DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

Rept.Bk.No. 79/119

# RELOGGING OF DIAMOND DRILL HOLE MM14, MUTOOROO MINES with Appendix of Petrographic Report by Pontifex and Associates Pty. Ltd. on DIAMOND DRILL HOLES MM15 and MM21A.

GEOLOGICAL SURVEY

by

D.J. FLINT

D.M. No. 725/75

16th July, 1979.

CONTENTS

DEPARTMENT OF MINES AND ENERGY
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# RELOGGING OF DIAMOND DRILL HOLE MM14, MUTOOROO MINES

## ABSTRACT

The deepest cored base-metal exploration hole in South Australia (MM14) is sited at the Mutooroo Mines in the Willyama Complex, Olary Province. Country rocks as intersected in the hole consist predominantly of gneissic amphibolite, pyroxene-bearing granulite and numerous varieties of quartz + feldspar + mica gneiss. These include augen gneiss and sillimanite + kyanite gneiss. Gneissosity was developed about 1700 Ma.

All lithologies are microscopically folded and retrogressed during a later schistosity-forming folding phase. Where this new schistosity is subparallel to parallel to the original gneissosity, sericitisation is extensive.

Chalcopyrite occurs either as disseminations in gneissic amphibolite or with pyrite and pyrrhotite as aggregates in pegmatitic, leucocratic segregations in or near gneissic amphibolite. Multi-element geochemistry of twenty samples produced only an anomalous result in lanthanum.

## INTRODUCTION

Exploration by Mines Exploration Pty. Ltd. from 1962 to 1974 established probable reserves of 8.7 million tonnes of 1.7% copper at the Mutooroo Mines (Horn, 1973). Mineralisation at the nearby Trinity Mine (Fig. 1) is apparently stratigraphically controlled, with enrichment in a fold hinge.

Lithologically the country rocks have stronger affinities with high grade gneisses near Broken Hill rather than other Willyama Complex rocks in South Australia. Unfortunately outcrop in the area is poor and hence the geological history is not well known. The deepest hole, MM14 (1618.9 m), of the Mines Exploration Pty. Ltd. program, represents the longest diamond-drilled base-metal exploration hole in South Australia. Although lithologies of country rock are representative, the hole did not intersect the mineralised zone. Based on other holes, the discordant lode veins show a close spatial relationship with a thick gneissic amphibolite unit. Most mineralised zones are bounded by gneissic amphibolite but where bounded by other gneiss types, there is neither diminution of ore grade nor width. MM14 revealed that the gneissic amphibolite was very much deeper and thicker than expected after extrapolation from adjacent diamond drill holes (Fig. 2).

In the primary zone, veins consist of chalcopyrite and rounded quartz granules disseminated through a pyrite and pyrrhotite matrix (Brooke, 1966). Minor gangue minerals are biotite, chlorite, feldspar and magnetite. In reserve calculations three vein systems are used; main orebody, western orebody and the southern low grade extension (Horn, 1973). Vein widths are generally less than 2 m but there are unsubstantiated reports of widths up to 21 m.

Details of drilling, tro-pari surveys and core/gneissosity angles for MM14 are reported by Mines Exploration Pty. Ltd. (1962-1974). Results of previous investigations are summarised in Stadter (1974, 1976).

Reported herein are relogging of the core (Appendix A), multi-element semi-quantitative analyses, petrography and preliminary geochronology carried out during 1978 and 1979. A bibliography for the Mutooroo Mines is included.

## HISTORICAL REVIEW

The Mutooroo Mines were discovered in 1887 and until their closure in 1914, were the biggest copper producer in the Willyama Complex. Fifteen shafts, the deepest being 140 m, extend along the strike of the ore body for 1.4 km in a north-northwesterly direction. Most of the workings were in the secondary enrichment zone but some shafts reached the quartz + pyrite + pyrrhotite + chalcopyrite ore veins. In the oxidised zone, malachite and chrysocolla occur with limonite, quartz and secondary silica (Brooke, 1966). Other minerals reported are azurite, cuprite, bornite and atacamite (Brown, 1908). The ore texture is often preserved with rounded quartz granules scattered through a limonite and secondary-silica matrix.

A westward-dipping fracture system which persists for over 1.5 km in a north-northwesterly direction and which transgresses the gneissosity contains the orebodies (Barton, 1943; King, 1952). Ore appears to exist as shoots which pitch northerly at 60$^{o}$; three shoots were worked in the secondary enrichment zone (Knight, 1950; Parkin, 1951). Records of production and grade details are poor and often conflicting. Total production is estimated at 6 000 tonnes of hand-dressed ore and copper precipitate from mine water. Grade varies from 6.58% copper (Cu) for 2557 tonnes produced between 1896 and 1899, to 19.3% Cu for 218 tonnes produced from 1907 to 1914 (McKeown, 1941). 110 tonnes of precipitate from mine water contained 36.3% Cu (Brooke, 1966).

## PETROGRAPHY

### Classification

The scheme used herein to distinguish and classify lithologies is based upon the present fabric and mineralogy. Genetic and premetamorphic interpretative terminology are avoided.

Most lithologies are classified as either schist or gneiss based on grain size rather than other fabric elements such as lithological banding, differentiation layering or mica content. However, the boundary is somewhat arbitary with no strict grain size limits.

Schist and gneiss are subdivided further by their present mineralogy and fabric e.g. presence or absence of lithological banding. Schistosity/gneissosity is distinguished from lithological banding. Schistosity and gneissosity are defined by dimensional preferred orientation of minerals, invariably mica. This deformational feature may or may not be parallel to a lithological banding, which appears to be mainly original bedding.

<u>Quartz + feldspar + mica gneiss</u>

As numerous gneisses consist mainly of quartz, feldspar and mica, a further subdivision has been adopted based on the proportion of quartz and feldspar to mica, generally muscovite and biotite. Quartzo-feldspathic gneiss contain less than 5% mica and mica gneiss contains more than 40% mica. The scheme is equivalent to, but not as detailed, as that used by the N.S.W. Geological Survey for the Broken Hill area (Stevens et al., 1979).

A distinctive feature common to many petrographic descriptions of quartz and feldspar-rich gneiss is a granoblastic or granuloblastic texture (Appendix B, P758/78; Appendix C). Quartz and feldspar typically form an equant, near-polygonal coarse-grained mosaic. As quartz and feldspar alignment is rare, the gneissosity is defined dominantly by mica. As the mica content approaches zero, gneissic textures are poor to absent and granofelsic textures predominate.

Superimposed on the coarse-grained texture are abundant small recrystallised quartz and feldspar grains. Many petrographic descriptions classify the lithology as "fine-grained gneiss" or "fine schistose gneiss" because of the extent of recrystallisation and smaller average grain size.

More pelitic varieties contain either staurolite, sillimanite or kyanite enclosed by retrogressive sericitic mica. Sillimanite is fairly common, in places intergrown with biotite. Staurolite is a retrogressive mineral as idiomorphic crystals up to 4 mm long in a fine-grained sericitic matrix.

Augen gneiss

Augen gneiss contains microcline porphyroblasts up to 3 cm long and 1 cm wide in a well-foliated finer-grained quartz and feldspar granoblastic mosaic, through which is developed a biotite and muscovite gneissosity.

Retrogression

Superimposed on all quartz + feldspar + mica gneisses is a strong retrogressive schistosity which, in places, grades to a crenulation cleavage. Mesoscopic folding of gneissosity is evidenced by retrogressive muscovite schistosity or crenulation cleavage as axial plane to folds. The angular difference between gneissosity and retrogressive schistosity has a strong control on the present mineralogy and texture. For a subparallel to parallel configuration, the retrogressive schistosity is very strongly developed, is distinctly planar and sericite is abundant. For a large angular difference, feldspars are poorly sericitised whilst the schistosity is poorly developed and curvi-planar.

Gneissic amphibolite and basic granulite

Commonly, amphibolite is schistose to gneissic and very rarely banded. Feldpsar phenocrysts are minor but are locally abundant in more massive portions. Hornblende (60-70%) and andesine plagioclase (25-30%) dominate with significant minor quartz and biotite. Components in trace amounts are ilmeno-rutile, sphene, sericite, epidote and disseminated chalcopyrite and pyrite. The schistosity/gneissosity is parallel to the regional first phase gneissosity ($S_1$).

Interlayered with gneissic amphibolite are pyroxene-bearing assemblages of up to 35% clinopyroxene and orthopyroxene with only minor hornblende. Granulite varies from massive and granoblastic to weakly schistose where schistosity (probably $S_1$) is defined by elongate aggregates of pyroxene.

Leucocratic veining is often present within gneissic amphibolite and adjacent lithologies. Veins are coarse grained to pegmatitic and contain feldspar, calcite/dolomite, biotite and pyrite + chalcopyrite + pyrrhotite aggregates and occasionally actinolite. Leucocratic segregations within gneissic amphibolite particularly when containing biotite, are also gneissic.

Margins of gneissic amphibolite are extensively altered to biotitic schist and chloritic mylonite (samples RS 164 to 167). Garnet is developed only within this altered zone. Amphibolite and pyroxene granulite are retrogressed in these marginal zones to biotite, chlorite, secondary K-feldspar, calcite, quartz, muscovite and pyrite assemblages.

## GEOCHEMISTRY

Twenty five samples representing the range of rock types in the core were assayed for twenty elements by semi-quantitative emission spectroscopy with a $\pm$ 50% accuracy. Results as tabulated in Appendix D are generally non-anomalous.

The only anomalous result is 700 ppm lanthanum (La) for chloritic mylonite in a retrograde shear zone on the lower margin of a 380 m thick gneissic amphibolite. The anomalous value is not repeated in three other samples from within a distance of 0.65 m. At the time of drilling MM14, this was the expected position for mineralisation.

## GEOCHRONOLOGY

Rubidium/strontium (Rb/Sr) geochronology was used to obtain the age of gneissosity development i.e. the first recognisable deformation and metamorphic episode. Six samples of augen gneiss were analysed (Fig. 3) as the effects of overprinting by the retrogressive schistosity phase are least evident. Plotted on an isochron diagram (Fig. 3), two samples are anomalous and the remaining four are sufficiently widely scattered that only a very approximate age is obtained. Maximum age for the gneissosity development is 1700 Ma which is consistent with dating of high-grade gneiss from the Mine Sequence at Broken Hill. There, estimates of 1640 ± 40 and 1690 ± 35 have been obtained by Rb/Sr and Pb/Pb methods respectively (Pidgeon, 1967; Reynolds, 1971).

Retrogression during later Olarian Orogeny events (1500 - 1600 Ma) and during the Delamerian Orogeny (approx. 450 Ma) have most probably caused Rb and Sr movements, producing the scatter of points in Figure 3.

## SUMMARY AND CONCLUSIONS

MM14 is the deepest diamond-drilled base-metal exploration hole in South Australia. The target was mineralisation on the same horizon as that exposed at Mutooroo Mines, where orebodies containing probable reserves of 8.7 million tonnes of 1.7% Cu have been outlined by Mines Exploration Pty. Ltd. Ore occurs in several veins within a long fracture system and consists of chalcopyrite and rounded quartz granules disseminated in a pyrite and pyrrhotite matrix.

Country rocks are gneissic amphibolite, basic granulite and varieties of quartz + feldspar + mica gneiss. Gneissic amphibolite contains hornblende + andesine with lesser biotite and quartz, first phase gneissosity, feldspar phenocrysts and probably represents igneous intrusives/extrusives. Basic granulite contains 30-35% clinopyroxene and orthopyroxene with little hornblende, is massive to very poorly gneissic and grades into gneissic amphibolite. Quartz + feldspar + mica gneiss varies widely in composition and texture. Most common types consist predominantly of quartz, microcline, albite and biotite while rarer types contain kyanite, sillimanite, staurolite and augen of microcline. The gneissosity has been dated by Rb/Sr geochronology at approximately 1700 Ma. All gneiss types have a superimposed retrogressive folding phase with a muscovite schistosity and crenulation cleavage evident in quartz + feldspar + mica gneiss.

Multi-element analysis of twenty five samples produced only one lanthanum anomaly and this occurs at the probable position of the lode horizon i.e. at 1491 m.

ACKNOWLEDGEMENTS

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DJF:ZV

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# APPENDIX A

## GRAPHICAL AND DESCRIPTIVE LOG - DIAMOND DRILL HOLE MM14

# APPENDIX A

## GRAPHICAL AND DESCRIPTIVE LOG – Mutooroo Mines DDH MM 14

### REFERENCE

| | |
|---|---|
| ~~ ~~ | Gneiss, banding poor or absent. |
| ~–~ | Gneiss, good banding |
| —·—·— | Schist |
| v v v | Amphibolite (meta–dolerite) |
| q q | Quartz vein |
| # # | Aplite or pegmatite |
| | Quartzitic and arkosic metasandstones |
| f~ | Quartzo–feldspathic gneiss |
| f>m~ | Quartz + feldspar > mica gneiss |
| f=m~ | Quartz + feldspar = mica gneiss |
| m~ | Micaceous gneiss |
| b—·—·— | Biotitic schist |
| g—·—·— | Garnetiferous schist |
| ~v | Gneissic amphibolite |
| +~ | Granitic gneiss |
| ⬭~ | Augen gneiss |
| — # | Banded aplite |
| RSZ | Retrograde shear zone |
| | Fractured core (superimposed on other symbols) |
| ——— | Sharp lithologic transition |
| ········ | Gradational lithologic transition |
| | Highly folded schist |

Where the micas present are only biotite, 'm' symbol replaced by 'b'.

Depths quoted are to the TOP of the indicated lithology

| | | |
|---|---|---|
| | DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA | SCALE |
| COMPILED: D.J.F. | MUTOOROO MINES–RELOGGING OF DDH MM 14 | DATE: August 1979 |
| DRN: S.R. CKD: | REFERENCE FOR GEOLOGICAL LOG | PLAN NUMBER S14220 |

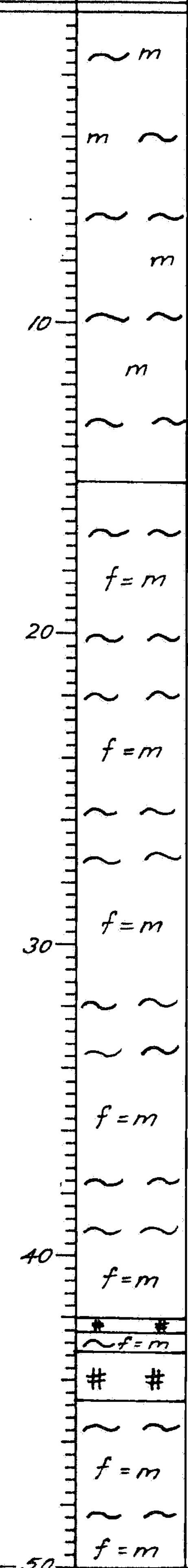
1540

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618.9 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM14
LOCATION Mutooroo Mines
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|




Biotite abundant

Only 30% core recovery to 15m.

slightly variable composition.

Strong biotite and muscovite schistosity - appears to be a retrogressive schistosity.

In places schistosity is crenulated.

As above.

Abundant biotite and muscovite.
Strongly crenulated.

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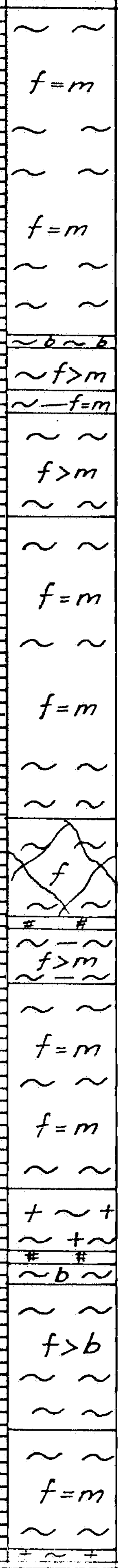
DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

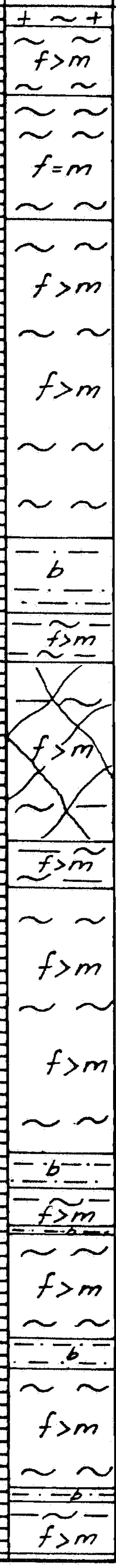
| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| |  | Poor banding developed.<br>Abundant biotite and muscovite.<br>Strongly crenulated. |
| 60 | | Planar gneissosity, parallel gneissosity and superimposed retrogressive muscovite schistosity. |
| 70 | | Strongly crenulated, abundant retrogressive muscovite. |
| | | *A 2014/79<br>Vein fracturing. Analytical sample of vein in-fill material. |
| 80 | | Bands vary in composition from feldspathic gneiss to f=m gneiss. |
| | | In places retrogressive schistosity superimposed on gneissosity, elsewhere $S_1$ gneissosity is crenulated. |
| | | Poor gneissosity. |
| 90 | | Notable lack of muscovite. |
| | | Locally feldspathic, elsewhere abundant muscovite and crenulations. |
| 100 | | Poor gneissosity. |



Nº 66

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| |  | |

Poor gneissosity.

Abundant muscovite.

Strongly folded and crenulated.
Abundant retrogressive muscovite.

110

Variable composition and texture from crenulated biotite schist, biotite gneiss to biotitic hornfels in the central portion. Most probably a retrograded diorite.

120

Biotitic, very little muscovite. Bands 1-10cm thick.

Folded and fractured. Fractures lined with f.gr. muscovite.

Poor banding.

130

With chlorite but no muscovite. Crenulated.

140

Crenulated. Minor f>m gneiss.

Crenulated.

150

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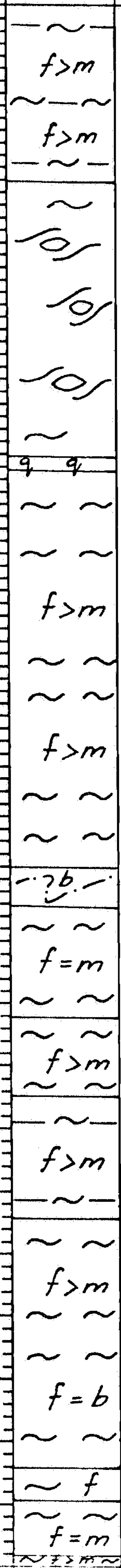
DEPARTMENT OF MINES AND ENERGY — SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|




Possibly kyanite between 151 & 152 m.

160

Small porphyroblastic feldspars to ½ cm.

170

Minor leucocratic pegmatite portions.

Strongly crenulated.

180

Straight gneissosity with superimposed, parallel, retrogressive, muscovite schistosity.
Minor biotite schist bands.

190

Increasing biotite % downwards.
Disseminated pyrite - chalcopyrite between 192·5 & 196·85 m.
Minor tourmaline and garnet at 196·65 m.

*A2015/79

Poor gneissosity.

Possible gneissosity.
Possible kyanite at 198·9 m. Abundant muscovite.

200

SHEET 4 OF 33

Nº 86

DEPARTMENT OF MINES AND ENERGY — SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH [illegible]
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
| --- | --- | --- |
| | f>m | |
| | f>m | |
| | b | crenulated |
| 210 | | Lineated, no banding. |
| | | Thin biotite schist band at the base. |
| | f=m | |
| 220 | | Variable in composition and in many places is close to a f>m gneiss. |
| | f=m | Some poorly-developed banding. |
| 230 | f=m | |
| | f | Varies slightly in composition from a granitic gneiss to a f>m gneiss. Latter type is crenulated. |
| 240 | | |
| | f>m | With garnetiferous layers. Garnets to 1cm. |
| | f=m | Abundant muscovite. |
| 250 | f>m | * RS 7033-159 A2016/79. Spotted staurolite between 248 & 249 m. |



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DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH [illegible]
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | ~ ~ f>m ~ ~ | Variable composition from feldspathic gneiss to f=m gneiss Pyrite on joint at 251m. |
| | ~b~ | |
| | ~ ~ f=m ~ ~ | crenulated, abundant retrogressive muscovite. |
| | # # | |
| 260 | ~ ~ f=m ~ ~ | strongly folded, abundant muscovite. |
| | # # | Large pink k-feld. |
| | ~ ~ f=m ~ ~ | |
| 270 | f>m ~ ~ | composition varies gradationally between lithologies indicated. |
| | f=m | Zone of strong folding. |
| | ~ ~ f>m | |
| 280 | ~ ~ f=m ~ ~ | |
| | f>m ~ ~ | |
| 290 | ~~+ | |
| | ~ ~ f>m ~ ~ | |
| | ~ ~ f>m ~ ~ | strong muscovite retrogression. Intense folding with new muscovite schistosity from 294.5 - 300 m. |
| 300 | | |



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DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | ~ ~ f>m ~ ~ ~ ~ | |
| 310 | f>m ~ ~ ~ ~ f>m ~ ~ | Strong retrogression and with a superimposed muscovite schistosity. |
| 320 | ~ ~ | |
| | ~f>m | Poorly developed gneissosity. |
| | ~ ~ f>m | Good gneissosity. Strong folding at 331·6 m with a biotite and muscovite axial plane schistosity. |
| 330 | ~ ~ ~ ~ | |
| | ~m~ | Biotitic; with a few thin quartz-feldspar bands. |
| | ~ ~ f>m ~ ~ | Some small massive portions. Possibly partly retrograded kyanite porphyroblast at 336·2 m. |
| | # # | |
| 340 | R.S.Z. | * RS.7033 -160 A2017/79 Strong muscovite schistosity development, abundant subhedral staurolite and tourmaline. Bands of relict augen gneiss. |
| | ~ ~ f=m ~ ~ | Superimposed schistosity parallel to gneissosity. Scattered staurolite and tourmaline down to 341·7 m with tourmaline. |
| | ~ b ~ | |
| | ~ ~ f=m | Abundant retrogressive muscovite in a strongly developed superimposed schistosity. |
| 350 | ~ b ~ | |



Mr 66

DEPARTMENT OF MINES AND ENERGY — SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618.8 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | ~ f=m | Scattered staurolite between 350.3 m & 350.7 m. |
| | NO CORE | |
| 360 | | |
| | NO CORE | |
| 370 | | |
| | NO CORE | |
| 380 | ~ ~ f=m ~ ~ | Biotitic; good gneissosity. |
| | ~ ~ f>m ~ ~ | Strongly retrogressed, abundant muscovite. |
| 390 | # # | |
| | ~ ~ f>m ~ ~ | Strongly retrogressed, abundant muscovite. |
| | v v | Retrograded (biotitic) diorite. |
| | ~ f>m | |
| | ~ f=m | Heavily retrogressed, abundant muscovite. |
| | ~ f>m | |
| 400 | | |



MF 86

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | ~f>m~ | |
| | ~f=m | |
| | ~f>m~ | Scattered tourmaline between 402·4 & 403·3 m. Retrogression dominant feature between 404·4 & 405·5 m; elsewhere muscovite abundant. |
| | ~f=m~ | |
| 410 | | |
| | ~f>m~ | |
| | ~f=m~ | |
| | v ~ | Partly retrogressed (biotite). |
| | ~ ~ f>m ~ ~ | Poor gneissosity, in places extensively retrogressed. |
| 420 | | |
| | ~ ~ f>m ~ ~ | Oxidised, friable core. |
| | ~ ~ f=m ~ ~ | Strong gneissosity, strong retrogression. |
| 430 | v v v v | Biotitic near lower boundary. |
| | ~m~ | Biotite-rich. |
| | ~f~ | Very poor gneissosity; verging on aplite. |
| | ~ ~ | Variable composition from biotitic to quartzo-feldspathic. |
| | v ~ v | Heavily retrogressed, biotitic. |
| | # # | |
| 440 | v v | |
| | ~ v | * R.S. 7033-161 ← A2018/79. |
| | v v | 10 cm. thick pegmatite at 442·6 m. |
| | ~ v | |
| | v v | |
| 450 | | |

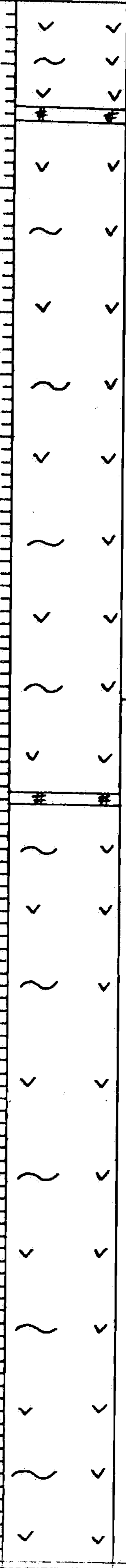


MF 86

# CORE DESCRIPTION

DEPTH 1616·9 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| 460 | | Weakly gneissic amphibolite. In places contains leucocratic veining with hornblende / actinolite - some as tension gash infilling with spiral growth across the vein. Minor pyrite - chalcopyrite in leucocratic veins. |
| 470 | | *R.S. 7033 -162 A 2019/79. unit more leucocratic towards the present base. |
| 480 | | |
| 490 | | |
| 500 | | |





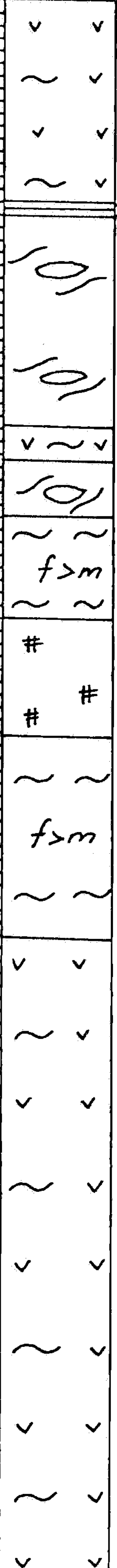
MF 66

...ARTMENT OF MINES AND ENERGY — SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618.9 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | | *more leucocratic towards the base.* |
| | | *Augen gneiss with K-feld.* |
| | | *Gneissic amphibolite.* |
| 510 | | *C.gr. augen gneiss. Abundant pink K-feld porphyroblasts.* |
| | | *Strong biotitic schistosity.* |
| | | *Poor augen gneiss, more extensively retrogressed.* |
| | f>m | *Extensive retrogression.* |
| 520 | | *Fractured and in places brecciated. Invaded by chlorite/biotite with minor pyrite and chalcopyrite. Probably related to amphibolite (of above).* |
| | f>m | *Poor gneissosity. Retrogressive schistosity dominant feature. Relict gneissosity folded.* *8cm of amphibolite at 529.4 m.* |
| 530 | | *Poorly gneissic amphibolite. Leucocratic segregation with quartz at 230.8m.* |
| | | *Feldspathic segregations at:* 541.2 m – 15cm thick. 542.7 " – 15 " " 543.3 " – 25 " " |
| 540 | | |
| 550 | | |





Nº 66

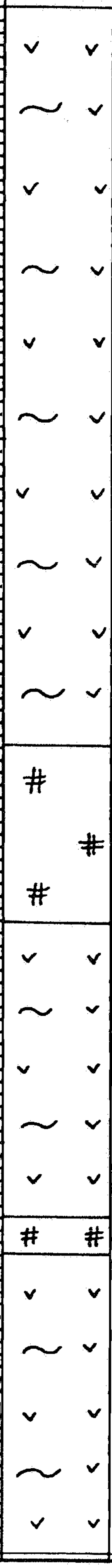
DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | | Poorly gneissic amphibolite. |
| 560 | | Feldspathic segregation at 559·1m (15cm thick). |
| | | Typical composition approx. 60% hornblende.<br>35% plagioclase. |
| 570 | | |
| | | Contains 5-10% biotite, may be related to the above amphibolite. |
| 580 | | |
| | | Biotitic and schistose near lower contact. |
| 590 | A2020/79 | Minor pyrite and chalcopyrite. |
| | | Disseminated f.gr. pyrite. |
| 600 | | |



SHEET 12 OF 33

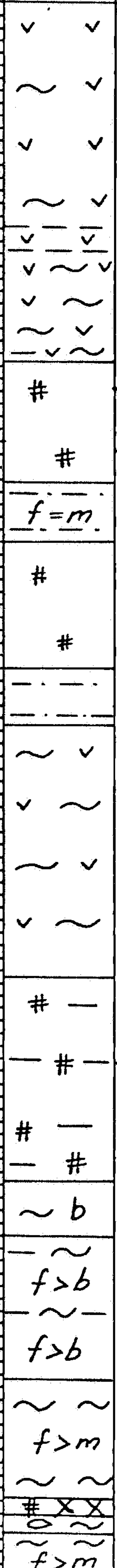
MF 86

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|




slight variations in composition.

Leucocratic amphibolite (~ 75% plagioclase)
c.gr. feldspars, some of which are distinctly lath-shaped.
Increasing lath % down-the-hole; composition ~ 50%
plag., 50% hornblende.

610

Pronounced gneissic banding at the base.

*A2021/79 Banded aplite, with thin biotitic bands and
disseminated f.gr. pyrite. Granoblastic texture
*A2022/79 predominant. Most probably related to the amphibolite.

strong, pronounced $S_1$ schistosity.

Leucocratic segregations containing some c.g. Biotite.

620

@ 627·8m (10cm. thick)
628·5m (15cm ")
628·8m (20cm ") } Gneissic texture.

630

Banded aplite. M.gr. with micaceous layers.
*A2023/79 Disseminated pyrite. (< 1%)
20cm thick plag. laths+biotite band (altered
amphibolite) at 635·7m.

crenulated.

640

Thin biotite-rich bands.
Folded, fractured and locally brecciated.

Strong muscovite retrogression with superimposed muscovite
schistosity parallel to gneissity. Open folds in gneissosity.

Fractured pegmatite, K-feld dominant.
Poorly developed augen gneiss.
Granoblastic texture pronounced, micas define a
gneissosity.

650

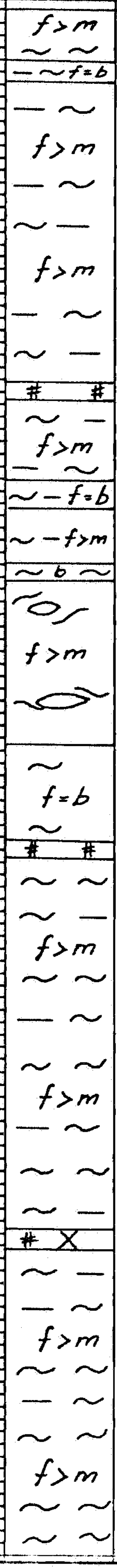


Nº E6

# CORE DESCRIPTION

LOGGED BY D. FLINT
DATE August 1979
LOCATION Mt. TOOROO MINES
BORE SERIAL No.

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|




Granoblastic texture pronounced, micas define a gneissosity. Contains superimposed musc. Schistosity in places. Tightly folded, approaching isoclinal folds.

Poorly banded, K-feld abundant with some very poorly developed augens. Open folds with some sections retrogressed.

10cm. chlorite vein at 661·45m.

660

Pegmatite quartz, feldspar & biotite. Pyrite in biotitic portions.

Poorly banded, granofelsic texture dominant in qtz. & feldspars.

Granofelsic; pyrite & pyrrhotite streaked out in biotite gneissosity.

Granofelsic, poor banding, minor retrogression.

670

augen gneiss. Folded biotite gneiss band between 670·0 & 670·25m.

Brood compositional banding. When biotitic, gneiss is crenulated. Pyrrhotite aggregates to 2cm across and cubes to 3mm at approx. 679·9m.
K-feld rich.

680

strong musc. retrogression and superimposed musc. schistosity.
Some thin (several cm) K-feld rich pegmatite veins.
Poor banding.
Radiating zeolites on fracture at 688·0m.

690

Fractured K-feld rich pegmatite.

Broad, poor compositional banding.
Muscovite retrogression pervasive, new muscovite schistosity developed.

700



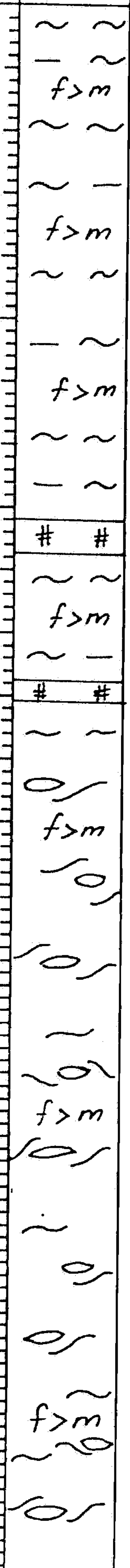
M.F. 86

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618.8 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

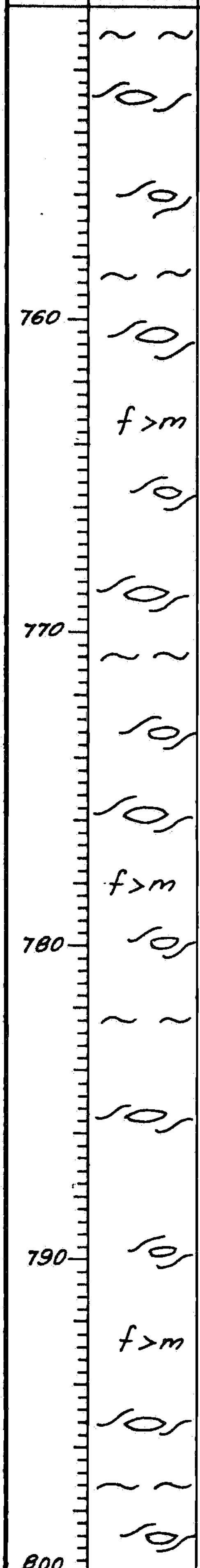
| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| |  | |
| | | *Broad, poor compositional banding.* |
| | | *Muscovite retrogression pervasive, new muscovite schistosity developed.* |
| | | *Quartz & feldspars define a granofelsic texture.* |
| | | *Pink-red K-feld pegmatite at 701.3 m (20cm thick).* |
| 710 | | |
| 720 | | *As above.* |
| 730 | | |
| | | *Flattened augen gneiss.* |
| | | *No compositional banding.* |
| | | *Between 738 & 743m, high % of feldspars leads to mutual impingement & lack of augens.* |
| 740 | | |
| 750 | | |

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|




*Flattened augen gneiss.*
*No compositional banding.*

*Quartz veins:*
*15cm thick at 751·90m.*
*15 " " " 753·0m.*

*Pegmatite (K-feld rich):*
*25cm at 753·95m.*

*some minor (<10 cm) biotite schist bands;*
*one 15cm thick at 791·0m.*



MF 86

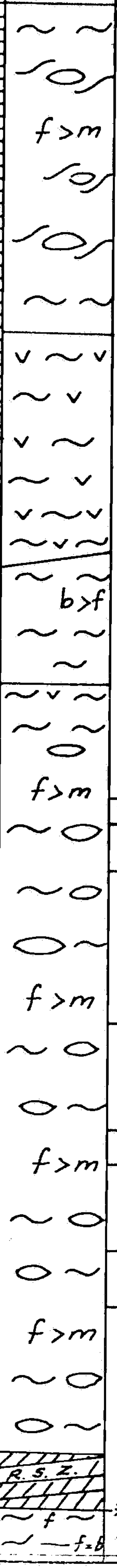
DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|




Flattened augen gneiss.
Minor biotite schist bands.
Zeolite (radiating aggregates) in vein and on joint surface at 806·95 m.

810

Scattered plag. phenocrysts in top 1m.

Contains c.gr. feldspar & biotite in segregations with feldspars up to 2cm across. Biotite-rich segregations contain a gneissic fabric and disseminated f.gr. pyrite.

Lineated and chloritic, minor anastomosing quartz veins.

Biotite-rich; with anastomosing quartz-feldspar bands parallel to the gneissosity. Bands are like pegmatitic segregations and contain pyrite with minor chalcopyrite.

820

Strong gneissosity and lineation; hornblende-rich.

*R.S. 89
*R.S. 88
*R.S. 90

Augen gneiss. Quartz-feldspar augens up to 8cm long and 3cm high. Minor scattered pyrite. Augens often highly flattened in the gneissosity.

830

*R.S. 91 & 92

*R.S. 93
*R.S. 94

840

*R.S. 95
*R.S. 96

Augens disappear towards the Retrograde Shear Zone.

Strong superimposed muscovite-sericite schisosity.

*P920/78 Poor gneissosity in leucocratic gneiss.
A2024/79 Superimposed schistosity present.

850

MF 66

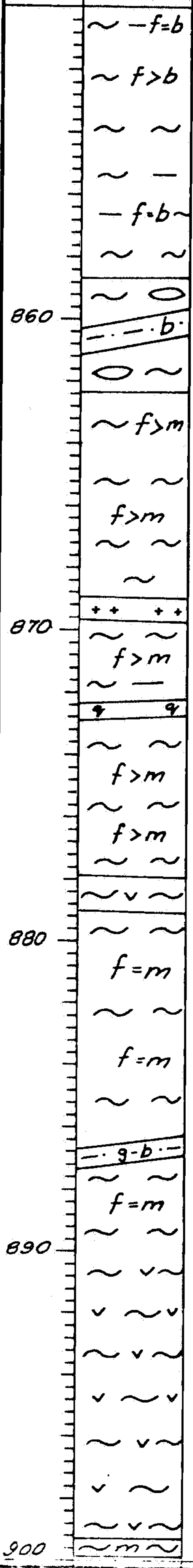
DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE MM 14
LOCATION MUTOOROO MINES
BORE SERIAL N°

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
| --- | --- | --- |




Broad compositional banding with a superimposed cross-cutting schistosity.

Deformed (flattened) augen gneiss with a cross-cutting biotite schist band (probably retrograded diorite.)

Only difference to above augen gneiss is texture — i.e., lack of augen/feldspar blastesis.

Occasional large quartz-feldspar aggregates with brown turbid alkali feldspars.

Lineated gneissic amphibolite; no layering.

Contains retrograde muscovite.

Small garnets in gneiss up to 1cm away from the schist-gneiss contact.
Muscovite fairly abundant.

Lineated with aligned hornblende.
Hornblende ~ 65%, plagioclase < 35%.

Gneissic amphibolite is micaceous near lower contact.

Abundant muscovite with a superimposed muscovite schistosity; heavily retrogressed.



MF 56

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·8 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | | DESCRIPTION |
|---|---|---|---|
| | m | | Abundant muscovite with a superimposed muscovite schistosity; heavily retrogressed. |
| | m | | |
| | m | | |
| | b | | Bronze coloured biotite, both aligned in schistosity and randomly oriented. |
| 910 | | | |
| | m | *P921/78 A2025/79 | Scattered but abundant pyrite-pyrrhotite, with one 5cm thick biotite-pyrite-pyrrhotite band at 914·6 m. |
| | f=m | | |
| | f=m | | |
| | f>m | | |
| | b | | Crenulations. |
| 920 | f=m | | |
| | | | Variable composition with some biotite schist bands to 15cm thick. |
| | f=m | | |
| | f=m | | |
| | g | | |
| | b | | Abundant porphyroblastic biotite in the schist and garnets within the gneisses upto 2cm. from the contact. |
| | f=m b | | Interlayered schists and gneisses. |
| | | *A2026/79? | |
| 930 | f>m | | |
| | f>m | | |
| | | | Occasional pink K-feldspar blastesis. Minor leucocratic segregations. Retrogression evident with muscovite abundant. |
| | f>m | | |
| 940 | f>m | | |
| | f>m | | |
| | f>m | *P923/78 A2027/79 | |
| 950 | | | |

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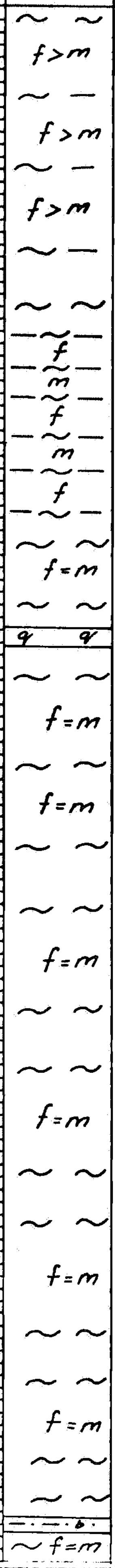
MF 86

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH [illegible] m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| |  | Occasional pink K-feldspar blastesis. Minor leucocratic segregations. Retrogression evident with muscovite abundant. Vein fracturing at 958·4 m. |
| 960 | | Well-layered gneisses consisting of bands often only 1 cm thick which range in composition from quartzo-feldspathic to biotitic. Abundant K-feldspar blastesis. |
| | | Retrogressive muscovite. 20 cm thick biotite schist band at 966·9 m with pyrite and chalcopyrite. |
| 970 | | Contains weathered pyrite. |
| 980 | | Rare pink K-feldspar blastesis. Abundant retrogressive muscovite aligned in superimposed cross-cutting schistosity; some zones extensively retrogressed. |
| 990 | | |
| | | 50 cm thick biotite schist band at 998·5 m. |
| 1000 | | |

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·6 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | f=m | Biotite schist band (20cm) at 1002·3m |
| | f=m | |
| | f>m | |
| | | Lower margin of pegmatite is biotitic and contains minor pyrite. |
| | f>b | |
| 1010 | | Development of augens increases down the hole. |
| | f>b | |
| 1020 | f>b | |
| | | * R.S.98 |
| | f>b | |
| | | * R.S.97 |
| 1030 | f>b | Quartz veins: 15cm thick at 1031·1m.<br>6 " " " 1037·1m.<br>20 " " " 1038·1m. |
| | f>b | |
| | | Numerous lithologies within one metre at the contact. |
| 1040 | | |
| | | Lineated but no banding. Feldspathic segregations at 1043·6 and 1045·5m.<br>Locally abundant feldspar phenocrysts. |
| | | * P924/78<br>A2028/79 |
| | | * P925/78<br>A2029/79 |
| 1050 | | |

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618.9 m
LOGGED BY D FLINT
DATE August 1979

DRILL HOLE DDH MM14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

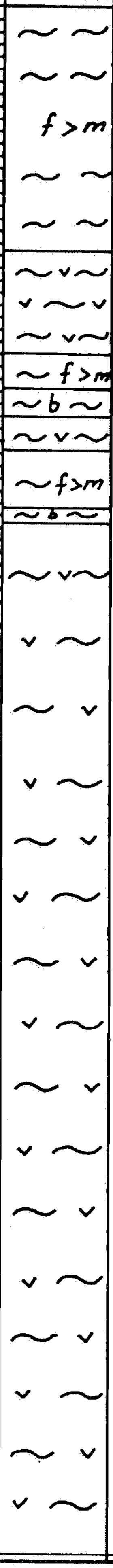
| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | | Leucocratic segregation 10cm thick at 1050·6m. |
| | | Lineated (aligned hornblende) |
| 1060 | f>b | |
| | | In places, contains poorly-developed augens. Best augen development between 1054·6 – 1055·4m. |
| | f>b | Biotite schist bands: 18cm thick at 1052·9 m; 9 " " " 1053·3 m; 10 " " " 1053·6 m |
| 1070 | f>b | |
| | f>b | |
| 1080 | | |
| | f>b | Between 1080 – 1093m. flattened augens, K-feld abundant, micas noticeably straight. |
| | | Biotite + muscovite + magnetite (4%) band 15cm thick at 1086·95m. |
| | f>m | |
| 1090 | | |
| | b | Fine grained with < 1% pegmatite. |
| | f>m | As above with poorly-developed augens. Several thin 10cm quartz+pyrite veins. |
| 1100 | | |

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·8 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

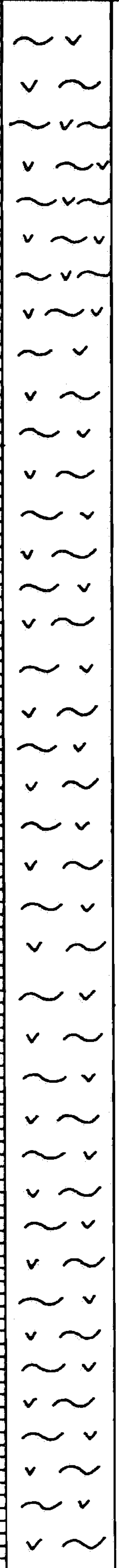
| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| 1100 |  | |
| | | *With some poorly-developed augens.* |
| | | *Heavily retrogressed and almost classifiable as a biotite schist. Chlorite trains common. Gradational upper and lower boundaries.* |
| 1110 | | |
| | | *Biotitic (low muscovite), poor gneissosity.* |
| | | *Flattened gneiss without augens.* |
| 1120 | | |
| | | *In places biotitic. Some leucocratic and stockwork veining. Very minor pyrite and pyrrhotite in gneissic amphibolite, more common within leucocratic veins. Carbonate in some leucocratic veins.* |
| 1130 | | |
| | | *10 cm. quortz-augen gneiss at 1148·3 m.* |
| 1140 | | |
| 1150 | | |

MF 86

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH [illegible] DRILL HOLE DDH MM14
LOGGED BY D. FLINT LOCATION MUTOOROO MINES
DATE August 1979 BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| 1160 |  | *In places biotitic, some c.gr. potash? feldspars to several cm across in the gneissic amphibolite (1166·88m).* |
| | | *Leucocratic veining and stockworks containing pyrite, pyrrhotite and carbonate.* |
| 1170 | | *Leucocratic veins:* <br> *30 cm at 1152·75m.* <br> *8 cm at 1190·74m. (with carbonate)* <br> *10 cm at 1195·7m.* |
| 1180 | | |
| 1190 | | |
| 1200 | | |



MF 86

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·8 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | | Vein assemblages appear to be:<br>potash feld. + carbonate + quartz.<br>potash feld. + epidote + magnetite + pyrite.<br>quartz + tremolite + pyrite + pyrrhotite. |
| 1210 | | |
| | | Further carbonate-bearing veins between 1207 & 1210·5m. |
| 1220 | | |
| 1230 | | |
| | | Elongate minerals are randomly orientated within the gneissosity and banding. Individual bands down to 1mm thick. 12 cm of banded augen gneiss at 1230·6mm. |
| 1240 | | |
| 1250 | | |



MF 86

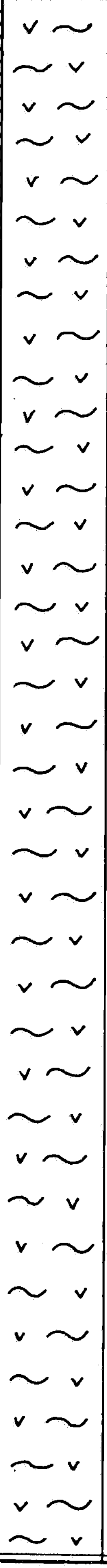
EPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH [illegible]
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| EPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| 260 | | |
| 270 | | |
| 280 | | |
| 290 | | *Relict phenocrystic feldspars between 1295 & 1300 m.* |
| 300 | | |



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MF 86

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | | Quartz + feldspar + biot. gneissic bands:<br>1·2 m at 1308·7 m.<br>20 cm " 1313·5 m.<br>35 cm " 1316·3 m. |
| 1310 | | |
| | | 12cm thick pegmatitic and leucocratic segregation at 1323·9 m. |
| 1320 | | |
| 1330 | | |
| | | Mica trains (muscovite and biotite) abundant between 1336 & 1341 m; retrogression origin. |
| 1340 | | |
| 1350 | | |

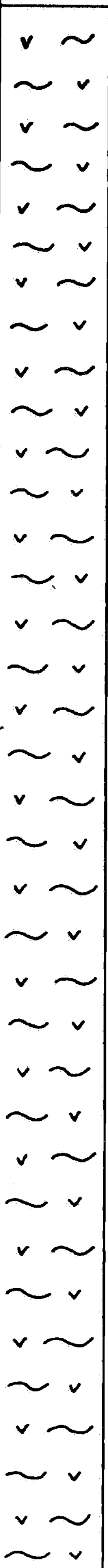
DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| 1360 | | |
| | | In places gneissic texture is subordinate and lithology looks more doleritic. |
| | | Leucocratic segregations:<br>30 cm at 1369·1 m.<br>2·6 m at 1372·5 m.<br>12 cm at 1393·6 m. |
| 1370 | | |
| | | In places retrograded with distinct biotite trains. |
| 1380 | | |
| 1390 | | |
| 1400 | | |





MF 86

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·8 m
LOGGED BY D. FLINT
DATE August 1979
DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | | *R.S.7033 A2030/79 -163 |
| 1410 | | In places gneissic texture is subordinate and lithology looks more doleritic. |
| | | Leucocratic segregations: 10 cm at 1418·70 m. 20 cm " 1429·55 m. |
| 1420 | | |
| 1430 | | |
| | | Gneissic amphibolite which is noticably more feldspathic. |
| 1440 | | Feldspars are c. grained and elongated in the gneissosity and weakly-developed banding is present. |
| | | Pyrite & magnetite vein at 1438·90 m. |
| | | Typical gneissic amphibolite. Probable relict plag. laths to 5mm long at 1448·5 m. |
| 1450 | | |



MF 86

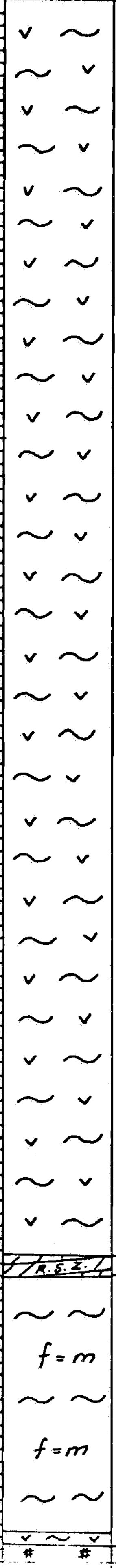
EPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| EPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|




460

Leucocratic segregations:
30 cm at 1463·0 m
15 " " 1465·22m
60 " " 1484·25m (includes 10cm of tightly-folded quartzo-feldspathic gneiss.

470

480

A 2031/79 → A 2034/79.

490

*R.S. 7033
*-164, 165, 166, 167.

Chloritic mylonite with pyrite & graphite.

Extensively retrogressed with musc./sericite schistosity present.
Retrogressive schistosity poorly-developed and lithology more feldspathic towards the base.

Weakly gneissic.

*A 2035/79 Sheared & retrogressed pegmatite. Some relict c.gr. portions containing pyrite and martite.

500

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | ~ ~ f=m ~ ~ | *Retrogressed, abundant muscovite. Some poor banding and thin pegmatite veins.* |
| | f=m ~ ~ | *Gradational boundary into amphibolite.* |
| 510 | ~ v v ~ ~ v v ~ | *Variable texture from massive dolerite through to chlorite schist. Some thin relict quartzo-feldspathic gneiss bands. 2 cm thick carbonate vein at 1507·8 m.* |
| 520 | ~ ~ ~ ~ f=m ~ ~ ~ ~ f=m | *Heavily retrogressed, muscovite generally abundant in a strong superimposed schistosity. Locally biotitic and with minor pyrite.* |
| 530 | ~ ~ ~ ~ f=m ~ ~ ~ ~ | *In places gneissosity is folded so that the retrogressive schistosity is across the gneissosity. The angle between the gneissosity and schistosity controls the texture and mineralogy. When the angle is large, texture is massive and lithology feldspathic. With a small angle, texture is distinctly more schistose and a retrogressive schistosity with abundant mica is strongly developed.* |
| 540 | f=m ~ ~ ~ ~ ~ ~ f=m | *Minor c.gr. pegmatite containing calcite.* |
| 550 | f=m ~ ~ ~ ~ f=m ~ ~ | *1cm. thick carbonate vein at 1545·4m.* |

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·8 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM 14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| | —·b —·b | biotitic schist on upper contact. |
| | v ~ | Weakly gneissic with feld and calcite veining. |
| | ~ v | *R.S.168 A2036/79 |
| | ~ ~ f=m | As before, with the angular relationship between gneissosity and retrogressive schistosity plane having a strong control on the texture and mineralogy. |
| 1560 | f=m ~ ~ | probable relict sillimanite at 1556·2 m. |
| | v ~ | |
| | ~ ~ f=m | *A 2037/79 |
| 1570 | ~ ~ f=m | Abundant retrogressive muscovite and a superimposed schistosity. |
| | f=m | In places poorly banded. Minor f>m gneiss. |
| 1580 | ~ ~ f=m | Pegmatite veins with pink K-feld. 20 cm at 1567·3 m. 10 " " 1578·0 m. (with calcite). |
| | ~ ~ f=m | |
| 1590 | ~ ~ f=m | |
| 1600 | ~ ~ f=m | |

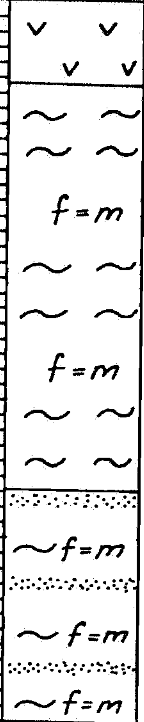
MF 86

DEPARTMENT OF MINES AND ENERGY—SOUTH AUSTRALIA

# CORE DESCRIPTION

DEPTH 1618·9 m
LOGGED BY D. FLINT
DATE August 1979

DRILL HOLE DDH MM14
LOCATION MUTOOROO MINES
BORE SERIAL Nº

| DEPTH (m) | GRAPHIC LOG | DESCRIPTION |
|---|---|---|
| |  | C.gr. and feldspathic at the top. |
| | | *R.S. 7033-169 A2038/79 Massive, some relict feldspar laths in a f.gr. hornblende-rich matrix which contains lineated hornblende. |
| | | As above, with the texture and mineralogy controlled by the angle between gneissosity and retrogressive schistosity. |
| 1610 | | |
| | | Quartzitic and arkosic metasandstone bands within an otherwise poorly banded gneiss. Most of the metasandstone bands are between 1612·81 & 1616·0 m. |
| 1620 | | END OF HOLE 1618·9 m. |

SHEET 33 OF 33

M.E. 66

# APPENDIX B

## PETROGRAPHIC REPORTS -
## DIAMOND DRILL HOLE MM14

Report GS 4087/78 by Sylvia Whitehead (Amdel)

Report GS 3879/79 by Sylvia Whitehead (Amdel)

GS 1/1/140 Progress Report No. 18 by Frank Radke (Amdel)

| DEPTH (metres) | PET. NO. | R.S. NO. 7033 RS... | ANAL. NO. | COMMENTS |
|---|---|---|---|---|
| 77.0 | | 170 | A2014/79 | Pegmatitic segregation. |
| 195.95 | | 171 | ....5... | Biotitic gneiss. |
| 248.2 | | 159 | ....6... | Retrograded staurolite gneiss. |
| 338.85 | | 160 | ....7... | " " |
| 441.4 | | 161 | ....8... | Meta-dolerite. |
| 472.4 | | 162 | ....9... | " |
| 589.8 | | 172 | A2020/79 | f>m gneiss. |
| 612.35 | | 173 | ....1... | Aplite. |
| 614.3 | | 174 | ....2... | Pyritic albitite ? |
| 633.8 | | 175 | ....3... | Pegmatite. |
| 825.9 | P755/78 | 89 | | Augen Gneiss. |
| 826.4 | ...4... | 88 | | " " |
| 827.9 | ...6... | 90 | | " " |
| 832.9 | ...7... | 91 | | " " |
| 832.9 | P758/78 | 92 | | Leucocratic gneiss. |
| 836.3 | ...9... | 93 | | Augen Gneiss. |
| 837.4 | P760/78 | 94 | | " " |
| 840.2 | ...1... | 95 | | " " |
| 842.0 | ...2... | 96 | | " " |
| 848.35 | P920/78 | 176 | A2024/79 | Retrograded gneiss. |
| 913.45 | ...1... | 177 | ....5... | Quartz-epidote metasomatite. |
| 929.2 | ...2... | 178 | ....6... | Retrograded gneiss. |
| 947.4 | ...3... | 179 | ....7... | Banded gneiss. |
| 1024.0 | P764/78 | ~~78~~ 98 | | f>m gneiss. |
| 1028.9 | ...3... | 97 | | f>m gneiss. |
| 1045.5 | P924/78 | 180 | A2028/79 | Amphibolite. |
| 1047.9 | ...5... | 181 | ....9... | " |
| 1408.99 | | 163 | A2030/79 | Meta-dolerite. |
| 1490.20 | | 164 | ....1... | Chloritic mylonite. |
| 1490.30 | | 165 | ....2... | " " |
| 1490.40 | | 166 | ....3... | " " |
| 1490.85 | | 167 | A2034/79 | Chloritic mylonite. |
| 1499.50 | | 182 | ....5... | Pegmatite. |
| 1553.60 | | 168 | ....6... | Schistose amphibolite. |
| 1567.70 | | 183 | ....7... | Pegmatite. |
| 1601.55 | | 169 | ....8... | Schistose amphibolite. |

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Phone Adelaide 43 8053
Branch Offices: Perth and Sydney
Associated with: Professional Consultants Australia Pty. Ltd.

Please address all correspondence to Frewville.
In reply quote: GS 1/15/11/0

4 July 1978

Director-General,
Department of Mines & Energy,
PO Box 151,
EASTWOOD, SA 5063.

Attention: Don Flint

A37/78.

REPORT GS 4087/78

| | |
|---|---|
| YOUR REFERENCE: | Application dated 18 May 1978 |
| MATERIAL: | 6 drill core specimens |
| LOCALITY: | Mutooroo diamond drill core (Mines Exploration) DDH MM14B. Env. 2080 Vol XXVI E.L. 73<br>Lat: 32° 15'00"S<br>Long: 140° 50'30"E |
| IDENTIFICATION: | Samples P920/78 – P925/78 |
| DATE RECEIVED: | 19 May 1978 |
| WORK REQUIRED: | Petrographic (MA1.3) and mineragraphic (MA2.2) descriptions |

Investigation and Report by: Sylvia Whitehead

Manager, Geological Services Division: Dr Keith J. Henley

Keith Henley

for Norton Jackson
Managing Director

jd/9

SUMMARY OF SPECIMENS

| Sample and TS No. | |
|---|---|
| P920/78<br>TS40280<br>PS26708 | Quartz-mica schist containing minor pyrite and a minute trace of chalcopyrite. |
| P921/78<br>TS40281<br>PS26709 | Metasomatically altered rock extensively replaced by epidote, soda-amphibole, pyrite, magnetite and calcite. There is a trace of chalcopyrite.<br>A band containing quartz and plagioclase may be a remnant of unaltered or partly altered metamorphic rock. |
| P922/78<br>TS40282<br>PS26710 | Quartz-mica schist containing minor pyrite and a trace of chalcopyrite. Some biotite has been replaced by chlorite and K-feldspar and there is a vein of K-feldspar. |
| P923/78<br>TS40283<br>PS26711 | Quartz-feldspar (plagioclase)-mica schist derived from a layered sediment. The presence of ilmenite, apparently of metamorphic origin suggests that there could have been an earlier episode of higher grade metamorphism but this should be treated with caution. |
| P924/78<br>TS40284<br>PS26712 | Amphibolite. There is no conclusive evidence of origin but a basic igneous rock is most likely. It is cut by a carbonate vein containing traces of chalcopyrite and secondary hematite. |
| P925/78<br>TS40285<br>PS26713 | Foliated amphibolite or hornblende schist containing traces of chalcopyrite and pyrite. |

DESCRIPTION OF METAMORPHIC ROCKS AND SULPHIDES
FROM DDH MM14B MUTOOROO

Sample: P920/78; TS40280; PS26708

Hand Specimen:
A pale, slightly greenish grey, micaceous schist containing a few scattered grains of yellow sulphide.

Thin and Polished Section:
A visual estimate of the minerals is as follows:

| | % |
|---|---|
| Muscovite | 50-65 |
| Quartz | 30-35 |
| Biotite (partly chloritized) | 3- 5 |
| Potash feldspar | 2- 3 |
| Plagioclase | trace |
| Tourmaline | trace |
| Pyrite | trace-1 |
| Zircon | trace |
| Chalcopyrite | minute trace |

The schist is composed mainly of intergrown muscovite and quartz with a common grain size of about 0.5 to 1 mm and a large proportion of the muscovite is subparallel to the schistosity as noted in the hand specimen. Quartz and muscovite are not uniformly distributed and, when the thin section is examined under very low magnification thin layers and lenticles composed predominantly of quartz can be seen. These are generally less than 1 mm thick and, although not very well defined they appear to be subparallel and at a very low angle to the direction of schistosity. There is also a slight suggestion of small crenulations in the schistosity but this is very poorly developed. Some thin bands in the schist are composed largely of muscovite intergrown with minor biotite.

A few crystals of bluish-green tourmaline up to about 0.8 mm in size are scattered through the rock and some tourmaline which occurs in an interstice with an extension along the grain boundary shows patchy coloration. There are a few small (less than 0.1 mm) zircon grains which appear well rounded and there is one elongate mass of apatite.

In the sample submitted there is no recognizable evidence of retrograde metamorphism and no sericite which could have replaced earlier metamorphic minerals was found in the section. There is no evidence to suggest that the muscovite has replaced earlier minerals. The only unusual feature in this rock is that potash feldspar has replaced some chloritized biotite. The feldspar (identified by low refractive index and staining of the hand specimen) has penetrated and grown out from cleavage planes in the chloritized biotite and also in a few flakes of muscovite and where it has replaced biotite it contains thin wisps of extremely fine-grained titaniferous material derived from the biotite. This is not necessarily an indication of retrograde metamorphism but more likely is due to some hydrothermal or metasomatic alteration.

Pyrite occurs as anhedral to subhedral crystals 0.4 to 1 mm long scattered through parts of the rock and some of these are elongated in the direction of schistosity. The pyrite occurs mainly in interstices between quartz and mica flakes. Two of the pyrite crystals in the polished section contain a very minute inclusion of chalcopyrite and one smaller pyrite crystal contains a slightly larger chalcopyrite inclusion about 0.05 mm long. No other sulphide was found in the section.

Conclusion:

Quartz-mica schist containing minor pyrite and a minute trace of chalcopyrite.

Sample: P921/78; TS40281; PS26709

Hand Specimen:

A grey and dull green rock with irregularly-shaped and vein-like patches of sulphide. This is described in the application form as 'mineralized zone'.

Thin and Polished Section:

A visual estimate of the constituents is as follows:

| | % |
|---|---|
| Epidote | 30-40 |
| Quartz | 30-40 |
| Sodium-bearing amphibole | 5-10 |
| Pyrite | 5-10 |
| Magnetite | 3- 5 |
| Calcite | 2- 3 |
| Plagioclase | 2- 3 (local) |
| Sphene | trace |
| Goethite | trace |
| Chalcopyrite | very minute trace |

This is a metasomatically altered rock much of which is now composed of medium-grained epidote intergrown with quartz and there are aggregates of a prismatic amphibole with pleochroism varying from straw yellow to green and lavender blue. Separate portions of this amphibole temporarily mounted in oils were found to have a refractive index of about 1.7 which suggests that it may be arfvedsonite. In one area concentrations of the amphibole along subparallel bands suggests the possibility of relict banding or layering but elsewhere it occurs in veins. One band in the rock about 6 mm thick contains a higher proportion of quartz intergrown with very turbid and partly altered plagioclase and less epidote than in other zones in the rock.

There is one very irregular vein containing calcite, magnetite and pyrite with some aggregates of amphibole and this is bordered by epidote. In other zones of the rock there are also vein-like aggregates of magnetite and pyrite. In general the magnetite and pyrite are closely intergrown and generally have a common grain size of about 0.5 to 2 mm but there are a few smaller crystals of pyrite. Some of the larger pyrite crystals enclose non-opaque mineral grains and some of the pyrite occurs in interstices between magnetite crystals. Chalcopyrite occurs mainly as small grains about 0.1 mm in size intergrown with the magnetite and pyrite and some is completely surrounded by magnetite. One very small chalcopyrite grain was found intergrown with, or included in, a non-opaque mineral possibly calcite and one very small inclusion was found in pyrite.

Conclusion:

This is a metasomatically altered rock now extensively replaced by epidote but it is possible that the zone containing intergrown quartz and plagioclase represents an unaltered or only partly altered remnant of the former metamorphic rock. Pyrite, magnetite and a minor trace of chalcopyrite are associated with introduced or migratory calcite in the mineralized zone.

Sample: P922/78; TS40282; PS26710

Hand Specimen:
A grey, medium-grained, micaceous schist containing a trace of sulphide. Staining tests show very minor potash feldspar and plagioclase with some potash feldspar along a small vein.

Thin and Polished Sections:
A visual estimate of the constituents is as follows:

| | % |
|---|---|
| Quartz | 45-50 |
| Muscovite | 35-40 |
| Partly chloritized biotite | 5-10 |
| Plagioclase | 3- 5 |
| Potash feldspar | 2- 3 |
| Pyrite | trace-1 |
| Ilmenite | trace |
| Leucoxene | trace |
| Chalcopyrite | minute trace |
| Zircon | trace |

This schist is very similar to sample P920/78, in that it contains abundant muscovite and quartz with the schistosity defined by subparallel orientation of most of the muscovite. Biotite, intergrown with the muscovite, has been partly chloritized particularly along some zones. There is some poorly defined banding or layering in that some bands about 1 mm thick contain high concentrations of mica and these alternate with bands of similar thickness containing high concentrations of quartz intergrown with less mica and some plagioclase. There is also a broader band or zone at least 8 mm thick which contains over 60% of quartz intergrown with streaks and aggregates of muscovite and chloritized biotite. This sample is also similar to sample P920/78 in that potash feldspar has invaded and partly replaced some chloritized biotite spreading out from cleavage planes and this potash feldspar now contains wisps and streaks of leucoxene derived from the replaced biotite. There is a small, cross-cutting vein 0.5 to 1 mm thick composed mainly of potash feldspar crystals (confirmed by staining the hand specimen) and lined with small flakes and aggregates of chlorite. A few very small, rounded zircon grains are scattered sporadically throughout the rock.

No definite evidence of retrograde metamorphism could be found in the thin section but there are a few aggregates of muscovite which could have replaced earlier metamorphic minerals although if so, all remnants and relict textures of the earlier mineral have been completely obliterated. Chloritization of the biotite and crystallization of the potash feldspar appear to have been the result more of hydrothermal or metasomatic alteration than of retrograde metamorphism.

A few crystals and crystalline aggregates of pyrite generally less than 0.5 mm long are scattered through the rock occurring mainly in interstices and there are very few crystals of chalcopyrite less than 0.05 mm in size, some intergrown with pyrite. Ilmenite occurs mainly as separate, elongate crystals and aggregates which vary in size from less than 0.1 mm to about 0.5 mm long. The texture of this ilmenite strongly suggests that it is of metamorphic origin and its presence therefore suggests that, at one time this rock was subjected to a moderately high grade of metamorphism as ilmenite generally does not crystallize in low or even medium grade metamorphic rocks. Therefore this could be interpreted as suggesting an earlier high grade metamorphism was followed by a later episode of lower grade metamorphism but caution is needed.

Conclusion:

Quartz-mica schist containing minor pyrite and a trace of chalcopyrite. No definite textural evidence or remnant minerals were found to definitely indicate retrogressive metamorphism but the presence of ilmenite suggests the possibility of an earlier episode of higher grade metamorphism.

There has been some metasomatic or hydrothermal alteration resulting in replacement of biotite by chlorite and potash feldspar and also the formation of a vein of potash feldspar.

Sample: P923/78; TS40283; PS26711

Hand Specimen:

A medium-grained rock with predominantly straight and parallel banding on a scale of 1 to 5 mm defined by variations in colour mainly pale and darker grey and brown.

Thin and Polished Sections:

A visual estimate of the minerals is as follows:

| | % |
|---|---|
| Plagioclase | 40-45 |
| Muscovite | 30-35 |
| Quartz | 10-15 |
| Biotite | 5-10 |
| Ilmenite | trace-1 |
| Zircon | trace |
| Rutile | trace |
| Allanite? | minute trace |
| Pyrite | minute trace |
| Apatite | trace |

This consists mainly of intergrown plagioclase, quartz and muscovite and the quartz and plagioclase have a common grain size of 0.2 to 0.4 mm and mica flakes are about 0.3 to 1 mm long. There are however a few larger plagioclase crystals up to 1.5 mm long which show slight evidence of deformation. The layers noted in the hand specimen contain varying proportions of the constituent minerals and in general layers about 1 mm thick composed predominantly of mica alternate with thick layers composed mainly of plagioclase, minor quartz and minor muscovite. There is a definite schistosity defined by subparallel orientation of much of the muscovite and this is at a high angle to the direction of banding.

The most abundant accessory mineral is ilmenite which occurs as anhedral and elongate crystals 0.1 to about 0.4 mm long occurring mainly in interstices and this ilmenite does not show any evidence of alteration. There are a few very small, apparently rounded zircon grains and there are two crystals 0.1 to 0.2 mm in size of a brownish, pleochroic mineral which is probably allanite but positive identification would require more detailed investigation.

Conclusion:

Quartz-feldspar-mica schist derived from a layered, probably pelitic sediment. It has probably been subjected to more than one episode of metamorphism and, as in sample P922/78, the presence of ilmenite of apparently metamorpic origin is at least some suggestion that there could have been an earlier episode of high grade metamorphism, however, this interpretation should be treated with caution.

Sample: P924/78; TS40384; PS26712

Hand Specimen:
A medium-grained, green rock composed of intergrown light-and dark-coloured minerals. It is cut by a vein about 3 mm thick which is predominantly almost white carbonate but locally there is an inner zone of brownish carbonate. This vein contains some very small, almost spherical dark coloured grains.

Thin and Polished Sections:
A visual estimate of the minerals is as follows:

| | % |
|---|---|
| Hornblende | 60-70 |
| Extensively altered plagioclase | 30-35 |
| Quartz | 2- 3 |
| Epidote | 1- 2 |
| Potash feldspar | trace |
| Chlorite | trace |
| Calcite vein | trace |
| Chalcopyrite (in vein) | trace |
| Pyrite | trace |
| Hematite | trace |

The rock contains a large proportion of hornblende crystals about 0.5 to 2 mm in size which are intergrown with apparently random orientation and many aggregates of hornblende crystals contain small grains of quartz 0.05 to 0.4 mm in size, some of which are included within hornblende crystals. The hornblende is intergrown with crystals of altered and sericitized plagioclase, many of which are between 0.5 and 1 mm in size and most of these are approximately equidimensional or only slightly elongate. They do not generally resemble the elongate or tabular plagioclase crystals commonly found in basic igneous rocks but the texture could well have been modified by metamorphism. These have been replaced commonly by sericite and secondary feldspar with traces of chlorite and epidote with more abundant epidote in some zones.

Only portion of a small vein is included in the thin section and this is all of calcite.

The polished section includes the larger carbonate vein and this has a trace of chalcopyrite as small crystals and aggregates in interstices between some carbonate crystals. The vein also contains some spherulitic aggregates or rosettes of hematite about 0.1 to 0.2 mm in diameter but there is no definite evidence to suggest the identity of the mineral which could have been replaced by this hematite. One grain of pyrite was found in the body of the rock and there is some very fine-grained, titaniferous material in some of the amphibole.

Conclusion:
This is an amphibolite in which there is no conclusive evidence of origin but a basic igneous rock is more likely than a calcareous sediment. It is cut by a carbonate vein containing a trace of chalcopyrite and a trace of secondary hematite.

Sample: P925/78; TS40285; PS26713

Hand Specimen:

A medium-grained rock composed of intergrown dark green and white minerals with a weak schistosity or foliation.

Thin and Polished Sections:

A visual estimate of the minerals is as follows:

| | % |
|---|---|
| Hornblende | 60-70 |
| Partly altered plagioclase | 25-30 |
| Quartz | 3- 5 |
| Ilmenite and sphene | 1- 2 |
| Epidote | trace |
| Chalcopyrite | trace-1 |
| Pyrite | trace |
| Calcite | trace |

This is similar to sample P924/78 in that it is composed largely of intergrown hornblende crystals 0.5 to 1.5 mm long but it differs from P924/78 in that many of these hornblende crystals are subparallel imparting a definite schistosity or foliation to the rock. Aggregates of hornblende contain smaller crystals of quartz and in some zones, quartz occurs in higher concentration than in P924/78 and strings or aggregates of small quartz grains are also parallel to the direction of schistosity but they do not form continuous bands. Turbid, partly sericitized plagioclase crystals are commonly 0.5 to 1 mm in size with some aggregates up to 3 mm in size and, in places, these are intergrown with, or adjacent to some aggregates of much clearer, recrystallized or secondary plagioclase. There is only a trace of epidote in some of the turbid, altered plagioclase.

Elongate crystals and aggregates of ilmenite up to 2 mm long are almost invariably surrounded by zones of fine-grained sphene. These crystals and aggregates are also parallel to the foliation.

The rock contains some finely disseminated chalcopyrite which occurs mainly as groups as very small to minute crystals, some of them only a few microns in size, but there are a few larger, anhedral crystals up to 0.3 mm in size. These are scattered sporadically throughout the rock and it is uncertain whether or not they are associated with any particular non-opaque mineral. In the thin section a group of very small, opaque grains showing a similar distribution to that of chalcopyrite is included in some epidote which has partly replaced both altered plagioclase and some hornblende. The rock also contains a few crystals of pyrite 0.1 to 0.3 mm in size but this is subordinate to chalcopyrite.

Conclusion:

Foliated or schistose amphibolite similar to, and very probably related to sample P924/78. It contains some disseminated chalcopyrite and pyrite.

amdel
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Pilot Plant: Osman Place, Thebarton, Sth. Aust.
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Branch Offices: Perth and Sydney
Associated with: Professional Consultants Australia Pty. Ltd.

Your ref: 12.05.0083

Please address all correspondence to Frewville.
In reply quote: GS 1/15/0

26 April, 1979

Director-General,
Department of Mines & Energy,
Post Office Box 151,
EASTWOOD, 5063.

Attention: D.J. Flint

REPORT GS 3879/79

| | |
|---|---|
| YOUR REFERENCE: | Application dated 26 March 1979 |
| MATERIAL: | 11 drill core samples |
| LOCALITY: | Mütooroo Mines; DDH MM14 |
| IDENTIFICATION: | Samples 7033 RS 159-169 |
| DATE RECEIVED: | 27 March 1979 |
| WORK REQUIRED: | Routine petrographic description (MA1.3) and, for three samples, routine mineragraphic description (MA2.2) |

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meo/17

# DESCRIPTION OF SCHISTS AND DEFORMED AMPHIBOLITES FROM DDH 14 MUTOOROO

## 1. SUMMARY OF SPECIMENS

| Sample, Section No's and depth | Description |
|---|---|
| 7033 RS159; TSC23008; 248.2 m | Quartz-plagioclase-mica-staurolite gneiss |
| 7033 RS160; TSC23009 338.85 m | Quartz-plagioclase-mica-staurolite gneiss similar to RS159 |
| 7033 RS161; TSC23010 441.4 m | Basic granulite. It has a metamorphic texture and is composed of plagioclase, clinopyroxene, minor orthopyroxene and hornblende. Probably derived from basic igneous rock. |
| 7033 RS162-163; TSC23011-12 472.4m; 1408.99 m | Basic granulite similar to RS161 except that there is a very weak or incipient foliation due to some parallel, elongate aggregates of pyroxene and lesser hornblende. Sample RS163 has a higher concentration of secondary, pale green amphibole. |
| 7033 RS164; TSC23013; PSD5402; 1490.20 m | Deformed and probably metasomatically altered rock in which there is no recognisable evidence of origin. It is now mainly sericite/muscovite, quartz, K-feldspar and chlorite, with local concentrations of magnetite, hematite and pyrite. |
| 7033 RS165; TSC23014 1490.30 m | Metasomatically altered amphibolite, now composed of chlorite, secondary K-feldspar, calcite and secondary quartz. There is minor iron oxide and a trace of pyrite. |
| 7033 RS166; TSC23015 1490.40 m | Deformed and metasomatically altered rock similar to RS164 except that in one zone there are traces of relict textures probably inherited from amphibolite. It is composed of secondary muscovite, quartz, chlorite and calcite with less K-feldspar than samples RS164 and 165. |
| 7033 RS167; TSC23016; PSD5403 1490.85 m | Biotite schist containing subordinate K-feldspar and quartz. Chlorite has replaced some biotite and textural evidence suggests that K-feldspar has also invaded and replaced some biotite. There is slightly anomalous apatite and minor pyrite. |
| 7033 RS168; TSC23017; PSD5404 1535.60 m | Schistose amphibolite very probably derived from basic igneous rock (dolerite?). It is composed of hornblende, plagioclase and biotite and minor Fe-Ti oxide. |
| 7033 RS169; TSC23018 1601.55 m | Schistose amphibolite. It differs from RS168 in that it does not have biotite and there are a few altered plagioclase phenocrysts which have been replaced by sericite and traces of epidote. |

## 2. PETROGRAPHY AND MINERAGRAPHY

Sample: 7033 RS159; TSC23008

Depth: 248.2 m

Hand Specimen:

A medium-grained, grey to almost white rock with a strong foliation and some evidence of compositional banding. It tends to split along some planes parallel to the foliation revealing lustrous, micaceous surfaces.

Staining with cobaltinitrite did not show any potash feldspar and staining with rhodizonate showed moderate plagioclase.

Thin Section:

A visual estimate of the minerals is as follows:

| | % |
|---|---|
| Quartz | 30-35 |
| Plagioclase | 25-30 |
| Muscovite | 15-20 |
| Biotite | 10-15 |
| Staurolite | 10-15 |
| Opaque oxide and leucoxene | Trace |
| Sillimanite | Trace |
| Zircon | Minute Trace |
| Sulphide | Very Minute Trace |

Much of the background of this rock is composed of intergrown quartz and plagioclase crystals, many of which are between about 0.4 and 0.8 mm, and, as shown by staining the hand specimen, the proportions of plagioclase to quartz vary in poorly defined bands about 3-5 mm thick. Most of the plagioclase shows no evidence of twinning and in the few crystals in which twinning is visible the extinction angle of twin planes,and also the fact that the refractive index of the plagioclase is slightly higher than that of quartz, suggests that it is probably oligoclase near andesine (near $An_{29-30}$). The quartz and feldspar are intergrown with generally straight to slightly curved grain boundaries, but the texture is rather uneven due to the variation in grain size.

Flakes of biotite about 0.2 to 1.5 mm long are scattered throughout much of the rock and most of these are subparallel to the foliation but there are a few small biotite flakes orientated in other directions, particularly where they occur along grain boundaries. Muscovite is not as uniformly distributed as biotite and it tends to occur concentrated in elongate streaks and thin bands which do not appear to be continuous, at least in the area sectioned. The muscovite shows preferred orientation but the thin bands and streaks show a wavy or slightly crennulated pattern and therefore the muscovite flakes are not all parallel. Although there are some lenticular and elongate aggregates of muscovite, no very definite evidence could be found to suggest that this had replaced an earlier metamorphic mineral, but the possibility cannot be excluded and in one of these aggregates of muscovite there are a few small patches of fibrous sillimanite, suggesting the possibility of a more complex history.

Stuarolite crystals about 0.5 to 3 mm long are unevenly distributed in the area sectioned and are concentrated mainly along two bands about

2 and 6 mm thick. The staurolite occurs as isolated crystals and as aggregates and, in general, the crystals have apparently random orientation. They contain small inclusions of quartz and possibly feldspar, and some have been fractured but the time of this fracturing is uncertain.

Small grains of opaque oxide and leucoxene about 0.05 to 0.2 mm in size are scattered throughout parts of the rock and the elongate grains are subparallel to the foliation. A few of these are included within stuarolite. There is a trace of goethite, possibly replacing sulphide, in the thin section and, when the specimen is examined in refractive light, one grain of yellowish sulphide can be seen.

Conclusion:

Quartz-plagioclase-mica-staurolite gneiss, probably derived from a siltstone or mudstone.

Sample: 7033 RS160; TSC23009

Depth: 338.85 m

Hand Specimen:

A medium-grained, pale grey to almost white, foliated rock very similar in general appearance to sample 7033 RS159.

Staining with cobaltinitrite shows no potash feldspar and staining with rhodizonate shows only relatively minor plagioclase.

Thin Section:

A visual estimate of the constituents is as follows:

| | % |
|---|---|
| Quartz | 50-55 |
| Muscovite | 15-20 |
| Biotite | 10-15 |
| Plagioclase | 5-10 |
| Staurolite | 5-10 |
| Chlorite | Trace |
| Opaque oxides and leucoxene | Trace |
| Sillimanite | Trace |
| Zircon | Trace |
| Apatite | Minute Trace |

This is essentially very similar to sample 7033 RS159, and a full description would involve needless repetition. It differs from that sample mainly in that it contains a lower proportion of plagioclase and correspondingly more quartz, but this is probably a feature of the banding. Special features are as follows.

Thin bands (1-3 mm thick) composed predominantly of muscovite are rather more conspicuous than in sample RS159 and also appear to be more continuous with less evidence of deformation or crennulation. Some biotite is intergrown with this muscovite and these bands curve around some of the larger crystals of staurolite. No textural evidence was found suggesting that this muscovite may have replaced an earlier mineral but in one area where some muscovite is in contact with staurolite there is a small patch (1 mm) containing some very fine, fibrous, sillimanite now included mainly in quartz intergrown with some plagioclase. There are a few other very minor traces of sillimanite associated with, or included within, some muscovite.

In one area there is an aggregate of chlorite flakes which have pseudomorphously replaced an earlier crystal about 1.5 mm in size, and this is associated mainly with biotite and some quartz. It is possible that the chlorite replaced garnet but there is insufficient of the crystal shape to enable identification of the earlier mineral.

Staurolite crystals are similar to those in sample 7033 RS159 and they contain inclusions of quartz and some of opaque oxide.

Accessory minerals are similar to those in the previous sample and are mainly elongate crystals of opaque iron-titanium oxide, a few small apatite crystals and a few very small, generally rounded, zircon grains.

Conclusion:

Quartz-plagioclase-mica-staurolite gneiss similar to sample 7033 RS159.

Sample: 7033 RS161; TSC23010

Depth: 441.4 m

Hand Specimen:

A medium-grained, slightly greenish-grey rock with a rather granular texture. Staining tests shows abundant plagioclase but no potash feldspar.

Thin Section:

A visual estimate of the constituents is as follows:

| | % |
|---|---|
| Plagioclase | 55-60 |
| Clinopyroxene | 25-30 |
| Orthopyroxene | 2-3 |
| Hornblende | 5-10 |
| Opaque oxide | Trace |
| Apatite | Minute Trace |

The rock now has a granoblastic texture and is composed of generally equidimensional plagioclase crystals 0.5 to 1 mm in size intergrown with pale-coloured clinopyroxene of generally similar size and a few crystals of orthopyroxene, some of which are up to 2 mm long. Brownish hornblende is also intergrown with the plagioclase and pyroxene and it tends to occur in interstices. In general it is slightly finer-grained than the plagioclase and pyroxene, but there are a few hornblende crystals about 1 mm in size. Most of the grain boundaries are smooth to curved and, in the plane of the section, there is no evidence of a foliation.

Many of the plagioclase crystals show twinning and the extinction angle in the symmetrical zone suggests a composition of labradorite. The twin planes are not deformed and the general appearance of the plagioclase crystals is similar to plagioclase of metamorphic origin. Although the plagioclase and darker minerals are not uniformly distributed, no definite evidence of relict textures could be found.

The brownish hornblende is closely intergrown with clinopyroxene and there is no definite evidence of replacement between these minerals; however, most of the orthopyroxene crystals are surrounded by a very thin film of pale green amphibole which is clearly a result of alteration and replacement of the orthopyroxene at a late stage in the history of this rock.

There are a few opaque oxide grains about 0.05 to 0.2 mm in size occurring in interstices and also included within a few pyroxene crystals. A few small apatite crystals occur in interstices and in plagioclase.

Conclusion:

The general texture is that of a metamorphic rock and similar to that of granulite. The mineral composition and also the general massive appearance and uniform composition suggests possible derivation from a basic igneous rock. However, no relict textures were found in the section. It is therefore classified as a basic granulite.

Samples: 7033 RS162 & RS163; TSC23011-12

Depths: 472.4 m and 1408.99 m

Hand Specimens:

Medium-grained, greenish-grey rocks very similar to sample 7033 RS161, except that there is evidence of a very weak foliation defined mainly by subparallel orientation of some elongate, dark crystals or aggregates.

Thin Sections:

In general composition these are essentially very similar to sample 7033 RS161 and are composed predominantly of plagioclase intergrown with clinopyroxene, lesser orthopyroxene and some greenish-brown hornblende. There are traces of pale green amphibole and of opaque oxide.

In texture and general appearance these samples are also similar to sample 7033 RS161 in that they have a general granoblastic texture and the plagioclase is typical of metamorphic plagioclase. These samples differ from sample 7033 RS161 in the following features.

There is a very weak or incipient foliation due mainly to the presence of elongate aggregates of pyroxene 2-3 mm long and a few subparallel, orthopyroxene crystals also 2-3 mm long. A little hornblende intergrown with some pyroxene also forms elongate aggregates parallel to the weak or incipient foliation. The plagioclase, however, forms a mosaic with straight to curved grain boundaries and no definite evidence of relict textures could be found.

Sample 7033 RS162 has very little of the pale green amphibole occurring along some grain boundaries, mainly against orthopyroxene, but in sample 7033 RS163 this secondary, pale green amphibole is more abundant (2-3%) and it occurs as films generally less than 0.05 mm thick composed of very small amphibole crystals generally rimming pyroxene. In places there are some thicker films of this amphibole partly replacing corroded remnants of pyroxene and some of this merges with the coarser-grained, brownish amphibole.

Sample 7033 RS163 is cut by a small vein containing a mineral with a very low refractive index, probably a zeolite.

Conclusion:

These samples are very similar to sample 7033 RS161 and could also be classified as basic granulites, but they differ in that they show a very weak or incipient foliation and sample RS163 has a higher concentration of the secondary, pale green amphibole.

Sample: 7033 RS164; TSC23013; PSD5402

Depth: 1490.20 m

Hand Specimen:

A dull, greenish-grey, fine-grained schist with unevenly distributed elongate and irregular patches of pink feldspar, mainly in a band about 1.5 cm thick. There are also some patches of dark grey iron oxide and yellow sulphide adjacent to the zone containing pink feldspar, and some sulphide is closely associated with the pink feldspar.

Staining with cobaltinitrite shows that the feldspar is potash feldspar.

Thin Section:

The composition varies in different zones and therefore the proportions given below may not be accurate for the whole sample. It contains the following minerals:

| | % |
|---|---|
| Muscovite and sericite | 30-35 |
| Quartz | 30-35 |
| Potash feldspar | 15-20 |
| Chlorite | 10-15 (varies) |
| Magnetite | 5-7 |
| Hematite | 3-5 |
| Pyrite | 1-2 |
| Calcite | 1-2 |

The section contains two zones or poorly defined bands 4-6 mm thick composed largely of deformed, strained and partly granulated, coarse-grained, recrystallized or vein quartz alternating with zones or bands now composed largely of very fine-grained muscovite or sericite with a few patches of coarser-grained mica and elongate patches or streaks of chlorite. Most of the muscovite and sericite in these zones do not show preferred orientation and very probably the mica has replaced an earlier, unidentified mineral but, as there are no relict textures this cannot be identified. The streaks of chlorite are subparallel to the weak foliation. There are a few patches or fragments of quartz and a few small aggregates of fine-grained iron oxide also scattered throughout the sericite.

There are elongate aggregates up to 4 mm thick composed of turbid, moderately coarse-grained potash feldspar intergrown with some calcite, and one of these bands contains aggregates of opaque minerals, mainly magnetite and pyrite, with some hematite. There are films of chlorite along numerous grain boundaries and small fractures in the larger masses of opaque iron oxides and pyrite, and in one area there is a band composed largely of chlorite with patches of sericite and muscovite separating the main mass of iron oxides and sulphides from another thin band now composed mainly of hematite.

There are other zones in the rock composed of rather chaotic and jumbled masses of fractured quartz, turbid potash feldspar, fine-grained muscovite and chlorite, with a few scattered patches of calcite, some of which contain flakes of chlorite. In one area calcite has clearly penetrated fractures and interstices between potash feldspar crystals.

A careful search of all areas of sericite, fine-grained muscovite and chlorite, did not show any evidence of relict textures from which to determine the earlier history of this rock.

In the polished section, some aggregates of opaque minerals can be seen to be composed largely of intergrown magnetite crystals about 0.2 to 1 mm in size and there are small patches and anhedral crystals of pyrite varying in size up to about 0.4 mm in some interstices in this mass of magnetite. On the boundary of this magnetite mass there is a larger crystal of pyrite over 2 mm in size which contains a few small inclusions of magnetite.

Another band or zone or iron oxide contains intergrown, specular hematite crystals, some of which are over 1 mm long, and a few of these tabular or elongate crystals have been bent or otherwise deformed. There are also some patches of hematite containing generally small, irregular remnants of magnetite, suggesting that some of the hematite could have crystallized across earlier magnetite, and there are also a few patches of altered magnetite? containing traces of secondary titanium oxide.

Conclusion:

Deformed and metasomatically altered rock of undetermined origin. There are local concentrations of migratory magnetite, pyrite and specular hematite.

Sample: 7033 RS165; TSC23014

Depth: 1490.30 m

Hand Specimen:

Most of the sample is a dull green, fine-grained rock with a weak foliation and when a wet, freshly cut surface is closely examined, small, dull, pink grains can be found.

Staining with cobaltinitrite shows that the dull pink grains are very probably potash feldspar. The sample submitted also has two subparallel bands of chloritic schist without the pink feldspar.

Small grains of yellow sulphide, probably pyrite, are disseminated throughout the rock and some occur along a small joint. There are also a few grains of opaque iron or iron-titanium oxide.

Thin Section:

A visual estimate of the minerals is as follows:

| | % |
|---|---|
| Chlorite | 40-45 |
| Potash feldspar and sericite | 35-40 |
| Quartz | 10-15 |
| Calcite | 5-10 |
| Iron oxide | Trace (more locally) |
| Sulphide | Trace |

The rock has a fairly uniform composition and texture except for the presence of subparallel bands or veins in which there are local concentrations of chlorite and some iron oxide.

The rock is now composed largely of chlorite interspersed with crystals and crystalline aggregates of turbid potash feldspar which contain varying amounts of sericite. There are also patches of quartz and numerous, interstitial patches of calcite which appears to have been the last mineral to crystallize. These minerals are almost certainly all secondary and have crystallized across earlier textures which have been moderately well preserved throughout much of the rock. The relict textures suggest that amphibole crystals 0.5 to 2 mm long were once relatively abundant in this rock and, although many had subparallel orientation, others were oriented in different directions. These relict textures and the general appearance of the rock strongly suggest that it was an amphibolite composed predominantly of amphibole and a feldspar, and the present minerals have crystallized across the earlier textures retaining some evidence of crystal boundaries and former cleavage in the amphibole. In general, amphibole crystals tend to have been replaced by chlorite and feldspar by very turbid potash feldspar heavily impregnated with sericite. Small patches of quartz are intergrown with some of the potash feldspar and also occur between feldspar and chlorite and in some interstices. Locally, the quartz contains minute inclusions of chlorite and sericite, particularly where it has apparently invaded some of the chloritized amphibole and turbid potash feldspar. Patches of calcite are closely associated with much of the quartz and this also contains inclusions of chlorite and a few of very fine-grained iron oxide.

Some of the patches of chlorite contain very fine-grained iron and titanium oxides, some of which are concentrated along sets of parallel lines, strongly suggesting former cleavage planes, but whether these cleavage planes were in the former amphibole or in earlier pyroxene cannot be determined with certainty.

One poorly defined band or vein in the area sectioned contains higher concentrations of chlorite and quartz and has a central zone in which there is a concentration of specular hematite crystals up to about 1 mm long. Small crystals of sulphide, probably pyrite, about 0.1 to 0.3 mm in size are scattered through the rock and there are also some elongate crystals of iron oxide or iron-titanium oxide.

Conclusion:

Metasomatically altered amphibolite now composed largely of chlorite and potash feldspar with lesser quartz and calcite.

Sample: 7033 RS166; TSC22015

Depth: 1490.40 m

Hand Specimen:

A dull green and grey, predominantly fine-grained rock with some poorly defined bands containing paler grey quartz, and some local concentrations of iron oxide.

Staining with cobaltinitrite shows a minor concentration of potash feldspar along one thin band closely associated with a concentration of iron oxide.

Thin Section:

A visual estimate of the minerals is as follows:

| | % | |
|---|---|---|
| Muscovite | 30-35 | |
| Quartz | 25-30 | |
| Chlorite | 25-30 | |
| Calcite | 3-5 | (varies) |
| Iron and titanium oxides | 2-3 | (more locally) |
| Potash feldspar | 1-2 | (local) |
| Sulphide | Trace | |
| Tourmaline | Trace | |
| Epidote | Minute Trace | |
| Apatite | Trace | |

This is a deformed and metasomatically altered rock essentially very similar to sample 7033 RS164, except that it has less potash feldspar.

Aggregates of quartz crystals of varying grain size are intergrown with, or interspersed with, aggregates up to 2 mm long now composed of intergrown muscovite crystals and, although the aggregates are parallel to a weak foliation, the individual muscovite crystals do not show any evidence of preferred orientation. These zones composed mainly of quartz and muscovite also contain streaks or elongate aggregates and flakes of chlorite, many of which are about parallel to the foliation, and many patches of chlorite contain fine-grained iron oxide. Calcite has penetrated and partly replaced these zones and it now contains some inclusions of quartz and chlorite and also aggregates of very fine-grained iron and titanium oxides. In one area some subhedral to euhedral quartz crystals are partly enclosed by this calcite.

Towards one end of the section there are some relict textures similar to those in sample 7033 RS165, suggesting the former presence of amphibole crystals up to 2 mm long which have been replaced by chlorite and calcite with some local patches of quartz. Aggregates of small muscovite crystals are also scattered throughout this zone and fine-grained iron-titanium oxides are dispersed through much of the chlorite.

Near the other end of the thin section there is a band about 4-5 mm thick containing fine-grained chlorite intergrown with some muscovite and associated with some patches of turbid potash feldspar. This band contains a concentration of specular hematite crystals, some of which form more or less continuous but extensively deformed, thin bands subparallel to the foliation. Some sulphide is associated with this hematite near the end of the section and on the other side of this band there is a zone containing concentrations, streaks or elongate aggregates of very fine-grained magnetite? mainly included in masses of fine-grained muscovite, but locally associated with quartz or chlorite. Between the hematite-rich and magnetite?-bearing bands there is one area in which some late calcite contains a corroded patch of tourmaline about 0.5 mm in size.

Conclusion:

Deformed and metasomatically altered rock, some zones of which are similar to sample 7033 RS164 and another zone has relict textures suggesting at least a patch of former amphibolite.

The rock is now composed mainly of secondary muscovite, quartz, chlorite and calcite.

Sample: 7033 RS167; TSC23016; PSD5403

Depth: 1490.85 m

Hand Specimen:

Dark, brownish-grey schist with some disseminated sulphide.

Staining with cobaltinitrite shows lenticular patches of potash feldspar parallel to the schistosity.

Thin Section:

A visual estimate of the minerals is as follows:

| | % |
|---|---|
| Biotite | 35-40 |
| Chlorite | 20-25 |
| Potash feldspar | 20-25 |
| Quartz | 10-15 |
| Iron and titanium oxides | 3-5 |
| Pyrite | 2-3 |
| Calcite | Trace |
| Apatite | Trace |

The schist contains abundant biotite flakes 1-4 mm long and a large proportion of these is orientated parallel to the schistosity, but there are a few isolated crystals and also a few elongate patches in which the biotite is not parallel to the schistosity. Throughout much of the biotite there are scattered, elongate crystals 0.1 to 0.2 mm long of opaque iron or iron-titanium oxide, and most of these are also parallel to the schistosity. Elongate patches of moderately coarse-grained quartz are scattered through the biotite schist and there are also a few patches of apatite, the largest being about 1 mm in size.

Some of the biotite is closely intergrown with green chlorite, much of which contains finer-grained iron-titanium oxide than the elongate crystals noted above, and it is very likely that this chlorite has replaced or partly replaced biotite. The biotite schist also contains elongate or lenticular aggregates of medium- to fine-grained potash feldspar which has penetrated along cleavage planes in the biotite and has spread out from these planes, possibly partly replacing the biotite, although the lenticular masses of potash feldspar still contain numerous small whisps of biotite and chlorite and also some elongate crystals of iron-titanium oxide similar to those included in the mass of biotite.

There are a few small patches of calcite which occur discontinuously along fractures parallel to the schistosity.

Scattered through the rock there are some elongate aggregates of pyrite varying in length from less than 0.5 mm to about 2 mm and most of these are parallel to the schistosity. One of the larger masses of pyrite included in the polished section contains a few inclusions of iron-titanium oxide.

The elongate crystals of iron-titanium oxide noted in the thin section can be seen in the polished section to contain some fine-grained intergrowths of hematite and titaniferous magnetite? and there are also a few elongate aggregates which are now titanium oxide. Some ilmenite may be present in some of the elongate crystals or aggregates and one small crystal of unoxidized magnetite was found included within pyrite.

Conclusion:

Biotite schist containing disseminated pyrite, iron-titanium oxides and slightly anomalous apatite. The biotite has been partly replaced by chlorite and has also been invaded and locally replaced by potash feldspar.

Sample: 7033 RS168; TSC23017; PSD5404

Depth: 1535.60 m

Hand Specimen:

A moderately fine-grained, dark greenish-grey rock with a very weak schistosity or foliation. It contains a trace of disseminated yellow sulphide.

Thin and Polished Sections:

A visual estimate of the minerals is as follows:

| | % |
|---|---|
| Hornblende | 40-45 |
| Plagioclase | 35-40 |
| Biotite | 15-20 |
| Chlorite | Trace |
| Potash feldspar | Trace |
| Apatite | Trace |
| Ilmenite and hematite | 1-2 |
| Pyrite | Trace-1 |
| Magnetite | Minute Trace |

This rock has a uniform composition and consists of green hornblende crystals 0.5 to about 1.5 mm in size intergrown with crystals of plagioclase mainly between 0.2 and 0.6 mm in size, and there are flakes of biotite 0.5 to 1 mm long. Much of the biotite shows some evidence of preferred orientation, although not all of the flakes are parallel, and there are also a few elongate or prismatic hornblende crystals parallel to this direction, but the foliation is not strongly developed and not sufficient to impart a definite schistosity. Many of the larger hornblende crystals contain some concentrations of very small opaque oxide inclusions, and also a few inclusions of plagioclase (or quartz), but in general these inclusions do not form any recognisable patterns to suggest relict textures. Plagioclase tends to occur in interstices between hornblende and biotite crystals and only very few of the grains show twinning. There are a few very small patches of potash feldspar in interstices generally associated with plagioclase and there are also a few small patches where turbid, fine-grained phyllosilicate has partly replaced some plagioclase.

There are a few small apatite crystals about 0.1 mm in size mainly intergrown with the plagioclase or included within plagioclase.

The rock contains scattered, elongate opaque oxide crystals about 0.05 to 0.2 mm long and, in polished section these can be seen to be mainly fine-grained, lamellar intergrowths of ilmenite and hematite. Some are predominantly ilmenite with very fine, parallel lamellae of hematite resembling exsolution intergrowths, but other grains contain higher proportions of hematite and the origin of this is uncertain. There is one small grain or aggregate in which the ilmenite with lamellae of hematite is associated with a trace of magnetite and it may be that some of the grains containing higher proportions of hematite once had some magnetite intergrown with the ilmenite. Some of the ilmenite is porous and slightly altered.

There are a few scattered crystals of pyrite, some of them partly enclosing altered and corroded iron oxide, and one of the pyrite crystals contains a minute inclusion of chalcopyrite.

Conclusion:

Schistose or foliated amphibolite, very probably derived from a basic igneous rock such as a dolerite.

Sample: 7033 RS169; TSC22018

Depth: 1601.55 m

Hand Specimen:
A medium-grained, dark greenish-grey schist with scattered, almost white grains or crystals about 2-3 mm long.

Thin Section:
A visual estimate of the minerals is as follows:

| | % |
|---|---|
| Hornblende | 65-70 |
| Plagioclase | 25-30 |
| Opaque iron-titanium oxide | 3-5 |
| Apatite | Trace |
| Pyrite | Trace |
| Epidote | Trace |

The bulk of this rock is now a medium-grained schist containing elongate or prismatic hornblende crystals, most of which are between 0.5 and 1 mm long, and a large proportion of these are subparallel defining a definite schistosity. The hornblende is intergrown with crystals and aggregates of plagioclase generally between 0.2 and 0.5 mm long, and there are also numerous, elongate crystals of opaque iron-titanium oxide 0.1 to 0.3 mm long, most of which are about parallel to the schistosity. Most of the plagioclase crystals do not show twinning but there are a few elongate aggregates of coarser-grained plagioclase in which some of the crystals show relatively simple polysynthetic twinning. In some of these elongate aggregates, some of the plagioclase has been partly replaced by very fine-grained, fibrolamellar phyllosilicate with traces of epidote.

There are a few relicts of phenocrysts scattered throughout the rock and most of these are about 2 mm long and still show some evidence of sub-rectangular shape. They have been almost completely replaced by sericite and traces of epidote and although they were almost certainly plagioclase, there is now insufficient evidence from which to determine their former composition.

When the section is examined under low magnification in reflected light a few scattered crystals and aggregates of yellow sulphide, very probably pyrite, can be seen.

Conclusion:
Schistose amphibolite almost certainly derived from basic igneous rock which probably had some phenocrysts of plagioclase.

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Attention: G. Pitt

# PETROGRAPHY OF ELEVEN GNEISSES FROM MUTAROO MINES DDH 14B

PROGRESS REPORT NO. 18

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mco/7

## PETROGRAPHY OF ELEVEN GNEISSES FROM MUTAROO MINES DDH 14B

| Sample No. | Unit No. | TS No. | Depth in metres |
|---|---|---|---|
| P754/78 | 7033RS88 | 40362 | 826.4 |
| P755/78 | 7033RS89 | 40363 | 825.9 |
| P756/78 | 7033RS90 | 40364 | 827.9 |
| P757/78 | 7033RS91 | 40365 | 832.9 |
| P759/78 | 7033RS93 | 40367 | 836.3 |
| P760/78 | 7033RS94 | 40368 | 837.4 |
| P761/78 | 7033RS95 | 40369 | 840.2 |
| P762/78 | 7033RS96 | 40370 | 842.0 |

All of these samples are very similar in both hand specimen and thin section and contain relatively large augen separated by well foliated grey bands. The mineralogy of any thin section would depend largely on whether the thin section was cut to include a large augen or not and all the samples have a very similar petrographic character so it was decided to give a general description including all eight samples.

Rock name:
Augen gneiss

Hand Specimen:
A well foliated rock containing felsic augen with a milky grey to pale pink colour set in a well foliated matrix with a darker grey colour containing narrow, black, biotite-rich bands. The felsic augen are generally below 1 cm wide and about 2-3 cm long. Microchemical tests show that the augen contain abundant potash feldspar but the well foliated matrix generally contains only minor amounts of potash feldspar.

Thin Section:
Due to the large felsic augen any estimate of the mineral proportions would depend largely on the location from which the thin section was cut, but the following list of mineral proportions represents an average of the whole rock:

| | % |
|---|---|
| Plagioclase | 30 |
| Quartz | 25 |
| Potash feldspar (microcline) | 25 |
| Biotite | 10 |
| Muscovite | 7 |
| Chlorite | 2 |
| Apatite | Trace |
| Zircon | Trace |
| Opaques | 1 |

This is a well foliated rock consisting of a granoblastic quartz and feldspar intergrowth through which well-developed biotite and muscovite flakes are distributed. Both the biotite and muscovite flakes exhibit a well-developed lepidoblastic foliation and tend to be concentrated in slightly undulose, discontinuous bands. The augen which were noted in hand specimen for the most part lack muscovite and biotite but contain a concentration of potash feldspar (microcline). The felsic augen also generally have a somewhat coarser grain size (generally about 0.5 mm) than the granoblastic matrix, which typically has a grain size below 0.3 mm.

The feldspar consists of both plagioclase, which forms both untwinned and polysynthetically twinned crystals, and gridiron twinned microcline. All of the feldspar has a very fresh appearance, showing only incipient alteration to produce well-developed, finely divided muscovite flakes and a localised, generaly turbidity. The fine muscovite flakes which are generally included within plagioclase crystals, form prismatic, stubby crystals some of which have a crystallographic orientation and are unlike typical sericitic alteration of feldspar which generally forms fine, flaky aggregates. The well-developed, prismatic crystals suggest that this represents recrystallised, finely divided sericite which was most likely produced during recrystallization of the felsic minerals under metamorphic conditions. The feldspar turbidity is produced by finely divided micron-sized inclusions which could represent opaque inclusions and shows slight variations in intensity between samples. Samples P754/78 and P755/78 have slightly less turbid feldspars than the other samples of this group.

Both the biotite and muscovite form very well-developed flakes up to 1 mm in length which generally have a parallel orientation, although a few muscovite and biotite flakes which transect the foliation direction are also present. The biotite flakes all have intensely pleochroic, pale yellowish-brown to very dark brown colours and a very fresh, unaltered character. Although most of the biotite flakes show no evidence of alteration, flakes of pleochroic green chlorite with anomalous blue interference colours are also present in the sample. A few of the larger chlorite flakes contain minor remnants of biotite, but most consist only of chlorite.

Traces of apatite and zircon are disseminated through this rock type as small crystals below 0.3 and 0.1 mm in size respectively. The apatite crystals tend to have anhedral shapes, while the zircon crystals generally have elongate, prismatic shapes. At least some of the zircon crystals exhibit low birefringence, indicating they are metamict. Opaques are disseminated through the rock as anhedral grains and granular aggregates generally below 0.1 mm in size. Minor opaques also form fine lamellar intergrowths with biotite or lamellar intergrowths along the cleavage traces of chlorite.

These samples represent an adamellitic rock which has suffered high-grade regional metamorphism (probable middle to upper amphibolite facies grade) to produce a recrystallized and well foliated rock with coarser-grained felsic augen. The quartz and feldspar has a recrystallized, granular mosaic character and the feldspar contains finely divided, well-developed muscovite crystals believed to represent recrystallized sericite. Except for the recrystallized sericite, the rock has a very fresh character with both the biotite and the feldspar showing very little alteration. Although most of the biotite flakes are completely unaltered, a small proportion show complete or almost complete replacement by chlorite.

These rocks are quite fresh and would be suitable for whole rock Rb/Sr dating.

Sample: P758/78; TS40366; 7033RS92

Location:
Mutaroo Mines DDH 14B at 832.9 m depth.

Rock Name:
Leucocratic gneiss

Hand Specimen:
A weakly foliated rock comprised of a finely granular intergrowth of milky grey quartz and grey to pink feldspar. Staining with sodium cobaltinitrite after a hydrofluoric acid etch showed the sample contains abundant potash feldspar.

Thin Section:
An optical estimate of the constituents gives the following:

| | % |
|---|---|
| Potash feldspar (microcline) | 35 |
| Quartz | 35 |
| Plagioclase | 25 |
| Muscovite-sericite | 4 |
| Biotite-chlorite | 1 |
| Calcite | Trace |
| Zircon | Trace |
| Opaques | Trace-1 |

This sample consists mainly of a fine-grained (typical grain size between 0.2 and 1 mm) mosaic of granoblastic quartz and feldspar. The feldspar consists of both gridiron twinned microcline and plagioclase, at least some of which exhibits polysynthetic twinning. Muscovite flakes up to 0.4 mm in length are disseminated through the rock and locally well-developed biotite flakes are also present. The biotite exhibits an intensely pleochroic brown colour and forms small flakes generally below 0.15 mm in length.

Most of the feldspar in this rock has a somewhat turbid character, most likely due to incipient epidotisation. A few plagioclase crystals exhibit highly turbid, altered cores with narrow, clear unaltered margins. Finely divided muscovite-sericite flakes are also disseminated through the plagioclase and, to a lesser extent, microcline crystals. These fine flakes generally have a well-developed character and at least in some crystals exhibit a preferred crystallographic orientation like the fine muscovite flakes in the previously described augen gneisses, suggesting that they represent recrystallized, finely divided sericite. For the most part the biotite is very fresh but a few biotite flakes show alteration to a pleochroic green chlorite. Traces of calcite were also noted, mainly as inclusions in feldspar.

Zircon is disseminated through the rock as very small, prismatic crystals generally below 0.05 mm in size. Minor opaques also form anhedral disseminated grains.

This rock most likely represents a leucocratic band within the previously described augen gneisses and the feldspar has a somewhat more altered, turbid character than the feldspar in the augen gneisses. Despite this alteration, the rock is still considered fresh enough for whole rock Rb/Sr dating.

Sample: P763/78; TS40371; 7033RS97

Location:
Mutaroo Mines DDH 14B at 1028.9 m depth.

Rock Name;
Feldspar-quartz-mica gneiss

Hand Specimen:
A well foliated rock with a somewhat banded texture, containing some elongate bands or lenticular bodies rich in pink feldspar. This sample lacks the well-developed augen present in the augen gneisses, although it does have somewhat smaller lenticular bodies which are similar to the augen in the augen gneisses.

Thin Section:
An optical estimate of the constituents gives the following:

| | % |
|---|---|
| Plagioclase | 30 |
| Quartz | 25 |
| Potash feldspar (microcline) | 20 |
| Biotite | 12 |
| Muscovite-sericite | 10 |
| Chlorite | 2 |
| Apatite | Trace |
| Zircon | Trace |
| Opaques | Trace-1 |

This is a well foliated rock consisting of a relatively fine-grained (typical grain size between 0.15 and 0.5 mm) granoblastic quartz and feldspar intergrowth with undulose, mica-rich bands. The mica-rich bands have a parallel orientation and the mica flakes within these bands exhibit a well-developed lepidoblastic foliation oriented parallel to the banding.

The feldspar consists of plagioclase,at least some of which exhibits polysynthetic twinning, and gridiron twinned microcline. All of the feldspar is quite fresh although locally feldspar grains with a somewhat turbid character, probably due to incipient epidotisation, are present. A few feldspar grains also contain finely divided, well-developed muscovite flakes similar to those in the previously described samples, which are believed to be recrystallized sericite.

The mica consists of both intensely pleochroic brown biotite and muscovite, both of which form well-developed flakes up to 1 mm in length. The biotite shows minor marginal alteration to a pleochroic green chlorite, and a few smaller biotite flakes have been almost completely replaced by this chlorite. The chlorite also has anomalous blue interference colours and at least locally contains fine lamellar intergrowths of opaques along its cleavage traces. The completely chloritized biotite flakes generally do not occur in the narrow, mica-rich bands, but are intergrown with the granular felsic mineral-rich bands.

Traces of apatite and zircon are disseminated through the rock as small crystals below 0.15 and 0.05 mm in size respectively. Minor opaques also form anhedral disseminated grains generally below 0.05 mm in size.

This is a gneissic rock, very similar to the previously described augen gneisses, except that it lacks the well-developed augen present in those rocks. The sample is considered suitable for whole rock radiometric dating.

Sample: P764/78; TS40372; 7033RS98

Location:
Mutaroo Mines DDH 14B at 1024.0 m depth.

Rock Name:
Feldspar-quartz-mica gneiss

Hand Specimen:
A well foliated and banded rock consisting of narrow pink coloured bands separated by thicker grey bands which contain narrower dark bands rich in biotite.

Thin Section:
An optical estimate of the constituents gives the following:

| | % |
|---|---|
| Plagioclase | 30 |
| Quartz | 25 |
| Potash feldspar (microcline) | 15 |
| Biotite | 15 |
| Muscovite-sericite | 10 |
| Chlorite | 3 |
| Calcite | 2 |
| Apatite, zircon | Trace |
| Opaques | Trace-1 |

This sample is quite similar to sample P763/78 (TS40371), consisting of a granoblastic quartz and feldspar mosaic intergrown with parallel, undulose, mica-rich bands. The quartz and feldspar have a typical grain size of 0.1 to 0.5 mm and the feldspar consists of both polysythetically twinned plagioclase and gridiron twinned microcline. The mica-rich bands are comprised of an intensely pleochroic, brown biotite and muscovite, both of which form well-developed flakes up to about 1 mm in length. Both the muscovite and biotite flakes have a well-developed preferred orientation defining a lepidoblastic foliation oriented parallel to the banding.

This rock is somewhat more highly altered than any of the previously described specimens, with both the feldspar and biotite showing more intense alteration. Although the feldspar grains are generally quite fresh, many have a turbid character and contain finely divided sericite. A few feldspar grains also contain well-developed, small mica flakes some of which have a crystallographic orientation and are believed to represent recrystallize pre-existing sericite. The biotite shows some marginal alteration to a pleochroic, green chlorite and some biotite flakes have been completely replaced by this chlorite. The chlorite also has anomalous blue interference colours.

Calcite is present as narrow vein and fracture fillings, generally below 0.2 mm wide, which are generally oriented along the foliation plane and within mica-rich bands. The calcite within these veinlets has a granular character and was positively identified by its staining with an alizarin red-S solution. Minor calcite is also disseminated through the rock as small inclusions within the plagioclase or very fine interstitial intergrowths.

Traces of apatite and zircon are disseminated through the rock as small crystals up to 0.1 mm in size. Minor opaques also form anhedral, disseminated grains up to 0.1 mm in size.

This is a gneiss quite similar to sample P763/78, which shows somewhat more extensive alteration to both of the feldspar and biotite as well as the formation of accessory calcite. Despite the more intense alteration, this rock is still considered suitable for whole rock Rb/Sr dating, although of the samples described in this suite, it would be the least suitable.

# APPENDIX C

# PETROGRAPHIC REPORT -
# DIAMOND DRILL HOLES MM15 and MM21A

Mineralogical Report No. 2598

by

PONTIFEX & ASSOCIATES PTY. LTD.

PONTIFEX & ASSOCIATES PTY. LTD.

Mineralogical Report No. 2598

14th May, 1978.

| Sample No. | Hole No. | 7033 R.S. No. | Depth (metres) |
|---|---|---|---|
| 1 | MM15 | 184 | 604.7 |
| 2 | " | | 635.57 |
| 3 | " | | 636.3 |
| 4 | " | | 638.5 |
| 5 | " | | 648 |
| 6 | " | | 664.8 |
| 7 | " | | 668 |
| 8 | " | | 678.85 |
| 9 | " | | 682.4 |
| 10 | " | | 694.8 |
| 11 | " | | 703.8 |
| 12 | " | | 707.6 |
| 13 | " | | 713.9 |
| 14 | " | | 717 |
| 15 | MM21A | | 93.7 |
| 16 | " | | 131 |
| 17 | " | | 281 |
| 18 | " | | 161.6 |
| 19 | " | 202 | 167 |

## COMMENTS

### ROCK NAMES

Each rock is given an essential description and a metamorphic rock name according to its present composition and texture, i.e. without genetic connotations. The terms schist, gneiss, and amphibolite, are employed, generally prefixed by the component mineral names, listed in order of increasing abundance. Relatively quite minor phases are written in brackets.

The term schist implies a predominantly schistose fabric, i.e. lepidoblastic, nematoblastic or foliated, however intercalated quartzo-felspathic layers are commonly microgranulose, thus 'schist' may be qualified by 'fine granulose'. With increase in these intercalated granuloblastic quartzo-felspathic layers, and corresponding decrease in foliated and lepidoblastic minerals, the fabric becomes relatively gneissic, although the grain size is finer than is generally regarded as characteristic of a gneiss. The terms fine gneiss or fine schistose gneiss are used to incorporate this fabric.

### ROCK GROUPS

On the basis of similar texture and gross mineralogy the suite can be divided into four groups, with the two massive sulphide samples representing a fifth group; these are :-

A. Fine granulose schist gradational to fine schistose gneiss, invariably containing essential quartz; with generally subordinate plagioclase. Minor to abundant staurolite, sillimanite and kyanite are regarded as diagnostic (together with the essential quartz).

Representatives of this group are listed below, showing the diagnostic aluminous silicate phase (where present) -

| | |
|---|---|
| No. 3 | staurolite accessory |
| 8 | |
| 9 | |
| 12 | sillimanite essential |
| 15 | kyanite essential, staurolite accessory |
| 16 | staurolite minor |
| 18 | minor hornblende indicates gradation to amphibolite group B below |

B. Amphibolites, composed basically of hornblende and plagioclase, but with variably accessory to essential quartz and biotite. These rocks are listed below showing the phases present in addition to essential plagioclase and hornblende -

| | |
|---|---|
| No. 1 | essential quartz (incipient sericite chlorite alteration) |
| 5 | essential biotite, minor quartz |
| 6 | minor quartz and biotite |
| 11 | minor quartz (incipient sericite alteration) |
| 17 | diopside-amphibolite, in which diopside is completely uralitised (unique to this sample only) |

C. Massive coarse granulose plagioclase rocks, unique within the suite by virtue of their relatively coarse grain size, and dominance of plagioclase (with minor quartz, muscovite and accessory rutile being the only other phases) -

No. 13
14

D. Fine layered gneiss, characterised by a predominance of plagioclase (of two generations), with minor to subordinate quartz, biotite -

| | |
|---|---|
| No. 2 | |
| 7 | (plus trace sillimanite) |
| 10 | |

E. Massive sulphide samples, dominated by pyrrhotite, inclusions of silicate minerals, accessory magnetite, apatite in sample 4, and minor intergrown chalcopyrite in sample 19 -

No. 4
19

METAMORPHIC GRADE (with discussion on metamorphic history)

Within the limited scope of this suite, the presence of (and indeed the relative abundance of) sillimenite, kyanite and staurolite, and the absence of andalusite, provide perhaps the most diagnostic evidence of metamorphic grade. This indicates that at least the group A rocks defined above, and thus no doubt the entire sequence through which they are intercalated, was metamorphosed under middle amphibolite facies conditions (temperatures of about 525 to 575$^{\circ}$C, pressures of about 4 to 5 Kb).

(Samples 13 and 14 may be exceptions as discussed later.)

Texturally the micaceous foliae throughout the suite, but mainly in petrographic group A, appear to represent a second generation ($S_2$) fabric, i.e. a broad-scale crenulation cleavage, superimposed on an earlier assemblage.

These foliae tend to incorporate, and locally incipiently wrap around staurolite (in No. 16), and sillimanite (in No. 12). Thus the aluminous-silicates are interpreted to represent the culmination of the same latest, single, (mid-amphibolite facies) metamorphic event, which then continued with decreasing temperatures, and possibly increased shear stress, with the development of the later micaceous foliae.

In many samples, relict, 'old' stressed, turbid and poorly twinned coarse plagioclase crystals, and lesser coarse stressed polycrystalline quartz grains, all with porphyroblastic relationships, vague grain boundaries and commonly crowded with minute inclusions, occur within a finer near-polygonal mosaic of quartz and quite clear, well twinned, unstressed, 'new' plagioclase. These relicts are evidence of an earlier mineral assemblage, which appears to be far more abundantly manifest in the coarse granulose rocks 13 and 14 which consist almost entirely of plagioclase of the exact same type as the relict porphyroblasts described above.

The second metamorphic event is only very weakly expressed in these plagioclase granulites 13 and 14, as granulation-recrystallisation along intergranular contacts of the coarse older plagioclase ± minor quartz and muscovite.

Conceivably the uralitisation of diopside in amphibolite sample 17 represents a later retrograde event (mid-amphibolite facies grade), superimposed on an earlier higher grade amphibole assemblage (except that unlike the biotite-muscovite foliae, this must have occurred under virtually stress free conditions.)

Accessory ilmenite is widespread throughout the sequence, virtually irrespective of the host rock type, certainly it is not restricted to the amphibolites. Rutile is a major accessory in samples 13 and 14, commonly as inclusions in plagioclase. Almost certainly these are metamorphic mineral phases, and both more likely to form at higher metamorphic grades than middle-amphibolite facies. Indeed, rutile is very common in granulite facies rocks. Thus these accessory Ti phases also tend to indicate a former higher grade metamorphic assemblage.

The thesis is presented that samples 13 and 14 represent a little-altered former terrain of plagioclase 'granulite', and relicts of this same material exist within the sequence stratigraphically above 13 and 14. In this sequence however the 'granulitic' plagioclase is inherently significantly diluted by other components noteably quartz, and the elements which now form micas, aluminous silicates and amphibole.

This former coarse plagioclase conceivably represents a granulite facies terrain (? Willyama metamorphism), which has been superimposed on by later mid-amphibolite facies event (? Adelaidean metamorphism).

## ORIGINAL ROCK TYPES

The interpretation of original rock types, pre-granulite facies metamorphism and the superimposed middle-amphibolite facies metamorphism postulated above, can only be based on gross mineralogical composition, which alone cannot positively differentiate between original sedimentary or igneous rocks of equivalent bulk chemical composition.

However, the original pre-metamorphic nature of the rocks is commented on, in order of the petrographic groups A to D defined above.

Group A is considered to basically represent a mixed pelitic-psammitic sedimentary facies, now mainly manifest by a predominance of quartz, subordinate micas and fairly common staurolite, kyanite and sillimanite. Variation in aluminous and quartz-rich domains conceivably reflects an original greywacke, shale, i.e. turbidite facies. However those samples excessively rich in plagioclase in this group, probably represent an additional tuffaceous component.

Alternatively this plagioclase-rich variation may be due to metasomatic enrichment which accompanied the first metamorphic event.

Group B - the amphibolites, may represent original basic igneous rocks (i.e. ortho), or a mixed calcareous, magnesic, aluminous sediment (para), or, indeed both may be present.

The extensive dilution of hornblende and plagioclase by quartz and biotite in samples 1 and 5, the apparent relict compositional layering, lack of apatite and epidote, the rare zircons, all suggest that at least these two samples derived from a mixed, impure calcareous sediment. The impurities were probably clastic quartz and pelitic material, but may have also included some tuffaceous material as in the group A facies. The hornblende, biotite, plagioclase quartz schist, no. 18, may be an extreme clastic variant of facies 1 and 5.

However the absence of garnet, and of carbonate, particularly in the amphibolites with minor to negligible quartz-biotite contamination (samples 6, 11, 17), is perhaps anomalous for a sedimentary origin. Rather these 3 rocks may be reconstituted basic sills, or tuffs.

Thus the origin of the amphibolites as a group is most inconclusive.

The coarse plagioclase granulose rocks forming Group C, and the layered, fine plagioclase-dominated schistose gneisses of Group D seem most unlikely to have derived from clastic sediments. Rather these seem to represent an original igneous facies of intermediate-felsic composition, and which was conceivably a tuff or a lava. The layering in the Group D rocks, particularly the intercalated biotite-quartz ± sillimanite layers of probable meta-clastic composition, suggest an original tuff, carrying minor intercalated sediment.

There is no objective, isolated evidence regarding the origin of the sulphide samples. The coarse inclusions of amphibole, quartz, biotite and plagioclase in pyrrhotite are completely non-diagnostic, and indicate an erratic association with all rock groups above.

The several coarse apatite inclusions in sample 4 however, are anomalous, since this mineral is absent from the remainder of the suite, and is possible, very tenuous evidence, of chemically deposited sulphides.

According to the above facies interpretations, Sample 4 underlies a tuffaceous (plagioclase) meta-sediment, and overlies a clastic contaminated (? para) amphibolite.

Sample 19 underlies an amphibolitic plagioclase meta-sediment, and overlies a retrograded diopside (? ortho) amphibolite.

## COMMENTS ON ENVIRONMENTAL MODEL AND CORRELATIONS

In a broad sense, the suite is interpreted as an original (submarine) sequence of intercalated pelitic-psammitic rocks, felsic tuffs, impure calcareous facies and/or mafic tuffs or lavas, together with massive sulphides. My impression from your letter is that the massive sulphides are intercalated and conformable within the sequence.

Thus the collective evidence seems to be that these massive sulphides have a generalised marine, clastic-volcanic association. The sulphide localisation ? may have a specific spatial relationship in that it overlies a predominantly amphibolitic facies in both drill holes (according to the listing of samples given in your letter.)

Regarding correlation with the Kalabity Sequence (questioned in your covering letter), I do not recall any rocks which I have described from there, which correlate with those in this suite.

The plagioclase-rich, probable meta-tuffaceous facies from the Kalabity Sequence may in part correlate with the 'new' fine granuloblastic crystalline plagioclase-rich domains in Group A samples. However, the massive coarse granulose plagioclase samples 13 and 14, while possibly chemically similar to some very felsic samples at Kalabity, are texturally quite different.

Specific comparison of amphibolite samples should be made from both areas, before meaningful comments on possible correlation can be made.

- -

No. 1 : hornblende plagioclase quartz schist
(or schistose quartzose amphibolite),
incipient sericitic, chloritic alteration

This rock has a fairly homogeneous composition and texture, with a compositional layering manifest by minor variations of the essential minerals.

Basically it consists of a micro (0.3 mm) granuloblastic to granoblastic mosaic of quartz (approx 25%) and plagioclase (25 - 30%) in which the grains are commonly elongate in the plane of the layering.

Somewhat ragged subhedral to euhedral prisms of green hornblende (30 - 35%) are ubiquitous throughout this mosaic, more or less in layers, and commonly oriented in the plane of the layering.

The plagioclase is generally turbid with clay 'dust' which may well be supergene, none the less twinning indicates an andesine composition. However about one third of the plagioclase is relatively densely clouded, and extensively replaced by a cluster of fine sericite + clays ± fine epidote (saussurite). This is primary alteration, and is most advanced in the plagioclase-rich layers.

Minor biotite altered to chlorite, and related muscovite occur in some layers. Accessory elongate/amoeboidal grains of ilmenite (3 - 5%), are scattered throughout; lesser pyrrhotite and trace chalcopyrite are also scattered but more or less restricted to poorly defined bands, where they tend to accompany altered silicate minerals.

A vein of saussuritic-uralitic alteration products + accessory pyrite cuts across the layering.

No. 2 : biotite quartz, plagioclase, very fine granulose schist (or fine gneiss)

This rock also has a vaguely defined compositional layering on a scale of about 15 mm; these layers also vary slightly in grain size from an average of 0.5 to 1 mm. Two layers are dominant.

One of these layers consists largely (50%) of a loose aggregate of coarse (2 mm) subhedral plagioclase porphyroblasts, which are also poikiloblastic due to abundant, fine inclusions of quartz, biotite and muscovite, and turbid with clays. These are more or less layered through a finer (0.3 mm) granuloblastic mosaic of untwinned oligoclase, minor quartz and similarly aligned dark brown biotite.

With gradual decrease in abundance of the coarse plagioclase this coarse inequigranular layer merges into the other dominant layer, composed of elongate, granuloblastic mosaic of albite and subordinate quartz, average size 0.5 mm, with minor similarly oriented brown biotite throughout.

Minor relative concentrations of biotite and quartz form thin layers, and accessory anhedral pyrite and chalcopyrite accompany one of these.

<u>No. 3</u> : (staurolite) muscovite-biotite, quartz plagioclase, very fine granulose schist

This rock has a compositional layering on a scale of 2 to 15 mm; the fairly evenly fine to medium size textures in each layer are all 'blastic', the type depending on the mineral components.

The broadest layer consists of a fine, slightly elongate granuloblastic mosaic of quartz and minor to subordinate untwinned plagioclase (? albite), and of wavy fairly continuous foliae of biotite and muscovite. Small (0.1 to 0.6 mm) crystals of staurolite occur in clusters, and in trains along the layering to form about 10% of this band. Clumps of fibrous sillimanite (3 - 5%) occurs in some biotite.

This grades into a much thinner, intercalated foliated band of dark brown biotite, with one margin of potash felspar replacing the biotite. Another intercalated band of coarse foliated biotite is studded with small staurolite crystals.

Remaining, quite broad bands consist of inequigranular, granuloblastic quartz, plagioclase, with minor biotite and staurolite in layers, also minor scattered, coarser turbid plagioclase, having porphyroblastic/poikilitic relationships as in sample 2.

No. 4 : fine aggregate of pyrrhotite carrying minor, scattered, generally single crystals of magnetite, apatite, pyrite, chalcopyrite, biotite, hornblende and quartz (in increasing order of abundance)

About 70% of this rock consists of a fairly massive fine grained sulphide aggregate. In thin section however this aggregate is seen to carry scattered, generally quite coarse (1 - 5 mm) single crystals of anhedral quartz, lesser euhedral hornblende, greenish biotite and single coarse crystal of apatite.

In polished section the sulphide aggregate is seen to consist of almost exclusively fine (0.1 to 0.6 mm), allotriomorphic mosaic of pyrrhotite. Small (0.1 to 0.7 mm) single grains of chalcopyrite, pyrite and magnetite are randomly scattered, but each forms less than 1% of the sample.

No. 5 : (quartz-biotite) schistose amphibolite

This rock consists basically of a foliated (lepidoblastic) mass of intimately interlocking, quite coarse, green hornblende and subordinate brown biotite, each in slightly idfferent abundance in different layers.

Minor finer anhedral quartz (15%) and subhedral; generally untwinned plagioclase (? albite) (20%), are together more or less restricted in mosaics forming discontinuous layers, about 5 mm thick, intimately intergrown with the hornblende and biotite. Sparse minute inclusions of plagioclase and quartz occur in hornblende.

The plagioclase commonly shows minor turbid patchy alteration to clay-sericite.

Trace pyrrhotite grains are present.

No. 6 :  (quartz-biotite) amphibolite

This rock has a similar gross composition to No. 5, although it contains less biotite, more plagioclase, and layering is not so obvious.

Basically a very poorly defined middle band about 10 mm thick in the section, consists of a more or less granuloblastic mosaic of green hornblende, with a finer mosaic of accessory poorly twinned plagioclase, and quartz, more or less intergranular.

A broader band (15 mm) either side of this also consists of an irregular granuloblastic aggregate of hornblende, but with twinned plagioclase (25 - 30%) of labradorite composition, of similar to finer size, forming an essential part of the aggregate. Minor much finer quartz is scattered, intergranular. Coarser brown biotite (10%) is randomly disposed.

Accessory minute grains of ? ilmenite and pyrrhotite are scattered.

No. 7 : (sillimanite quartz biotite) plagioclase gneiss

Compared with most of each sample described above this is a markedly leucocratic rock, albeit with minor (7%) dark foliae fairly evenly spaced at about 10 mm intervals.

About 35% of the rock consists of coarse (to 3 mm) irregularly anhedral rather turbid plagioclase crystals, carrying abundant minute inclusions of quartz and lesser mica. These poikiloblastic/porphyroblasts have a more or less layered distribution through a clearer, somewhat more ordered granuloblastic mosaic, average size 0.5 mm, and composed mainly of apparently albitic plagioclase, and minor quartz.

Accessory extremely fine biotite, ilmenite and sparse rutile are scattered.

Thus the bulk of this rock, except for the accessory phases is much like the coarser more felsic layers in sample No. 2.

The thin dark foliae consist of fine to medium discrete flakes of biotite $\pm$ trace ilmenite, rutile, and rare single sillimanite prisms, through a band of fairly clear near-polygonal albite mosaic.

No. 8 : (plagioclase) muscovite biotite quartz fine gneiss

Compositional layering on a scale of about 5 mm is manifest as bands dominated by foliated micas, intercalated at frequent intervals with bands of fine (0.5 mm) granulo-blastic, irregularly polygonal, felspathic-quartz mosaic.

The micaceous foliae consist of a generally similar amount of intimately intergrown biotite and muscovite.

The intercalated fine granulose bands consist predominantly of near-polygonal quartz (? 50%) with generally minor poor or un-twinned plagioclase (? 20 - 30%), and scattered fine single flakes of biotite (10 - 15%) and magnetite (7 - 10%). Albite is more abundant in some bands. Trace pyrrhotite is present.

Thus quartz and muscovite are relatively more abundant than in most quartzo-felspathic rocks above. Also the magnetite is fairly distinctive.

No. 9 : (biotite plagioclase) muscovite quartz fine gneiss

This rock also contains proportionately more quartz and muscovite than in most samples above, indeed it compares with sample No. 8, although the quartzose layers are slightly coarser and relatively inequigranular.

Fairly evenly and closely spaced, somewhat wavy foliae of medium sized muscovite (30 -35%) with minor intergrown biotite (10%), are quite continuous through a markedly inequigranular granuloblastic aggregate of quartz (35%) and lesser plagioclase (15 - 20%).

The inequigranular texture is manifest as irregularly rounded single and polycrystalline quartz grains (2 - 3 mm), and rare turbid, ragged plagioclase of this size, distributed in vague layers through a finer mosaic of quartz, turbid, stressed anhedral plagioclase, and smaller, clearer, well twinned (recrystallised) albite.

Trace to accessory very fine grains of chalcopyrite and magnetite are scattered.

No. 10 : (biotite) quartz, plagioclase fine gneiss

This rock is layered on a scale of 2 to 15 mm; it compares very largely with sample No. 7, and to a lesser extent with No. 2 described above.

Two major bands in the section consist of a loose packed aggregate of subhedral to anhedral, coarser, turbid plagioclase crystals, ranging in size from 2 to 4 mm, vaguely layered within a microgranuloblastic mosaic of much finer (0.5 mm) clearer albitic-plagioclase, subordinate quartz, and minor biotite. These coarse crystals commonly contain abundant very fine inclusions of quartz and rare micas, and their boundaries are highly irregular where they appear to be encroached upon by the matrix.

Minor small single crystals of rutile are scattered through this band.

A thinner layer between these two layers consists of essential, quite coarse biotite, relatively concentrated into a foliation, within a fairly homogeneous fine (0.5 mm) near-polygonal mosaic of albite and minor quartz. This thin intercalated layer is therefore essentially the same as the matrix in the coarser bands, but with relatively concentrated biotite.

No. 11 : quartz amphibolite

About 50% of this rock consists of a vaguely layered fairly tight crystalline aggregate of green hornblende, in variable and rather patchy grain size of 0.1 to 1 mm. Some crystals are crowded with fine quartz inclusions, and/or intergrown with more or less graphic quartz.

Subhedral to anhedral, reasonably well twinned crystals of plagioclase (15 - 20%), of andesine-labradorite composition, have a vaguely layered distribution, but form an essential part of the rock aggregate.

Relatively distinctly anhedral plagioclase (25%) show diffuse twinning in calcic cores with diffuse zoned more sodic margins. They are commonly partly sericitised, ± minor saussurite and have a layered distribution as part of the essential aggregate.

Generally much finer anhedral quartz (7 - 10%) is more or less interstitial but does tend to be more abundant in some poorly defined bands, and in patches.

Accessory very small anhedral grains of ilmenite (1 - 2%) are scattered.

No. 12 : muscovite biotite sillimanite quartz plagioclase 'gneiss' (with layers of essentially quartzite)

This rock has a compositional layering on a scale of 5 to 10 mm. The broadest and most leucocratic of these consists of a fine granoblastic to granuloblastic mosaic of quartz and minor (fairly clear) albitic plagioclase), with minor similarly oriented but single plates of muscovite and chloritised biotite. This band is basically a quartzite.

The darker, thinner foliated layers consist of essential biotite, sillimanite, minor muscovite, accessory hematite and trace pyrite, through a fine granular mosaic of quartz and turbid albitic plagioclase. Sillimanite is rarely altered to sericite. The hematite carries fine exsolution lamellae of ilmenite.

Layers between these micaceous foliae consist of fine granulose quartz-plagioclase mosaic, including some (inequigranular), coarser polycrystalline quartz and turbid weakly poikiloblastic plagioclase (as for example in sample No. 9). Minor micas, accessory altered sillimanite and trace ilmenite also occur in these bands.

No. 13 : massive coarse granulose plagioclase rock, stressed and partly recrystallised

The coarse, metamorphic granulose texture and highly felsic composition is characteristic of this rock. The felspar is predominantly essentially albite (in spite of the predominantly pink colour of the hand specimen, which superficially suggests a potassic felspar composition).

About 75% of the section consists of a fairly tight, random aggregate of stressed, turbid plagioclase crystals, average and fairly consistent size about 3 mm. These carry sparse fine inclusions of quartz and micas. They have an essentially anhedral form with highly irregular serrated margins, due to granulation/recrystallisation along contacts with adjacent crystals.

Intergranular 'matrix' is highly irregular and poorly defined, but does consist largely of granulated/recrystallised plagioclase micromosaic, with minor fine quartz and muscovite, and very fine crystals of rutile (3%).

Minor superimposed shears contain muscovite and quartz.

No. 14 : massive coarse granulose plagioclase rock, stressed and partly recrystallised

This is essentially the same as sample No. 13. However the microcrystalline albite mosaic is more extensive between the aggregate of coarse stressed and deformed albite crystals, and along serrated marginal contacts of these. This reflects a slightly more advanced intergranular granulation/recrystallisation within a coarse plagioclase aggregate. Minor fine muscovite, quartz and very small crystals of rutile are scattered through the recrystallised plagioclase domains.

Another small difference with sample No. 13, is that minor coarse polycrystalline quartz forms part of the coarse felsic aggregate.

No. 15 : (muscovite) plagioclase, kyanite biotite, quartz fine 'gneiss'

This rock has a compositional banding on a scale of about 15 mm, but with finer micaceous foliations within some bands, more abundant than in others.

These relatively more foliated bands are characterised by foliae of biotite and intergrown muscovite, fairly common, elongate (lepidoblastic) prisms of mainly (colourless) kyanite, and accessory squat euhedral crystals of amber to yellowish staurolite. These occur through a slightly elongated, otherwise polygonal micromosaic of quartz, with poorly or untwinned albite.

The relatively more massive bands consist of an inequigranular, albeit generally fine granoblastic to granuloblastic mosaic of quartz, subordinate albite, and minor, scattered similarly oriented biotite and muscovite. Accessory fine ilmenite is also scattered through these bands.

No. 16 : (plagioclase) staurolite muscovite biotite, quartz schist or fine 'gneiss'

The bulk of this rock consists of wavy, foliae of quite coarse muscovite, and subordinate, intimately intergrown biotite; quite continuous and closely spaced, through a generally fine, but somewhat inequigranular, near-polygonal micromosaic of quartz and minor untwinned albite.

Whereas the average grain size of this mosaic is 0.25 mm, coarser (1 - 2 mm) polycrystalline grains of quartz are scattered to form about 25% of the quartzose layers. Minor turbid, irregularly anhedral coarser plagioclase crystals are scattered, reminiscent of those in several felsic rocks described above.

The most diagnostic feature in this rock however is the commonly oriented ragged prisms of stauorlite (25%), up to 2 x 5 mm, typically with abundant small quartz inclusions. These lie in the generally more micaceous layers, and some more squat crystals of staurolite form porphyroblastic knots within biotite foliae, intergrown with quartz.

Accessory magnetite is disseminated.

No. 17 : diopside amphibolite, in which former diopside is completely pseudomorphically replaced by extremely fine actinolite (? uralite)

This rock has an homogeneous composition and texture; it is vaguely layered by virtue of generalised elongation of the mafic minerals which are evenly disposed to form an essential part of the aggregate described below.

It consists of a loose aggregate of interconnected, slightly elongate subhedral to euhedral pseudomorphous crystals (30%), composed of extremely fine bluish green actinolite mat, which encloses relatively discrete, fine brown hornblende (10 - 15%). These composite mafic grains more or less enclose individual euhedral plagioclase crystals (40 - 50%), average and consistent size about 1 mm.

The uralite pseudomorphs appear to selectively replace former diopside. The hornblende is essentially unaltered.

The plagioclase is very clear, with well-defined twinning indicating an andesine to labradiorite composition.

Trace to accessory very fine ilmenite and/or magnetite is disseminated.

No. 18 : hornblende biotite, plagioclase quartz, fine granulose schist or fine 'gneiss'

The bulk of this rock (50 - 60%) consists of a fine (0.5 to 1 mm) granuloblastic (near-polygonal) mosaic of plagioclase and minor to subordinate quartz. The plagioclase is quite unaltered, with fairly clear twinning indicating an oligoclase to andesine composition.

Quartz tends to be slightly more abundant in poorly defined patches and layers, than in the aggregate of the rock as a whole.

Brown biotite (25 - 30%) and green hornblende (10 - 15%) as fairly discrete plates, are scattered with similar orientation throughout the (quartz) plagioclase aggregate, with a vague tendency to be differentiated into layers.

Minor turbid plagioclase crystals, carrying minute quartz inclusions are slightly coarser than normal, and compare with similar plagiodase in several samples above.

Accessory fine magnetite (? ilmenite) and pyrite are dissminated.

No. 19 : massive pyrrhotite with minor intergrown chalcopyrite, inclusions of magnetite and various silicate phases

This is a sample of fine grained massive sulphide. In thin section it is seen to carry numerous silicate-mineral inclusions, average size about 4 mm. These consist mainly of single and polycrystalline grains of quartz; and of turbid-plagioclase composite with altered hornblende; also fragments of quartz-albite-biotite schist or gneiss. Single plates of biotite are also scattered.

In polished section the great bulk of the sulphide is seen to consist of a fine to medium aggregate of pyrrhotite, essentially as in sample No. 4. This carries minor alltriomorphic grains, or patches of chalcopyrite (more than in sample No. 4) and accessory small single crystals of magnetite (the same as in sample No. 4).

APPENDIX D

GEOCHEMICAL REPORT

- DIAMOND DRILL HOLE MM14

Report AC 4486/79 by Amdel

The Australian
Mineral Development
Laboratories

...ington Street, Frewville,
South Australia 5063
Phone Adelaide 79 1662
Telex AA 82520

Please address all
correspondence to
P.O. Box 114 Eastwood
SA 5063
In reply quote:

amdel

# NATA CERTIFICATE

AC12 05-0083 1/15/0
-4486/79

21 June 1979

The Director General,
Department of Mines & Energy,
PO Box 151,
EASTWOOD, SA 5063

Attention: D.J. Flint

## REPORT AC 4486/79

YOUR REFERENCE: Application dated 4 May 1979

IDENTIFICATION: As listed

LOCATION: DDH DDMM14 (Mutooroo Mines)

DATE RECEIVED: 10 May 1979

Enquiries quoting AC 4486/79 to the Manager please

D.K. Rowley
Manager
Analytical Chemistry Division

D.G. Boundtel
for Norton Jackson
Managing Director

mhb

...lot Plant: Osman Place
Thebarton S.A.
Telephone 43 8053
...anch Laboratory: Perth

# THE AUSTRALIAN MINERAL DEVELOPMENT LABORATORIES

## DATA LAYOUT FOR METALSCAN

METALLIC RESOURCES
FORM DP 29

AMDEL PROJECT NO ..............   SADM PROJECT NO ..............

AMDEL REPORT NO 4486/79 ....   SADM PROJECT NAME ..............   SHEET .... OF ......

DATE ..............

| Detection Limit | 200 | 5 | 20 | 10 | 3 | 5 | 100 | 50 | ~~100~~ 50 | 10 | 0.1 | 50 | 1 | 1 | 1 | 30 | 1 | 20 | 3 | 100 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A-G NUMBER | Ba | Co | Cr | Mn | Mo | Ni | V | W | La | Y | Ag | As | Bi | Cu | Pb | Sb | Sn | Zn | Au | P | | |
| A2014/79 | 500 | 40 | 400 | 300 | X | 150 | 150 | X | 150 | 50 | 0.1 | X | X | 10 | 300 | X | X | 200 | X | 700 | | |
| A2015/79 | 600 | 100 | 80 | 300 | X | 600 | 400 | X | 50 | 200 | 0.2 | X | X | 40 | 200 | X | 1 | 40 | X | 100 | | |
| A2016/79 | 1000 | 40 | 300 | 700 | X | 50 | 200 | X | 150 | 50 | 0.1 | X | X | 5 | 20 | X | X | X | X | 200 | | |
| A2017/79 | 700 | 30 | 150 | 600 | X | 40 | 200 | X | 100 | 60 | 0.2 | X | X | 10 | 100 | X | 1 | 30 | X | 300 | | |
| A2018/79 | X | 80 | 400 | 2000 | X | 150 | 200 | X | X | 10 | 0.1 | X | X | 100 | 50 | X | X | 150 | X | X | | |
| A2019/79 | X | 80 | 400 | 2000 | X | 200 | 300 | X | X | 20 | 0.1 | X | X | 100 | 50 | X | X | 70 | X | X | | |
| A2020/79 | 500 | 40 | 80 | 200 | X | 40 | 100 | X | X | 50 | X | X | X | 5 | 30 | X | X | X | X | 5000 | | |
| A2021/79 | X | 80 | 150 | 100 | X | 10 | 70 | X | 50 | 40 | X | X | X | 20 | 100 | X | X | 40 | X | 300 | | |
| A2022/79 | X | 300 | 100 | 100 | X | 30 | 60 | X | 100 | 50 | X | X | X | 5 | 80 | X | X | 30 | X | 200 | | |
| A2023/79 | X | 600 | 300 | 200 | 15 | 50 | 100 | X | 150 | 50 | X | X | X | 150 | 80 | X | X | 50 | X | 300 | | |
| A2024/79 | 800 | 40 | 200 | 100 | X | 70 | 200 | X | 200 | 100 | 0.3 | X | X | 10 | 100 | X | X | X | X | X | | |
| A2025/79 | X | 200 | 70 | 1000 | X | 150 | 100 | X | X | 30 | 0.3 | X | 1 | 200 | 200 | X | 4 | 200 | X | X | | |
| A2026/79 | 800 | 30 | 150 | 300 | X | 50 | 200 | X | 100 | 50 | 0.4 | X | X | 20 | 100 | X | X | X | X | 100 | | |
| A2027/79 | 500 | 10 | 150 | 300 | X | 40 | 150 | X | 150 | 60 | 0.3 | X | X | 10 | 50 | X | X | X | X | 300 | | |
| A2028/79 | X | 100 | 200 | 1000 | X | 150 | 400 | X | X | 20 | 0.3 | X | X | 50 | 80 | X | 1 | 150 | X | X | | |
| A2029/79 | 200 | 200 | 150 | 800 | X | 150 | 1000 | X | X | 50 | 0.3 | X | X | 150 | 40 | X | X | 200 | X | X | | |
| A2030/79 | X | 100 | 200 | 1000 | X | 100 | 400 | X | X | 50 | 0.1 | X | X | 150 | 50 | X | X | 100 | X | X | | |
| A2031/79 | X | 80 | 150 | 800 | X | 100 | 200 | X | 200 | 40 | 0.1 | X | X | 10 | 70 | X | 4 | 30 | X | X | | |
| A2032/79 | X | 20 | 200 | 800 | X | 200 | 200 | X | 50 | 10 | X | X | X | 30 | 30 | X | X | X | X | 100 | | |
| A2033/79 | X | 40 | 200 | 300 | X | 200 | 300 | X | X | 10 | 0.1 | X | X | 10 | 40 | X | X | 30 | X | X | | |
| A2034/79 | 400 | 100 | 60 | 500 | X | 100 | 400 | X | X | 50 | 0.4 | X | X | 50 | 100 | X | 4 | 80 | X | 500 | | |
| A2035/79 | 300 | 300 | 80 | 1000 | X | 70 | 200 | X | 100 | 30 | X | X | X | 10 | 60 | X | X | 30 | X | X | | |
| A2036/79 | X | 150 | 600 | 3000 | X | 150 | 400 | X | X | 70 | 0.1 | X | X | 150 | 200 | X | 5 | 100 | X | X | | |
| A2037/79 | 1000 | 40 | 60 | 300 | X | 40 | 40 | X | 150 | 40 | 0.1 | X | X | 40 | 200 | X | X | 50 | X | X | | |
| A2038/79 | X | 80 | 80 | 3000 | X | 40 | 200 | X | X | 30 | 0.2 | X | X | 200 | 50 | X | X | 200 | X | 500 | | |

**NOTE:** 9997 : 10000 ppm   9998 : > 10000 ppm   9999 : >> 10000 ppm

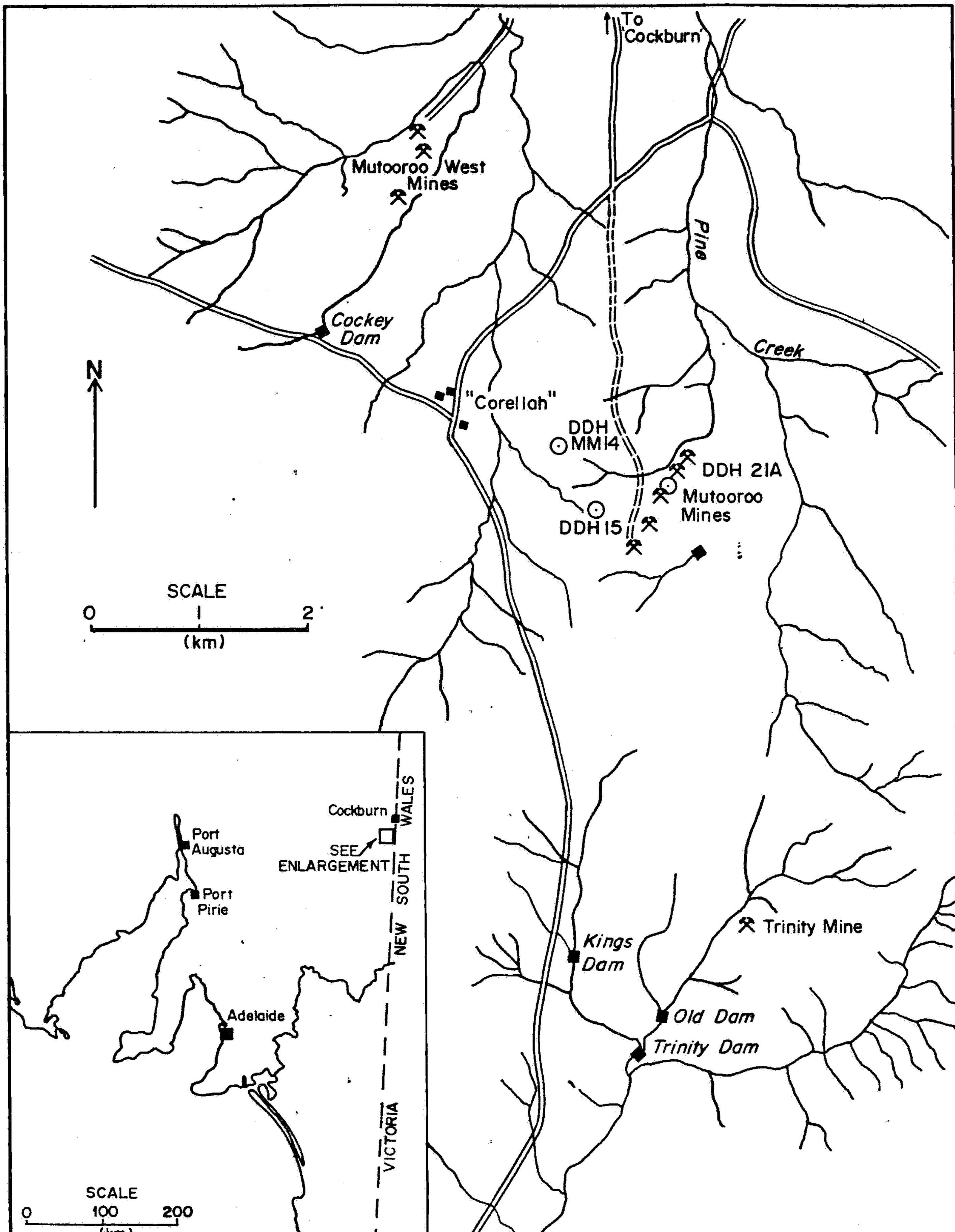
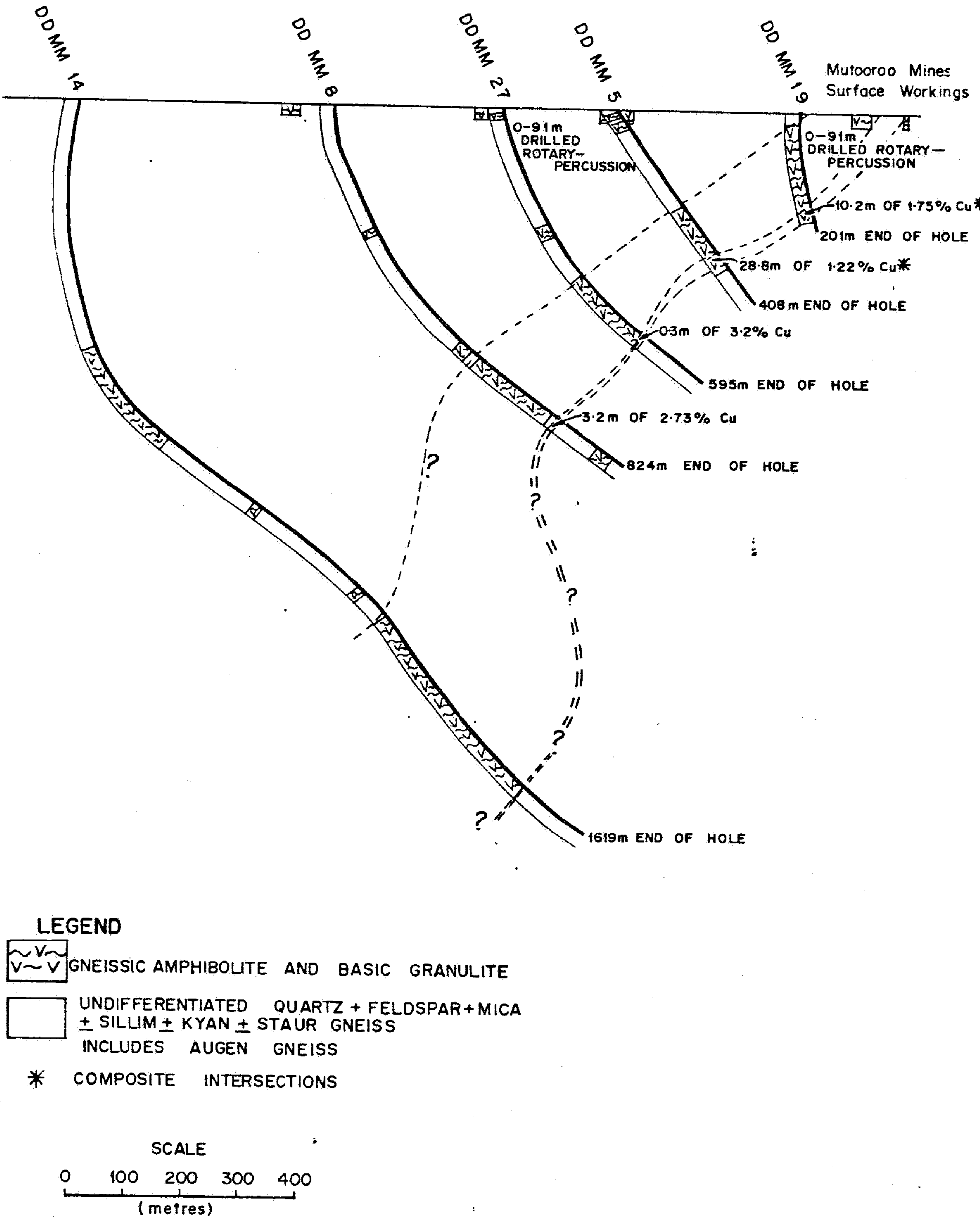



FIG. 1

| | | |
|---|---|---|
| | DEPARTMENT OF MINES AND ENERGY<br>SOUTH AUSTRALIA | SCALE As shown |
| COMPILED D.J.F. | MUTOOROO MINES-RELOGGING OF DDH MM14<br>LOCALITY PLAN | DATE August 1979 |
| DRN S.R. CKD | | PLAN NUMBER<br>S14221 |



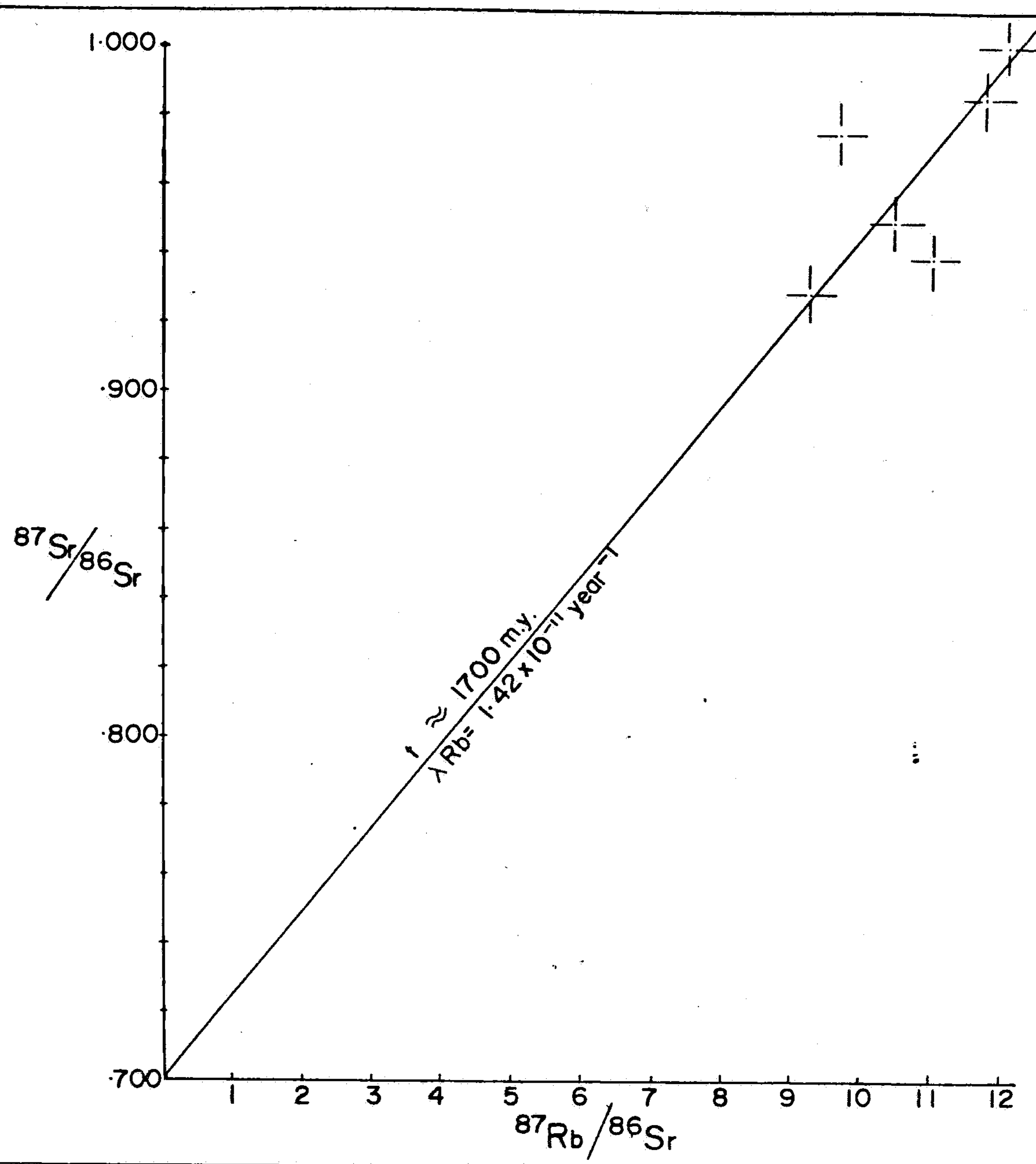

MODIFIED FROM MINES EXPLORATION PTY. LTD. (1962-1974)

FIG. 2

| | | |
|---|---|---|
| | DEPARTMENT OF MINES AND ENERGY<br>SOUTH AUSTRALIA | SCALE 1:10 000 |
| COMPILED D.J.F. | MUTOOROO MINES-RELOGGING OF DDH MM 14<br>CROSS-SECTION | DATE August 1979 |
| DRN SR. | CKD | | PLAN NUMBER<br>S14222 |

1540

FIG. 3




| SAMPLE No. | DEPTH(m) | Rb/Sr | $^{87}Rb/^{86}Sr$ | $^{87}Sr/^{86}Sr$ |
|---|---|---|---|---|
| 7033— | | | | |
| RS 89 | 825·9 | 3·980 | 11·804 | 0·9850 |
| RS 90 | 827·9 | 4·066 | 12·079 | 1·0018 |
| RS 92 | 832·9 | 3·271 | 9·6931 | 0·9759 |
| RS 93 | 836·3 | 3·735 | 11·029 | 0·9388 |
| RS 95 | 840·2 | 3·122 | 9·2095 | 0·9282 |
| RS 96 | 842·0 | 3·541 | 10·466 | 0·9491 |

| | | |
|---|---|---|
| | DEPARTMENT OF MINES AND ENERGY<br>SOUTH AUSTRALIA | SCALE |
| COMPILED D.J.F. | MUTOOROO MINES-RELOGGING OF DDH MM14<br>Rb/Sr GEOCHRONOLOGICAL RESULTS | DATE August 1979 |
| DRN S.R. CKD | | PLAN NUMBER<br>S 14223 |

1540