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# AN ATTEMPT TO DISTINGUISH BETWEEN CALC-SILICATE AND BASIC IGNEOUS ROCKS IN THE MARY KATHLEEN AREA, NORTH-WEST QUEENSLAND



by

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## SUMMARY

At the request of Rio Tinto Finance & Exploration Ltd., thirty one specimens of rocks from the Precambrian strata of the Mary Kathleen Uranium bearing area, which have been mapped in the field as either basic igneous or calc-silicate rocks were investigated petrologically.

It was hoped that some diagnostic differences might be established to distinguish basic igneous rocks from calc-silicates by laboratory methods and the results suggested that probably all of the pre-granite material submitted was calc-silicate.

The pre-granite rocks of the Mary Kathleen area occur in a zone of intense metamorphism and metasomatism and are plagio-clase-pyroxene and scapolite-pyroxene-hornblende granulites.

Specimens have been classified into two genetic groups (i) those of basic igneous origin and (ii) those of sedimentary origin.

In the first division three specimens of the post-granite dolerite dykes have been identified. Two other rocks, of pre-granite age, may possibly be scapolitized counterparts of basic igneous rocks from the Rosebud Copper mine area, 7½ miles south-south-west of the Mary Kathleen area.

A variety of calc-silicate granulities from the Mary Kathleen area form the second division. Their compositional differences probably reflect original differences in the sediments from which they were derived. The three groups into which they have been divided, are based mainly on mineralogical and structural differences.

The groups are: (1) those from an "organic" horizon, a zone containing possible Precambrian algal remains, (2) ferro-magnesian-rich granulites and (3) ferromagnesian-poor granulites. A few other specimens, which do not fall into any of the above categories are described individually in appendix I. They have no significance in distinguishing basic igneous from sedimentary rock types, hence their exclusion from the general discussion.

In the Rosebud area, altered basic igneous rocks can be identified from calc-silicates by texture. A comparison of rocks of each group with rocks in the Mary Kathleen area supports the view that most, perhaps all, of the pre-granite Mary Kathleen rocks submitted had a primary sedimentary origin, probably having been derived from impure calcareous and dolomitic rocks. The points in favour of a sedimentary origin for the rocks under consideration on the one hand, and an igneous origin on the other, are listed in table I.

Laboratory work at present has not provided a conclusive answer. Microscopic determinations do not agree with the field naming as given to many of the rock outcrops in the locality. Where several specimens have been examined from an area shown on the company's map to contain one particular rock type, these specimens often show a great diversity of rock types.

## INTRODUCTION

A group of twenty eight rock specimens from the Mary Kathleen Uranium mine area were submitted in February, 1956, by Mr. R. S. Matheson of the Rio Tinto Finance and Exploration Ltd., for description and determination. The report on the mine (Searl and Fraser 1956) and the accompanying maps and specimen locality plans were received in July.

The Mary Kathleen mine is situated about 37 miles by road west of Cloncurry and approximately midway between Mt. Isa and Cloncurry townships.

Because the specimens have been highly metamorphosed and metasomatized, calc-silicates and basic igneous rocks could not be distinguished in the field. For this reason petrological determinations were sought; further, it was thought that detailed petrological work in conjunction with the field evidence might establish the origin of the various rock types present.

This report sets out the conclusions reached as a result of the petrological work. Comparative descriptions, together with conclusions drawn from them, are presented in an endeavour to separate the two genetically different types in this area. The above company report and maps by Searl and Fraser should be studied in conjunction with this report.

In addition to the specimens supplied by Mr. Matheson, three specimens from near the Mary Kathleen mine were obtained from Dr. A.A. Opik, and four collected by the author and other workers in the course of regional mapping of the Cloncurry Mineral Field, have been sectioned and examined for comparative purposes.

## BASIC IGNEOUS ROCKS

### Those of definite igneous origin: Post-granite dolerite dykes.

Specimens 4677, 4683 and 4684 are the only specimens which can be definitely identified under the microscope as igneous in origin. They were collected from long linear dykes which cut both granite and the adjacent country rocks. This post-granite phase of basic igneous activity was widespread throughout the Mt. Isa-Cloncurry area, but limited in quantity.

In the Mary Kathleen area there is evidence in both slides 4677 and 4684 of minor post-consolidation shearing, which has not been recognised in the post-granite dolerites elsewhere. The resulting fractures are filled with soda-rich felspar, which in some cases is fresh, while in others is altered. The felspathization associated with this post-granite fracturing may have contributed to the extreme alteration of the rocks in the Mary Kathleen area.

In this section none of the specimens appears particularly fresh; most of the felspar is saussuritized too extensively to determine its composition. In this respect these basic rocks are more altered than their counterparts elsewhere, although the latter also have strongly sericitized felspar grains; slide 4683 is the freshest and shows typical

ophitic texture. It consists essentially of felspar laths and pyroxene of about 2 mm. grainsize. Extinction angles of indistinct albite twins suggest a labradorite composition for the felspar. Pyroxene is the least altered mineral, though some grains are partly uralitized. It has a moderately low positive 2 V, indicative of pigeonite, slide 4677 shows greater alteration of the pyroxene than do 4683 and 4684; some chlorite mica is present but iron ore is absent.

Skeletal grains of ilmenite in 4683 and 4684 are moulded on laths of altered pyroxene and felspar; some have been partially altered to leucoxene. In these slides the pyroxene is almost completely altered to amphibole; some of the cores of residual pyroxene have partial rims of uralite.

The three slides described above are dolerites, which show strong alteration due to deuteric or autometamorphic changes. The severity of these changes in part results from post-consolidation fracturing and alteration.

Those of possible igneous origin:

Most slides to be described under this and following headings show that thermal metamorphism of a moderate to high grade has been superimposed on an earlier regional metamorphism, which was associated with major folding in the area. The Mary Kathleen mine area occurs in a narrow strip of country rock, about 2 miles wide, between two large masses of granite referred to as the Eastern and Western Granites by Searl and Fraser (1956): hence the thermal metamorphism. Also, all show greater or lesser degrees of metasomatism, - either felspathization, scapalitization, epidotization or apatization, or a combination of two or more of these.

In their specimen locality maps, Searl and Fraser (1956) show that a number of the specimens submitted were collected from outcrops mapped as pre-granite basic igneous rocks. They present field evidence to support the basic igneous origin of only the "Scapolite diorite", an intrusive referred to by them. The marked diversity in texture and mineralogy of specimens submitted is a conspicuous feature remarked upon throughout the following study, and it is especially difficult to explain if they have all come from essentially the same basic igneous types.

Specimens 4663, 4664 and 4665 come from outcrops of "Scapolite diorite" and none is remotely alike. Specimens 4663 and 4664 appear to be calc-silicates and 4665 shows but doubtful evidence of basic igneous character under the microscope. According to Searl and Fraser the "Scapolite diorite" is intrusive into the Corella beds (David, 1932: - Shepherd, 1946).

Specimen 4673 is compared with 4671 and 4668 (appendix 2) both of which will be shown shortly to be calc-silicates or from members of the Corella beds. There is a close petrological similarity between 4665 and 4673.

Rocks 4665 and 4673 occur at the southern end of the "Scapolite diorite" mass about 700 feet north-east and 1200 feet south-east of the Mary Kathleen lode respectively. Petrologically, they show the closest similarity of any two pre-granite rocks submitted from the area, and from petrological determination, 4673 could be considered a southern extension of 4665 horizon.

Both slides are poikiloblastic, a texture which may have been produced from an original ophitic texture, or alternatively, it could simply have resulted from metasomatic alteration of a calc-silicate. Broadly viewing the texture, it shows a number of angular grains of pyroxene completely surrounded by optically continuous scapolite. Pyroxene prisms perhaps were originally moulded on felspar laths which are nor metasomatized to scapolite, as with ophitic texture; and pyroxene is converted to diopside.

In 4665 some scapolite grains are partly sheared and tend to be fibrous. This feature may correspond to the late phase shearing noted in 4677. Grainsize ranges from 0.5 mm. to 3 mm. the angular prisms of pyroxene, and grains of sphene, being 0.5 mm. in size, surrounded and included in 3 mm. plates of scapolite.

The green tint shown by the pyroxene is generally lighter than that of the other diopsidic pyroxenes seen in the calc-silicates described in the next section. This feature is not significant when considering the origin of such rocks, since Edwards & Baker (1954) note that the greenness of pyroxenes varies quite considerably in the various calc-silicates they describe; it may simply be a function of the different composition of the sedimentary horizon from which each was derived.

Groups of small light green amphibole grains occur throughout 4665, while corresponding amounts are present in 4673 but in this case as (small) individual grains. Sphene occurs in small proportions as grains up to 0.5 mm. size in both slides. A light brown garnet in association with calcite was observed only in 4673. Some multiple twinned plagioclase and altered felspar grains were seen in 4665.

The greater proportion of both slides is diopsidic pyroxene - perhaps 65 percent - with another 25 percent scapolite and about 5 percent each of hornblende and sphene.

Petrographic evidence is not decisive in identifying whether these two rocks are derived originally from basic igneous or sedimentary rock types. They may be either scapolitized basic igneous rocks or calc-silicates.

## CALC-SILICATE ROCKS

### The "Organic" Horizon:

Three specimens O-A, O-B and O-C, which were made available by Dr. Opik are of a particular rock type referred to by Searl and Fraser (1956) as the "organic" horizon. The stratum contains concentric and roughly conical structures which may represent remains of Precambrian fossil algae. In some places the rock consists entirely of these curious structures. Thin banding, which is probably original bedding, is also found in this horizon. Specimen 4663, and perhaps 4669, are petrologically the same as the "organic" horizon specimens O-A, O-B and O-C, though according to Appendix 2, Specimen 4663 occurs within the "Scapolite diorite" next to the "organic" horizon. All the specimens referred to in this section come from rock outcrops about 800 feet north-east and east of the Mary Kathleen lode, except for 4669 which crops out about 600 feet south-south-east of the lode.

Rocks O-A, O-B and O-C in hand specimen are dark green-grey rock showing a ferruginous weathered surface with small (5 mm.) circular elevations. On a fresh surface rings of white felspar and scapolite can be seen in a dark grey groundmass of pyroxene and amphibole. Specimen O-B shows larger structures which measure up to 5 cm. in diameter. Rocks 4663 and 4669 are very dark rocks which show small sparkling facets of hornblende.

Texturally all the slides are granular and the distribution of the essential minerals pyroxene and felspar throughout the slide is uneven. Those portions of the slides consisting essentially of felspar and some scapolite grains, that is, the parts rich in light minerals, represent the relict structures of possible algal remains. Epidote-rich zones also occur within these portions, and also a few small individual grains of pyroxene. Ferromagnesian minerals are concentrated between the concentric rings of felspathic material, which is almost absent from this dark mineral zone of the slides. In the general body the rocks granular ferromagnesian minerals are evenly distributed, with felspar grains in roughly equal proportions. The curious structures which occur in these rocks may have been selectively felspathized preserving the rudiments of their original form.

In 4663 the distribution of dark mineral grains relative to felspar is more even than in O-A, O-B and O-C, although the slide is texturally similar. Zones of altered felspar in 4663 contain more small individual diopside grains than O-A, O-B and O-C. Another structural feature which occurs in 4663, and which is described in detail in the next section (spec. 4671), is the circular or ring structures formed of amphibole laths end to end. In 4663 they measure up to 0.25 mm. in diameter, either surrounding voids in the rock or including amphibole grains.

Slide 4669, which shows some similarity to the slides of the "organic" horizon, is finer and more even grained, but still granular, groups of interlocking scapolite grains contain numerous inclusions of small pyroxene grains. There appears to be fragmentary evidence of ring structures similar to those in 4671.

In slides O-A, O-B and O-C the pyroxene is a light green variety. It is finer grained in O-B than in the other two, and not quite so abundant as in O-A. It shows slight alteration to amphibole, which fringes groups of diopside grains in O-B. Some amphibole grains in O-C tend to be plumose. Slide 4663 differs in that hornblende is more abundant than pyroxene. Distributed through aggregates of hornblende grains in 4663 occur fine flakes and laths of honey brown pleochroic mica minerals, probably a variety of biotite.

Brown colouring due to the alteration and release of finely divided iron in felspar grains is characteristic of, and similar to that in the "red" rocks from Duchess and Trekelano, described by Edwards and Baker (1954), and from Mt. Philip and Rosebud areas. In 4663 this alteration outlines the cleavage traces of the original felspar crystals. Felspar alteration is not so common in O-C.

Felspar is more abundant in O-A than in O-B, because the "organic" structures that it replaces are larger. Ill-defined multiple twinning according to the

albite law gives a maximum extinction of 15°; grains are of low relief, grey and optically negative. The felspar is a soda-rich variety. In 4663 it is of the same composition.

Scapolite is more abundant in O-A than in O-B. Apatite occurs as small grains scattered throughout slide O-A and a few grains of apatite and spene occur in O-B, O-C and 4663. Epidote and a few grains of quartz are also scattered throughout 4663. Zones of a nondescript material in the groundmass of O-B and O-C include grains of calcite and epidote minerals. The material surrounding these grains cannot be resolved; it is possibly derived by alteration of felspathic material. Rare grains of fluorite also occur in these zones.

Slide 4669 consists of light green to colourless diopside in a fine groundmass of scapolite and felspar, but no amphibole. Scapolite and pyroxene occur in approximately equal proportions. Sphene, quartz and a few apatite grains occur throughout this slide.

The "organic" horizon possibly represents original impure limey and dolomitic sediments. Microscopically the slides O-A, O-B and O-C, 4663 and 4669 are plagioclase-pyroxene and plagioclase-pyroxene-amphibole granulites.

Those of definite sedimentary Origin:

(1) Ferromagnesian - rich:

Specimens grouped under this heading are 4675, 4676, 4678, 4671, 4668, 4674 and possibly 4670 and 4664. This group is considered almost definitely to be calc-silicates. By referring to the specimen locality plan (Scale 1" = 200') and Appendix 2 it can be seen that, as mapped by Searl and Fraser, they came from a number of rock outcrops of different rock type. Rocks 4678, 4668 and 4664 were thought to be basic igneous rocks, numbers 4675, 4671, 4674 and 4670 were mapped as garnet-diopside rock, and 4676 as a banded diopside-garnet granulite. The specimens come from the east and south-east of the Mary Kathleen lode.

It is interesting to note that a number of the specimens submitted come from zones mapped as garnetized rocks, that is, specimen numbers 4670, 4668, 4671, 4672, 4675, 4674, 4682, 4676, 4679, 4681 and 4680, but of these only in 4673 and 4675 has garnet been seen in thin section.

Hand specimens 4675, 4676, 4678, 4671, 4668, 4674, 4670 and 4664 are dark basic rocks, commonly showing small splinter-like glistening facets of ferromagnesian mineral.

In thin section, the texture of slides show them to be completely recrystallized; they are now granulites. The present arrangement of the minerals approximates to glomeroblastic texture, with an uneven distribution of mineral grains rather similar to that in slides of specimens from the "organic" horizon. The development of scapolite in large irregular plates which contain numerous inclusions of diopside grains is similar to poikiloblastic textures in calc-silicate rocks of the Fugald River, Duchess and Trekelano areas (Edwards and Baker 1954). Grainsize in these rocks grades up to 4 mms. for scapolite and pyroxene porphyroblasts and averages 0.1 mm. in the groundmass.

Localized and more specialized textures occur in a number of slides. A symplektic-type structure is developed in slides 4670, 4675, 4678 and 4674. It results where diopside grains, which have a globular shape, occur in a rough radial arrangement as inclusions in scapolite plates. It is suggested that the present large irregular shaped scapolite plates formed by the coalescing of many smaller grains and incorporated small diopside (4670, 4674), epidote (4671, 4678) and sphene (4678) grains in the process. The early stage in this process of development results in normal poikiloblastic textural features, but in the more advanced stages, localized symplektic structures result.

Small ring structures, referred to in the previous section on the "organic" horizon (p.5.) are also prominent in the rocks of this group, especially in slide 4671, where they have a maximum diameter of 0.3 mm. These structures also occur in 4678, 4668, 4674, 4670 and 4657. They consist of small amphibole laths placed end to end to form a roughly circular ring. In 4671 there may be two amphibole types, the dark green amphibole which forms these ring structures, and a bluer variety, perhaps more soda-rich, which constitutes the amphibole of the rock in general. The ring structures are not confined to some Mary Kathleen rocks only; they have been seen in calc-silicate rocks further south, around the Rosebud mine (slide J601 and J603). Here there is strong evidence that the rock is bedded calc-silicate. The origin of the ring structures is unknown, but it is suggested that they represent some original sedimentary feature. One possibility is that they represent original oolites in dolomitic rocks. Texturally such structures have no significance as to their origin.

In slide 4676 the distribution of pyroxene and amphibole grains suggests a rough banding of the rock which may reflect original bedding (as referred to by Edwards and Baker, 1954). In 4678 indistinct banding of iron ore may represent original iron-rich sedimentary bands. Specimen 4670 shows a similar banded distribution of mineral grains.

Scapolite- and epidote- rich bands in 4676 are veins of introduced material, resulting from regional metasomatism. These veins approximate to the general trend of mineral grains in the section.

In slide 4674 an unusual band of fresh pyroxene grains cuts right across the slides. This is not a vein of fresh pyroxene, for the margins of the band are not boundaries of grains. Pyroxene grains cut across the margin of the band, and that part of the grain within the band appears unaltered, while the remainder of the grain penetrating the body of the rock shows amphibole alteration characteristic of all other pyroxene grains in the rock. The band therefore represents a zone cutting the slide in which there was an absence of the agent of alteration of pyroxene grains to amphibole. The reason for, and significance of, this feature is unknown.

A well developed cleavage in scapolite in 4670, (as noted in 4675, 4680 and 4665) probably results from slight shearing; in places it approaches an almost fibrous habit. This phase of stress can be compared with the introduction of felspar along planes of failure in post-granite dolerite, specimen 4677, which suggests very late-stage minor shearing and felspathization in the area.

Section 4668 is broken by fractures; this may be a related feature.

The rocks of this group consist essentially of fine granular pyroxene and amphibole with large plates of scapolite. Accessory minerals include epidote, sphene, apatite and iron ore.

The pyroxene is a light green diopsidic variety, some sections of which are slightly pleochroic. It has a large 2V and is optically positive. In coarse angular portions of slide 4670 pyroxene is intergrown with plumose amphibole.

Amphibole is generally a normal medium green variety with a pleochroic scheme of X = light yellow green, Y = light grass green and Z = blue green. In slide 4676 the outer zone of zoned amphibole is the more soda-rich, and in 4671, as noted, amphibole of the rock is more soda-rich than that of the ring structures.

Slide 4678 is similar to 4668 and 4670. Pyroxene and amphibole occur in roughly equal amounts, but in 4668 pyroxene predominates. Amphibole is more abundant than diopside in 4675, though in 4670 the predominance of amphibole is not so great.

Some amphibole grains in 4674 show numerous inclusions of scapolite. They are optically continuous but the scapolite grains are not. In this slide hornblende surrounds pyroxene and occurs in cleavage traces of pyroxene grains. It may also be seen as inclusions in some pyroxene grains. In 4671 some larger plates of amphibole contain pyroxene inclusions and indefinite zones where pyroxene is in part converted to amphibole. Edwards and Baker (1954) state that in the Duchess and Trekelano areas alteration of pyroxene is to amphibole; this agrees with the observations recorded above.

In 4675 scapolite occurs around granular aggregates of light brown garnet. Radiating out from the garnet is a symplektic development of diopside; both garnet and diopside grains are included in a mosaic of scapolite grains (4674).

In 4670 occur large grains (1.5 mm.) of sphene, specimen 4668 is rich in an epidote mineral which is nearly as abundant as diopsidic pyroxene. Epidote occurs in 4676. Sphene is almost universally present in the pre-granite rocks from the Mary Kathleen area. Slides 4678, 4668 and 4670 contain grains of sphene and iron ore scattered throughout the slides.

In 4678 various plagioclase grains show multiple twinning according to the albite law and have a maximum extinction angle of 16°, indicating a soda-rich composition.

Although 4664 is considered to belong to this group, it is rather different in that it consists almost entirely of diopside and amphibole. Texturally, it is granular and contains many large prisms of poikiloblastic pyroxene, with inclusions of honey-brown biotite flakes and sparse grains of sphene. The only light mineral present is scapolite, of which a few irregular and poikiloblastic grains were observed. The pyroxene is similar to the pyroxene of the group above with a high positive 2V and shows incipient alteration to green amphibole along cleavage traces and other cracks.

The amphibole is a medium green variety but some grains are bluer, indicating that they are probably richer in soda than others.

The rocks described above - specimens 4664, 4668, 4670, 4671, 4674, 4675, 4676 and 4678 - are different types of pyroxene - amphibole scapolite granulites, as described by Edwards and Baker (1954) or hornfelses of Joplin (1954), with modifications according to the presence of key minerals of Goldschmidt's diagram (1911), such as garnet, epidote and others.

The hornfelses result essentially from thermal metamorphism. As Joplin (1954) has pointed out, many of these calc-silicate rocks are true hornfelses according to Goldschmidt's (1911) classification. For example, the mineral assemblage in 4675 is a true class 8 hornfels consisting of a plagioclase-diopside-garnet assemblage. Others in the group can be considered medium grade wet class 8 (Joplin, 1935) where epidote replaces garnet in the mineral suite, while still others may be grouped in class 7. The hornfelses result from the metamorphism of calcareous-argillaceous sediments.

(2) Ferromagnesian - Poor.

Rocks 4672, 4680 and 4681 are in this category. Slide 4672 is very similar to 4681, but 4680 is richer in ferromagnesian minerals. All are ferromagnesian-poor with respect to those of group (1).

Rock 4672 comes from the east of the Mary Kathleen lode and on a line projected south along the strike from the "Scapolite-diorite" mass. In Appendix 2 it is referred to as laminated and probably intrusive, containing garnet. Rocks 4680 and 4681 crop out farther south than 4672, but on the same line of projection. The outcrops from which they were taken are not delineated on the map (Scale 1" = 200'), but in appendix 2 rock 4681 is considered to be a laminated igneous rock and distinct from 4680.

All the rocks of this group are lighter coloured in hand specimen than group (1) rocks. They are streaky dark grey rocks in which only green amphibole grains can be identified in hand specimen.

Slides 4672 and 4681 are alike; they have similar granular textures and an even grainsize which averages about 0.1 mm. Mineral grains, particularly the ferromagnesians in 4681, show a distinct directional trend. The laminated character of the rock recognized in the field by Searl and Fraser (appendix 2) evidently results from the directional trend of these mineral grains. A small shear which cuts slide 4681 is filled with epidote, which was probably introduced along this line of weakness.

Felspar alteration along fractures and shears results in alteration of grains adjacent to the breaks and release of specular iron ore similar to that referred to in other calc-silicate rocks mentioned previously. Generally, felspar is more altered in 4672 than 4681, and scapolite grains near the shear are almost fibrous. This means that fracturing occurred after scapolitization and the minor shearing can be compared with that referred to in 4677, 4675 and 4665. (P. 3 and 7).

Potash felspar, mostly grains or microcline, constitutes 60 percent of slide 4681.

It probably results from potash metasomatism. Few grains of scapolite occur. Slide 4672 differs from 4681 in that microcline is not quite so abundant, but scapolite and epidote are relatively more abundant.

The ferromagnesian minerals, diopsidic pyroxene and moderate green-coloured amphibole make up the remainder of slides 4672 and 4681, that is, they constitute about 40 percent of the slides. Amphibole is slightly more abundant than pyroxene in 4681, but they occur in roughly equal proportions in 4672. Very little quartz occurs in either of the slides. Apatite is abundant in 4672.

The rocks were both originally impure calcareous sediments and now have been metamorphosed to granulites. They show different degrees of metasomatism with the formation of scapolite and in some cases accompanied by felspar or apatite.

Slide 4680 is coarser grained and richer in ferromagnesian minerals than 4672 and 4681 but lacks their mineral alignment. It is granular, with leucocratic minerals up to 0.5 mm., and ferromagnesian minerals up to 2 mm. in size. Pyroxene and hornblende grains form aggregates of approximately equal amounts, resulting in a glomeroblastic texture. Amphibole porphyroblasts show sieve structure. The incipient porphyroblastic development in this slide may represent an early stage in the process by which pyroxene porphyroblasts developed in 4657 and 4658. The aggregates of pyroxene grains have been partially altered to amphibole which, when fully developed, forms large optically continuous grains, or porphyroblasts, with relatively fresh inclusions of pyroxene in random orientation.

As for specimen 4681, 60 percent of the slide consists of felspar, mostly microcline, but with scapolite and minor amounts of plagioclase. The plagioclase shows a maximum extinction of 15° from albite twins and therefore is probably oligoclase.

Other minerals present include some pleochroic light to dark brown amphibole, grains of calcite, and a few small grains of sphene and apatite.

Although 4680 has been referred to (appendix 2) as laminated, there is little evidence of a directional feature or banded grain development in the slide. The origin of the garnet observed in this stratum by Pearl and Fraser (1956) was not determined because none occurs in the section examined.

Rock 4680 clearly had a different sedimentary composition from rocks 4672 and 4681. It results from the moderate to high grade thermal metamorphism of an impure calcareous rock, which was richer in lime than 4672 and 4681.

Those of probable sedimentary origin:

Specimens 4666, 4667 and 4657, 4658 were mapped as basic igneous rocks in the field. As a result of the petrological work the author considers them to be probably of sedimentary origin. Though none is very much alike, for the purposes of description, they are divided into two groups. Slides 4666 and 4667 will be discussed together and so will 4657 and 4658.

Rocks 4657 and 4658 come from mineralized stressed basic rocks mapped west of Mineral Ventures lease and occur in the "Older Sequence" beds (appendix 2). It is assumed that this refers to the postulated basic flows and sills (Searl and Fraser, 1956) in the lower members of the Corella beds.

Rocks 4666 and 4667 are from outcrops 500 feet south-east of the Mary Kathleen lode (appendix 2 and specimen locality map Scale 1" = 200').

Slides 4657 and 4658 are both medium grained. Slide 4658 is distinctly porphyroblastic; slide 4647 shows incipient porphyroblastic development, but is much richer in ferromagnesian minerals than 4658. The only real relationship between the two is their juxtaposition in the field and their porphyroblastic character, although they are considered in the field to be the same age and type (Table 2). Slide 4657 differs from 4658 in that it contains a few ring structures of hornblende grains as described in 4671 (p.8).

Grainsize in 4657 ranges between 0.5 mm. to 2.0 mm. and in 4658 up to 0.5 mm., with porphyroblasts up to 5 mm. in size.

Slide 4658 contains large porphyroblasts of pyroxene, which are pleochroic from colourless to a pale tint of green. Some porphyroblasts are euhedral, simply twinned and moderately fresh, although in part altered to hornblende.

Some pyroxene grains are rimmed with hornblende, formed by alteration of the pyroxene and incipient hornblende development is apparent along cleavages and cracks. A similar alteration relationship can be seen in 4675, where hornblende surrounds aggregates of pyroxene grains. Other grains contain many inclusions of both amphibole and green mica, probably biotite. These inclusions are not a safe guide to the order of alteration and it is evident that the last process to operate is shown by the partial alteration of pyroxene to amphibole.

Some exceptional pyroxene porphyroblasts have grown and incorporated inclusions of scapolite, biotite, hornblende and plagioclase. Alteration of these optically continuous pyroxene plates along margins and cracks to amphibole would perhaps, in these cases, be a secondary effect.

In 4658 pyroxene and hornblende constitute 40 percent of the slide and they occur in roughly equal amounts. Scapolite constitutes half the slide and occurs in close association with grains of plagioclase and microcline, some grains of which it no doubt replaces.

Other minerals present in 4658 include sphene and quartz. The quartz and microcline grains are slightly strained. Green biotite occurs in association with groups of epidote grains, as well as in the form of inclusions in pyroxene porphyroblasts, as mentioned above.

Development of the pyroxene porphyroblasts is significant when considering the origin of 4658. It is referred to as an "Older Sequence" rock (appendix 2)

and the problem arises whether the pyroxene represents original phenocrysts of a basic magma in the process of alteration to amphibole, or porphyroblasts in a calc-silicate rock. The latter is thought to be the case. An answer is sought below by comparing the specimens from the Mary Kathleen area with rocks from a roughly similar environment further south in the Rosebud area. Before a comparison is made between these two areas, slides 4657, 4666 and 4667 will be considered. Slide 4657 differs considerably in its mineral assemblages from that of 4658. It is rich in dark green amphibole throughout which occurs small lenticular grains of apatite. Epidote is abundant and is closely associated with grains of pyroxene. It also differs from 4658 in that it contains small cubes of pyrite and grains of sphene. Very little scapolite is present, and untwinned felspar grains show only slight alteration.

Rock 4657 is a typical hornblende-pyroxene-epidote granulite, or a modified class 8 hornfels (Joplin, 1935). The abundance of epidote, apatite and microcline suggests they have been metasomatically introduced. This is probably true for 4666 and to an even greater degree for 4657. As with 4664, 4666 and 4663, slide 4657 is too rich in ferromagnesian minerals to have been a rock of basaltic origin.

Slides 4666 and 4667 are both considered to be calc-silicates. Slide 4666 has essentially a decussate arrangement of medium-green hornblende grains, some prisms of which are poikiloblastic. Slide 4667 is coarsely granular with a tendency towards a decussate fabric. It is rich in dark green amphibole, but does not contain as much as 4666. The amphibole is for the most part well cleaved, and in 4666 is only a moderate green colour. Indistinct amphibole ring structure occur in 4666. (cf. p.7 spec. 4671).

The pyroxene in both slides is a colourless variety in contrast to the usual green diopside described previously. It occurs in lesser amounts in 4666, and it has a high positive 2V. In parts of slide 4666 it forms cores in hornblende grains and shows incipient alteration to amphibole along cracks.

Scapolite in 4667 contains inclusions, mainly of diopside but also a few hornblende grains.

Small grains of an epidote mineral in hornblende prisms of 4666 have light to medium brown pleochroic haloes around them.

Other mineral constituents include minor quartz in 4666 and extensively sericitized felspar in both. Some twinned plagioclase grains in 4667 have a composition between oligoclase and andesine. Microcline is more abundant than plagioclase, these together with scapolite form about 35 percent of the slide. Microcline may result from potash metasomatism. The remainder of the rock consists of amphibole with a few grains of apatite and sphene.

As in the case of 4663, 4664, 4657 and 4658, perhaps the most striking feature of 4666 and 4667 is the marked difference in textural and mineralogical composition of the slides. They all seem too rich in ferromagnesian

constituents to be derived from igneous rocks of basaltic type. It is therefore suggested, as for 4657 and 4658 that 4666 and 4667 are calc-silicate granulites which were originally impure calcareous rocks of various compositions.

## CALC-SILICATE AND BASIC IGNEOUS ROCKS - ROSEBUD AREA

Four rocks from the Rosebud area will be briefly described before they are compared with similar rock types in the Mary Kathleen area. Slides J601 and J603 were lent by Dr. G.A. Joplin and are cut from calc-silicate rocks exposed in the Corella River bed at the Rosebud dam site. The other two, numbers 9529 and 9576 are definitely basic, and occur a few hundred yards south of the dam site.

It is apparent that slide 9529 and 9576 are basic igneous rocks, from the fact that they show relict ophitic texture characteristic of a basic igneous intrusive and also from the relative abundances of their several constituents. They are essentially plagioclase-amphibole rocks with some sphene, iron ore, scapolite and epidote grains scattered throughout. Alteration is of a moderate thermal type and has produced partly sericitized felspars and sieve structure in amphibole grains. The characteristic features are their relict igneous texture, thermal alteration only, and low proportion of scapolite associated with approximately equal amounts of plagioclase and hornblende. The prominence of iron ore is another feature.

The two calc-silicates chosen for comparative purposes, (J601 and J603), show features characteristic of calc-silicate rocks in the Rosebud area, but are not so intensely altered as the Mary Kathleen rocks. Slide J601 is distinctly banded, granular and consists essentially of moderate-green amphibole and altered felspar in approximately equal proportions. Another feature of note is the presence of indistinct ring structures. The rock is slightly sheared and transected by parallel fractures along which some felspathic material, some sericitized and haematized, has penetrated. Felspar alteration includes pitting and brown colouration due to release of finely divided iron. This appears as red streaks in the hand specimen. Apatite is abundant and is introduced by metasomatic processes. Sphene, quartz and some iron-ore grains occur throughout the slide. Scapolite is scarce.

Slide J603 is quite different from J601 - as would be expected, since it comes from another sedimentary stratum of the Corella beds. It has a granular texture, and some mineral grains show a distinct parallelism. Ring structures of amphibole laths are numerous and are similar to those in 4671 (p.3 and 8). Medium-green amphibole grains show sieve structures characteristic of a thermally metamorphosed rock, and they comprise about half the slide. Leucocratic minerals constitute the remaining half. Mineralogically, J603 is rich in scapolite which occurs in glomeroblastic groups of grains. Numerous grains of honey brown mica, perhaps phlogopite, occur. Sphene, felspar, calcite and a few grains of iron ore are scattered throughout the slide.

## COMPARISON BETWEEN ROCKS OF MARY KATHLEEN AND ROSEBUD AREAS

The Rosebud Copper mine occurs 7½ miles south-south-west of the Mary Kathleen Uranium deposit. The rocks are of the same type and have been affected by roughly similar environmental conditions. For this reason the rock types of the two areas are compared.

In the Rosebud area there are both distinctive basic igneous and calc-silicate rocks which have had thermal metamorphism and metasomatism superimposed in an earlier regional metamorphism. Both still preserve textural and mineralogical features which identify the original rock type from that which they were derived.

It appears that in this area regional metamorphism (Harker 1950) was not intense enough to obliterate the original texture of the rocks and as is usually the case, the ensuing thermal metamorphism has not changed their fabric further. Consequently, original basic igneous textures are still preserved and features characteristic of the calc-silicate rocks can be recognized.

Searl and Fraser (1956) state that the rocks of the Mary Kathleen area occur in a dominantly unstressed and thermally metamorphosed environment. Since no igneous textures are preserved in the Mary Kathleen rocks, they are probably calc-silicates derived from sedimentary, (impure calcareous and dolormitic) strata of different original compositions.

Microscopic evidence suggests a porphyroblastic development of pyroxene in 4657 and 4658 and incipient development s in 4681, rather than original phenocrysts of an igneous rock, since no other igneous textures are preserved.

In the Rosebud area basic igneous rocks, possibly of late regional folding age, but probably older, transgress the Corella beds, but there is no evidence of interbedded contemporaneous types of basaltic composition. Furthermore, it has not been demonstrated convincingly that much, if any, basic igneous activity occurred during the lower Corella succession in any part of the Mt. Isa-Cloncurry region. Thus, some doubt arises as to the existence of abundant interbedded basic rocks in the Mary Kathleen area.

Careful search by the author in the synclinal structure of Corella beds in the Rosebud area did not reveal any such flows or sills interbedded with the calc-silicates.

Therefore, of the various pre-granite rocks submitted from the Mary Kathleen area only slides 4665 and 4673 could doubtfully be considered of basic igneous origin and these would then be related to type slide 9529, a basic igneous intrusive of the Rosebud area.

## DISCUSSION AND CONCLUSION

Searl and Fraser (1956) refer to the concordant intrusives examples 4663, 4664 and 4665 as "Scapolitized diorite". The only evidence in their report is that

"small related apophyses and sills intrude adjacent rocks" and "assimilation of adjacent rocks occurs at some places on the margin and flow banding is present". They also state "in the main body of diorite the appearance is unstressed and the texture poikilitic, in the related apophyses it is stressed with development if biotite" (Underlining by K.R. Walker).

The fact that apophyses, assimilation and flow structures have been observed in detailed mapping of rock outcrops suspected to be of basic igneous origin must receive closer field examination. It is pointed out that:

1. Flow structure in basic igneous intrusive is rare and, in rocks as metamorphosed as these Proterozoic (rocks) exceptional. Careful observation should be made to see whether flow structure has not been mistaken for contorted banding in calc-silicate rocks which have flowed plastically under pressure. No evidence of flow structure was seen in the rock slides.

2. The observation of assimilation in marginal zones should also be re-examined.

3. The occurrence of minor apophyses needs checking, for the minor intrusive phases into adjacent rocks could occur in calcareous rocks when confined under moderate localized pressures. Searl and Fraser observe that the apophyses are stressed although the main body is unstressed. Point three may be an explanation of the apparent intrusive character of a number of calc-silicate rocks mapped.

Comparing the gruping of the various specimens as established in this paper, with that outlined in appendix 2 from field work, it is seen there is a marked difference in the results obtained.

The significance of this disparity is emphasized by the fact that rocks 4663, 4664, 4666, 4667, 4678, 4672 and 4675 were collected from presumed basic igneous outcrops (appendix 2). As a result of subsequent alteration of this original rock type of uniform composition, and under similar environmental conditions, they are now all different in texture and composition. For this reason it seems more preferable that they were different sedimentary types before alteration. Also, those rocks which under the microscope are most convincingly calc-silicates have been variously mapped as

1. Basic igneous (4664, 4668? and 4678, also 4672, 4680 and 4681).
2. Garnet-diopside rock (4668?, 4670, 4671? 4674 and 4675).
3. Banded diopside-garnet granulite (4676).

It is apparent from this analysis that most microscopic rock identifications made do not agree with the field name given to their outcrop on the map. This either casts doubt on many rock boundaries or indicates that various rock types occur within boundaries shown as enclosing a single rock type. It allso means that most rock boundaries actually differentiate types of calc-silicate granulites and contain few, if any, basic igneous rocks. These facts demonstrate the difficulty encountered in mapping such a complex area.

The conclusion is reached that few, if any, pre-granite basic igneous rocks occur in the Mary Kathleen area, that those which have been previously mapped as such, are probably all calc-silicate rocks, and that differences in composition derive from differences in the original sediments. The only basic igneous rocks definitely identified are post-granite dykes.

Tabulated below are various points which are considered significant textural and compositional features differentiating basic igneous rocks from those of sedimentary origin. From this table it is seen that the weight of evidence available strongly suggests a sedimentary origin for the rocks studied.

| Point No. | Basic Igneous Origin: | Sedimentary Origin: |
|---|---|---|
| 1. | | The abundance of alleged flows and sills at the Mary Kathleen area relative to other adjacent areas where Corella beds crop out, must be considered exceptional. The only basic intrusive known to occur is that in the Rosebud area. |
| 2. | Flow structures and minor apophyses in the field occurrences are recorded by Searl & Fraser (1956). (Note: flow structure is rare in basic igneous intrusives generally, and therefore it would be exceptional in the Proterozoic rocks of this area. There is no evidence of microscopic flow structure, and hence perhaps the suggested flow structure in the field results from plastic deformation of calc-silicate rocks). | |
| 3. | | Magnetite bands could represent iron-rich seams in a sediment. |
| 4. | | Close petrological similarity is apparent between specimens described as "basic types" and the strata of the adjacent "organic" horizon, as well as proven calc-silicate rocks of the Rosebud area. The "organic" horizon is believed to be of sedimentary origin. |
| 5. | | Ring structure of hornblende laths arranged end to end may represent oolitic structures of a dolomitic rock, or may possibly result from some original organic remains. |
| 6. | Texture of 4665 and 4673 may represent a strongly scapolitized basic igneous texture. | The complete absence of relict basic igneous structures supports the view that the specimens are not altered basic igneous rocks. |

Such structures would not normally be obliterated by contact metamorphism, though they may be by regional metamorphism. But igneous structures have not been destroyed in the Rosebud area, where similar rock types occur in a similar metamorphic environment.

7. Porphyroblasts in 4658 etc. are the result of crystal growth by metamorphism and are not relict phenocrysts. No other basic rocks are recorded in the area which contain pyroxene phenocrysts.

8. All of the rocks in the Mary Kathleen area suspected on field evidence to be of basic igneous origin, differ amongst themselves so markedly in textural and mineralogical composition, that it is hard to explain this fact if they were all derived from the one basaltic magma type. More probably they represent products of originally different sedimentary bands.

9. The preponderance of ferromagnesian minerals in some slides makes it hard to explain where plagioclase has gone to from the presumed original basic igneous rock.

The absence of free quartz in some slides implies $S_1O_2$ has migrated or the original rocks were quartz poor.

10.

Apatite: is found in alkaline basic rocks, but the chemical composition of basic rocks from the area which have been analysed does not suggest that they are alkaline or contain high $P_2O_5$.

11. Apatite could be metasomatically introduced as a result of emanations associated with igneous activity or possibly result from phosphate organisms in sediments. Abundant apatite occurs in proven calc-silicate rocks of the Rosebud and Duchess-Trekeland areas (Edwards & Baker, 1954).

Titania: some slides are rich in sphene and a slightly soda hornblende suggesting an alkaline rock.

12. Titania: Edwards & Baker (1954) refer to calc-silicate rocks with similar mineralogy from the Duchess and Trekelano areas. (Note - they also describe pyroxene in calc-silicates ranging from colourless to bright green.)

13. Microcline either results from potash metasomatism or is derived from sericite originally in an argillaceous rock type. (Note - apatite and epidote metasomatism, in addition to scapolitization and felspathization are common in these calc-silicate rocks.)

14. Scapolite: calc-silicate rocks in scapolitized zones are usually rich in scapolite mineral, but basic rocks in the same environment are usually poor. The rocks examined from the Mary Kathleen area are mostly scapolite-rich.

15. Complete incompatability of the petrological determinations with the field observations and the comparisons as listed in appendix 2. means that perhaps little significance can be applied to field correlations.

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## APPENDIX I.

Descriptions of other specimens submitted:

The individual rock descriptions in this section play no part in the preceding argument but are included for the sake of completeness. Rock numbers 4679, 4682 and 4660 were not sectioned. Specimen 4660 is a fine grained granite rich in ferromagnesian mineral. Rock 4679 is adequately covered by the description of 4680. Rock 4682 is an extensively weathered calc-silicate.

The locality of 4685 was not given and rocks 4661 and 4662 occur within the western granite mass. Specimen 4659 was collected on the western edge of the basic mass, mapped about half a mile south of the Mary Kathleen camp site, and is described in the typed remarks accompanying the specimens, as "stressed basic 'older' from east of Wells 'Valley Amphibolite'".

Slide 4661 is fine, even-grained and granular, small grains of hornblende and iron ore show a distinct directional trend, with banding of pyrite. Ring structures of hornblende grains similar to those described in 4671 are present. Grainsize averages 1 mm. but some amphibole grains in a ferromagnesian-rich band are 2 mms. in size.

The slide is cut by a zone rich in epidote and hornblende, which probably resulted from epidotization. This zone approximates to the general mineral trend. Epidote also occurs as small grains in amphibole prisms.

Some green amphibole grains show an unusual structure in which cracks or cleavage planes of grains are filled with a lighter bluish amphibole of a more soda-rich variety.

The rock consists essentially of hornblende and felspar. Felspar grains are nearly all altered. Fresh twinned plagioclase is a soda-rich variety according to the extinction angle measurements from albite twins. A little sphene is present.

The rock is a hornblende-plagioclase granulite, possibly a remnant of calcareous sediment caught up in the granitic rocks.

Slide 4662 is also fine, even-grained and granular, but the directional trend of mineral grains is not so distinct as in 4661. Indistinct ring structures similar to those in 4671 occur. Average grainsize is 0.5 mm.

The slide contains approximately equal proportions of amphibole and felspar, with minor quantities of biotite, sphene, iron ore and apatite.

Amphibole is granular and is the normal green variety. Felspar is fairly fresh, and indications are that it is albite.

Biotite is closely associated with the amphibole, and occurs as grains and laths. Some incipient biotite grains are also present.

Apatite is abundant, and is commonly concentrated along definite lines of development or in a number of isolated patches. Some small grains form inclusions in amphibole prisms. Apatite is probably metasomatically introduced.

This, too, is a hornblende-plagioclase granulite, and it is thought that it represents an original sedimentary remnant in the Western granite mass, as suggested for 4661.

Slide 4659 is also granular but coarser-grained than 4661 and 4662. It is slightly sheared and amphibole grains show a rough directional trend. The average grainsize is 0.5 mm. with a few grains about 1 mm. across.

It contains hornblende and albite in approximately equal proportions, with minor quantities of iron ore, and a few grains of apatite scattered through the slide. Amphibole is the normal green variety.

Some felspar grains are badly altered, but in general are fresh and untwinned. The low R.I. and optically positive character indicates that it is probably albite.

This is also a hornblende-plagioclase granulite.

Slide 4685 is poikiloblastic with garnet grains containing inclusions of ferromagnesian minerals and calcite. The slide is cut by calcite veins. The average grainsize of the groundmass is 0.5 mm., but garnet, calcite and scapolite porphyroblasts may be as large as 3 mms.

Garnet is the most abundant mineral, and is a yellow-brown variety, probably almandite or andradite. Light green pyroxene and medium green amphibole occur in approximately equal proportions. One prism of twinned amphibole is surrounded by a rim of light green amphibole. Scapolite occurs in amounts roughly equal to those of calcite, as large cleaved and cracked grains. The slide also contains some iron ore grains. No field description of the specimen was supplied, it was not included in the list which appears as appendix 2. The rock is a garnet-rich pyroxene-amphibole rock.

## APPENDIX 2.

### Localities and Remarks supplied with Specimens

| MKU NUMBER | NORTH-EAST MAP. REF. | | | | Remarks |
|---|---|---|---|---|---|
| 4657 | See Specimen Location Map 4" to 1 mile. | | | | Mineralised stressed basic. "Older sequence" (Near E edge M.V. basic). |
| 4658 | " | " | " | | Spec. from centre of same basic as above. |
| 4659 | " | " | " | | Stressed basic "older" from east of Wells. "Valley Amphibolite". |
| 4660 | " | " | " | | Hybrid in Granite west of drome. |
| 4661 | " | " | " | | Stressed basic at north west corner of drome, in granitised area. |
| 4662 | " | " | " | | Stressed basic from granitised area west of Thiess Bros. camp site. |
| 4663 | See | 10700 11300 | See 1" to 200' | Geol.Map | Towards E edge scap. diorite, near "organic" horizon. |
| 4664 | " | 10740 11160 | " | " " | Centre scap. diorite, near tank. |
| 4665 | " | 10780 11120 | " | " " | " " " |
| 4666 | " | 9784 11404 | " | 1" to 40' " | Towards E edge of scap.diorite ?igneous material or altered seds. |
| 4667 | " | 9790 11346 | " | " | Stressed scap. diorite. As 4666. |
| 4668 | " | 9372 11462 | " | " | Dyke or altered sed? Note changing character along strike to south. |
| 4669 | " | 9563 11058 | " | " | Example of altered contact rock W edge same dyke. Any organic remnants? |
| 4670 | " | 9509 11127 | " | " | Brecciated appearance of material near W edge dyke. Igneous or essentially sedimentary? |
| 4671 | " | 9163 11364 | " | " | As for 4668. |
| 4672 | " | 9020 11572 | " | " | Laminated, probably intrusive. Nature of garnet in laminae? Original constituent or metasomatic? |
| 4673 | " | 8935 11390 | " | " | As for 4671. |
| 4674 | " | 8644 11366 | " | " | Poorly exposed, igneous or sed. Correlate with 4671, 4666, 4663, 4664, 4668. |
| 4675 | " | 8756 11120 | " | " | As for 4674. |
| 4676 | " | 8575 11206 | " | " | Laminated basic (igneous?) distinct from 4672. |
| 4677 | " | 9153 11275 | " | " | "Younger dyke" later than scap. diorite. |
| 4678 | " | 9124 10864 | " | " | Mineralised basic igneous (?) rock Correlations with any above? |
| 4679 | " | 8490 11683 | " | " | Laminated igneous (?) basic |
| 4680 | " | 8461 11785 | " | " | As for 4679. Same type (?) |
| 4681 | " | 8462 11736 | " | " | Laminated igneous distinct from 4680, 4679. |
| 4682 | " | 8477 11334 | " | " | Altered basic igneous or altered sed. Same as 4674 (?) |
| 4683 | " | Spec. Locality Map 4" to 1 mile | | | "Younger dyke" 1.4 miles NNE of MKU camp. |
| 4684 | " | " | " | | "Younger dyke" (?) from Rita Lease. See A.B.Clark's map of Rita 4900N 1256E. |

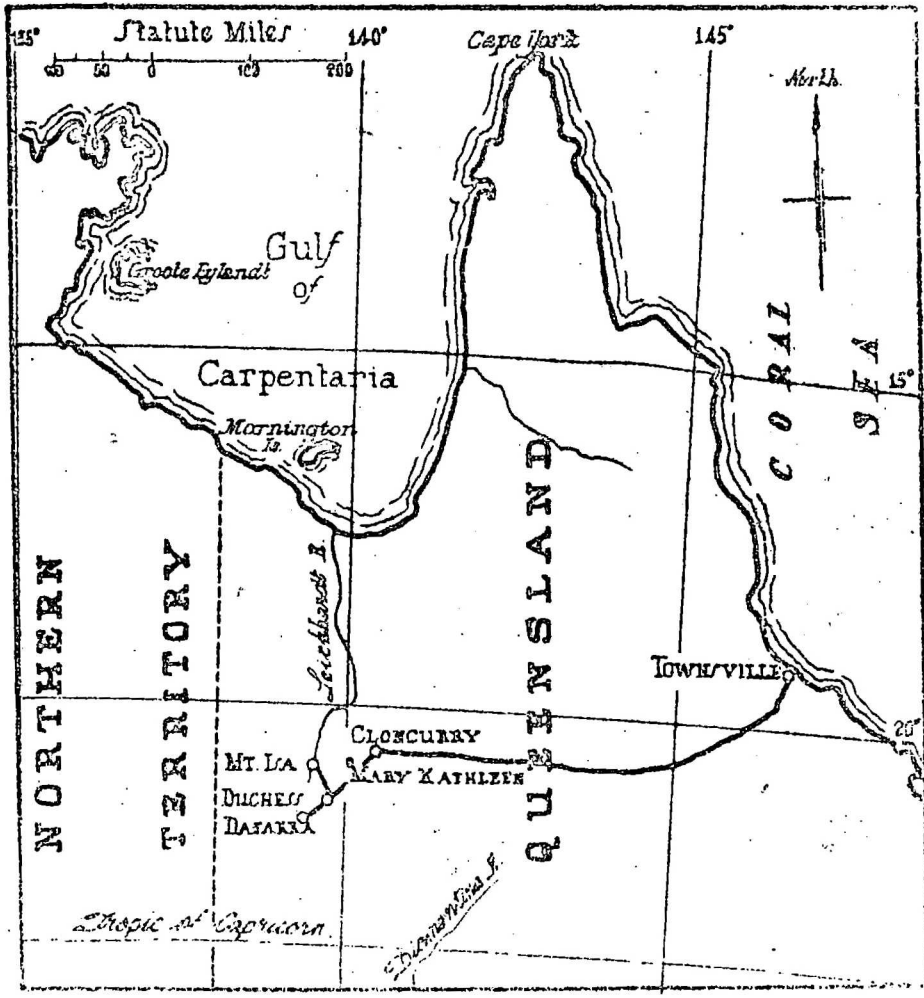



Fig 1. Locality Map showing Merry Fairbairn

# MARY KATHLEEN URANIUM LTD

## GEOLOGY OF AREA
## SURROUNDING MARY KATHLEEN PROSPECT

Geology by — R. A. Searl and R. B. Fraser.

Scale : 1 inch = 200 feet

200 150 100 50 0 200 400 600 800

## LEGEND

— PRE-CAMBRIAN —

- Outcrop of ore-body.
- Boundary of main garnet metasomatism.
- Zone of garnet metasomatism, mainly garnetite (almandite with some andradite) and garnet diopside rock, with varying content of felspar and/or scapolite
- b Areas of undifferentiated basic rocks in garnetised zone
- Almost monomineralic scapolite rock ranging to diopside-scapolite rock White to mottled green and white, minor felspar, hornblende and sphene Restricted occurrence of minute uraninite within diopside.
- Coarsely banded and massive diopside garnet granulite with albite scapolite and quartz Irregular replacement zones of garnetite spreading from joints and fractures
- Green and pink diopside felspar scapolite granulite Usually banded.
- d Dark, fine grained, banded zones in diopside felspar granulite, rich in hornblende and scapolite
- a Undifferentiated strongly banded narrow basic sills associated with diopside felspar-scapolite granulite
- Stressed strongly felspathised zones in diopside granulites containing pyrite, chalcopyrite, and pyrrhotite Felspars partly kaolinised to limonite stained clays Weakly schistose due to strong shearing stresses
- Aggregate of diopside, hornblende, phlogopite, orthoclase and quartz, contains abundant concentric and conical structures probably of organic origin.
- Brecciated green diopside granulite, felspathised and scapolitised. Preferentially banded felspathised bands show as irregular bandings on differentially weathered surfaces.
- Light coloured aggregate of potassic felspar, altered diopside, apatite and quartz, much fractured Occurs massive and unreplaced or has brecciated appearance due to garnet metasomatism along fractures surrounding unreplaced portions of the original rock Allanite replacement with uraninite and uranophane is locally associated with the garnetite
- Breccia conglomerate(?) Fragments angular to subangular up to boulder size and consist of
  - (1) Microcline, perthite, and soda plagioclase with fine granular epidote (this is the commonest type)
  - (2) Almost completely albite with minor epidote
  - (3) Dominantly pyroxene
  - (4) Subrounded boulders of quartzites at one horizon Matrix consists of fine mottled dark green diopside and felspar with minor pholidolite and deep blue hornblende. Sedimentary banding occurs in finer materials. Fragments derived from felspar rich rocks probably mainly from the rock types described immediately above

CORELLA-BEDS

- Felspar diopside gneissic rocks
- Impure scapolite marbles with calc-silicate granulite bands.
- Calcite veins.
- Quartz-mica hornblende schist
- Banded and massive scapolite granulites containing felspar, pyroxene, amphibole, epidote and garnet Some calcareous bands, copper stainings and generally pyritised. Some biotite-rich varieties.
- Pyritised quartzites.
- Altered sheared quartzite rocks, extensively weathered, quartz filled strike fissures. Some chalcedonic silica, slickensiding and brecciation
- Scapolitised diorite Principal minerals - mariolite, diopside, hastingsite and normal hornblende Pyritised, locally trace of purple fluorite Massive or banded garnetite fills some joints Shows marginal modifications
- Stressed basic igneous rock, possibly associated with basal Corella igneous activity
- Stressed and modified basic rocks essentially rich in hornblende Variable felspar, quartz, diopside, scapolite.
- Fine to medium grained microgabbro or dolerite. Transgresses scapolitised diorite. Equivalent to post granite basic dykes.
- Zone of limonite and limonitic jasper probably related to garnet zones

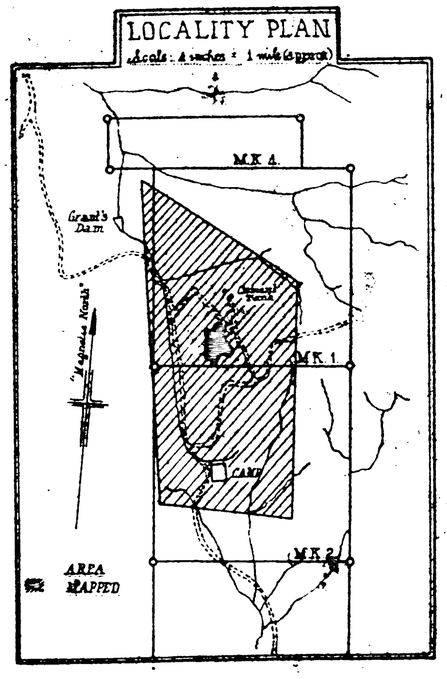
NOTE — Arrangement of legend not in stratigraphical sequence, but according to disposition of outcrop

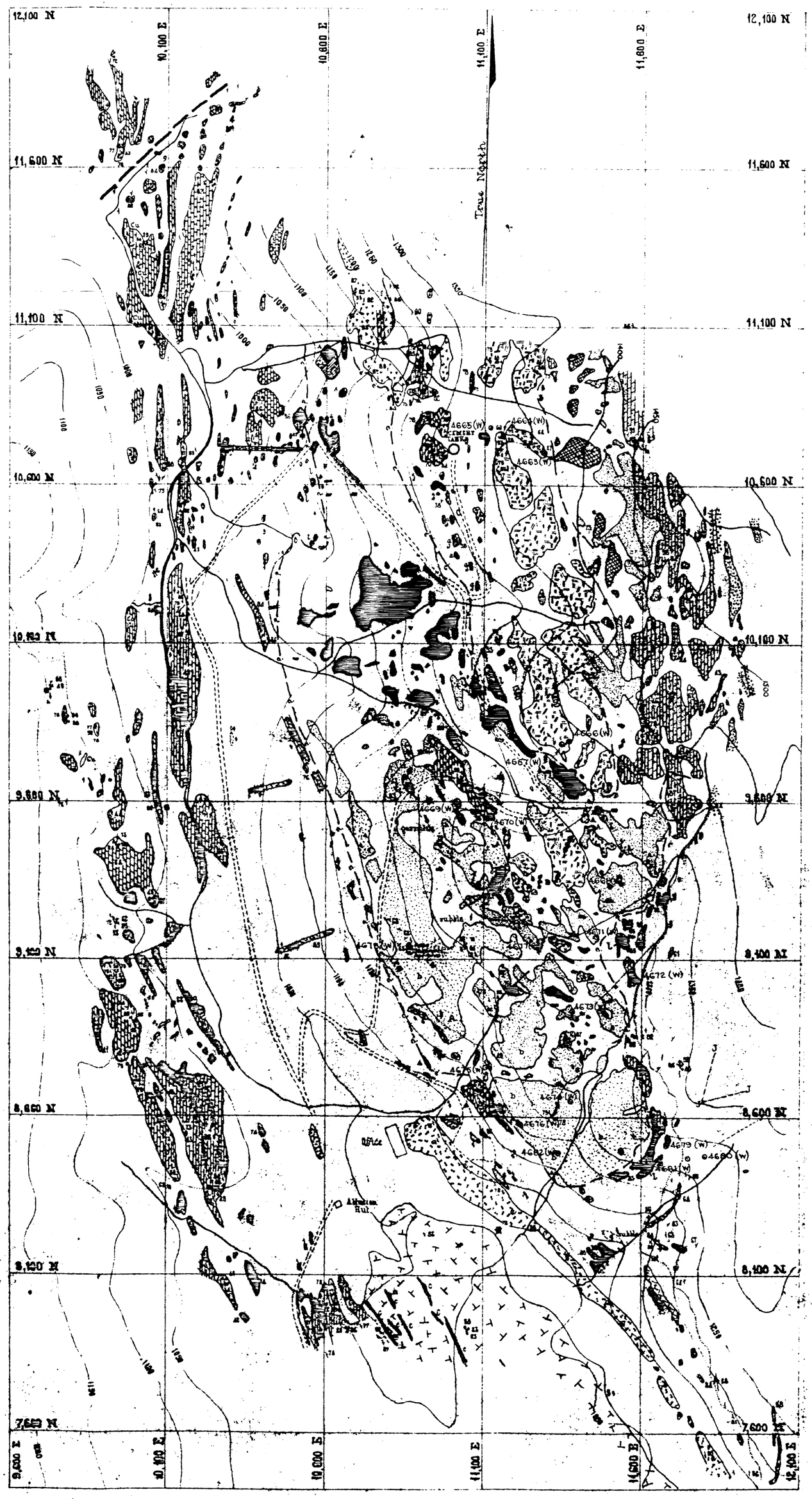
## REFERENCE

- Strike and dip of beds.
- Vertical Dip
- Strike and dip of overturned beds
- Strike and dip of lineation
- Fault established with dip and strike
- Fault established position approximate
- Fault showing relative horizontal movement
- Established boundary
- Established boundary position approximate
- Inferred probable boundary
- Outcrop boundary of quartzite granulite succession approx.
- Boundary of amphibolitised sediments
- Strike and dip of joints
- Vertical joint
- Plunge of beds
- Minor mineralisation - A. Radioactive Anomalies
- Cu Copper
- Co Cobalt
- Q Quartz
- Costean
- Roads
- e Brecciated quartz & quartzite
- Contour lines - 50 foot intervals

LOCALITY PLAN

Scale : 4 inches = 1 mile (approx)




MGKingston 23%