INVESTIGATION OF THE TUNGSTEN
POTENTIAL OF EXPLORATION

LICENCE NO. 3466
HARTS RANGE CENTRAL AUSTRALIA

PREPARED ON BEHALF OF
UNION OIL DEVELOPMENT CORPORATION

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SUMMARY

Scheelite mineralization within E.L. 3466 was originally indicated by heavy mineral stream sediment geochemistry and subsequently confirmed by night lamping. The area is extremely complex structurally and is dominated by northerly trending and easterly dipping isoclinal folds. At least three periods of deformation are indicated in parts of the area.

The mineralization found to date preferentially occurs within calc-silicate bearing quartzites (possibly reworked acidic tuffs) which occur within the "upper" member of the Proterozoic Brady Gneiss. Stream sediment geochemistry suggests that some mineralization may also occur in the "lower" member of the same formation.

In the Brumby Bore area, where the strongest quartzite-hosted mineralization occurs, remobilization of the scheelite during deformation is indicated. Most of the mineralization in this area is localised at the crests of very small (wavelengths of a few centimetres) isoclinal folds.

Although scheelite mineralization is wide-spread, grades are generally low and individual occurrences are extremely small. Work to date has failed to indicate potential for economic concentrations of scheelite and no further work is recommended.
1. **INTRODUCTION**

Exploration Licence 3466 was acquired by Union Oil Development Corporation (UODC), with a view to investigating the areas tungsten potential, following a detailed review of the available geological data on the eastern portion of the Arunta Block.

This report has been prepared by Peter Goldner & Associates on behalf of UODC and specifically deals with work undertaken by the writer during 1983. Results from work carried out by UODC staff during the 1982 field programme have also been incorporated into this report.

Initial work during 1982 involved a helicopter supported heavy mineral stream sediment sampling programme and some limited anomaly follow-up.

During the current 1983 field programme the licence area was investigated in more detail, with most work being concentrated on two areas where comparatively strong tungsten anomalies had been defined the previous year.

2. **LOCATION & ACCESS**

The area under investigation is located approximately 300 road kilometres east northeast of Alice Springs (see Inset to Figure 1). Access from Alice Springs is via the main Stuart Highway north for 70 kms to the Plenty River Highway then easterly along this latter highway for 186 kms to the Indiana Homestead turnoff. The northern boundary of the area lies approximately 20 kms south of the turnoff along the Indiana road.

Within the licence area numerous station tracks facilitate access. Water is available from a number of station bores and
dams scattered throughout the area. A light aircraft landing ground is available at Indiana Homestead at the southern edge of the tenement area.

3. TENEMENT DETAILS

Exploration Licence 3466, covering an area of 248.77 sq. kms, was granted to Union Oil Development Corporation on January 8, 1982 for an initial period of twelve months. The area was subsequently renewed in full until January 7, 1984.

The boundaries of the licence area are described below and are shown on Figure 1.

Commencing at the intersection of latitude 23 degrees 05 minutes with longitude 135 degrees 23 minutes thence proceeding to the intersection of latitude 23 degrees 05 minutes with longitude 135 degrees 28 minutes thence proceeding to the intersection of latitude 23 degrees 20 minutes with longitude 135 degrees 22 minutes thence proceeding to the intersection of latitude 23 degrees 16 minutes with longitude 135 degrees 23 minutes thence proceeding to the intersection of latitude 23 degrees 05 minutes with longitude 135 degrees 23 minutes.

4. PREVIOUS HISTORY

Numerous small pegmatite-hosted mica deposits, forming part of the Harts Range Mica Field, have been worked in the past from within and around E.L. 3466, however production was very limited. Beryl, frequently occurs associated with the mica and uranium and niobium mineralization was noted in a mica deposit just to the west of the licence area. Details of the Harts Range Mica Field can be found in Joklik 1955*.

The most recent detailed investigation of the area, predating the current programme, was undertaken by the Bureau of Mineral Resources (BMR) as part of the regional mapping of the Quartz 1:100,000 geological sheet. The 1:25,000 preliminary compilation maps produced by the BMR were obtained and utilized in the present programme.

The presence of tungsten mineralization within the area does not appear to have been recognized prior to UODC's activities. Regionally however, tungsten (in the form of scheelite) has been known for some time in the Bonya, Molyhil and Jervois areas north and northeasterly from E.L. 3466. Minor scheelite mineralization has also been noted previously in the vicinity of Valley Bore on the Mt. Riddock 1:100,000 sheet east of E.L. 3466.

5. **UODC EXPLORATION PROGRAMME**

5.1. **General Statement**

Initial exploration of the area during 1981/82 consisted of regional heavy mineral stream sediment sampling, preliminary follow-up of visually determined scheelite and limited thin section petrological examination of some of the scheelite bearing units.

During the current 1983 programme the following work was undertaken:

1. Geological reconnaissance of the licence area utilizing 1:25,000 colour aerial photographs to establish a broad understanding of the stratigraphy and structure of the area.

2. Infill heavy mineral stream sediment sampling.

3. Detailed mapping and evaluation of a small area, to the west of Brumby Bore in the central part of the licence using enlarged (1:8,500) aerial photographs. Wide-spread scheelite mineralization had been detected in this area during the 1982 programme. Another area of scheelite mineralization near the Mirror Finish Dam area was also investigated although no detailed mapping was undertaken.
4. Thin section petrological examination of a representative suite of the various lithologies within E.L. 3466.

5. Trace element geochemical studies on a suite of rocks from the area.

5.2 Geology of E.L. 3466

During the current programme work concentrated on the detailed examination of the Brumby Bore and, to a lesser extent, on the Mirror Finish Dam areas where indications of scheelite mineralization are present.

A number of regional geological traverses, utilizing 1:25,000 colour airphotographs, have been completed mainly in the poorly exposed eastern and northern portion of the licence. This work was curtailed due to rain and the western central and southern portions of the licence area have not been adequately inspected by the writer. The geology shown on Plan 1, as well as the descriptions below, incorporate a considerable amount of data from the BMR 1:25,000 geological compilation sheets.

The units underlying E.L. 3466 belong to the upper two Formations of the Early Porterozoic Harts Range Group, i.e. the Irindina Gneiss and Brady Gneiss. Both Formations have been further subdivided by the BMR. The lower Irindina Gneiss contains a unit known as the Stanovos Gneiss Member while the Brady Gneiss has been subdivided into an "upper" ($RChb_2$) and "lower" ($RChb_1$) unit. For the purposes of Plan 1 and Figure 2 the Stanovos Gneiss is shown as a separate formation. The various units are briefly described below.

5.2.1. The Stanovos Gneiss - $RChS$

This unit consists of a sequence of biotite, quartzo-feldspathic and porphyroblastic feldspar gneisses, quartzites, calc-silicate rocks and marble. The gneisses are typically coarse grained with a strong schistose texture and in places vary to coarse
MAINLY GARNET-BEARING MUSCOVITE-BIOTITE-QUARTZ RICH SCHIST & GNEISS, SOME CALCISILICATE ROCK.

GARNET-BIOTITE-QUARTZ-PLAGIOCLASE GNEISS; SOME COMMONLY GARNETIFEROUS QUARTZOFELDSPHATIC GNEISS

BIOTITE GNEISS; PORPHROBLASTIC FELDSPAR GNEISS; QUARTZOFELDSPHATIC GNEISS, MARBLE ZONES.
grained schists. Two samples from this unit (Q135 and Q138B) have been thin sectioned and petrographic descriptions are included in Appendix 2. Both rocks are coarse grained gneisses, Q138B is crudely banded, contains K-feldspar porphyroblasts and has a higher biotite content than Q135. Original textures have been destroyed however a single rounded quartz grain in Q138B indicates a sedimentary origin and the rocks were probably arkoses.

5.2.2. The Irindina Gneiss - EChi

As shown on Plan 1 and Figure 2, this unit occurs as a wedge of metasediment between the underlying Stanovos Gneiss and the overlying Brady Gneiss. This unit was not traversed during the current programme however the BMR describe it as interbedded schistose garnet-biotite-quartz-plagioclase gneiss, biotite gneiss, para-amphibolite and calc-silicate rock.

5.2.3. The Brady Gneiss - EChb

The main part of the licence area is underlain by this unit and it has been subdivided by the BMR into a "lower" (EChb₁) and "upper" (EChb₂) unit.

Where inspected in the field EChb₁ unit is dominated by gneissic rocks varying from gneissic biotite-(muscovite) schists to feldspar-biotite gneisses. BMR mapping suggests that a garnet-muscovite-biotite gneiss is the dominant rock type however this unit was not present in the areas traversed in the current programme.

The EChb₂ unit is the host to scheelite mineralization in the Brumby Bore and Mirror Finish areas and has consequently been investigated in detail during the current programme. In general terms it appears to contain finer grained lithologies than EChb₁ and is essentially an interbedded sequence of biotite schists, quartz-feldspar-biotite meta-arenites, ortho-amphibolites and
calc-silicate bearing quartzites. Gneisses are comparatively subordinate and were only noted in the northern part of the licence. Detailed lithological data is presented in Sections 5.4 and 5.5 and will not be repeated here.

The BMR have suggested the EChb₁ unit lenses out in the southern part of the licence as shown on Figure 2. Based on the results from the current field programme and the lithological descriptions shown on the BMR compilation sheets the boundary between the two Brady Gneiss units has been revised as shown on Plan 1.

5.3 Stream Sediment Geochemistry

5.3.1 Survey Method

At each sample location a large panning dish of sieved stream sediment was collected and subsequently panned down to a heavy mineral concentrate. The concentrate was examined under ultra-violet light and the number and size of the scheelite grains present recorded. Samples were then sent to Comlabs Pty. Ltd. in Perth for analysis. Initial samples collected in 1982 were analysed for tungsten, tantalum, tin, niobium, chromium, yttrium and lanthanum/celenium. A later series of samples collected the same year were analysed for tungsten, tantalum, tin and gold while the infill samples collected during the 1983 programme were analysed only for tungsten.

5.3.2 Results

Total grain counts (scheelite) and the tungsten analyses in ppm are shown on Plan 2 while the full analytical results and grain count data are presented in tabulated format in Appendix 1. A cumulative probability plot of the tungsten results is shown as Figure 3. The inflection point for the curve shown is about 130 ppm W and this value has been used as a threshold for E.L. 3466. Two subjectively chosen values above and below the threshold have been used to divide the results into four class intervals for the purposes of Plan 2. A number of samples in the Mirror Finish area
TUNGSTEN IN HEAVY MINERAL CONCENTRATES

E1.3466 ARUNTA BLOCK, CENTRAL AUSTRALIA

FIG. 3

INFLECTION POINT 130 ppm W
were misplaced and it has been necessary to estimate in which class interval they would be likely to occur on the basis of the grain count information.

Three zones of tungsten anomalism have been outlined by the stream sediment results. Anomaly 1 corresponds to the Brumby Bore scheelite occurrence which was investigated and mapped in some detail during the 1983 programme and is discussed in Section 5.4. Anomaly 3, to the west of Mirror Finish Dam has also been inspected in the field although it was decided that detailed mapping was not warranted on the basis of the visible mineralization present (see Section 5.5). Anomaly 2, has not been inspected in the field.

The anomalous value (sample No. 3647) between Anomalies 1 and 2 has not been designated as an individual anomaly as it is only marginally above the threshold and is not supported by results from adjacent creeks. When compared with the regional geological map of the area (Plan 1) Anomalies 1 and 3 lie within the "upper" unit of the Brady Gneiss whereas Anomaly 2 appears to be underlain by the "lower" unit of the same formation. Field work in the Anomaly 1 and 3 areas indicates a similar stratigraphic succession is present (see Sections 5.4 and 5.5).

5.4 The Brumby Bore Scheelite Occurrence

This area is located in the central western part of the licence approximately 5 kms southwest of Brumby Bore. The mineralization was initially detected by the stream sediment sampling results (as shown on Plan 2, Anomaly 1) and subsequently confirmed by night lamping using ultra-violet lamps. Scattered scheelite mineralization was noted over a considerable area and the region of interest was mapped in detail at a scale of 1:8,500 using enlarged 1:25,000 colour air photographs. Plan 3 is a geological outcrop map while Plan 4 is an interpretative geological map. Plan 5 is a sample location map for the same area.
5.4.1. Detailed Geology

A number of separate lithologies have been recognised within the area covered by the detailed mapping (Plans 3 and 4). These are as follows:-

(a) Coarse grained quartz-biotite schist
(b) Granular, medium to fine grained quartz-biotite-(feldspar) meta-arenite
(c) Calc-silicate bearing quartzite
(d) Amphibolite
(e) Pegmatites

These various lithologies are described in more detail below:

(a) Coarse grained Biotite Schist
This unit is typically strongly schistose, and occasionaillion banded with mafic biotite rich bands alternating with lighter bands richer in quartz and feldspar. Individual bands rarely exceed 0.5 cms in width. Some varieties of this lithology contains comparatively large elongate white patches of what appears to be clay and these probably represent weathered or retrograded feldspar porphyroblasts.

Sample Q96A is a representative sample of this unit and a petrographic description can be found in Appendix 2. The rock is considered to have been originally a pelitic sediment.

(b) Granular, medium to fine grained quartz-biotite (feldspar) meta-arenite
This unit is typically mesocratic and usually has a characteristic fine to medium grained saccaroidal texture, although in places it varies to a harder quartzitic unit. The unit commonly has a weak to moderate schistosity which is defined by the preferred orientation of the biotites.

In thin section (sample Q56, Appendix 2) the rock consists largely of quartz and biotite with only relatively minor plagioclase present. Some textural evidence (rounded quartz and zircon grains) indicates a detrital origin for this unit and the original rock was probably a "dirty" sandstone.

(c) Calc-silicate bearing quartzites
A number of different quartzites were distinguished during field mapping viz.:-
(i) A garnet bearing quartzite

(ii) a leucocratic quartzite containing small amphibole laths and

(iii) a melanocratic amphibole rich quartzite with rare scattered garnets.

All the quartzite units are usually fine to medium grained, equigranular and variably banded. For the purposes of Plan 3 the quartzites were categorized into a garnet bearing quartzite (i) above) and an essentially garnet-free quartzite which includes (ii) and (iii) above. In the latter case the difference in colour index is indicated on Plan 3 by means of annotated comments.

(i) Garnet bearing quartzite

This unit is typically pale green to cream with either aggregates or, single crystals of pale pink garnet. In some samples compositional banding (alternating pink garnet-rich bands and green diopside/clinozoisite-rich bands) is well developed. In a number of cases a quartzite with pale brown garnets was noted however, no subdivision into a separate unit is made.

Samples Q14B, 16A, 49, 94, 95A, 95B, 120 and 122 (Appendix 2) are all included in this unit. In thin section the rocks typically contain a high proportion of quartz associated with plagioclase, diopside, garnet often clinozoisite or zoisite and minor hornblende. Compositional banding was frequently noted and probably reflects original bedding.

(ii) Leucocratic Quartzite

The leucocratic quartzite typically contains small green to brownish laths of amphibole in a fine grained siliceous matrix. Although garnet is rare, or more commonly absent, from this lithology layers of the garnet bearing quartzite ((i) above) frequently occur within the leucocratic quartzite and the two rock types are almost certainly facies variants. The distinction between the two units on Plan 3 is based on which quartzite was dominant in any given area. It may be significant however that the garnet bearing quartzite tends to predominate where coarse biotite schist ((a) above) is present. The leucocratic quartzite commonly occurs associated with the granular meta-arenite ((b) above).

Two samples of this unit have been thin sectioned (Q65 and 68, Appendix 2) and petrologically they are almost identical to the garnet bearing quartzite. In fact Q65 contains minor garnet and Q68 contains some vesuvianite.
(iii) **Melanocratic Quartzite**
This unit occurs as a dark, amphibole rich quartzite and in hand specimen some samples appear to be massive fine grained amphibolites. Occasional red (rather than pale pink) garnets occur and the unit, when present, is quite thin and always in close association with (ii) above. It is likely that it is merely a compositional layer within the leucocratic quartzite.

Sample Q125 is an example of this unit and petrographically (Appendix 2) consists of hornblende, quartz, plagioclase and minor poikiloblastic garnet. Apart from the relative proportions of the various mineral constituents it is compositionally very similar to the other quartzites.

The three quartzite varieties described above are, in general, quite similar and gradations between the various sub-types is not uncommon. Metamorphism has destroyed original textural information however in a few cases some rounded quartz grains have been noted. It is felt that the rocks may have originally been reworked acid tuffs deposited or re-deposited under marine conditions.

(d) **Amphibolite**
This is characteristically a thin discontinuous unit ranging from 2-8m thick in outcrop. The rock has only been noted in the southern portion of the area mapped in detail and frequently appears to be associated with the garnet-free calc-silicate quartzite ((c) (ii) above) and the granular meta-arenite ((b) above).

The unit has a distinctive mottled (black and white) appearance due to knots of coarse amphibole alternating with aggregates of felsic minerals. A well developed schistosity is ubiquitous and the amphibole aggregates are elongate parallel to the schistosity.

Samples Q38 and Q107 are thin sectioned examples of this unit (Appendix 2) and both rocks are essentially composed of hornblende and feldspar with subordinate quartz.

The amphibolite was undoubtedly an original basic igneous rock and although the unit appears to be quite discontinuous it is conformable with the stratigraphy. The original rocks may have been either basic flows or sills.

(e) **Pegmatites**
These occur as relatively thin (2-10m wide) dykes which dominantly trend parallel to the regional cleavage. In many cases the pegmatites themselves exhibit a distinct schistosity and have obviously been intruded after at
least the last stage of deformation. In some cases the pegmatites can be seen to have intruded along fold axes. The rocks are typically composed of quartz, K-feldspar and subordinate muscovite. Black tourmaline is a common accessory and in one occurrence, euhedral ruby pink garnets are also present. A thin section of this lithology is not available.

On Plan 3 the zones of pegmatite intrusion are indicated by annotation and they have been omitted from Plan 4 for purposes of clarity.

5.4.2. **Structure and Stratigraphy**

Structurally the area is extremely complex with the dominant deformation involving tight isoclinal folding along axis trending west to northwest and the foliation dips consistently north or northeasterly at between 25° and 60°. The folding has occurred at all scales and wavelengths ranging from a few centimetres to 50 metres or more have been observed. The interpretation shown on Plan 4 indicates the presence of larger similar style folds with wavelengths of 600-700 metres.

Where noted in the field, fold plunges have been consistently to the east or northeast at between 15° and 45°, however it is suspected that westerly plunges also occur and this would produce a sequence of domal structures which is the overall impression gained in the field. On a number of the small rolling hills in the area, the outcrop pattern suggests the current erosion surface is sub-parallel to small fold domes. It has not been possible to represent this feature diagrammatically on Plan 4.

Occasional evidence for a later period of folding along axis trending NNE has been noted but is not strongly developed.

As mentioned previously the pegmatite dykes have been emplaced in many cases along east-west trending fold axes but also frequently exhibit a cleavage trending in the same direction and this suggests that there has been at least two phases of deformation parallel to the same direction.
The detailed stratigraphy is not well understood. Original sedimentary textures have been destroyed by metamorphism and the isoclinal nature of the folding has produced a regional cleavage which is parallel or almost parallel to the compositional layering. It is therefore not possible to determine whether the beds are right way up or overturned. The stratigraphic succession as shown on Plan 4 is therefore only tentative and is based on the subjective structural interpretation shown on the cross section on the same plan.

Facies changes within the various units are almost certainly present both along strike and down-dip and further detailed mapping would be required to clarify both the stratigraphy and the structure.

As can be seen from Plan 4, two quartzite horizons have been proposed one "below" and one "above" the biotite schist. Both contain scattered scheelite mineralization (see section 5.4.3. below) although it is more strongly developed in the "lower" quartzite. Along the north-south fence line in the western part of the area, small thin bands of quartzite occur throughout the biotite schist. These bands often have boudin-shaped outcrops and it is clear that they are in fact small fold crests of the "lower" quartzite which have been exposed by erosion of the biotite schist.

The quartzite horizons are thought to be quite thin, and the comparatively thick outcrop pattern shown on Plan 4 is considered to be due to the repetition of the sequence by tight isoclinal folding.

5.4.3. Mineralization

The Brumby Bore scheelite mineralization dominantly occurs within the calc-silicate bearing quartzites and is most abundantly developed within the "lower" garnet bearing quartzite. Rare grains of scheelite have been noted during night lamping in all
the other lithologies including the amphibolites and the pegmatites. Scheelite bearing quartzite invariably occur adjacent to these occurrences.

The "lower" quartzite, while characteristically garnet bearing, is compositionally banded and numerous bands within the unit are either garnet-free or garnet-poor. It is within these "garnet-free" bands that the scheelite is most commonly found. While the compositional bands may be up to a metre wide the scheelite is usually confined to a much narrower width (often only 2-10 cms wide) and the individual scheelite horizons are less than a metre in length.

When inspected in daylight the mineralization was found to occur mainly on the crests of small, tight isoclinal folds. The mineralization has a relatively fine grain size (<2mm) and where it is not located along fold axes it frequently occurs as a very fine dust. It is felt that, in this area, some remobilization and possibly concentration has occurred during at least one phase of the structural deformation.

Composite chip samples were collected (at night with the aid of a UV lamp) from six areas of scheelite mineralization in the Brumby Bore area. The individual sites were subsequently inspected in daylight to determine the geological characteristics and descriptions and assay results of the individual samples are tabulated below. The mineralized samples were assayed for a number of elements in addition to tungsten, in conjunction with a suite of barren calc-silicate bearing quartzite samples from the Brumby Bore area and other parts of the licence. Only the tungsten results are given below and the other results are discussed in Section 5.6. Sample locations are shown on Plan 5.

The mineralized zone almost certainly continues west of the area covered by Plans 3 and 4 and this is supported by the stream sediment sampling which indicates the anomaly extends some distance west of the north-south fence line (Plan 2).
It is likely that the mineralization in this area would be of the same tenor as that within the area covered by Plan 4.

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Scheelite zone sampled Width</th>
<th>Length</th>
<th>W%</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>3 cm</td>
<td>20 cm</td>
<td>0.33</td>
<td>Occurs within a 20 cm wide quartzite horizon within biotite schist. Scheelite restricted to a coarser grained leucocratic horizon within the quartzite and is located at the crest of a small fold.</td>
</tr>
<tr>
<td>S2</td>
<td>20 cm</td>
<td>1 m</td>
<td>1.36</td>
<td>Very tightly folded, 40 cm wide quartzite band within biotite schist. Coarse grained scheelite occurs within a leucocratic horizon at the crest of a tight fold. Intraformational pytymatic folding noted. Best visible mineralization found.</td>
</tr>
<tr>
<td>S3</td>
<td>15 cm</td>
<td>50</td>
<td>0.36</td>
<td>Small elliptical outcrop of quartzite (1.5 m long and 0.5 m wide) within biotite schist. This appears to be an exposed crest of a small fold. The scheelite is restricted to a small part of the exposure.</td>
</tr>
<tr>
<td>S4</td>
<td>5-10 cm</td>
<td>30 cm</td>
<td>0.68</td>
<td>Crescent shaped 30 cm wide quartzite band in biotite schist. The quartzite band can be traced for about 1.5 m along strike. The scheelite mineralization is restricted to the nose of the fold.</td>
</tr>
<tr>
<td>S5</td>
<td>3 cm</td>
<td>30 cm</td>
<td>0.12</td>
<td>Arcuate band (60 cm wide) of quartzite within an area of quartzite rubble. Visible scheelite is restricted to the nose of the fold.</td>
</tr>
<tr>
<td>S6</td>
<td>0.7</td>
<td>1 m</td>
<td>0.15</td>
<td>Small fold crest of quartzite within biotite schist. The fold appears to plunge at about 35° to the NE. Scheelite occurs as randomly scattered grains throughout the quartzite and the composite chip sample was taken from the whole of the quartzite exposure and not restricted to areas of visible scheelite.</td>
</tr>
</tbody>
</table>

Note: Samples S1-4 were taken from the areas of comparatively strong scheelite mineralization. Samples S5 and 6 are more typical of the mineralization noted in the area as a whole.
5.5 The Mirror Finish Dam Scheelite Occurrence

This occurrence was detected during the 1982 stream sediment survey and anomalous values were obtained from streams draining a north-south strike length of 2.5 kms (Plan 2, Anomaly 3). The mineralization extends south of the anomaly shown on Plan 2 to about the position of Q151 shown on Plan 1.

The area was inspected in detail during the 1983 programme however detailed mapping was not considered warranted.

In general terms the Mirror Finish Dam area has the same lithological sequence developed at the Brumby Bore occurrence although the relative proportions of the various rock types is somewhat different. In the Mirror Finish area, calc-silicate quartzites and amphibolites are more abundantly developed than at Brumby Bore while the biotite schist is comparatively uncommon.

In this area the calc-silicate quartzite is typically pale green, often displays well developed rhythmic banding and garnets are rarely present. The unit appears to be similar to the "upper" quartzite horizon at Brumby Bore and this is supported by the close association of meta-amphibolite with the quartzite in the Mirror Finish area. Sample Q151 is typical of the dominant quartzite in this area, and a detailed petrological description can be found in Appendix 2. It is a quartz-K feldspar-hornblende-diopside-clinozoisite rock and is possibly of original tuffaceous origin. In a few cases a distinctly banded quartzite with alternating pink and green bands was noted in the field. It was assumed the pink bands were garnet-rich however petrological examination (see Q174, Appendix 2) failed to detect any garnet and the pink colour appears to be due to calcite.

The Mirror Finish area appears to be structurally less complex than the Brumby Bore area. In general the small fold domes of quartzite noted at Brumby Bore are not seen in this area. Dips are again uniformly easterly and range from 25 to 80 degrees and probably average 40°. Small scale, complex, ptygmatic folding is well
developed in the granular biotite bearing meta-arenite to the west of the quartzite and this may be due to drag folding on the limbs of the larger folds.

In the northern part of the area, around Q174 (see Plan 1), extensive pegmatite dykes are present. On the aerial photographs an anticlinal nose appears to occur in this area however this is not supported by the dips collected in the field. The unusual outcrop pattern on the airphotographs is probably due to the pegmatite dyking in the area.

In the southern part of the area around Q151 (Plan 1) very little scheelite was noted during night lamping. Where present the scheelite occurs as fine grains in very thin bands (1-2 mm wide) within the pale green quartzite. Individual bands cannot be traced for more than a metre along strike. In a few places sparse, coarser grained, scheelite was noted associated with thin bands of white (possibly remobilized) quartz found on some of the quartzite float in the area. Three samples were collected from this part of the area (S7 to S9) and details are given in Table 2 below.

In the northern part of the Mirror Finish Dam area, in the zone of extensive pegmatite dyking, some extremely coarse grained scheelite (slugs up to 5 cms across) was found within a pegmatite. The scheelite mineralization was found over a 20 m x 20 m area and two samples (S10 and S11) were collected from this zone. Results are included in Table 2 below and the sample positions are marked on Plan 1. The mineralization in the pegmatite has a strong yellow fluorescence indicating a high molybdenum content and is responsible for the very high grain counts obtained in heavy mineral samples 8358 and 8369 collected from this area (Plan 2). Only very minor scheelite was noted in the quartzite further to the west and south of this area.
TABLE 2  MIRROR FINISH SAME SAMPLING

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Scheelite zone sampled Width</th>
<th>Length</th>
<th>W%</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>S7</td>
<td>10 cm</td>
<td>1 m</td>
<td>0.13</td>
<td>Scheelite occurs as fine grains in a band 1-2 mm wide within a banded green calc-silicate bearing quartzite.</td>
</tr>
<tr>
<td>S8</td>
<td>Float</td>
<td>Sample</td>
<td>690ppm</td>
<td>Two to three grains of scheelite in association with remobilized quartz on the face of a piece of coarse grained amphibole bearing quartzite.</td>
</tr>
<tr>
<td>S9</td>
<td>Float</td>
<td>Sample</td>
<td>500ppm</td>
<td>One grain of scheelite within a piece of very coarse grained leucocratic quartzite.</td>
</tr>
<tr>
<td>S10</td>
<td>20 m</td>
<td>20 m</td>
<td>3.11</td>
<td>Selected scheelite (yellow fluorescing) bearing pegmatite float. Individual grains of scheelite up to 5 cms across.</td>
</tr>
<tr>
<td>S11</td>
<td>Float</td>
<td>Sample</td>
<td>920ppm</td>
<td>Very coarse scheelite (yellow fluorescing) in a piece of coarse grained pegmatite.</td>
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</tbody>
</table>

5.6 Quartzite Geochemistry

Thirty three calc-silicate bearing quartzite samples collected from various parts of the area were analysed for a suite of elements in addition to tungsten. Two samples of mineralized pegmatite (S10 and S11) from the Mirror Finish Dam area were also included in this work.

Nine of the quartzite samples (S1 - S9) contained visible mineralization and the tungsten analyses for these samples are presented in Tables 1 and 2 Section 5.4.3. and 5.5 respectively. The remainder of the samples contained no visible mineralization.

The elements determined for each sample were:- Tungsten, Tantalum, Tin, Rubidium, Niobium, Antimony, Arsenic, Boron, Barium and Sulphur. The full analytical results are included in Appendix 3.
Of the thirty three quartzite samples, twenty two were obtained from the Brumby Bore area, eight from the Mirror Finish Dam area and three from the northern part of the licence near the Old Indianna Road. Locations for the Brumby Bore samples are marked on Plan 5, while the locations of the other samples are shown on Plan 1.

Only three of the unmineralized quartzite samples, all from the Brumby Bore area, contained tungsten values greater than 40ppm W (Q 1, 18 and 41) with the highest value being 810ppm W in Q18.

Antimony, sulphur, niobium, tin and tantalum are uniformly low in both mineralized (tungsten) and unmineralized samples. Arsenic values tend to be slightly higher (>15ppm As) in mineralized quartzite samples from the Brumby Bore area, however this is not the case for the mineralized quartzites from the Mirror Finish Dam area. S10, the scheelite bearing pegmatite from this latter area however contained the highest arsenic value (120ppm As) obtained and this sample also yielded a slightly higher than normal niobium analysis (45ppm Nb). Niobium mineralization has been noted in one of the old mica mines, a short distance to the west.

The barium and boron content of the quartzite does not vary sympathetically with tungsten. Two samples S8 and Q146 contained notable barium contents of 0.30% Ba and 0.13% Ba respectively however these do not appear to have any particular significance.

There appears to be no specific correlation between tungsten content and the other elements determined. In general the tungsten content of the unmineralized quartzite samples is extremely low and indicates that the calc-silicate quartzite are not uniformly enriched in tungsten.
6. **RECOMMENDATIONS**

While wide-spread, low grade scheelite mineralization has been outlined, the individual occurrences are small and do not represent viable targets for further investigation. There are no indications that potentially economic concentrations of scheelite exist within the licence area and no further work is recommended. Consequently E.L. 3466 should be relinquished.
APPENDIX 1

STREAM SEDIMENT

HEAVY MINERAL CONCENTRATE

DATA TABLES
<table>
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<tr>
<th>SAMPLE NO.</th>
<th>GRAIN COUNTS</th>
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<th>Ta/Sn</th>
<th>Nb</th>
<th>Cr</th>
<th>Y</th>
<th>La &amp; Ce</th>
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<th>COMMENTS</th>
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APPENDIX 2

PETROLOGICAL DESCRIPTIONS

SAMPLES: Q16A, 68, 94, 95B, 135 & 151
by DR. B. J. BARRON

by P. T. GOLDNER
PETROLOGICAL EVALUATION OF SIX ROCK SAMPLES FROM NORTHERN TERRITORY

Report No: W2/83/219a
For: Weddarla Pty. Ltd.

2nd May, 1983.

Dr. B.J. Barron, Consulting Petrologist.
Sample No. Q - 16A

Rock Type Foliated, metamorphically recrystallised and banded impure calc-silicate rock. (Quartz-plagioclase-hornblende-diopside-garnet rock).

Hand Specimen A medium grained foliated sample which comprises a dominant dark green-grey host lithology and a narrow band of pale grey to brown stained material which is approximately parallel to the foliation. Staining for K-feldspar gives positive results for rare small grains in the grey host lithology.

Thin Section This is a strongly recrystallised metamorphic rock with an overall equigranular to granoblastic texture. No clear relict textural features remain except for a prominent compositional banding which is reflected in the metamorphic mineralogy. The band represented in the thin section is about 0.5 cm wide and appears to cut across the rock at a shallow angle to the distinct foliation direction. The dark green-grey fraction of the host rock has an average grain size of roughly 0.16 mm and includes approximately equal major proportions of felsic and mafic phases. The felsic material in turn includes almost equal amounts of quartz and calcic plagioclase, with trace proportions of K-feldspar (see staining), while the mafic component includes dominant green hornblende, together with subordinate diopsidic clinopyroxene and sparse small patches of poikiloblastic garnet. Sphene, zircon and oxides are fine grained, more or less evenly distributed accessory phases. In the band of pale grey to brown stained material mafic phases are subordinate and the felsic component comprises dominant calcic plagioclase with patchy quartz. The mafic material in this case includes mostly irregular patches of pale green diopsidic clinopyroxene, common clusters of green hornblende and, as in the darker host fraction, abundant accessory sphene and zircon, together with sparsely disseminated, partly oxidised fine grained sulphides.

The texture of this sample clearly reflects strong recrystallisation due to metamorphism, and its only recognisable relict texture is a compositional banding most likely reflecting original bedding in the parent rock. The present metamorphic mineralogy indicates an impure calc-silicate parent which was probably quite fine grained.
Sample No.          Q - 68

Rock Type          Weakly foliated and recrystallised impure calc-silicate rock, (quartz-scapolite-plagioclase-diopside-vesuvianite-carbonate rock).

Hand Specimen       A rather massive mid-grey grey coloured sample which is medium grained and contains sparse, more or less evenly distributed patches of dark green-grey material. The rock appears to be foliated. K-feldspar staining proved negative except for rare minute grains.

Thin Section        This is a metamorphic rock with a more or less equigranular to granoblastic texture and an average grain size of about 0.3 mm but with certain grains reaching 1 mm across. Mafic phases account for about 20% of this sample and include mostly very pale green diopsidic clinopyroxene with common multiple twinning, subordinate patchy green hornblende and strongly anomalous vesuvianite. Sparse small clusters of prismatic tourmaline crystals are accessory. The abundant felsic fraction of the rock contains very abundant quartz, common scapolite, with subordinate plagioclase and scattered small grains and clusters of carbonate which appears to be in textural equilibrium and most likely is not a retrograde phase. Accessory phases include more or less evenly distributed small crystals of pleochroic pink sphene, sparse metamict grains of ?allanite enclosing rare small bright yellow central patches of an isotropic ?uranium bearing phase, small apatite crystals, and rare small crystals of zircon.

The texture of this rock is unquestionably of metamorphic origin and no primary mineralogy remains. Unlike the previous sample, conspicuous banding is not developed, but its present metamorphic assemblage indicates an impure calc-silicate sedimentary parent. Metamorphic grade is probably upper amphibolite facies, but diagnostic assemblages are not developed in this rock.

Sample No.          Q - 94

Rock Type          Strongly recrystallised, weakly foliated, banded, folded sediment of impure calc-silicate composition, (or plagioclase-quartz-diopside-garnet-vesuvianite rock).
Hand Specimen  A rather fine grained compact sample which represents the hinge of a fold in a distinctly banded rock. The banding is in the order of 1 cm thickness and includes pale green-grey coloured bands, as well as mid-brown coloured bands. K-feldspar staining proved negative.

Thin Section  The green-grey coloured central folded hinge portion of this strongly recrystallised metamorphic rock comprises a more or less equigranular granoblastic mosaic with an average grain size of roughly 0.23 mm. This fraction is dominated by calcic plagioclase with common diopsidic clinopyroxene with subordinate proportions of quartz and strongly prismatic shaped crystals of vesuvianite, which tend to be elongate parallel to the rather weak foliation. Accessory phases in this fraction include small crystals of garnet, numerous small crystals of sphene and apatite. In the outer band of the fold is developed a rather similar mineralogy, but with very different proportions of essential minerals. Mafic phases are most abundant, and these include very abundant dense patches of strongly prismatic vesuvianite crystals, equant crystals of diopsidic clinopyroxene and garnet, set amongst patches of granular to granoblastic quartz, that generally lack plagioclase. Again sphene is the most abundant accessory phase.

This is a strongly recrystallised metamorphic rock which represents a folded banded sediment of impure calc-silicate composition, or in metamorphic terms, it may be classed as a banded and folded plagioclase-quartz-diopside-garnet-vesuvianite rock, probably of upper amphibolite facies.

Sample No.  Q 95 B
Rock Type  Banded (?bedded), folded and metamorphically recrystallised sediment of impure calc-silicate composition.

Hand Specimen  The sample represents a distinct symmetrical fold and banding, (probably bedding) is developed on a scale of about 1 cm to 2 cm. This involves fine to medium grained material which is dark green-grey on the outer margin of the fold, mid-green, and pale grey with oxidised red-brown spots centrally. K-feldspar staining proved negative.

Thin Section  As in the previous samples the present sample is a completely recrystallised metamorphic rock in which no relict textural
features are preserved. The banding, which reflects distinct compositional differences, is reflected by changes in the present metamorphic mineralogy. The outer dark green-grey material of the fold comprises an equigranular granoblastic mosaic including quartz and calcic plagioclase, in approximately equal major proportions with subordinate but common patches of dark olive green hornblende with sparse small poikiloblastic crystals of garnet, common accessory sphene and apatite. Small crystals of partly oxidised sulphides comprise a minor accessory phase. The mid-green grey band of the hand specimen also contains an equigranular granoblastic metamorphic assemblage including abundant quartz, calcic plagioclase and pale green diopsidic clinopyroxene, with subordinate patches of anhedral garnet and strongly anomalous birefringent clinozoisite. Small crystals of sphene form a common accessory phase and apatite is also present. In the pale grey coloured band which occupies the central portion of the fold calcic-plagioclase is characteristically absent and quartz, together with pale green diopsidic clinopyroxene and clinozoisite, are present in approximately equal major proportions. The clinopyroxene is distinctly oxidised along fractures and cleavage surfaces, which is responsible for the red-brown hematite spots of the hand specimen. A single patch of granular ?powellite (lower birefringence than scheelite), occurs centrally in the hinge area of the fold. Accessory phases in this portion of the rock include garnet, sphene and traces of apatite.

This sample most likely represents a banded, folded and metamorphically recrystallised sediment of impure calc-silicate primary composition.

**Sample No.**

Q - 135

**Rock Type**


**Hand Specimen**

A medium grained mid-green grey coloured, more or less equigranular rock with a distinct, very fine lensed layering. This is particularly well marked by sparse narrow lenses of material which gives strong positive results for K-feldspar staining.

**Thin Section**

As in the previous sample the present rock exhibits a
more or less equigranular granoblastic metamorphic texture and most phases are elongate parallel to a rather poorly defined foliation. The average grain size of the rock is about 0.3 mm and the felsic fraction comprises about two thirds of the rock. This component includes mostly quartz with K-feldspar (microcline) and subordinate calcic plagioclase. The mafic portion of the rock includes mostly strongly pleochroic dark bluish green to pale yellow brown hornblende in elongate clusters, with epidote, diopsidic clinopyroxene and small completely altered and oxidised sites which may have contained biotite. Accessory phases include quite abundant evenly distributed small crystals of sphene, rare small crystals of apatite and sparse small opaque oxides that are marginally converted to red-brown limonitic oxides.

The sample most likely had a ?tuffaceous sedimentary parent of impure calc-silicate composition, but containing a component from an acidic K-feldspar bearing source. However, the very narrow lensed layering especially marked by the distribution of K-feldspar most likely represents a tectonic transposition rather than a primary banding. The metamorphic assemblage and texture of this rock suggests metamorphism has attained the upper amphibolite facies, and the sample may be classed as a quartz-K-feldspar-plagioclase-hornblende-diopside-epidote rock.

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<th>Sample No.</th>
<th>Q 151</th>
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<td>Rock Type</td>
<td>Weakly banded quartz-K-feldspar-hornblende-diopside-clinozoisite rock probably of ?tuffaceous sedimentary origin.</td>
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<tr>
<td>Hand Specimen</td>
<td>A compact equigranular, medium grained, weakly foliated rock which is mottled pale green-grey and dark green-grey. K-feldspar staining gave strongly positive results, indicating that about 20% of the rock comprises this phase and that the distribution of K-feldspar appears to define a weak banding.</td>
</tr>
<tr>
<td>Thin Section</td>
<td>This is a completely recrystallised metamorphic rock with a granular to granoblastic texture and a weak foliation defined by an elongation of the constituent phases. Layer silicates are not present. The weak banding present in the hand specimen is not particularly obvious in thin section and the average grain size of the rock is about 0.3 mm. The present</td>
</tr>
</tbody>
</table>
metamorphic mineralogy of this sample reflects a parent of impure calc-silicate composition, possibly with a tuffaceous K-feldspar-bearing acidic component and includes the following phases in approximately equal major proportions: quartz, K-feldspar (microcline), olive green hornblende, clinozoisite with strongly anomalous birefringence, and pale green diopsidic clinopyroxene. Subordinate essential phases include calcic plagioclase, and irregular shaped patches of carbonate, several of which appear to be retrograde. Sphene is a ubiquitous accessory phase, and this is a strongly pleochroic dark pink variety. Other accessory phases include apatite and a partly metamict radioactive phase with distinct pleochroic haloes, as well as small crystals of monazite. Sparse small subhedral to irregular shaped sites of secondary brown limonitic oxides probably replace trace proportions of previous sulphides.

The sample is a very weakly banded, completely recrystallised metamorphic rock, the present mineralogy of which suggests a parent of impure (tuffaceous) calc-silicate composition. The weak banding suggests that a sedimentary origin is most likely, but since the sample lacks clearly recognisable relict textural features, it may be classed as a quartz-K-feldspar-hornblende-diopside-clinozoisite rock.
Sample 14B  (Type sample Csq₂)
Name  Calc-silicate bearing quartzite
      (Zoisite - amphibole - (garnet) bearing quartzite)
Hand Specimen  Darkish green, fine grained, granular quartzitic rock containing numerous small dark mineral laths which define the foliation. Small, occasional brown grains are noted scattered through the rock and these appear to be garnets. Compositional banding (alternating darker and lighter bands) are evident and this parallels the foliation defined by the small lath-shaped mineral.

Thin Section  The rock has an essentially granoblastic texture and is composed mainly of equigranular, slightly elongate strained quartz grains (65%). A few grains appear to be rounded and this may indicate an original well sorted sediment. Pinkish zoisite is present (up to 20%) and tends to be concentrated in bands and this obviously forms the layering noted in hand specimen. Amphibole (10%) occurs in small, thin, poorly formed laths which have a preferred orientation and occur mainly in the zoisite rich layers. Minor (<2%) plagioclase occurs interstitially to the quartz and the crystals tend to be smaller than the quartz grains. Small, often oblate, pinkish sphene occurs throughout the rock and these tend to lie parallel to the foliation. No garnet occurs in the thin section although this mineral was noted in hand specimen.

The rock appears to have been originally an impure calcareous arenite which can now be described as a zoisite - amphibole - (garnet) bearing quartzite.

Sample Q38  (Type sample of mottled amphibolite)
Name  Hornblende-plagioclase-quartz amphibolite
Hand Specimen  This is a coarse grained dark mottled rock containing large black aggregates of amphibole interspersed with subordinate creamy white felsic minerals probably consisting largely of plagioclase.
Thin Section  The specimen consists of coarse grained pale greenish hornblende (60%) which occurs in large aggregates which in turn
are concentrated within poorly defined bands. These are interspersed with smaller aggregates of plagioclase (25-30%) and quartz (5-10%). The relative proportions of the mafic and felsic aggregates defines a weak colour banding. A number of large glomeroporphyritic aggregates of sphene occur scattered throughout the rock.

The original texture of the rock has been completely destroyed however compositionally it is likely that it was an original basic igneous rock however whether it was intrusive or extrusive is unknown.

Sample Q49  
(Type sample of Csq₁)

Name  
Calc-silicate bearing quartzite  
(Clinozoisite-garnet-(plagioclase-calcite) bearing quartzite)

Hand Specimen  
The rock is a pale green, hard, siliceous quartzite exhibiting a distinct foliation defined by numerous elongate patches of pink garnet. Small elongate black laths of amphibole (?) occur throughout the rock and these have a distinct preferred orientation and tend to be concentrated in bands.

Thin Section  
The specimen is distinctly banded with an overall granoblastic texture. The specimen consists mainly of quartz (65-70%), clinozoisite (15%) which tends to be slightly pinkish in thin section and occurs interstitial to the quartz. Small pale green pleochroic laths of amphibole are present throughout the rock although there is a tendency for these to be concentrated in bands. Very pale pink anhedral garnet (10%) occurs either as single grains or in aggregates. Minor plagioclase and calcite are also present but constitute < 5% of the rock. Sphene occurs as small crystals throughout the groundmass.

The rock is similar to Q14B however garnet is present in the thin section in this sample and calcite was also noted.

The specimen can be termed a clinozoisite-garnet-(plagioclase-calcite) bearing quartzite and probably represents a calc-arenite or reworked calcareous tuff.
Sample Q56 (Type sample of gb-sample)
Name Granular, biotite bearing meta-arenite.
Hand Specimen The sample is a fine grained equigranular sandy
textured biotite bearing "sandstone" with a slightly schistose
texture defined by the preferred orientation of the biotite laths.
Thin Section The rock has a fine grained granular texture and
consists mainly of equigranular (sub-rounded), often strained,
recrystallised quartz (75%) with minor (<5%) interstitial
plagioclase grains. Small laths of strongly pleochroic biotite
constitute about 20% of the rock and the strong preferred
orientation of the biotite laths gives the rock its schistose
texture. Accessory, fine grained, rounded zircon and very minor
garnet are present. Small amounts of an opaque mineral occur in
patches and this may be magnetite.

The original rock appears to have been an impure ("dirty") sandstone
and the sub-rounded quartz grains (modified by metamorphism)
suggest an original detrital origin for this unit. The rounded
zircons also indicate an original sedimentary origin. The rock
may be termed a granular biotite bearing meta-arenite.

Sample Q65
Name Calc-silicate bearing quartzite
(Clinozoisite-hornblende-(garnet-plagioclase) bearing
quartzite)
Hand Specimen The rock is a hard, pale creamy brown, fine grained
quartzite containing numerous small brownish laths which define a
distinct foliation.
Thin Section The rock has a distinct granoblastic texture and
appears compositionally similar to Q14B. Quartz, usually with
strained extinction, is the dominant phase, (60%) with pale
greenish clinzoisite forming 20% of the rock. Small laths of
pleochroic hornblende (15%) have a preferred orientation and
define the specimens foliation. Abundant small sphene occurs
throughout the rock and some very minor, almost colourless, garnet is
also present. Minor plagioclase (<1%) occurs interstitially to
quartz.

The unit is a clinozoisite-hornblende-(garnet-plagioclase) bearing quartzite and the original rock was probably a calcareous sandstone.

**Sample Q95A**  (Scheelite bearing csq)
**Name**  Banded calc-silicate bearing quartzite
**Hand Specimen**  Diopside-zoisite-plagioclase (garnet hornblende calcite) bearing quartzite.

Medium brown, distinctly banded, quartzitic rock containing scheelite within a distinct horizon. The banding consists of an outer dark brown to black, probably amphibole rich layer less than 1 cm wide which occurs along both sides of the specimen which may be part of a tight fold. Two inner bands are present, one slightly darker brown than the other. Both bands are about 1.5 cms. wide and the lighter of the two bands contains the disseminated scheelite. The darker band appears to be garnet rich while the lighter band contains garnet plus a greenish mineral which may be diopside.

**Thin Section**  Outer dark rim  This consists of quartz (60%), plagioclase 15% and weakly disseminated hornblende (25%) and minor pleochroic sphene is present in the matrix. A dark unidentified iron stained mineral is scattered throughout the groundmass.

**Lighter inner band**  This consists of granoblastic quartz (50%), plagioclase 10-20%, pale green diopsidic pyroxene (20%) which occurs in glomeroporphyritic aggregates and very pale pinkish zoisite 10%. Minor pleochroic amphibole and a little calcite is also present. Small euhedral sphene crystals and some pleochroic zircons are scattered throughout the matrix. A think band of granular scheelite occurs within this zone associated with a higher than usual zoisite content. There is a suggestion of a thin fracture which controls this band of scheelite. Small euhedral pale pink garnets occur throughout (5%).

**Darker inner band**  This is compositionally somewhat similar to the lighter inner band although tends to have a coarser grain size and is richer in clinopyroxene and contains less zoisite and no garnet.

The rock is an upper amphibolite to lower granulite facies
calc-silicate bearing quartzite. The banding almost certainly represents original sedimentary layering and the original sediment was probably an impure calc-arenite or reworked tuff.

Sample Q96A  (Type sample of cbs)
Name  Biotite-quartz-feldspar schist (meta-pelite)
Hand Specimen  This is a strongly foliated coarse grained biotite rich schist containing abundant quartz and feldspar.
Thin Section  The rock contains large elongate pleochroic (Light to dark brown) biotite crystals (50%) which have a distinct preferred orientation which defines the strong foliation. Coarse granoblastic quartz and plagioclase occur in equal proportions (20% ea) intimately associated with each other. Minor muscovite flakes are also present. The rock was obviously a pelitic sediment originally.

Sample Q107
Name  Mottled coarse grained amphibolite (meta-basic igneous rock)
Hand Specimen  This is a medium grained, schistose black and white mottled rock which in hand specimen appears to consist of amphibole, quartz and feldspar.
Thin Section  The rock has a distinct foliated schistose texture largely defined by large euhedral to subhedral pleochroic (brown to pale green) hornblende (65%) which tend to have a preferred orientation. The felsic component (35%) appears to be largely composed of granoblastic K-feldspar (?) with subordinate quartz.

The rock was almost certainly an original basic igneous rock and is similar to sample Q38 although the present sample contains K-feldspar whereas the Q38 contains plagioclase.

Sample Q120
Name  Zoisite bearing quartzite
Hand Specimen  This sample is a hard leucocratic foliated quartzitic rock which appears to contain abundant creamy feldspar and probably
small hornblende laths.

**Thin Section**  The rock has a distinct equigranular granoblastic texture consisting largely of strained quartz grains (75%) and only minor plagioclase (up to 2%). Elongate crystals of zoisite (10%) occur throughout and small pale weakly pleochroic hornblende laths (10%) are common and define the rocks foliation. Accessory fine grained sphene is scattered throughout the matrix and occasionally occurs within individual zoisite crystals. No garnet was noted.

The original rock was almost certainly a slightly calcareous arenite.

**Sample Q122**

**Name**  Banded calc-silicate bearing quartzite  
(Diopside-(garnet)-plagioclase-(calcite) bearing quartzite or skarn)

**Hand Specimen**  This is a well banded quartzitic unit consisting of a thick dark grey layer which appears to be largely composed of quartz and a thick pinkish-brown garnet rich band.

**Thin Section**

- **Grey band**  This has fine grained equigranular granoblastic texture and is composed of quartz (75%) plagioclase 10% and pale green coarse grained diopside (15%). Accessory fine grained sphene and zircon occur scattered throughout the band.

- **Pinkish-brown-band**  This is slightly finer grained than the grey band and consists of quartz, 40%, plagioclase (5-10%) calcite (10%), coarser grained diopside 20%, and glomeroporphyritic aggregates of pale pink to almost colourless garnet (20-25%). Small grains of zircon occur throughout the matrix.

The layering present undoubtedly represents original compositional horizons in a calcareous arenaceous unit.
Sample Q125

Name    Hornblende-plagioclase-quartz-(garnet) rock
        Possibly an original basic volcanic or a banded
calcareous meta sediment.

Hand Specimen  This is a dark fine grained rock with occasional
scattered red garnets and appears in hand specimen to be possibly
an amphibolite.

Thin Section  The rock is fine grained distinctly foliated specimen
containing granoblastic quartz (30%) and plagioclase (15%) as the
felsic components. The mafic component consists of pleochroic
dark to pale green hornblende. Distinct banding is present which
is defined by plagioclase rich bands with minor hornblende
alternating with hornblende rich bands with subordinate felsics.
Large poikiloblastic pale pink garnet occurs in a thin band.

The rocks texture suggests a possible original flow although this
may be tectonic foliation. The rock may have been an original
basic volcanic but could equally have been a calcareous sediment.

Sample Q138A

Name    Sheared quartzo-feldspathic gneiss

Hand Specimen  This is a medium grained pinkish leucocratic
gneissic rock which consists largely of K-feldspar and quartz with
minor biotite and possibly some muscovite.

Thin Section  The rock has coarse grained granoblastic texture
and consists of quartz (30-35%) and plagioclases (up to 10%).
Some of the K-feldspar grains have been altered to sericite or
illite. Biotite (< 2%) occurs in large dark brown elongate
euhedral to subhedral crystals which have a preferred orientation.
Muscovite (<2%) occurs in rather small ragged crystals.

Original textural features have been destroyed however the rock was
probably a coarse grained arenaceous sediment.
Sample Q138B
Name: Coarse grained Feldspar-Biotite Gneiss
Hand Specimen: This is a mesocratic coarse grained sheared rock containing K-feldspar, quartz and abundant biotite. The K-feldspar tends to occur as porphyroblasts and the rock has a distinct gneissic texture.
Thin Section: The rock has a coarse granoblastic texture with some crude banding developed defined by alternating biotite rich, quartz rich and feldspar rich horizons. Compositionally, strained granoblastic quartz constitutes 50% of the rock while the K-feldspar (20-30%) occurs in much larger subhedral crystal aggregates. Some minor (<5%) plagioclase is also present. Biotite (~20%) occurs in coarse subhedral crystal aggregates. Very minor muscovite is present and sericite is noted altering some of the K-feldspar.

Original textures have been destroyed although one almost spherical quartz grain within a K-feldspar crystal was noted and this may be an original sedimentary grain. The original rock was probably an arkose.

Sample Q174
Name: Strongly banded calc-silicate bearing quartzite or skarn.
Hand Specimen: This is a distinctly banded, pale greenish grey quartzitic rock with regular 3-4 mm wide pinkish bands alternating with 10-15m wide greenish bands.
Thin Section: Greenish bands: These consist of quartz 60%, diopsidic clinopyroxene 20%, clinozoisite 5-10% and scapolite (?). 10%. Extensive accessory strongly pleochroic sphene occurs in the matrix.
Pinkish bands: These are composed of calcite 55%, quartz 30%, clinopyroxene <5% and scapolite 5%. No clinozoisite or garnet is present however minor fine grained hornblende was noted. Accessory sphene is again abundant in the matrix.

Both bands have a equigranular granoblastic texture although the pinkish bands tend to have an overall coarser grainsize. There is some compositional gradation between the bands with calcite
and clinozoisite occurring near the margins of the compositional horizons.

The rock was almost certainly a calcareous arenite and the banding noted probably reflects original compositional layers.
APPENDIX 3

ROCK GEOCHEMISTRY RESULTS
### LABORATORY REPORT

**Batch No.:** D054  
**Client:** PETER GOLDNER & ASSOCIATES  
**Area Contact:** MR. PETER GOLDNER  
**Date Received:** 19/04/93  
**Date Completed:** 22/04/93  
**Order No.:** LETTER 15/4/93  
**Sample Type:** ROCK  
**No. of Samples:** 35

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<th>b</th>
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| SAMPLE NO. | AREA | 172 | 110 | 210 | 10 | 0.01 | 4 | 5 | 10 | 10 | 20 |
| SAMPLE NO. | AREA | 179 | 110 | 230 | 10 | 0.01 | 4 | 20 | <10 | 5 | 20 |

**UNITS LEGEND**
- m - Parts per million
- g - Parts per billion
- % - percent
- a - Absorbance

_Signature:_ [Signature]

**AUSTRALIAN LABORATORY SERVICES PTY. LTD.**

CONSULTING CHEMISTS & ANALYSTS

OFFICE & LABORATORY
P.O. BOX 66
EVERTON PARK QLD 4053

LABORATORY REPORT

Batch No.: D084
Client: PETER GOLDSMITH & ASSOCIATES
Address: SUITE 707, 7TH FLOORS
Date Received: 19/04/83
Date Completed: 22/04/83
Area Contact: MR. PETER GOLDSMITH
Address: 60 PITT STREET
SYDNEY N.S.W. 2000

Order No.: LETTER 15/4/83
Sample Type: ROCK
No. of Samples: 35

| SAMPLE NO. | XRF 1A | IC583 | XRF 1A | XRF 1B | AI59 | XRF 1A | XRF 1A | XRF 1B | XRF 1A |
| SAMPLE NO. | m | m | m | m | m | m | m | m | m |

Signature: [Signature]