE : About 1-2%, elongate prismatic to fibrous. Low to moderate birefringence. Pleochroic in shades of green. Weakly poikiloblastic (quartz, epidote). Some alteration to chlorite - green, low birefringence, and biotite - brown, pleochroic. Concentrated at edges of quartz rich patches and generally bent around them.

342-103

MACRO : A medium grained epidote amphibole rock. Essentially granoblastic, the amphibole appearing felted with interstitial epidote.

MICRO : A fine to medium grained granoblastic amphibole rich rock with subsidiary amounts of epidote, chlorite, plagioclase and quartz.

AMPHIBOLE : About 65-70% size 0.2 - 1.6mm. Xenoblastic, prismatic with ragged terminations to elongate prisms. Strongly pleochroic α = pale green-straw, β = dark green, γ = blue-green, some colour patching. Biaxial (-), 2v = 70°-75°, $Z \wedge c = 19^{\circ}$. Alteration ? to golden brown biotite along cleavages etc. Also some alteration to green chlorite.

EPIDOTE : About 15-20%, size o.1mm. Xenoblastic granular, pleochroic colourless to yellow (quite strongly). Moderate to high relief, moderate birefringence. Biaxial (-) length slow.

CHLORITE : About 2%, alteration product of amphibole green, little or no pleochroism, low birefringence Commonly associated with opaque rods, blebs etc.

PLAGIOCLASE : About 2-3%, Xenoblastic, colourless, intergranular to amphibole and epidote. No twinning. Biaxial(+) and (-).

ACCESSORIES :

Quartz - colourless, Uniaxial (+), cracked, anomalous 2v in some grains.

Opaques - Xenoblastic granules altering to sphene.

Biotite - Xenoblastic to subidioblastic grains associated with amphibole and chlorite.

342 - 104 A

MACRO : Medium grained amphibole in a pink fine grained plagioclase groundmass.

MICRO : A fine grained plagioclase rich rock with subsidiary amounts of fine to medium grained amphibole, epidote and sphene.

PLAGIOCLASE : About 75-80%, size 0.3 - 0.9mm. Xenoblastic interlobate to lath shaped with crenulated edges. Moderately to well developed multiple twinning, odd lamellae commonly bent. Biaxial (-), Ab_{68}. Also present as a finer grained mosaic with quartz. Inclusions common and include zircon and amphibole, chlorite, bubbles, dust and needle opaques crystallographically oriented.

AMPHIBOLE : About 10%, size 0.2 - 2mm. Xenoblastic, prismatic with ragged terminations or thin elongate prisms (which originally all belonged to one crystal since extinguish at same time). Biaxial (-), $2v = 75^{\circ} - 80^{\circ}$. $Z \wedge c = 20^{\circ}$.

CHLORITE : About 2-5% green, as alteration product of amphibole.

ASSESSORIES :

Sphene : granular, pink, high relief.

Epidote : elongate prismatic, pleochroic pale yellow-green, moderate relief.

Quartz : mosaic with fine grained plagioclase.

342 - 104 B

MACRO : Fine to medium grained green amphibole and very dark tourmaline set in a fine grained plagioclase groundmass.

MICRO : Fine to medium grained amphibole and tourmaline in a fine grained equigranular amoeboid groundmass of plagioclase and quartz with accessory opaque.

AMPHIBOLE : About 40%, size 0.1 - 0.8mm. Xenoblastic prismatic with ragged terminations to irregular, moderately embayed crystals. Strongly pleochroic α = straw, β = medium green, γ = dark green or blue green. Poikiloblastic with quartz, opaques, plagioclase inclusions. Biaxial (-), 2v = 80-85°, $Z\hat{}c$ = 17°.

TOURMALINE : About 5%, Xenoblastic, strongly pleochroic buff-pink to olive-grey green (polarizer) Moderate birefringence. Uniaxial (-), length fast associated with amphibole.

PLAGIOCLASE : About 50%, Xenoblastic, fine grained, interlobate to amoeboid mosaic giving appearance of welded grains. Some multiple twinning is present as is chequerboard twinning. Biaxial (-), Inclusions of zircon ?, amphibole, opaques, bubble dust etc. Very irregular extinction.

QUARTZ : Accessory, exsolution ? blebs in plagioclase plus odd grains.

OPAQUES : About 1-2%. Very fine xenoblastic grains commonly altering to sphene along edges.

342 - 107

MACRO : A fine to medium grained amphibole, plagioclase rock, dark green amphiboles being set in a cream plagioclase groundmass.

MICRO : A fine to medium grained crystalloblastic inequigranular plagioclase amphibole rock.

PLAGIOCLASE : About 80%, size 0.2 - 1.0mm. Xenoblastic, commonly lath shaped with crenulated edges and strain shadows (undulose extinction). Twinning moderately common including chequerboard type. Biaxial (-). Some untwinned Biaxial (+). Some alteration to sericite along grain boundaries. (with some quartz.)

AMPHIBOLE : About 15-20%. Xenoblastic, prismatic with ragged terminations. Pleochroic α = straw, β = pale green, γ = blue green. Biaxial (-), $2v = 75^{\circ} - 80^{\circ}$, $Z \hat{} c = 19^{\circ}$. Some colour patching especially darker near edges. Odd inclusions especially opaques (often altering to sphene), plagioclase, zircon ? (producing pleochroic haloes) and dusty opaque commonly alligned along cleavage. Alteration to fine grained brown biotite along cleavages common.

OPAQUES : About 1% - Xenoblastic fine grained (approx. 0.05 mm) altering to granular sphene.

SPHENE : About 1-2%. Xenoblastic commonly granular, high relief, generally weakly pleochroic in pink. Odd grain strongly pleochroic and coloured in shades of brown. Commonly with irregular opaque cores.

MACRO : Fine to medium grained grey-green crystalloblastic essentially granoblastic amphibole - plagioclase rock.

MICRO : A fine to medium grained granoblastic decussate amphibole platioclase rock.

AMPHIBOLE : About 60%, size 0.2 - 1mm both as interlocking (felted) prisms with ragged terminations and as fine acicular prisms within plagioclase-quartz regions. Strongly pleochroic α = straw, β = dark green, γ = blue green. Some show a distinct twinning. Biaxial (-), $2v = 85^o$, $Z\hat{}c = 15^o$. Weak to moderately poikiloblastic with inclusions of opaque, sphene, quartz ? feldspar. Acicular prisms in plagioclase subideoblastic to ideoblastic, pale green, both crystallographically oriented and random.

PLAGIOCLASE : About 35%, size 0.5mm. Xenoblastic, inequigranular, interlobate to crenulated edges, larger crystals lath shaped. Large crystals with no twinning and irregular extinction are Biaxial (+) (welding of smaller grains?), some quartz blebs. Some show twinning but commonly irregular Biaxial (+). Some finer twinning is present in odd small grains, commonly Biaxial (-). The grains give appearance of welding together of smaller grains (forerunner of chequerboard ?). Exsolution blebs ? of quartz are not rare particularly along indistinct twinning and crystal boundaries. Other inclusions are acicular - prismatic amphibole, zircon, sphene, opaque, dust etc.

OPAQUES : About 1% Xenoblastic, granular to skeletal, associated with the amphibole, commonly altering to sphene.

SPHENE : About 1-2%, Xenoblastic granular, alteration of opaques and along cleavages of amphibole.

ACCESSORIES :

Zircon ? - as inclusions in plagioclase.

342 - 109

MACRO : A very fine grained pale grey green epidote rich amphibole rock.

MICRO : A fine grained granoblastic epidote amphibole rich rock with minor opaques and biotite.

EPIDOTE : About 85% size 0.2mm. Xenoblastic, equidimensional, some elongate subideoblastic, high relief. Biaxial (-). Moderate birefringence, bright interference colours. Grains irregularly cracked. Pleochroic colourless to pale yellow. Odd inclusions of sphene, opaques, dust, rutile (orange). Some staining along cracks.

AMPHIBOLE : About 10-15%. Relict xenoblastic prisms (fragmental) strongly altering to golden brown biotite ? Strongly pleochroic α = straw, β = dark green, γ = blue green. Poikiloblastic with epidote, opaque and biotite inclusions.

ACCESSORIES :

Biotite - up to 1-2% as fine xenoblastic crystals. Odd inclusion of sphene.

Quartz - odd xenoblastic grain, strained somewhat.

Opaques - about 1%, xenoblastic intergranular.

342 - 110

MACRO : A very fine grained well banded rock with micas being concentrated in thin (approx. 1mm) bands in a light grey quartz feldspar matrix. The banding is not truly planar. A cleavage is well developed at a steep angle to banding.

MICRO : A very fine grained finely banded biotite, muscovite, opaque, plagioclase, quartz ? rich rock, the micas being concentrated in bands approx. 1mm wide and spread throughout the rock. A coarse grained quartz-plagioclase band runs through the rock parallel to the banding.

PLAGIOCLASE : About 75% (possibly). Fine grained (0.02 - 0.08 mm). Xenoblastic interlocking mosaic Only odd grain shows twinning hence much could be quartz (most too small for sign). Appears coarser grained in biotite rich bands. Full of inclusions - sphene, opaques, apatite.

BIOTITE : About 5-8%, size less than o.2mm. Xenoblastic. Strongly pleochroic α = straw, β = medium yellow brown, γ = dark olive brown. Mottling at extinction.

MUSCOVITE : About 10-12%, size less than 0.2mm. Xenoblastic, colourless, moderate birefringence. Positive relief, length slow. Associated with biotite in bands but concentration greater than biotite between bands. Some muscovite bands with minor biotite.

ACCESSORIES :

Opaques : About 2-3%, extremely fine grained ($\sim$ 0.01mm), spread throughout the rock.

Sphene : size 0.05 - 0.15mm, high relief xenoblastic pale orange brown granules.

Quartz : cannot distinguish from plagioclase - odd grain lower R.I. hence probably quartz.

Apatite : ideoblastic elongate prisms, high relief Bright interference colours.

Zircon ? : odd high relief, colourless, xenoblastic grain.

MACRO : A medium grained plagioclase amphibole rock (in about equal proportions) with minor opaques.

MICRO : A fine to medium grained granoblastic plagioclase amphibole opaque rich rock with a relict "ophitic" relationship (a relict doleritic texture probably).

PLAGIOCLASE : About 50%, size 0.5 - 2mm. Xenoblasti[c] commonly lath shaped (no preferred orientation) with crenulated edges. Both Biaxial (+) and (-). The (+) shows some very fine twinning to being untwinned, generally shows patchy extinction to chequerboard twinning - some zoning could be present on extinction. 2v - 80-85°. Biaxial (-), Ab_{68} is generally twinned. Inclusions common - amphibole, sphene, zircon, epidote, opaque and dust. However, rims tend to be much clearer, if any inclusions at all. Chequerboard twins tend to be clearer as well.

AMPHIBOLE : About 45%, size up to 2mm. Relict ophitic texture with plagioclase. Xenoblastic, very irregular with crenulated edges. Strongly pleochroic α = straw, β = grass green, γ = blue green. $Z \hat{} c = 16^\circ$. Commonly quite poikiloblastic with opaques, sphene, zircon, plagioclase inclusions often oriented along cleavages. Patchy alteration to brown biotite is no uncommon.

OPAQUES : About 5-8% generally xenoblastic to skeletal, closely associated with amphibole. Alteration to red haematite ? and granular sphene.

ACCESSORIES :

Chlorite - alteration of amphibole, green, low birefringence.

Epidote - high relief, pale yellow, moderate birefringence associated with plagioclase.

MACRO : A fine to medium grained quite well banded amphibole plagioclase rock, green amphibole forming thin stringers and reasonable bands in a white, very fine plagioclase groundmass.

MICRO : A fine to medium grained granoblastic finely banded plagioclase quartz amphibole rock with minor sphene, leucoxene, chlorite etc.

PLAGIOCLASE : Possibly 60% - because most of the plagioclase is untwinned and fine grained its distinction from quartz is achieved with difficulty if at all. Much of the untwinned grains are Biaxial (+) with a high 2v and is probably sodic oligoclase. Inequigranular i.e. ranging from 0.08 - 1.5mm with variation between banding. As an interlocking mosaic, xenoblastic equidimensional crystals. Both Biaxial(+) and (-) the latter generally showing some twinning. Twinning is not very common - ranges from well developed multiple to small zones of twinning in a larger untwinned crystal (Biaxial (+)) giving Ab_{90}. The finer grained mosaic shows less twinning making separation from quartz difficult. Inclusions rare and in cores only with generally clear edges - include zircon, dusty opaques, sphene and bubbles.

QUARTZ : Possibly contains more inclusions than plagioclase (ones tested for Uniaxial (+) did so). If true then would be about 20%. Inclusions restricted to cores - originally detrital quartz.

AMPHIBOLE : About 10-15%, size up to 1mm long. Xenoblastic, elongate prismatic. Intergranular to quartz - plagioclase mosaic i.e. around grains. Weakly pleochroic α = pale green, β = medium green, γ = blue green. With some colour patching especially darker borders. Biaxial (-), $Z \hat{} c = 19^{\circ}$.

Odd inclusions especially sphene, zircon, plagio-
clase, quartz. Some alteration along cleavages.

SPHENE : About 1%. Fine granular throughout rock. Larger crystals contain opaque cores, pale pink pleochroism.

ACCESSORIES :

Biotite - associated with amphibole, xenoblastic-subideoblastic strongly pleochroic in brown. Mottling near extinction.

Chlorite - associated with amphibole and biotite, low birefringence, pleochroic in green, fibrous often radial.

Microcline ? - odd grain diffuse crosshatching.

Opaques - odd very fine grain

Apatite - high relief, Uniaxial (+), may reach 1%

Rutile - golden brown very fine granular (leads to pleochroic haloes when within amphibole).

MACRO : About equal proportions of green, medium grained amphibole and white, fine to medium grained plagioclase in a weak to moderately banded rock. The amphibole shows an irregular outline.

MICRO : Fine to medium grained amphibole plagioclase rock with minor epidote, sphene and opaque. A slight tendency for banding of the amphiboles. In general the amphiboles are coarser grained.

AMPHIBOLE : About 50-55%, size 0.4 - 1.7mm. Xenoblastic, prismatic with ragged terminations. Pleochroic α = straw to pale green, β = medium green, γ = blue green. Fine inclusions are common especially opaque dust. Pleochroic haloes (brown) around some inclusions. Biaxial (-) $2v = 85^{\circ}$, $Z\hat{}c = 20^{\circ}$. Alteration to golden brown granular material along grain boundaries and cleavages (sphene ?).

PLAGIOCLASE : About 45% - 50%, size 0.1 - 0.8mm. Intergranular to amphibole, xenoblastic equidimensional to lath shaped commonly with crenulated edges. Commonly twinned, Biaxial (-) and Ab_{68}. When untwinned commonly Biaxial (+), $2v = 80-85^{\circ}$ with a patchy nature (forerunner of chequerboard?) where small areas of quite well twinned plagioclase exist with no set orientation. Chequerboard twinning also found - Biaxial (+). Inclusions common and numerous, commonly crystallographically oriented - small blebs and needles (opaque). Some larger granular sphene.

ACCESSORIES :

Sphene : less than 1%, small xenoblastic to granular pale pink-red crystals, high relief, some quite strongly pleochroic.

Epidote : Small, xenoblastic, pale yellow, high relief.

Biotite : brown, flaky strongly pleochroic.

Opaques : odd large grain.

342 - 117A

MACRO : A medium grey-green, medium grained plagioclase amphibole rock, the plagioclase showing a distinct lath shape (diverse orientation) or as a finer intergranular groundmass.

MICRO : A medium grained plagioclase rich rock with intergranular amphibole, opaque, calcite and epidote in a relict doleritic texture (diabase).

PLAGIOCLASE : About 75%, size 0.8 - 3mm. Xenoblastic to lath shaped, diverse orientation, crenulated to amoeboid edges, interlocking grains. Twinning varies from very diffuse, good multiple twinning to chequerboard twinning. Crystals poorly to not twinned are generally Biaxial (+), $2v = 85^0 - 90^0$. (sodic oligoclase) - also a very patchy crystal where smaller grains have been welded together ? (predecessor of chequerboard twinning - could be looking at (010) section). The better twinned varieties are Biaxial (-). Inclusions common - amphibole, opaques, zircon ? biotite and dust often crystallographically oriented.

AMPHIBOLE : About 20%, size 0.5mm xenoblastic, fragmental between plagioclase laths. Bending of cleavage lamellae common even though 90^0 accompanied by undulose extinction. Pleochroic α = straw, β = green, γ = blue green, colour patching common. Biaxial (-), $2v = 75^0$, $Z \wedge c = 20^0$,

ACCESSORIES :

Opaque - 1-2%, xenoblastic, opaque to deep red (isatropic?)

Calcite - 1%, xenoblastic, appears to mould between other grains; uniaxial (-), high birefringence and relief.

Epidote - 1% xenoblastic, colourless to pale yellow (pleochroic).

Biotite - strongly pleochroic in brown. Also a lensoid, matted fibrous, pale yellow mineral group, probably biotite.

MODAL ANALYSIS (2000 counts)

Amphibole	32%
Plagioclase	58.5%
Opaques	6.2%
Epidote	0.6%
Biotite	0.5%
Carbonate	2.2%

342 - 117B

MACRO : As for 117A except grains more equidimensional and a weakly developed banding.

MICRO : Medium grained crystalloblastic plagioclase amphibole rich rock with minor calcite, opaques and epidote. Grains more equidimensional than in 117A.

PLAGIOCLASE : About 75%, size about 1mm, approximately equidimensional. Xenoblastic to subideoblastic; twinning absent, well developed as multiple twinning or as chequerboard twinning. Some fine granular crystals appear welded (irregular extinction) and some very amoeboid small grains (forerunner of chequerboard ?) Chequerboard about 50% of all plagioclase. Twinned generally Biaxial (-) - multiple and chequerboard.

AMPHIBOLE : About 20%, size 0.2 - 1.5mm. Xenoblastic. Pleochroic α = pale brown-straw, β = grass green, γ = blue green, patching of colour common especially darker edges. Biaxial (-), $Z \wedge c = 27^{o}$. Pleochroic haloes common.

ACCESSORIES :

Calcite : About 1-2% Xenoblastic, as for 117A.

Epidote : Generally with calcite.

Apatite : Colourless, high relief, low birefringence.

Opaques : Up to 1mm. Xenoblastic (edges to sphene

Chlorite : Pleochroic in green, low birefringence

Biotite : Odd grain, bright yellow, fibrous (as in 117A).

342 - 118

MACRO : Fine to medium grained amphibole plagioclase rock, the amphibole as light and dark green irregular crystals, the plagioclase appearing intergranular.

MICRO : A fine to medium grained crystalloblastic plagioclase amphibole rich rock with amphibole greater than plagioclase in a relict doleritic (diabase) texture.

PLAGIOCLASE : About 40% size 0.5 - 1.2mm. Xenoblastic commonly lath shaped crystals with crenulated edges. Some finer grains giving appearance of welding. Good multiple twinning rare, either broad diffuse lamellae or no twinning more common. Both Biaxial (+) and (-). One crystal (-) gives Ab_{73}. 2v = 85°. Inclusions common, generally oriented opaque dust, sphene, epidote and disoriented crystals including amphibole needles.

AMPHIBOLE : About 55-60%, size 0.2 - 1.2mm. Xenoblastic prismatic with ragged terminations or as fine acicular amphiboles commonly within plagioclase. Strongly pleochroic α = straw, β = medium green, γ = blue green, colour patching common especially darker near edges. Biaxial (-), 2v = 75°, $Z\hat{}c$ = 21°. Inclusions common, some crystals have cores full of minute inclusions (epidote ? sphene ?) although not restricted to centres of grains. Twinning is not rare.

EPIDOTE : Less than 1%, fine granular, colourless to pale yellow, moderate birefringence (bright colours), high relief.

OPAQUES : About 1%. Xenoblastic.

342-121 A

MACRO : A medium grained plagioclase amphibole rock now replaced somewhat by black fine grained tourmaline. The tourmaline forms a solid mass and stringers into rock, itself containing veinlets and patches of amphibole and plagioclase, generally broken up considerably.

MICRO : A fine to medium grained tourmaline, amphibole, plagioclase rich rock with amphibole and plagioclase occuring in a vein-like band (approx. 8mm - 10mm wide) in fine veinlets perpendicular to the main vein and in patches within the tourmaline rich zone. A somewhat banded nature of the tourmaline zone is evident on grain size.

TOURMALINE : About 40%. In two main grain sizes. 0.5-1.2mm and about 0.1mm. Xenoblastic to subideoblastic elongate crystals. Strongly pleochroic from pink to dark olive green (polarizer). Length fast. Parallel extinction. Uniaxial with several colour rings but sign indeterminate due to strong mineral colour. Some cracks parallel to length. Inclusions common especially opaques.

AMPHIBOLE : About 30-35%. In veins appears continuous i.e. all extinguishes together and no breaks - surrounds areas of plagioclase. Pleochroic α = pale green, β = medium green, γ = blue green, patchiness of colour common.

SPHENE : About 5%, size 0.05-0.4mm. Xenoblastic, equidimensional to elongate, very high relief, colourless to very pale pink. Cracking common. Uniaxial (+) also odd grain with small 2v - many grains do no extinguish. High birefringence - many colour rings in figure. Some fine opaque inclusions, opaque cores common.

PLAGIOCLASE : About 20% - Biaxial (+) and (-).

Extremely xenoblastic interlocking amoeboid grains with a welded appearance, leading to chequerboard twinning (-). In amphibole vein and in patches within tourmaline zone.

ACCESSORIES :

Epidote, opaques (commonly ideoblastic).

342 -121B

MACRO : A fine to medium grained grey-green amphibole plagioclase rock, the plagioclase as equigranular and decussate lath shaped crystals.

MICRO : A fine to medium grained crystalloblastic plagioclase amphibole rock showing a relict doleritic texture i.e. decussate plagioclase laths with intergranular amphibole and opaques.

PLAGIOCLASE : About 50-55%, size 0.4 - 1.2mm. Xenoblastic commonly lath shaped though forms a weak mosaic with amphibole. Random orientation of crystals. Both Biaxial (+) and (-) the former generally untwinned, the latter twinned $2v = 85^o - 90^o$. Twinning varies from not developed, through diffuse broad lamellae to quite good multiple twinning (Biaxial (-). Inclusions common - amphiboles (some acicular being oriented), opaques opaque dust, colourless blebs (unidentified), biotite and sphene.

AMPHIBOLE : About 45-50%, size 0.1 - 0.8mm. Xenoblastic fragmental, roughly intergranular to plagioclase. Strongly pleochroic α = straw, β = grass green, γ = blue green. Biaxial (-), $Z \hat{} c = 18^o$. Inclusions common especially needle-like opaques, which are oriented crystallographically, elongate plagioclase.

ACCESSORIES :

Opaques : About 1%, size 0.5mm. Xenoblastic granular, deep orange-red edges.

Chlorite : Pale green, fibrous, weakly pleochroic Low birefringence with anomalous blue, violet and brown interference colours.

342 - 125

MACRO : A medium grained crystalloblastic plagioclase amphibole rock with elongate plagioclase in random orientation.

MICRO : A fine to medium grained crystalloblastic plagioclase amphibole rock showing a possible relict doleritic texture (plagioclase larger and more common).

PLAGIOCLASE : About 50-55% size 0.6-4.5mm. Xenoblastic to subideoblastic, commonly lath shaped with crenulated edges (resorbed and recrystallised Twinning varies from non-existent to a few broad lamellae. Biaxial (+) for all grains measured. Full of inclusions especially epidote (in the cores mainly), amphibole, biotite often oriented along broad twins and crosscutting cleavage. Biaxial (+), 2v = 80°.

AMPHIBOLE : About 40%, size 0.1 - 1.2mm. Xenoblastic prismatic with ragged terminations to fragmental. Crenulated edges. Strongly pleochroi
α = straw, β =grass green, γ = blue green.
Biaxial (-), 2v = 80°, Z^c = 17°. Inclusions of biotite, needle-like opaques along cleavages, plagioclase etc.

ACCESSORIES :

Biotite : About 2-3%. Small tabular prisms, strongly pleochroic pale brown, straw to olive green.

Epidote : Xenoblastic aggregates concentrated in cores of plagioclase. High relief, colourless to pale yellow. Contains some minute opaques and amphibole inclusions.

Opaques : few xenoblastic crystals, some altering to sphene.

MACRO : A fine to medium grained patchy rock with dark green patches and veins of amphibole in a grey-green finer grained rock.

MICRO : A fine grained rock with a band of relict dolerite running through a coarser grained plagioclase chlorite rock, the contact appearing in general quite distinct.

PLAGIOCLASE : About 40%. In the relict doleritic textural area exists as subideoblastic laths (0.8mm x 0.1mm) in random orientation with odd larger equidimensional crystal, whilst in chlorite -plagioclase zones as much coarser, roughly equidimensional (0.4-0.6mm) or broad laths say 1mm x 0.5mm still random. All of the grains are brownish due to many fine dusty inclusions. Other inclusions are epidote, apatite, amphibole. Both Biaxial (+), 2v = 85 - 90° with broad twinning or no twinning and Biaxial (-) where twinning. Also a "welded" mosaic in doleritic part. In coarser grained areas larger laths with twinning (-) and untwinned (+) Ab_{68}.

AMPHIBOLE : About 30%. Xenoblastic, polygonal aggregate in doleritic zone. Strongly pleochroic α = straw, β = grass green, γ = blue green, colour patching common generally darker edges. Biaxial (-). $Z \hat{} c = 19°$. Between grains golden brown alteration product.

CHLORITE : About 25-30% Radial to completely spherulitic arrangements of fibrous crystals. Some green-brown and shows mottling at extinction (derived from or interlayered with biotite). Otherwise near isotropic, green and shows anomalous blue-violet, brown interference colours.

Pleochroic in shades of green i.e. pale green to medium blue green. Biaxial (-), length slow. Some bending of lamellae. Opaques (deep red) generally rim edges of spherulites.

ACCESSORIES :

Sphene - with opaque cores may rach 1%

342 - 127

MACRO : A weak to moderately banded amphibole plagioclase rock.

MICRO : A microporphyroblastic lepidoblastic amphibole plagioclase rock, the amphibole being prismatic and showing a preferred orientation and weak banding, set in a fine grained plagioclase mosaic.

AMPHIBOLE : About 25%, size 0.1 - 1.2mm. Xenoblastic prismatic with ragged terminations, extremely elongate. Strongly pleochroic α =straw, β = medium to dark green, γ = blue green, patching of colour common. Strongly poikiloblastic especially with plagioclase. Biaxial (-), 2v = 85-90°.

PLAGIOCLASE : About 70-75%, size 0.05 - 0.2mm. Xenoblastic interlobate mosaic of equidimensional grains. Biaxial (+), twinning very rare and where found generally Biaxial (-). Inclusions common e.g. opaques, biotite, sphene etc. Intergranular positions commonly brownish.

ACCESSORIES :

Biotite : About 1-2%, Small elongate crystals, strongly pleochroic, straw to olive green.

Opaques : Commonly as small needle-like crystals.

Epidote :

Sphene :

MACRO : A very well banded quartz, amphibole, opaque rich rock, the quartz forming a light grey distinct (opprox. 5mm) band and surrounded by darker grey well laminated amphibole, quartz, opaque bands, which show a crenulation. The amphibole poor, quartz rich band is broken clearly in odd places.

MICRO : A fine to medium grained porphyroblastic, quartz, plagioclase ? amphibole, opaque rich well banded rock. The rock is divided into amphibole rich and poor bands with the other minerals being present in all bands. A course grained opaque and quartz band separates the two zones and in one place breaks into the amphibole poor band.

- The opaque banding appears to pass both around and through the amphibole porphyroblasts and it is suggested that these porphyroblasts formed during or just after the formation of the banding.

AMPHIBOLE : About 25-30%, size 1-2mm. Xenoblastic to subideoblastic with irregular edges. Porphyroblasts. Strongly pleochroic α = pale green, β = grass green, γ = blue green. Very poikiloblastic with quartz and opaque inclusions, probably defining a lineation through the mineral. The long axis of the porphyroblasts are randomly oriented to the banding Biaxial (-).

QUARTZ : About 50-55%, size 0.8mm, Xenoblastic, granoblastic mosaic. Coarser bands (non-amphibole band) generally 0.15 - 2.5mm. Odd coarse secondary veins at angle to banding (contains little opaque). Uniaxial (+) through small 2v common (strain shadows). Inclusions common especially opaques.

OPAQUES : About 10%. Generally fine grained (less than 0.05mm) through odd coarser band (about 0.1 - 0.2 mm) Xenoblastic to ideoblastic. Defines a layering, as intergranular crystals and as inclusions.

BIOTITE : About 10%. Small subideoblastic platy to fibrous crystals. Mostly restricted to amphibole rich band. Follows folding in many bands around amphibole porphyroblasts. Defines a possible crenulation. Strongly pleochroic.

EPIDOTE : Accessory mineral, associated with amphibole.

APPENDIX III

(M.A. COBB)

TOTAL ROCK ANALYSES AND Na_2O/K_2O IN SURROUNDING SCHISTS OUTWARDS FROM CONTACT.

TOTAL ROCK ANALYSES :

Suring the periods of field mapping a total of 11 rocks were chosen for total rock analyses and analyses of their Ni and Cr content. Care was taken in the choosing of such samples to avoid weathered and veined rock, the latter a characteristic of the amphibolite body. Preparation of the individual samples involved the removal of all weathered surfaces by slicing and grinding, followed by careful washing. The samples were initially crushed on a fly-press to a suitable size (about ¼") care being taken to minimise sample loss. The rock fragments were crushed in an agate mill on a Seibtechnik crusher, the powder then being sieved in non-contaminating plastic sieves through bolting cloth. The sample size -120 mesh was collected, the coarser portion being recrushed, resieved and collected. Total loss during the complete process was negligable. The weights crushed are given in the following Table.

Fusion buttons of each sample were prepared and the total rock analyses, less Na_2o, were achieved by X.R.F. methods using a 1.5kV Cr or Mo tube. The Na_2o analyses were obtained by Flame Emission techniques from solutions obtained by dissolving a sample of each crushed rock in HF/H_2SO_4., the weights dissolved being given in the following Table. The self-same solutions were used for Ni and Cr analyses by Atomic Absorption. It was decided at a later date to analyse the rock samples for Cu and Co and consequently a second HF/H_2SO_4 digestion was performed, the weights of each sample dissolved being given below. The total rock analyses may be found in Table 3.

TABLE 7

SAMPLE NO.	WEIGHT CRUSHED gms.	WEIGHT DISSOLVED FOR Ni, Cr, Na_2O. gms.	WEIGHT DISSOLVED FOR Cu, Co. gms.
341 - T	590	0.49097	0.51339
342 - V	570	0.50326	0.47675
342 - 117	720	0.50348	0.48663
342 - 190	375	0.34847	0.49252
342 - 125	595	0.35749	0.51513
342 - 11	430	0.50041	0.49923
341 - X	470	0.49961	0.46937
341 - 163	510	0.50888	0.46661
341 - W	470	0.50396	0.48951
341 - U	460	0.50170	0.51587
341 - Z	390	0.50245	

Na_2O/K_2O.

Seven schists were chosen from a creek on the north side of the body, being approximately equally spaced out from the amphibolite - schists contact. Due to their very nature it was found difficult to obtain samples showing little if any weathering.

Each sample was thoroughly washed, broken into smaller fragments especially along the schistosity and rewashed. The schistosity planes were round to contain the greater amounts of contamination - soil, weathered rock etc. Fresh, clean fragments were chosen for further crushing. The crushing process used was identical to that for total rock except that a chrome-steel mill was used on the Seibtechnik crusher. The approximate weights crushed and the weights digested by HF/H_2SO_4 are given below (Table 8).

The resulting solutions were analysed for Na_2o and K_2o by a Flame Emission technique (see Table 9 for values obtained).

TABLE 8.

SCHIST SAMPLE	APPROXIMATE WEIGHT CRUSHED (Gms)	WEIGHT DISSOLVED FOR Na_2o, K_2o IN HF
14	1000	0.05390
12	670	0.05116
B	990	0.05466
209	490	0.05665
C	700	0.05355
D	740	0.04398
E	1140	0.04686

TABLE 9. Na_2O/K_2O IN SCHISTS OUT FROM BODY

SAMPLE NO.	Na_2O IN ROCK %	K_2O IN ROCK %	Na_2O/K_2O
14	6.40	2.46	2.60
12	3.52	3.32	1.06
B	1.05	4.02	0.26
209	1.45	3.71	0.39
C	1.23	4.58	0.27
D	1.16	4.66	0.25
E	1.01	4.59	0.22

APPENDIX IV

LIST OF ROCK SPECIMENS AND THIN-SECTIONS SUBMITTED

LIST OF THESIS MATERIAL (B.J. MORRIS)

ROCK SPECIMENS

341 :- W, V, X, 9, 13, 21b, 25, 27b, 34, 43, 55, 56, 57, 66, 67, 68, 72, 81, 86, 87, 98, 117, 118, 121a, 126, 127, 128, 130, 132 :

THIN SECTIONS

341 :- Y(125), W, X, V, 9, 13, 21a, 21b, 27a, 27b, 34, 43, 55, 56, 57, 66, 67, 68, 72, 81, 86, 87, 98, 104, 117, 118, 121a, 121b, 127, 128, 129, 130, 132 ;

LIST OF THESIS MATERIAL (M.A. COBB)

ROCK SPECIMENS

342 :- 1, 5B, 5C, 9, 14, 25, 31, 37, 43, 48, 54C, 58, 61, 63, 81, 82A, 88, 89, 99, 102, 110, 114, 121a, 126, 128, 174, 177 :

THIN SECTIONS

342 :- As for rock specimens but in addition 13, 35, 104B :

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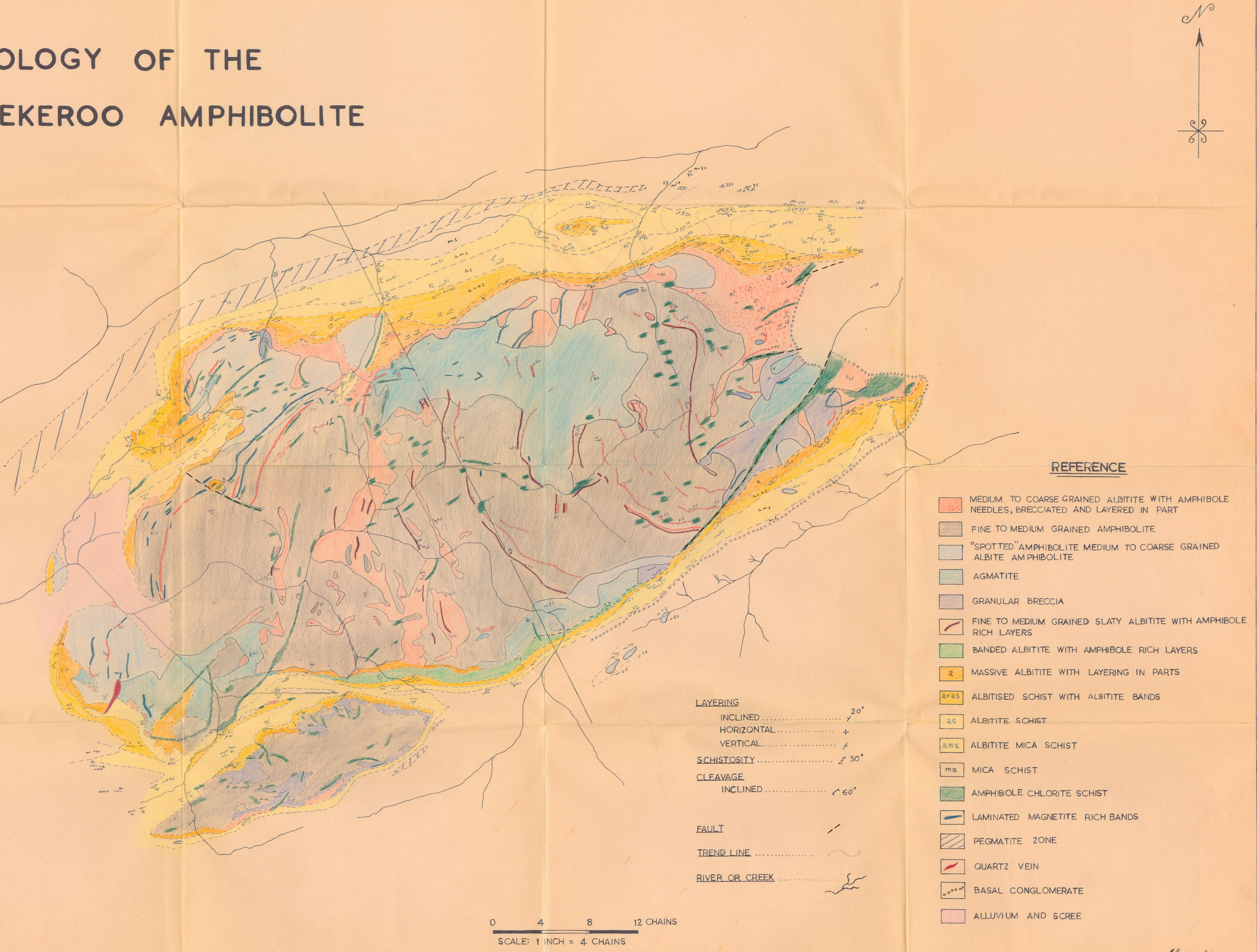
GEOLOGY OF THE WEEKEROO AMPHIBOLITE



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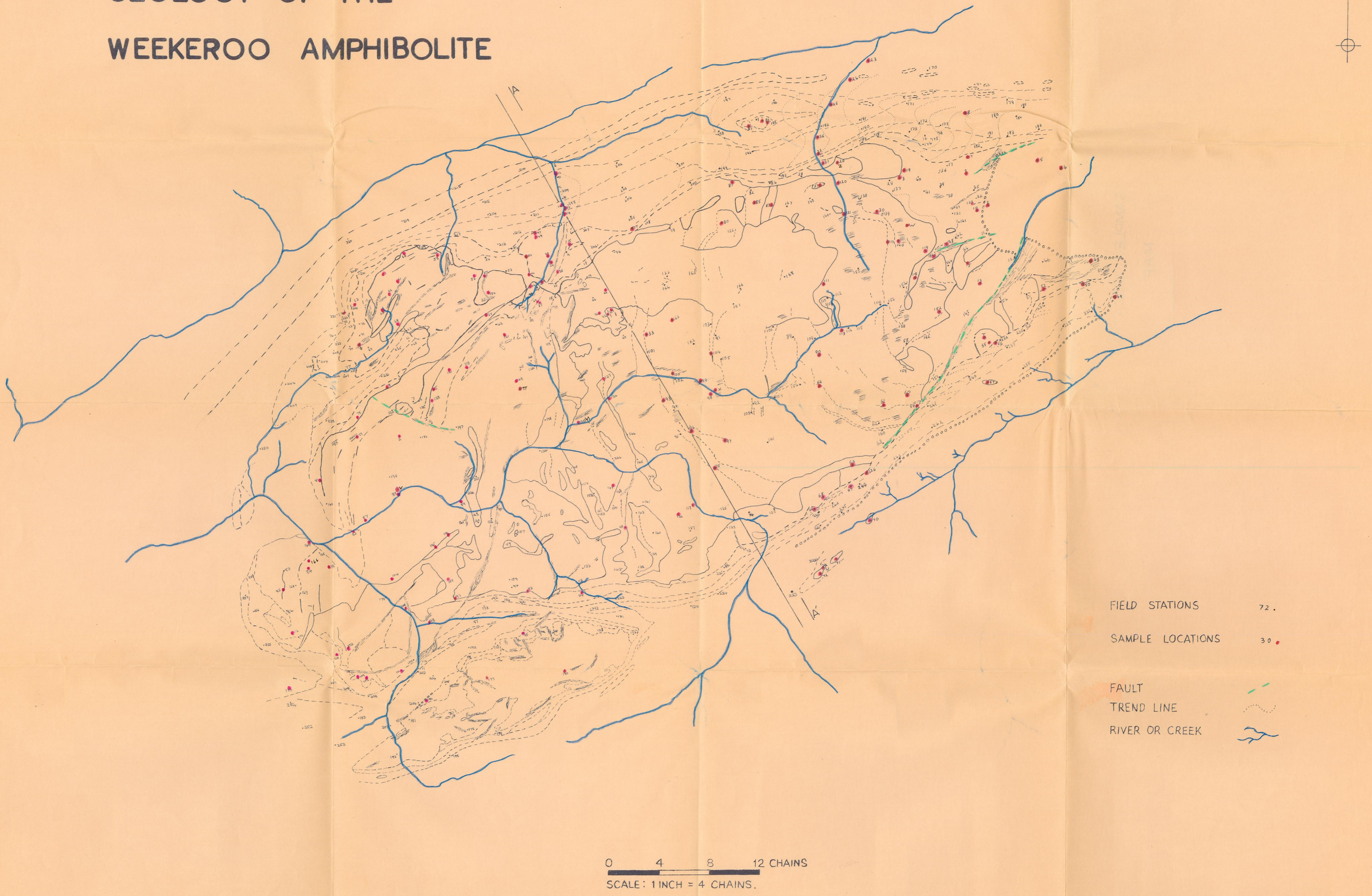
GEOLOGY OF THE WEEKEROO AMPHIBOLITE



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