4.1.4.1 Work Done

The grid was mapped in detail. The Harding Springs Fault runs EW through the centre of the grid and hosts the uranium hotspots. Grab sampling gave assays between 5-350ppm U and <0.2ppm Th. Conjugate fractures trending NNW/SSE splay off the main E-W fracture. An indistinct zone of mylonitic rocks, broadly conformable with the metamorphic structure, runs N-S across the grid.

The uranium anomalies are clustered around the intersection of the E-W and NNW-SSW fractures. Wall rocks are Bruna Gneiss (predominantly the felsic variety), minor Entia Gneiss and Entia Granite (containing xenoliths of country rock). Minor calcisilicate lenses were located in the NW corner of the grid. The mylonitic zone also hosts several, mainly Th>U hotspots (100-1,000 cps EDA), located in old (sheared) pegmatites (Figure 63).

Three trenches were dug to test the EW trending retrogressed fault (see geology: Figures 64-66, legend: Figure 67, radiometrics: Figures 68-70). A total of 33 assays were collected, the uranium contents ranging between 2.4 ppm to 410 ppm whereas thorium registered values between 0 and 21 ppm. The anomalous assays were all collected from zeolite veined, clay altered fault gouge. Detailed geological maps of the trench walls are shown on Figures 64-66.

Both ground magnetic (Figure 71) and radiometric surveys (Figure 72), measured at 25 x 10 patterns respectively were undertaken.

4.1.4.2 Appraisal

The steeply dipping retrogressed fault hosts thin but continuous pods of uranium mineralization. A good drill target is defined, with testing dependant on results of further investigations at Pony.

4.1.5 Zephyr

ZEPHYR Prospect is located 1.5km east of PONY, within the layered Entia Gneiss (Figure 38). Although the Pony Fault passes through the ZEPHYR grid, it contains no anomalies. Radiometric anomalist at ZEPHYR is of two types; uraniferous allanite hosted by a pegmatite dyke, and uraniferous epidosite hosted by a stratiform calc silicate layer. The epidosite occurrence was the focus of subsequent investigations.

4.1.5.1 Mapping and Sampling

Lithologic types at ZEPHYR include felsic gneiss, minor para amphibolite and minor marble/calc silicate horizons. Semi-conformable, foliated pegmatite and granitoid is inter layered with felsic gneiss, and massive, crosscutting, megacrystic pegmatite forms dykes from 1 - 20 metres thick. Rare mafic plugs are also present. A retrogressed, zeolitic portion of the Pony Fault crosses the southern part of the map grid. A more ductile, shear-like structure crosses the central portion of the grid. Neither structure hosts any radiometric anomalies.

The anomalous calc silicate comprises a package of marble, epidosite and garnetiferous calc silicate members. This package is highlighted on Plate 19.
BONNIE TRENCH 1

RADIO METRICS (lead shielded SPP2)

WEST WALL Kriging

EAST WALL Kriging

SAMPLE NUMBERS
Prefix = HR0
A 5905, B 5499
C 5854, D 5497
E 5500, F 5495
BONNIE TRENCH 2

RADIOMETRICS (lead shielded SPP2)

WEST WALL Kriging

EAST WALL Kriging

Sample intervals (Prefixed by HRO 58)
BONNIE TRENCH 3

RADIOMETRICS (lead shielded SPP2)

WEST WALL Kriging

EAST WALL Kriging

SAMPLE NUMBERS
A  HR0-5878
B  HR0-5877
C  HR0-5876

Figure 70
BONNIE GRID
GSPEC CONTOURS

1:5000

4 channel plots
2 ratio plots

grid 73 x 63, linear triangulation

Figure 72
Radiometric anomalies occur as clusters centred on lensoidal (boudined?) epidote-dominated pods within the "target stratum". The pod designated "Zephyr-3" measures 20 x 5 metres on the surface and is continuously anomalous over this area, with sharp radiometric and lithologic contacts with enclosing rocks. The pod designated "Zephyr-2" is probably larger, perhaps 30 x 5 metres, but is much less accessible.

The allanite-based anomalies at Zephyr-1 are of no economic significance.

4.1.5.2 Trenching

Two backhoe trenches, designated "North Trench" and "South Trench" were excavated; geology and sampling details are shown on Figure 73. The North Trench is located north of the main creek, on a down-dip outlier originally connected to Zephyr-2. The South Trench is located at Zephyr-3.

In both trenches, the uraniumiferous horizon is very hard, and proved difficult to accurately channel sample. Some of the uranium assays are likely to be understated, due to over sampling of softer, un-mineralised, adjacent rock. A total of 13 channel samples were taken from both trenches. Uranium values are also shown on Figure 73. The best channel sample interval resulted in an intersection of 2m at 285 ppm uranium. Best assays from grab samples are 390-480 ppm U and 9-25 ppm Th.

The true width of the uraniumiferous horizon in South Trench is 1.7 metres, and 1.3 metres in the North Trench.

4.1.5.3 Geophysics

The grid at Zephyr (approx. 400 x 400 m) has been covered by ground spectrometer and magnetic surveys at 10 x 12.5 and 10 x 25m patterns respectively. Radiometric and magnetic contours are shown in Figures 74 and 75.

Both North (Zephyr-2) and South (Zephyr-3) trenches were radiometrically profiled and contours are shown on Figures 76 and 77.

4.1.5.4 Appraisal

Both the dimensions and uranium grades of the Zephyr anomalies are sub-economic. It is likely that good down-dip continuity exists for Zephyr-3, rather like a shoot or mullion structure, and that the grade is understated by channel sampling. However, the lack of lateral continuity with other pods severely restricts potential volume parameters. No further work is indicated for this prospect.

4.1.6 Moondyne-Swallow

Limited work was carried out at MOONDYNE-SWALLOW in 1995 (see location: Figure 78). Just a further two trenches were excavated by blasting and backhoe. A total of 7 samples were collected from the trenches and one grab sample collected.
ZEPHYR TRENCH 2

RADIOMETRICS (lead shielded SPP2)

NORTH WALL Kriging

SOUTH WALL Kriging

Figure 76
ZEPHYR TRENCH 3

RADIOMETRICS (lead shielded SPP2)

WEST WALL Kriging

EAST WALL Kriging

Figure 7
4.1.6.1 Trenching

Inspection of Trench TM3, sited on a radiometric hotspot in hematitic epidosite float (discovery site) at MOONDYNE showed that the trench intersected the westerly extension of the retrogressed fault exposed in TM1. However only a weak (200 cps EDA) anomaly was discovered in epidosite adjacent to the fault. A flat lying pegmatite has been truncated by the fault (see Figure 79). Plate 20 shows the location of the trench. Figure 80 shows the radiometric data from the trench.

From the results of the trenching at MOONDYNE, both TM1 (1994) and TM3, it appears that the fault was the focus for the epidote metamorphosis. This view is based on the presence of epidotized rotated blocks of amphibolite within the fault zone at TM1, the interpretation that the layer parallel epidotization and silicification is leakage out of the fault and that the epidotization in TM3 is restricted to a fragment of dragged wall rock adjacent to the fault. Subsequently, clay-carbonate-zeolite retrogression has been superimposed on the fault.

At SWALLOW, inspection of trench TS4 (located EW across the anomaly) showed that it succeeded in intersecting both epidotized shear zones. The upper zone (exposed in TS2 in 1994) is about 1.25 m wide and averages 100 ppm U with 10-30 cm lenses going 100-1500 ppm U (1994 results). The lower zone (the megacrystic zone) gives 400-800 cps (shielded SRAT) over a width of 30 cm (best assay 700ppm U). Figures 81 and 82 show the geology and legend for TS4; radiometric contours are shown on Figure 83. Only the north wall was mapped due to the length of the trench.

Sampling in 1995 gave similar results to 1994; i.e. 130-250 ppm U-Y for the upper zone. The lower zone was inaccurately sampled, hence the assays do not reflect the radiometry. A grab sample (HR05892) from SWALLOW NORTH (see Plate 20), collected from a biotite filled shear adjacent to a pegmatite gave 2400 ppm U, 430 ppm Th, 5400 ppm Y and 700-1600 ppm Ce-La-Zr.

4.1.6.2 Appraisal

Presently, the grade of mineralization (50-680 ppm U and 100-500 ppm Y) and the minor amount of epidotization exposed in the trenches suggests little potential for ore grades and/or economic volumes at MOONDYNE. The uranium anomalies at SWALLOW, while more persistent and of marginally better grade (100-1500 ppm) than at MOONDYNE and while they occur in a better defined structure, still only represent a marginal drill target.

4.1.7 Garnet

GARNET is located at the northern part of the Moondyne-Swallow-Garnet grid (see Figure 78).

4.1.7.1 Mapping

Part of the GARNET grid was remapped to try and confirm the nature and orientation of the structure hosting the pegmatite and the biotite-garnet alteration and associated U-Y-Nb-Zr mineralization. Figure 84 shows the 1995 mapping of the western portion of the grid.

The pegmatite body is poddy in form and appears to have both steep (SW edge) and shallow (NE edge) dipping contacts with the wall rocks. Confirmation of a low angle fault could not be made but the adjacent gneiss outcrops do show drag folds suggestive of sinistral movement. Several low angle, strongly lineated discordant planar structures are also visible in the adjacent outcrops indicating the
SWALLOW TRENCH 4

RADIOMETRICS (lead shielded SPP2)

SCALE 1:50
partial development of a superimposed foliation on the regional metamorphic foliation. A partially epidotized (consisting of quartz-epidote rock with lesser amounts of garnet and pegmatoid material) boudinage-shear zone cuts across the grid and intersects the main pegmatite at about the zone of garnet-biotite alteration. This leads to the suggestion that the alteration at GARNET may well be a variant of the regional epidotization. Petrological work (Just, 1993) describes the altered pegmatite material as consisting of a mixture of mica-quartz-epidote-garnet with interstitial zircon and pyrochlore. Elsewhere epidote-garnet mixtures have been reported as part of the epidotization process; e.g. Swallow, Haddock, Midori and Frenzy. Patches of biotization are also a feature of the epidotized rocks; e.g. Swallow and Bronze. Hence, though the mineralogy is different (U-Y-Nb-Zr) compared with only U-Y for the epidotites it is probable that the GARNET mineralization and associated alteration is associated with a metasomatic process that has used the same structural weakness as the pegmatite but is not directly related to the pegmatite intrusion.

4.1.7.2 Trenching
The GARNET trench was also remapped. Boudinage and curved low angle shear surfaces were mapped associated with biotite-garnet alteration. Sampling of the garnet-epidote altered pegmatite exposed in the trench gave results in the range 50-700 ppm U, 210-2400 ppm Nb, 560-3800 ppm Zr and 640-3800 ppm Y. Figure 85 shows the east wall of the trench. Figure 86 shows the radiometric map for the trench.

4.1.7.3 Appraisal
At zone of epidote-garnet-biotite altered low angle shearing has been delineated that is weakly to moderately mineralized over 25 m. Results to date, indicate that ore potential grades and volumes of mineralization are unlikely to occur hence the prospect can only be considered a marginal drill target.

4.1.8 Culay
CULAY is a copper-gold showing investigated in some detail in 1994. Some features of the mineralization exposed in the previous trenching suggest a cross-cutting structure and associated biotitization and calc-silicate alteration of the wall rocks. Accordingly further investigations were planned for 1995.

4.1.8.1 Trenching
A single trench was dug across the northern extension of the Culay copper mineralisation at 7 429 454 N; 512 670 E. The objective was to test an outcropping layer of quartz-feldspar-garnet-biotite gneiss, exhibiting malachite smears where a grab sample had given a 1800 ppb Au assay (1994). The trench intersected only shallow-dipping, almost barren biotite-sillimanite gneiss. There was no sign of garnet-biotite or calc silicate gneiss, despite both these mineralised rock types outcropping a few metres north and south of the trench.

Only minute traces of malachite smear were visible in the northern trench wall. There were no radiometric anomalies in the trench. Because of the lack of mineralization no mapping, radiometric or sampling was undertaken.
GARNET TRENCH

RADIOMETRICS (lead shielded SPP2)

EAST WALL Kriging
4.1.8.2 Appraisal
Three trenches have been dug at Culy to date, targeting surface copper mineralisation. Only the central trench hosting calc silicate and garnet-biotite gneiss, showed significant mineralisation below the surface. The copper mineralisation is, therefore not laterally continuous, but pod-like. Without significantly higher precious metal credits, this copper prospect is unlikely to warrant further work.

4.2 Grid Work Other Tenements

4.2.1 Torbernite (EL 8220 - Entia)
The TORBERNITE Prospect is located on an indurated shear zone in the north east quadrant of the Entia Dome (see Figure 38). The shear forms a prominent ridge at or near the contact between the Entia Gneiss and the overlying Brady Gneiss. Site assessment to date comprises 1:1000 scale mapping (200 x 450m grid); ground radiometric and magnetic surveys; 10 rock chip grab samples; supported by other cursory inspections of sites along strike (outside the TORBERNITE grid). Plate 21 shows the main geological outcrops and hotspots within the gridded area.

4.2.1.1 Mapping and Sampling
Surface radiometric anomaly is confined to a narrow ridge, near which various tectonised rocks outcrop. Two interleaved lithologies predominate:

(a) megacrystic pegmatite; exhibiting brittle deformation zones, evidenced by sub-vertical 340° trending breccia zones and containing silica-limonite cemented fragments.

(b) Felsic and amphibolitic gneiss. This layered sequence locally trends 310°; dips 35-60° NE and exhibits ductile (mylonitic) deformation. A quartz-kaolinite-limonite overprint predominates though isolated outcrops of fresh amphibolite immediately adjacent to heavily clay altered rock was noted.

The pegmatite locally forms semi-concordant layers within the gneiss or forms voluminous slabs enclosing gneiss remnants. Radiometric anomalies occur in the pegmatite (mixed U/Th), in breccia zones (mostly U) and in the adjacent gneiss wallrock (U-dominant). Some 24 in-situ hotspots were located, ranging from 200-6500 cps EDA.

Linear zones of tectonised pegmatite, breccia veining and adjacent altered gneiss control the distribution of radiometric anomalies and uranium secondary minerals.

Breccia veins, 30 cm wide and up to 10 metres long outline a NNW-trending zone about 20m wide cross-cutting both pegmatite and layered gneiss. These veins are silica-limonite cemented and geochemically enriched in the following elements (values in ppm):

\[
\begin{align*}
\text{U} & : 100-240 \\
\text{Mo} & : 55-95 \\
\text{Cu} & : 150-250 \\
\text{Pb} & : 160-240 \\
\text{Ba} & : 390-4250 \\
\text{Mn} & : 250-9600
\end{align*}
\]
The best uranium assays have come from altered gneiss adjacent to breccia veining. These assays range from 290 to 2300 ppm U. The location of these rock chip assays is shown on Plate 21.

S.E.M. studies (J. Just 13.8.94) on HR01408 identified U-Ca phosphate. X-ray diffraction work on a nearby site (HR06865) identified a green surface coating as meta-uranocircite. An autoradiograph of the same sample could only identify zircon grains as the only identifiable radioactive phase (Mason Rpt. No. 2183).

The shear at TORBERNITE extends, beyond the grid, over a length in excess of seven kilometres. Five other uranium anomalies occur within or adjacent to this shear. A comparison between the alteration systems at TORBERNITE and PONY reveals certain similarities and differences. Both systems are of low temperature/low pressure origin and may represent variations of a regional system. The significant points of comparison are as follows:

(a) The alteration is silica-limonite-kaolinite for TORBERNITE and carbonate-silica-zeolite-smectite-apatite for PONY.

(b) Uranium mineralization comprises uraniferous apatite at PONY and uranium-phosphate secondaries at TORBERNITE.

(c) Anomalous base metals are present at TORBERNITE but absent at PONY.

(d) The major elemental differences appear to be Ca-P component at PONY and the Fe component at TORBERNITE. The Fe (limonite) may indicate original disseminated pyrite.

4.2.1.2 Geophysics
A linear array of airborne radiometric anomalies broadly coincides with the topographic ridge that hosts Torbernite.

Numerous radiometric anomalies, ranging from 200 to 7000 cps were measured whilst mapping the Torbernite grid. Minor anomalies of 200 cps are considered significant as anomalies as low as 300 cps have returned assays in excess of 300 ppm U, thus indicating quite erratic radiometric disequilibrium. Ground spectrometric data is shown on Figure 87. A clear NW-SE trend of uranium anomalies is visible in the contoured results of the uranium channel. The pegmatites and lithological layering are shown as a series of ENE-WSW trends in the thorium channel contours.

The acquisition of ground magnetic data was rendered inconclusive, due to failure of the base station. The results are presented on Figure 88. The data has no diurnal correction hence the contours show a marked grid effect. This was reduced by manual manipulation but not eliminated.

4.2.1.3 Appraisal
Two possible mechanisms are suggested for the origin of the Torbernite U occurrence.

(a) The uranium was originally present within the voluminous pegmatite intrusive as disseminated uraninite. Subsequent deformation facilitated the ingress of oxidised meteoric
water, resulting in modest supergene U enrichments in solution channel ways and along foliation planes in adjacent gneiss wall rock. This model implies no more than a surficial (uneconomic?) U presence.

(b) The brecciated, ferruginous veining could be of hydrothermal origin, suggesting the presence of a vein-like, sulphide-uraninite zone at depth. Elevated base metal assays tend to support this interpretation. Implicit in this model is that surface outcrops are both well oxidised and leached of all but residual uranium.

Model (b) above, if correct, represents a viable exploration target in terms of both concept and potential mineralised dimensions. A concept diagram supporting model (b) is shown in Figure 89.

Doubtless, more ground traversing would reveal more uranium anomalies (within grid and along strike), however in order to decide which model, (a) or (b) above is applicable, drilling is required. A pair of stepped diamond-core holes, collared at or near 9965N, 10170E and drilled toward grid SSW would resolve the true nature of the mineralisation in terms of the above models.

Case histories of the Angelo River and Kintyre deposits (among others) show that substantial leached zones can occur within fault zones, with near barren zones ranging in depth between 40-80 metres, overlying mineralization at depth.

4.2.2 Brumby (EL 7990 - Maud Creek)

4.2.2.1 Mapping & Sampling
A large grid of 2km by 1.4km, with 25 x 50m spaced pegs, was completed in the Brumby area during the 1995 field season (see Figure 90 for an overview and Plate 22 for a detailed view). Also four infills, at 25 x 25m spacings, were placed to cover all uranium and U-allanite occurrences (See Plates 23-25). Plate 23 covers the two northernmost infill areas. The main grid was mapped at 1:5,000 scale, whereas the infill areas were mapped at 1:1,000 scale. A total of 68 assays and 9 petrological samples were collected (see above plates for locations).

Within the main grid the country rocks consist of biotitized mylonitic amphibolites which are probably re-worked Bungitina Group rocks with the tectonic re-working taking place during movement along the Florence Creek Shear Zone. However it is possible that they are part of the Irindina Group as suggested by the RGB image (see 1994 Annual Report). The mylonitic texture has been superimposed on the older NE-SW trending metamorphic texture. The mylonitic texture has also been modified by a series of later undulose shears that possibly represent younger movements/re-working along the Florence Creek Shear Zone and rotation of mega-boudins and relatively un-sheared blocks due to the later movement.

The whole metamorphic sequence was intruded by pegmatoidal to aplitic sills and veins generally conformable to the mylonite fabric. Numerous, small (10-20m diameter, occasionally to 50m) ortho-amphibolitic bodies also intrude the sequence and occur as mega-boudins within the mylonites.

A detachment zone along which a silicified amphibolitic formation is overthrust upon the biotitized mylonitic para-amphibolites was mapped running SW-NE across Plate 22. This thrust zone is accompanied by a porphyroblastic Bungitina granitic sheet and is marked by pods of epidotized
Brittle shear zone
Silicification
Kaolinisation
Limonitisation and secondary U development in both wall rocks and breccia

Legend:
- Fault
- Breccia vein
- Voluminous pegmatite
- Brady gneiss
- Enita gneiss
- Surface secondary uranium
- Postulated sub-surface uranium

Conceptual breccia vein and disseminated wall rock uranium mineralization

PNC Exploration (Australia) Pty Ltd

Torbernite concept section
BRUMBY TRENCH 1

RADIOMETRICS (lead shielded srat)

WEST WALL Kriging

EAST WALL Kriging

Figure 92
BRUMBY TRENCH 2

RADIOMETRICS (lead shielded srat)

NORTH WALL Kriging

SOUTH WALL Kriging
BRUMBY TRENCH 3

RADIOMETRICS (lead shielded scat)

NORTH WALL Kriging

SOUTH WALL Kriging
BRUMBY TRENCH 6

RADIOMETRICS (lead shielded srat)

NORTH WALL Kriging

SOUTH WALL Kriging

Figure 101
BRUMBY TRENCH 7

RADIOMETRICS (lead shielded srtr)

NORTH WALL Kriging

SOUTH WALL Kriging

Figure 103
amphibole. The presence of this nappe is confirmed by the mapped tectonic window around T9 (see SE infill map). Another one can be also inferred in the eastern part of the map due to the presence of uraninite outcrops at a lower level of erosion, near the creek (See Plate 22 near 7422000N - 491750E).

The quartz mylonitic rocks within silicified amphibolite occur proximal to the biotitized amphibolitic rocks. Another two small detachment zones were mapped on the western/north western part of the grid along shear zones accompanied by epidotized amphibolites. The presence of these detachment zones is the result of differential movements along block and lithological boundaries during the mylonitization process.

The metamorphic complex was slightly dislocated along a younger NW/SE fault system. Several sheared pegmatitic rocks crop out along these fractures but contain only thorium anomalies.

Four infill grids were constructed. The north-western infills (See Plate 23) was located to investigate in detail two uraninite occurrences (T1, T2), 2 U-allanite outcrops (T4, T5), and minor copper mineralization (T3).

Two tectonic contacts between porphyritic Bungitina gneiss and biotitized mylonitic amphibolites were mapped; in the north-western part and south-eastern part of the infill. A truncated detachment zone along an old NNW-SSW shear zone accompanied by epidotized amphibolites was mapped on the western side of T4. A similar shear appears to link the mineralization in Trenches T2 and T3 and possibly also that in Trench T1. The north-eastern part (after the main creek) is characterized by widespread Bruna Gneiss outcrops which shows intrusive relationships with the amphibolite. Younger pegmatoid rocks crop out along NW/SE trending faults hosting thorium anomalies.

The south-western infill (See Plate 24) was placed to investigate two uraninite occurrences hosted by a pegmatitic rock (T7). Several uranium anomalies were located on the western part of the grid within felsic orthogneiss sheets. A detachment zone along an epidotized amphibolitic strip was mapped across the middle of the infill area.

The south-eastern infill (See Plate 25) was located to follow-up several U-allanite occurrences (T8, T9). A tectonic window of biotitized mylonitic amphibolites was mapped. The two large areas with quartz mylonitic rocks could indicate the extension of the mineralization to the south (under silicified amphibolite) at shallow depth.

The mineralization located within the grid can be grouped into four mineralogical classes; e.g. uraninite "eggs" and crystals; U-allanite (allanite + zircon + thorogummite + uraninite); euxenite +/- brannerite, monazite and allanite + quartz +/- zircon.

16 uraninite "eggs" were found on the Brumby grid, all of them being hosted by porphyroblastic quartzofeldspathic mylonites (meta-pegmatoidal to aplitic rocks). Most of the uraninite occurrences are placed along shear zones where the biotitization is well developed. It can be considered as a retrogression process which probably has the same age as the Florence Creek shear zones.

A number of assays were collected from uranium anomalies which outcrop in Brumby grid. Uranium content ranges from 66 ppm to 53.6% in HR05317. In this sample both Y-uraninite (analysis 18) and Th-uraninite (analyses 19, 20) were identified by scanning electron microscope (SEM). Both are partly altered, giving variable Si and/or Al abundances. Uraninite appears within the porphyroblastic
quartz feldspathic mylonites as small equant to anhedral grains and aggregates that form a more-or-less uniform and continuous mosaic throughout the rock. The uraninite is incipiently altered to a pale yellowish material (uranophane?) uniformly distributed throughout the uraninite grains.

10 assays were collected from U-allanite occurrences, the results displaying a large uranium content range from 2,100 ppm to 2.2% in HR05556. Thorium content ranges from 1,500 ppm to 9,500 ppm. This type of mineralisation occurs in the same geological context as the uraninite "eggs". But in both mineralization types continuity to depth and along strike could not be established by following trends due to the strong deformation and dislocation along shallow-dipping shear zones. Some of these shear zones were mapped as thrusts, but they are very difficult to be recognized due to the conformable detachment and lack of cataclastic zones in outcrop.

Most occurrences of U-allanite consist of large black vitreous crystals with fewer showing clusters of small grey blocky crystals. In polished thin section (HR05556, HR05574) the samples display a phenoblastic metamorphic texture with interstitial material consisting of zircon (up to 20%), quartz (up to 10%), epidote, biotite, thorogummite and uraninite grains. Uraninite was identified by SEM (HR05556) and confirmed by XRD (analyses 1, 2, 4, - Mason Report 2123 see Appendix 4 for details).

Only three occurrences of euhexinite +/- brannerite were found in Brumby grid, another two outcrops being identified outside of the grid, immediately and adjacent to the western boundary. Two samples (HR05986, HR05996) assayed 2.2 - 2.8 % U with significant contents in Nb, Y and Ta. All occurrences are hosted by pegmatoidal rocks and appear as euhexinite crystals partly altered to secondary uranium minerals. The petrological description (HR05908) of a euhexinite crystal shows also a small content in K-feldspar, quartz, muscovite, allanite, monazite and goethite. The metamorphic alteration is supposed to have occurred during metamorphic crystallisation.

Only one monazite occurrence was found within a pegmatoidal rock at the eastern border of the southwestern infill area (HR05910). Two large monazite crystals (up to 12cm in size) were found in the same outcrop. In polished thin section, this sample displays a coarsely crystalline texture with minor inclusions of other minerals as quartz, xenotime and iron oxides. It is supposed to have grown in a metamorphic environment.

Many allanite + quartz +/- zircon occurrences were identified both within the Brumby grid and outside of it. 18 assays were collected, uranium contents ranging from 93ppm to 7,900 ppm with thorium between 530 ppm to 16,000 ppm. High contents in Ce, La and Y were also registered and in two assays a significant content in Nb and Ta was found (HR05995, HR05998).

Generally, these occurrences are hosted by pegmatoidic rocks although several outcrops were found near the NW-SE trending fracture system (Plate 23).

In sample HR05575 allanite appears as crusts and veins filling cracks in a sheared pegmatitic rock. Allanite prismatic crystals have undergone replacement by very fine-grained orange-brown material along crystal margins. The well developed 120° triple grain junction observed in polycrystalline plagioclase areas is an evidence for high grade regional metamorphic conditions (see Appendix 4 for full descriptions).
A total of 23 samples were collected from quartz-tourmaline +/- carbonate veins which are spread throughout the grid. The best result was registered in one sample near T3 (HR05323) which assayed 4.1% Cu and 3.5 g/t Au.

4.2.2.2 Trenching
A total of 9 trenches were excavated by blasting and/or backhoe work. Typical dimensions were 15 x 1 x 1.5m. Scintillometer (lead shielded SRAT-SPP2) readings were taken on 50cm centers from all trenches.

The trenches were mapped at 1:50 scale and were sited over uraninite "eggs" and U-allanite occurrences. One trench was sited on a Cu-Au showing discovered during 1994.

T1 was dug on the northern part of the north-western infill area and targeted an uraninite anomaly associated with a slickensided quartz-feldspar vein. Only one uraninite "egg" was found in the trench, adjacent to a discontinuous convolute pegmatoidal vein within an east dipping cataclastic shear that crosscuts the shallow north dipping mylonite fabric. Some feldspathic (white?) alteration and chlorite-carbonate alteration was also noted. See Figure 90 for location and Figures 91 and 92 for the trench map and trench radiometrics.

T2, located on the main Brumby uraninite anomaly (discovery site where numerous fragments and crystals of uraninite associated with a slickensided aplite vein were found in 1994) confirmed the structural complexity in which the uranium mineralisation occurs. An uraninite "egg" was identified adjacent to a boudinaged apliteic sweat enclosed in a west dipping, cross cutting cataclastic shear, apparently superimposed on the mylonite fabric. Figure 93 shows the geology while Figure 94 shows the radiometric image.

T3 was sited 60m south of T2 to follow-up a copper mineralisation hosted by quartz-tourmaline veins. Eleven assays were collected for copper and gold contents (see the table in Figure 95). Figure 96 shows the radiometric data. The results show numerous veins of varying thickness filling vertical fractures in the wall rocks but no suggestion of continuous mineralization.

T4 was dug in the western part of the same NW infill area to test a U-allanite outcrop hosted by disturbed pegmatoidal rocks. Only small pods of mineralisation were found by trenching associated with convolute apliteic sweets within a complex shear, that is probably superimposed upon the regional mylonitic fabric. The east end of the trench has been cut by a younger vertical fault. Figures 97 and 98 show the geology and radiometrics respectively.

T5, located in the southern part of the north-western infill was sited to follow-up the thrust plane along which appears a large sheet of porphyroblastic Bungitina orthogneiss displaying an obvious mylonitic texture (HR05313) on its margins. A few allanite + zircon blocks were found along a shear zone within the host amphibolitic rocks (Figure 99). This shearing appears to be a re-working of the mylonitic fabric around a mega-boudin of orthogneiss. No radiometrics were made due to the shallowness of the trench and lack of anomalous exposure in the trench walls.

T6 was dug across pegmatite float in which a uraninite "egg" was found at the surface. Little interesting was found after trenching, but some weak radiometric anomalies adjacent to a porphyroblastic Bungitina orthogneiss body were measured. Again it appears that the uraninite is
associated with felsic sweats associated with shearing surrounding a mega-boudin of orthogneiss. Figure 100 shows the geology while Figure 101 the radiometric image.

T7, located in the south-western infill was sited to test a sheared pegmatoid body containing two uraninite "eggs". Nothing interesting was found in the trench. Minor U-Th radiometric anomalies were measured within a zone of boudinaged pegmatite within a shear zone that appears to have developed around a mega-boudin of aplitic Bungitina gneiss. Figure 102 shows the geology and Figure 103 the radiometrics.

T8 was dug to follow-up numerous U-allanite blocks found in the soil. More U-allanite blocks were found but the continuity of the mineralisation to depth was not confirmed. The U-allanite is associated with felsic sweats within a low angle east dipping catalastic shear zone associated with biotite alteration. A narrow vertical fault was exposed in the west end of the trench. Figures 104 and 105 show the geological mapping and the radiometric image respectively.

T9, located 150m up to the north of T8 was dug across sheared pegmatoidal rock affected by E-W trending shear zones. Figure 106 and 107 show the results for Trench T9. Blocks of U-allanite were found at the contact between pegmatite and soil; an area of 1.5 x 0.5m with uranium hot spots up to 10,000 cps was identified. Several phases of deformation were observed in the trench;
D1 - a shallow north dipping mylonite fabric with north over south kinking,
D2 - an east dipping shear-boudin-catalastic fabric that brecciates D1,
D3 - minor west dipping discrete shear's that displace D1 and probably re-work D2.

4.2.2.3 Geophysics

Ground spectrometry and ground magnetometry at 50 x 10m spacing were carried out on the Brumby grid. The infill areas were covered at 25 x 10m spacing.

The uranium ground spectrometer readings show a low background (2 ppm eU) over the amphibolite units but a noisy uranium background for some of the pegmatoid occurrences (Figure 108). Two significant anomalies occur around T9 and south-west of T8. Other small anomalies are due to several pegmatoid occurrences.

The thorium readings show appreciable and variable amounts of thorium within pegmatoid rocks. A high content in potassium was identified in porphyroblastic Bungitina orthogneiss which occurs in the north-western and south-eastern part of the Brumby grid.

The overthrust silicified +/- epidotised amphibolitic formation is less magnetic than other rock units. Maximum magnetics were registered where ortho-amphibolitic rocks occur. Two significant dipole-type anomalies associated with basic rocks were identified both in the north-eastern and south-western part of the grid. Figure 109 shows the magnetic contour map.

4.2.2.4 Appraisal

The 9 trenches sited within the Brumby grid area located sparse uraninite and/or U-allanite anomalies similar to the surface anomalies but no substantial repetitions to depth could be established. However, retrogressed shears, superimposed upon the regional mylonitic foliation, do provide target zones for speculative drilling on the basis that they do host sporadic uraninite mineralization.
4.2.3 Grid Work On EL 7992 - Kongo and Ono (Kong Bore)

During regional ground checking of airborne anomalies (1994) the following Cu-Au-Ag-Pt-Pd Showing (KONGO) within EL 7992 was located. KONGO occurs approximately 2.5 km W of White Hill Dam and adjoins Pasminco tenement EL 8787. A quick grid (100 x 200m) was constructed at KONGO to cover the mineralization. Plate 1 shows the location of the tenement and the showings.

The mineralization is hosted by an amphibolite body of approximate 100-150 m in width and 500 m in length. The western end is mineralized over an area of 130 x 40 m. The mineralization consists of several malachite stained quartz veins with occasional remnant blebby sulphides and more frequently malachite stained, sulphide mineralized, narrow shears in the host amphibolite. The enclosed 150 x 200 m grid map shows the western end of the amphibolite and the distribution of the mineralization (Figure 110).

Mineralized samples give assays in the range 0.1 to 6.8 % Cu, 1 to 12 ppm Ag, 100 to 5800 ppb Au, 100 to 620 ppb Pt and 100 to 1400 ppb Pd. However, the best assays of the precious metals came from the first sample (HR01481) collected and though repeat and additional sampling did achieve interesting assays (e.g. 3500 ppb Au, 210 ppb Pt and 940 ppb Pd) the discovery assays could not be bettered. A total of 36 samples were collected, five of which were from macroscopically un-mineralized amphibolite outcrop (HR06833-34, 36, 38, 41). Of the 31 mineralized samples collected 4 gave gold assays greater than 1000 ppb (i.e. > 1 g/t). One of the un-mineralized samples gave 1200 ppb Au.

The complete metal assays are listed in Appendix 5.

A quick grid was constructed at ONO to cover the pegmatite hosted uraninite mineralization located in 1994 and removed after mapping (100 x 100m). Several E-W orientated shears cutting a saprolized amphibolite-garnet gneiss sequence were mapped. The uraninite bearing pegmatite is hosted by one of these shears. No further indications of uranium mineralization were found. Figure 111 shows the results of the mapping. Figure 112 shows the results of detailed total count readings using an EDA spectrometer. The hotspots to the east and to the south of the pit proved to be thorium sourced.

4.2.4 Ryoma (EL 7991 - Christmas Creek)

Figure 78 shows the location of the grid.

4.2.4.1 Mapping

The RYOMA grid was refurbished prior to re-mapping. The aim being; to assess relationship between mineralization and flat dipping mylonite zones (high strain zones) and vertical late stage fracturing.

Two retrogressed faults were mapped; one 75m north and the other 50-75 m south of the uranium anomaly. The northern fault appears to dip 30-45 deg north with a footwall up displacement while the southern fault appears to be vertical in orientation. No anomalies were found along the faults. Retrogression includes chloritization and epidotization of the wall rocks along with zeolite, bladed quartz and carbonate veining. Between the two faults, numerous bleached and hematized fracture
zones occur that surround the uranium showings. This fracturing/alteration does not appear to control the mineralization. Figure 113 shows the results of the additional mapping.

The showings appear to be localized by a zone of re-crystallized shearing (as suggested by crosscutting stringers of quartz tension fillings), feldspar-tourmaline metasomatism and perhaps some brecciation. This zone dips at approximately 5 deg southward and disappears into the south bank of the creek. It is approximately 30 m long and 30 cm thick. The origin of this zone is obscure but it seems likely that it has occurred during the development of several parallel, shallow dipping and N-S orientated mylonite zones, one of which occurs about 10-15 m above the uraninite showings. These mylonites exhibit a strong N-S lineation, silicification of foliation surfaces and the development of veined pods of quartz-feldspar rock with frequent thorium enrichments and occasional U-(Y) enrichments (e.g. CASPER).

4.2.4.2 Appraisal

The occurrence of uraninite at RYOMA seems to have many similarities to the BRUMBY showings; i.e. syn-metamorphic growth of uraninite imbedded in the host rock associated with a metasomatic retrogression. The economic potential appears to be moderate due to the limited surface expression; however a limited amount of drilling to test for possible sub-surface repetitions is recommended.

4.2.5 Pacer (EL 8220 - Entia)

At PACER a 200 x 150 m grid was constructed to investigate a surface anomaly located during 1995. See Plate 2 for the location of the grid area. On Figure 38, PACER is located east of PONY but is not shown.

4.2.5.1 Mapping and Sampling

PACER is located over a partly dilatant, retrogressed, E-W fault, which cuts layered felsic and mafic Entia Gneiss. Sporadic zeolite veining marks the dilatant segments of the fault zone. Elsewhere the fault is marked by non-dilatant fracturing. The fault can be traced from the Horse Fault in the west across to the east, just south of ASP (see 1994 report).

PACER is a replica of Pony-style uranium mineralisation, though on a much smaller scale. In the vicinity of the Pacer trench the surface radiometric anomaly is about 15 metres long and is accompanied by rare, loose, zeolite float. Grab soil sampling produced assays of 140-160 ppm U and 5400-6200 ppm P. (samples HR05501-5503). Alteration (silicified zeolite) was traced over 100 m.

Refer to Figure 114 for prospect geology and trench location (PC-1).

4.2.5.2 Trenching

A single backhoe trench was excavated and channel sampled at PACER (see Figure 115).

The trench exposed a well defined fault zone about two metres wide and inclined steeply towards the south. Unlike the PONY occurrences, very little crystalline zeolite is visible and the fault material is dominated by siliceous fault breccia or rubble and fault-clay. Both disseminated and replacement layers of green nontronite clay-alteration are prominent at the margins of the rubbly fault material.
Only spotty radiometric anomalies are present on the trench walls associated with siliceous rubble (100 - 500 cps shielded SRAT). Figure 116 shows the radiometric image. Channel sampling revealed a familiar association of uranium and phosphorous, indicating uraniumiferous apatite (collophane) to be the likely uranium host phase. The best channel sample assay was 0.5 m at 260 ppm U. Refer to Figure 115 for location of channel sample lines. A total of 22 channel samples were taken.

4.2.5.3 Geophysics

Like PONY, there is little or no discernible airborne radiometric anomaly at PACER. The prospect is largely masked by soil cover. A low-order radiometric anomaly of 150 cps (EDA) was noted during prospecting, and was subsequently enhanced to 1000 cps by digging. The anomaly could only be traced some 15 metres along strike.

Ground spectrometric survey data failed to show a discernible uranium channel trend (see Figure 117). The trench site is occupied by a magnetic low probably associated with a neighbouring high as part of a shallow dipole just south of the fault. Figure 118 shows the magnetic contour map.

4.2.5.4 Appraisal

PACER is too small in size and uranium grade to warrant further work. It's discovery does however, add to an expanding inventory of late, Alice Springs Event, retrogressed-fault-hosted uranium shows. This in turn, has encouraging implications for all Alice Springs Event structures across the Arunta Block.

4.2.6 Bronze (EL 8036 - Quartz Hill)

4.2.6.1 Work Done

An area of 500 x 400 m was gridded and two trenches were sited to follow-up a 300 m long epidosite layer hosting several hotspots. The host rock for the epidotization is an amphibolitic formation which overlies a felsic suite. The sequence is cut by cross-cutting, shallow dipping, narrow (1-2 m) pegmatites. The BRONZE Prospect is shown as a 1995 gridded area on Figure 38.

The epidotization appears to be associated with a low angle shear zone (see trench BRT-1) which is modified by a younger fault well exposed in trench BRT-2. The shear zone grades from a cataclastic zone, to a zone of diffuse epidotization to a zone of intense boudinage (high stress zone) from NE to the SW along the shear. Epidotized pegmatite margins at the contact with the shear zone host the strongest hotspots (2,300 cps EDA). Plate 26 shows the epidosite trace marked in green. The aplite and pegmatitic rocks found in trenches seem to be syntectonically emplaced along low angle fracture sets.

17 assays were collected, the best results being recorded in HR05464 (2,000 ppm U/25 ppm Th). The remainder of the assays range between 2-180 ppm U, 0.6-43 ppm Th and 10-680 ppm Y.

The mapping results from the two trenches are shown in Figures 119 and 120. Figure 121 displays the geological legend for the trench maps. Radiometric images are shown on Figures 122 and 123. Locations of channel samples are also indicated on Figures 122-123. Ground geophysical results are displayed on Figures 124 and 125.
PACER TRENCH 1
RADIOMETRICS (lead shielded SPP2)

WEST WALL Kriging

EAST WALL Kriging

Figure 116
LEGEND

Epidote rock, cataclastic
Hard, quartz > Epidote rock
Epidote - Hornblende rock
Aplite
Pegmatite, Cataclastic
Pegmatite dyke
Para-amphibolite
Biotite Gneiss
Carbonate
Quartz
Felsic Gneiss
Actinolite
Epidotisation

Vein with label
Shear / Sheared
Fracture
Foliation trend
Sharp contact

Quartz
Sample site
Channel Sample

Strong radiometric anomaly
(BRT-1: $X \geq 250$ cps, BRT-2: $X \geq 500$ cps)
Isoradiometric line ($X \geq 200$ cps)

Figure 121
BRONZE GRID - GROUND MAGNETICS

1:2000

INVERSE DISTANCE 2
4.2.6.2 Appraisal
A distinct zone of epidosite metasomatism and minor sporadic uranium mineralization was delineated. The potential for sub-surface mineralization appears to be low. No further exploration is recommended unless work at HADDOCK and SWALLOW proves the viability of the Epidosite Target.

4.2.7 Hof (border EL 7967 - Mt Muriel and EL 7991 - Christmas Creek)

4.2.7.1 Work Done
26 assays were collected from HOF area, the uranium contents ranging from 2.9 to 470 ppm whereas thorium registered a range between 0 and 34 ppm.

A grid of 800 x 300 m was completed and three trenches were sited to follow-up an EW trending retrogressed fault. The fault has been mapped over an 800m length. It bifurcates towards the western end, resulting in several clay-zeolite altered splays and parallel gashes, but no more anomalies were discovered. The mineralization is similar to that at PONY. Plate 27 shows the results of the mapping.

All three trenches were dug on the eastern end of the fault where previous mineralization was located in 1994 (max. 250 ppm U). Figures 126-128 show the trench mapping. Figure 129 shows the legend for the trench maps. The mineralized zone (100-450 cps EDA) exposed in the trench walls varies between 5-8 cm in thickness whereas the wider clay-zeolite altered zone varies between 5-8 m in thickness. The radiometric images, which illustrate the low order anomalies found, are shown on Figures 130-132. The channel sampling details are also shown on Figures 130-132. The best assay of 260 ppm U was found in Trench 1.

The best assay results were recorded along a NNE/SSW trending band of epidotized rocks hosted by an amphibolitic formation, immediately to the south of the retrogressed fault which apparently displaces the epidosite band (HR05491-94). The hotspots seem to be related with older conformable low angle shear zones (see BRONZE, SWALLOW etc.). Assays were 300-470 ppm U, 140-250 ppm Y and <20 ppm Th.

The results of detailed ground geophysical surveys are shown on Figures 133 and 134.

4.2.7.2 Appraisal
The HOF grid contains mineralization of both the PONY and Epidosite types. The retrogressed fault (PONY-TYPE) appears to be both thinly and weakly mineralized hence only a low order drill target can be postulated. The Epidosite mineralization was not investigated in detail hence its potential remains un-assessed. Its potential is unlikely to be very strong.

4.3 Airborne Survey - World Geoscience Survey
World Geoscience Corporation (WGC) was contracted, during 11-28 December 1994, to carry out an airborne radiometric and magnetic survey over four areas (three within and/or marginal to the Entia domal structure and one within the Brumby area).
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**Strong radiometric anomaly**
(HT-1: X≥300cps, HT-2: X≥200cps, HT-3: X≥150cps)

**Isoradiometric line (X≥200cps)**
HOF TRENCH 1

RADIOMETRICS (lead shielded SPP2)

WEST WALL Kriging

EAST WALL Kriging

SAMPLE NUMBERS
Prefix: HRO
A 5484  E 5480
B 5483  F 5479
C 5482  G 5478
D 5481

Figure 13
Approximately 2,600 line km were flown at 200m line spacing. Terrain clearance was a nominal 80m, 10 readings/second acquisition rate for magnetics and 1 second count time for radiometrics. A crystal of 331 was used.

4.3.1 Data Processing

Standard 1:25,000 map sheets of stacked spectrometric profiles were received from the contractor. Additionally flight line maps were also supplied. Magnetic contour maps of Total Intensity were also supplied at 1:25,000 scale. Spectrometric colour contours were supplied at 1:50,000 scale. Flight path maps were also supplied at 1:50,000 scale. No additional data processing was undertaken due to budgetary constraints.

4.3.2 Anomaly Selection

Initial analysis of the airborne data was done by visually scanning the analog charts provided by the contractor. A total of 40 uranium anomalies were delineated. These were rated as first priority based on the 1993-94 experience. According to peak height, peak slope and thorium contribution; they were ranked WA1-5.

A total of 638 airborne uranium channel anomalies were distinguished by the visual evaluation of stacked profile data (5 sheets at 25,000 scale), of which 213 were ground checked. Plates 28-32 inclusive show the plotted locations of the anomalies with posted anomaly numbers and a follow-up ranking key. The key is explained as a footnote on the anomaly listings in Appendix 6.

These anomalies were ranked WC1-4 and WX1 based on peak height, peak shape, thorium influence and overall radiometric noise signature. Classes WC2-4 were regarded as being of very low potential because they represent anomalies within the noise envelope of the uranium channel and a high percentage (>90%) of false anomalies can be expected. The WC1-4 anomalies were derived from the preliminary maps and the WX1 anomalies from a re-check of the final edited data.

Table 5 classifies the data with respect to tenement and priority.

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4.3.3 Airborne Follow-Up
This work was carried out by 2 man crew using a Bell47-G for support. Anomalies were located using a combination of helicopter and hand held GPS units and airphoto plots.

An area of approximately 300 x 300 m was searched at each site to adequately check for any suggestion of surface mineralization. Grab samples collected during the follow-up are listed on Plate 33.

Appendix 6 lists the details and locations of the airborne anomalies and the results of the ground checks.

4.3.3.1 Brumby Area (EL 7990, EL 9031 and EL 9032)
A total of 111 anomalies were checked by helicopter, only 70 of them being placed within PNC tenements (EL's 7990, 9031, 9032). The anomaly locations (see below) are plotted on Plate 2.

The main results are as follows:

- 21BM75; one uraninite "egg" hosted by a porphyroblastic felsic mylonite from Florence Creek Mylonitic Zone,
- 21BM18 several beta-uranophane anomalies occurring within silicified, Ca-plagioclase rich Bungitina granite dykes, in the west Florence Creek area south of the Claraville road (1000-3000 cps).
- 21BM97 (few uraninite "eggs" and U-allanite occurrences within pegmatoid rocks, N Brumby area).

The remainder of the anomalies being spurious. The main cause being lithological contrasts between felsic and mafic units within the heavily tectonized rocks within and adjacent to the Florence Creek Shear Zone.

4.3.3.2 Spriggs Area (EL 7994 - Western part and EL 8906)
A total of 42 anomalies were checked in this area (17 within EL 8906, 6 within 7994 and 19 outside of the tenements). Very few actual radiometric hotspots could be located on the ground. The majority of anomalies almost certainly are the result of terrain or contrast effects. The best anomaly located was:

The identification of an euxenite mineralisation in the Eastern Chief area (W Mt Bruna, 12EC04, Pearly Gates) located within EL 7994. Mineralogically the euxenite consists of coarse grained aggregates of euxenite, allanite, minor K-feldspar, quartz, muscovite and uraninite (HR05909). Uraninite was identified by electron microscope and contains up to 12% ThO₂. The metatamict euxenite (identified by XRD) consists of euxenite, aeschynite, liandrite, thorite, petscheckite, uraninite and cerianite (HR05909A, B). A total of 12 euxenite crystals were found (max. 10,000 cps) in two distinct ellipsoidal pegmatoid bodies intruding amphibolites (Irindina Formation) at the discovery site. Further prospection found another five uranium anomalies (up to 3,000 cps) along a NE-SW trending pegmatitic dyke of more than 500m in length to the NE of the discovery site. The location of Pearly Gates is shown on Plate 2. The potential for further work based on the pegmatite genesis is judged as low.
4.3.3.3 *Inkamulla Area (EL 8675, EL 8220 - northern part and EL 7994 - eastern part)*

A total of 63 anomalies were checked in this area (28 within EL 7994, 22 within EL 8220, 10 within EL 8675 and 3 outside of these tenements). The main anomalies (see below) are plotted on Plate 2.

Numerous anomalies were located on the ground in the Inkamulla Area (EL8220). These anomalies fall into four groups:

(a) High amplitude spot anomalies hosted by pegmatite dykes. Chemical assays approximate to "yttropyrochlore". Typical examples include anomalies: 22IN11 (HR05545); 22IN93 (HR05805). These anomalies tend to cluster north of the Inkamulla Dome.

(b) Secondary uranium occurrences around the rim of the Inkamulla Dome. Two such sites were located: 22IN77 (HR05817) and 22IN89 (HR05543).

(c) Thorium-based anomalies in felsic gneiss, along the western rim of the Inkamulla Dome.

(d) Rare episodite hosted uranium anomalies along the NE side of the Inkamulla Dome. Best example: 22ML99.

In cases (b) and (c) above the host rocks comprise quartz sweets and biotite-rich segregations respectively, within felsic gneiss. These occurrences are limited to just a few square metres in extent. Maximum values range 510 to 870 ppm.

None of the above occurrences warrant further work.

4.3.3.4 *Mt Long Area (EL 8220 - north eastern part)*

A total of 60 anomalies were checked in Mt Long area and can be classified into three groupings. These anomalies are named on Plate 2.

(a) Anomalies (mostly uranium-based) associated with the ridge-forming shear zone that passes through TORBERNITE. Specific anomaly host rocks include:

(i) altered felsic gneiss; eg 22IS06 (HR05542, 340 ppm U)

(ii) ferruginous veins; eg 22ML10 (HR05550 700 ppm U) and 22ML26 (HR05538, 380 ppm U)

(iii) massive radioactive pegmatite; eg 22ML21.

(b) Anomalies within the Brady Gneiss terrain; usually spurious, untraceable or pegmatite-related.

(c) Anomalies within the Entia Gneiss terrain; mostly episodite or allanitic calc silicate related; eg Frenzy 22ML74 (HR05807).

The anomalies in group (a) above are significant finds, because they directly extend the influence and magnitude of the TORBERNITE Prospect.
The lack of success in locating group (b) anomalies, above, generally downgrades the prospectivity of Brady Gneiss. The only significant anomalies within Brady Gneiss terrain seem to be the HOLSTEIN-type REE-Th-U veins (see 1994 Annual Report).

A number of group (c) anomalies lie in an arc-like zone extending from 13GC45 (Schnabel) to 22ML74 (Frenzy). All are too small to warrant "stand-alone" prospect status as the amount of mineralized outcrop rarely extends to 1m².

4.4 Previous Airborne Surveys - Additional Follow-Up

4.4.1 Airborne Follow-Up

Approximately 63 anomalies from the two previous airborne surveys that remained unchecked at the end of the 1994 field season were checked. The ones checked were mainly in the eastern parts of EL 8220 and EL 8036. A few checks were carried out within EL 7967, EL 7991 and EL 7992. The ground within EL 9149 which was recently acquired by PNC was also checked. This brought the coverage for the KA1, GA1, KC1, GC1, GZ1 and GAZ classes (ranks) of airborne anomalies close to 100%.

Unfortunately, no significant anomalies were located. Generally terrain effects accounted for most of the spurious anomalies with contrast effects between adjacent rock types causing most of the remainder. Appendix 7 lists the results of the ground checks.

(a) Two anomalies were checked near EL 7992 (Kong Bore) near Old Station Well. Only Th dominant monazite sourced hotspots were found.

(b) On the western slope of WHITE MOUNTAIN (EL 7967) another four uranium anomalies (up to 2,000 cps) were located within the large pegmatitic mass containing visible secondary uranium minerals. A sample assayed 920 ppm U and 71 ppm Th (HR05967).

(c) Within the QUARTZ grid (EL 8036) a 23,000 cps hot spot was located, several Y-samarskite crystals were found adjacent to the discovery site within quartz-pegmatite material. A sample assayed 550 ppm U and 220 ppm Th (HR05968).

(d) A few Y-samarskite crystals were found within the FELSPAR grid being hosted by similar pegmatitic rocks (EL 8036).

(e) Three km NE of Log Cabin Dam (EL7967) a U-allanite occurrence was found within a pegmatoid dyke which assayed 1800 ppm U and 180 ppm Th (HR05973).

4.5 Prospecting And Mapping

4.5.1 EL 7967 (Mt Muriel)

Numerous areas in the vicinity of HOF and BONNIE were checked during the mapping of the detailed grids. In particular the Harding Springs Fault was extensively traversed to find repetitions of the BONNIE showing. A minor anomaly, 1.0km east of BONNIE (see Figure 135) was located. However
the anomalous area was very small (2 sq m) hence no detailed work was initiated (140 ppm U, HR05664).

The VERDANT showing, located 2.5 km south of the Spriggs Airstrip, was visited to evaluate the significance of a 2000 cps EDA anomaly located in 1994 (see Plate 2). The main anomaly is caused by U-allanite float within soil. An assay gave 900 ppm U and 180 ppm Th (HR05674). The source of the mineralization appears to be a cross cutting pegmatite dyke and not the adjacent epidotized altered gneiss. Minor patches of radioactive epidotite were found to the south of VERDANT; however, potential for further work is limited.

Traverses were carried out along a narrow epidotite band that leads off from the lower epidotite layers at HADDOCK. Two small patches of anomalous carbonate-epidotite material were located. Assays gave 180-510 ppm U and 23-280 ppm Th (HR05551-52).

4.5.2 Brumby Area (EL 7990 - Maud Creek, EL 9031 - Florence and EL 9032 - Mullers)
A large area of 310 sq km (17 x 18.3 km) was mapped and prospected at 1:25,000 scale covering two main tectonic units; Strangways Orogenic Belt (SOB) and Harts Range Cover (HRC). The first is supposed basement which is separated from the cover rocks by the Florence Creek Shear Zone (R.L. Oliver et al., 1987). Plate 34 shows the results of the mapping and locations of grab samples collected during prospecting.

Strangways Group rocks, which outcrop over a large area, are characterised by having a high proportion of quartz-feldspathic lithologies. The Harts Range Group rocks are predominantly mica rich gneiss, amphibolite and calcisilicates. The Florence Creek Shear Zone, is interpreted by James and Ding (1988) to be part of a detachment zone between the two complexes. The Bruna Gneiss is considered by these authors to have been emplaced into the detachment zone during detachment.

Generally, the rocks of the Strangways Orogenic Belt are of a higher metamorphic grade (amphibolite-granulite facies) and display more migmatitic and granitoid development than the amphibolitic facies in Harts Range Cover. The deformational histories of the two complexes seems to be distinct in that the SOB structures trend fairly consistently NNE-SSW, whereas those of the HRC are more variable.

The SOB units which appear to the south of Florence Creek Shear Zone consists of Bungitina metamorphics, Bungitina granitoid complex and carbonatic Cadney formation.

The area is characterized by the extensive development of mylonitic foliation accompanied by retrograde metamorphism during which biotite formed at the expense of ortho-pyroxene and orthoclase; a reaction which involves the introduction of water and results in enhanced ductility, because the resulting quartz-biotite aggregates deform more easily (Snow and Black, 1991). Structural evidence and Rb-Sr isotopic dating indicates that hydration, accompanying mylonitization during thrusting, occurred both at 1500-1400 Ma and between 400-300 Ma (Alice Springs Age).

The radioactive minerals are hosted by Bungitina orthogneiss of various compositions. Generally in leucocratic facies (sweats), uranium occurs as uraninite crystals or "eggs" in strongly deformed pegmatoidal to aplitic rocks. On the other hand, uranium in the melanocratic facies is located in accessory minerals such as monazite, zircon and apatite). Additionally uranium enrichments can also
occur as uraninite concentrations in late magmatic (viscous state) shear zones associated with mineralogical evidence of a fluid phase rich in phosphate, B, F, Zr and light rare earth elements.

In the Brumby area, most of the uraninite occurrences were located within pegmatoidal to aplitic rocks emplaced in a biotitized mylonitic amphibolite; hence are probably associated with felsic differentiation processes of a metasomatic nature occurring during regional deformation.

The main results (outside of the Brumby grid) are the identification of 8 uraninite "eggs" and crystals in North Brumby area at the contact with Florence Creek Mylonitic Zone and several beta-uranophane occurrences hosted by silicified felsic orthogneiss dykes emplaced within biotite-garnet gneisses (SW Brumby grid and NE Bungitina granitoid pluton).

Few "Pony Type" anomalies (CHARGER) were located along a WNW-ESE trending retrogressed fault in the northern part, at the contact between Strangways Metamorphic Complex and Florence Creek Mylonitic Zone (HR05683-85, HR05665, HR05667). The samples assayed 200-510 ppm U and 0-14 ppm Th.

A mylonitic zone was mapped and named the Florence Creek Mylonitic Zone on Plate 34 being defined as part of the more extensive Florence Creek Shear Zone. Lithologically, this unit consists of an alternating felsic and mafic mylonites. The eastern part with anastomosing branches diverges around a large mass of Bruna Gneiss of predominantly felsic mylonites in which can be recognized as tectonically modified porphyroblastic Bungitina sheets and dykes, Bruna Gneiss and undifferentiated felsic gneisses.

The western part is predominantly mafic, with interbedded minor felsic mylonites. Most of the airborne anomalies in this part, are due to the backgrounds difference between mafic mylonites (20-30 cps) and felsic mylonites (100-120 cps). Mafic mylonite consist of both para-amphibolites and ortho-amphibolites. Often, in this mylonitic zone less-affected cores of dioritic and gabbroic rocks could be recognized.

Within the Florence Creek Mylonitic Zone the following anomalies were located; one uraninite "egg" (Bantam anomaly), two beta-uranophane outcrops (W Brumby Bore) and several allanite +/- uraninite occurrences hosted by thin porphyroblastic quartz-feldspathic mylonites at the contact with mafic mylonites (amphibolitic rocks).

In the BANTAM area detailed prospecting was carried out to attempt to locate more uraninite occurrences. However, no further uraninite showings were found. The uraninite (HR05316) is hosted by a felsic mylonite and occurs as blocky crystals with interstices filled by fine grained uranophane.

Two outcrops with allanite + quartz + zircon + apatite +/- uraninite were found in the Bantam area (HR05318, HR05572). Allanite appears as bladed crystals, the interstices between them being filled by anhedral grains of quartz, stumpy zircon crystals, pyrite grains and small equant crystals of uraninite (sometimes partly altered into intergrown yellowish gummite material).

A large mass of granitoid rocks in the west of the mapped area (coarse grained alkaline granite-adamellite) and an associated spectrum of dykes, sheets and pegmatoidal sills and veins were mapped, as well. The body appears to be a pluton intruded in the Bungitina country rocks. Many occurrences of allanite and thorium anomalies were located around the granitoid mass.
In the southern part of the Brumby grid and near Hale River some occurrences of uraninite-bearing trondhjemitic rocks were identified (HR05951, HR05911-12). The uraninite appears as small cubic crystals, irregularly distributed throughout the rock, occurring in plagioclase, quartz, and mafic aggregates. All uraninite grains display variable degrees of metamictic alteration. A high grade of metamorphism is inferred from the colour of the hornblende and the antiperthitic texture in the plagioclase (HR05951).

The presence of magnetite and the dark brown colour of the biotite suggest relatively oxidising conditions. It is supposed that these rocks to be older than Bungitina orthogneiss due to the stronger deformations and a predominantly sodic composition which suggests a basic source (provenance). Taking into account the extension of the primary basic magmatism (orthoamphibolites) and the felsic gneisses in the south of Hale River, we suggest the presence of a bimodal magmatism which was previously described in the Central Province of Arunta Inlier (Stewart et al., 1984).

To the south of Florence Creek Mylonitic Zone two areas with beta-uranophane mineralization were identified. The first one is placed in the south-western part of Brumby grid. The mineralisation is hosted by silicified Bungitina dykes which contain up to 20% K-feldspar. Uranophane was identified by XRD (HR05914) and appears as yellow secondary patches in association with xenotime crystals, magnetite, zircon and allanite in a polycrystalline plagioclase mosaic. The rock underwent a dynamic regional metamorphism which caused deformation and partial recrystallisation. The intimately magnetite intergrown with xenotime and zircon suggests a metasomatic phase although a primary accessory phase can be accepted as well.

The second area is placed in the north-eastern border of the Bungitina granitoid pluton (HR05582, HR05974, HR05579, HR05591-92, HR05599). Uranophane occurs in deformed silicified Bungitina dykes emplaced within biotite-garnet gneiss. The samples collected from the area assayed 51-590 ppm U and 92-870 ppm Th.

In the eastern part of the map (Lizzie Creek) a WNW-ESE trending limonitized fault located within Florence Creek Mylonitic Zone at the contact with seepentinized amphibolites (Irindina Formation) was identified. The extension of this mineralised fault (1-2m wide and over 500m in length) could be interesting for copper, zinc and gold contents (HR05563 1000 ppm Cu, 530 ppm Zn and 7 ppb Au).

Additionally this material is very similar to that in the Torbernite Fault hence may also be prospective for uranium.

The most significant copper assay (3.7%) was registered in sample collected from a pegmatitic rock near Hale River (HR05581).

4.5.3 EL 7991 (Christmas Creek)

Prospecting traverses (3 man-days) were carried out in the area immediately NNE of Harding Springs, east of HOF. The aim being to locate and check retrogressed fault zones, clearly visible as prominent photo lines on the 1:25,000 scale enlargements, based on possible extensions/repetitions of the mineralization located at the HOF and PONY prospects. Though moderate amounts of retrogressed material such as zeolite veining, vuggy quartz and white-grey clay were noted no significant anomalies were detected.
4.5.4 EL 7992 (Kong Bore)

Limited traversing (4 man-days) was carried out around the ONO and KONGO prospects. At ONO no significant anomalies were detected. Samples (HR05657-58), from moderate radiometric anomalies to the east and NE of ONO all proved to be Th dominant. A sample from altered wall rock near an ultramafic intrusive also gave nothing of significance (HR05659).

At KONGO, scout traverses located several minor occurrences of malachite staining on blocks of amphibolite occurring as 5-10m diameter boudins in more felsic country rocks. These are located 100-250m north of KONGO. An assay gave 5000 ppm Cu (HR05661).

To the SW of KONGO a very unusual outcrop of a skarn (?)-like rock was located consisting of quartz-garnet-epidote with accessory amounts of coarse (cm sized) chlorite, ilmenite and hematite. Samples gave 0-260 ppm As, 14-27% Fe, 50-8700 ppm P and 400-11000 ppm Ti (HR05662-63).

4.5.5 EL 7994 (Mt Bruna)

A limited amount of work was carried out around Bens Show. An outcrop of U-allanite. A four gallon bucket of moderately radioactive material (800 cps) was collected by the local prospector Ben Pope. Sampling gave assays of 930-1000 ppm U (HR05544, 5679) and a petrological report identified epidote (allanite), with suspected uraninite traces, as the source mineralogy.

4.5.6 EL 8036 (Quartz Hill)

The SE parts of the HUCKITTA SHEAR, near and east of the Solo Mica Mine, were prospected by two-man prospecting crews. Two faults filled with TORBERNITE-type material were checked. Both can be traced over several km. No radiometric anomalies were discovered. Three grab samples were collected but proved to be disappointing (HR05651-53).

The western part of the HUCKITTA SHEAR and several associated splays were also traversed by a two man crew. The samples collected all proved to be of no significance (HR06817-20). One thorium dominant radiometric anomaly associated with a pegmatite block within the shear was located (HR06817, 150 ppm U and 720 ppm Th). Other traverses near Huckitta Bore failed to locate any significant anomalies.

The areas adjacent to KEIFER and FLOATER were also extensively prospected.

Approximately 10 man-days were spent on locating the source of the FLOATER anomaly (1980 ppm U). It appears likely that this material was derived from one of several strongly weathered pegmatites that crop out on the steep slope above FLOATER. This interpretation is supported by the abundant float of pegmatite around the mineralized float. The epidote-garnet layer in the cliff face above the mineralized float does not appear to be mineralized.

Approximately 12 man-days were spent in re-locating and following up the KEIFER showing (440 ppm U). A greater than 200m long zone of epidotized, silicified and boudinaged interlayered felsic gneiss and amphibolite was located. Four uranium dominant hotspots in the range 500-3500 cps EDA were found. However, all hotspots occur adjacent to cross cutting pegmatites so that the
mineralization would appear to be pegmatite related rather than epidote related. Trenching would be needed to resolve the situation but the uranium exploration potential appears to be minimal. Samples gave 350-3000 ppm U and <20 ppm Th (HR05696-5700).

A second zone of epidote associated with a mylonite zone (WEST KIEFER) was also located but the hotspots were much lower (100-400 cps EDA).

Prospecting traverses (approximately 5 man-days) were also carried out in the areas NNW of Hardings Springs around Mt Lionel. The aim being to locate and check retrogressed fault zones, clearly visible as prominent photo linears on the 1:25,000 scale enlargements, based on possible extensions/repetitions of the mineralization located at the HOF and PONY prospects. Though moderate amounts of retrogressed material such as zeolite veining, vuggy quartz and white-grey clay were noted, no significant anomalies were detected.

4.5.7 EL 8148 (Mt Palmer)

Limited follow-up (2 man days, helicopter support) was undertaken to re-sample the copper anomaly found in 1994 (1200-1450 ppm Cu). The target horizon, a 100 x 1 m lens of vuggy limonite-garnet-quartz rock was traced along strike but no significant extension of the original discovery was found. Samples HR05815-16 were collected. The best results were 3.2% Cu, 44 ppm Bi, 5.0 ppm Ag, 95 ppb Au, 22% Fe and 7100 ppm Ti.

4.5.8 EL 8220 (Entia)

Prospecting traverses (approximately 12 man-days) were also carried out in the areas south and east of PONY towards Black Mountain. The aim being to locate and check retrogressed fault zones, clearly visible as prominent photo linears on the 1:25,000 scale enlargement, based on possible extensions/repetitions of the mineralization located at the HOF and PONY prospects. Though the mineralization located at the HOF and PONY prospects. Though moderate amounts of retrogressed material such as zeolite veining, vuggy quartz and white-grey clay were noted only the minor PACER anomaly was discovered (see section 4.2.5). Samples HR06850 and HR05900 were collected from pegmatites.

Two radioactive epidote occurrences (670, 840 ppm U), discovered late in the 1994 field season and located NE of PONY (east of HORSE) were prospected (2 man-days) but no further anomalies were discovered. The significance of these anomalies will depend on the results of detailed work at HADDOCK.

VIMY RIDGE was also investigated. Here a thin (1-2m) 1.5km length of silicified and weakly epidotized rock (possible a cross cutting silified shear) shows frequent hotspots in the range 100-500 cps (mixed U<Th) with a few zones (50-100m long) showing U-allanite sourced hotspots giving counts in the range 500-2500 cps. In particular the southern 250m on the structure (?) is frequently mineralized. Samples HR-5675, 6814-15 were collected. Assays range 340-820 ppm U, 160-580 ppm Y, 10-130 ppm Th and 2700-10,000 ppm Ti.

The HUCK FINN epidote hosted anomaly, located 500m NNW of Huckitta Bore, was followed-up. However no repetitions of the 1994 discovery anomalies (610-1500 ppm U) could be discovered. The epidote occurs, associated with frequent patches of silicification, as numerous poddy layers and
boudins in a NNE-SSW trending high strain zone extending over 1.0 km northwards from Huckitta Creek. Numerous hotspots in the range 100-600cps EDA occur within 200 m of the creek but the frequency and intensity (60-100 cps EDA only) of the hotspots reduces rapidly further north.

Two radioactive quartz-epidote samples dropped off by Ben Pope proved to be both uranium dominant. Both were located in the Walter Smith area (see 1994 Annual Report and section 4.1.3.4 this report). Assays gave 160-500 ppm U (HR05678, 80).

The vicinity of the DAICOS anomaly (790 ppm U), a small patch of epidote-garnet rock, located approximately 2km SE of HADDOCK, was also followed-up. Approximately 5 man-days were spent prospecting the general area. The anomaly could not be re-located and only minor amounts of epidote-garnet-quartz material could be located. A minor anomaly was found and sampled (HR05673, 100 ppm U). The potential for further work is limited but positive results at HADDOCK may indicate the need for more persistent investigations.

Near GOSPOST, a narrow retrogressed fault with silica-zeolite alteration was located about 400m N of the Cu-Au mineralization located in 1994. The retrogressed fault extends over 80m in lengths and hosts a 15m section with EDA readings in the range 100-500 cps (U-dominant). The visible copper mineralization (malachite stain) can be traced over 200m north of the discovery site as flecks on pegmatoidal and/or quartz sweats within the gneisses.

4.5.9 EL 8901 (Holstein)

This tenement was taken up to protect the eastern edge of EL 8220 and the HOLSTEIN Th-REE anomaly in light of the proposed change to a new Geodetic Datum by the Northern Territory which would have the effect of shifting all minute blocks 130 m (approximately) to the SW. As this proposed change has been postponed the tenement was surrendered.

4.5.10 EL 8906 (Spriggs)

Apart from the airborne follow-up work no other work was carried out on this EL. The CUSP copper showings were deemed not worthy of detailed grid work. The CUSP, BOBSU and CORNER radioactive pegmatites do not represent viable uranium targets.

4.5.11 EL 8675 (Inkamulla)

Apart from the airborne follow-up no other work was carried out on this EL.

4.5.12 EL 9149 (Boots)

The Boots Exploration Licence area, located immediately to the west of Yambla (Plate 1), was prospected and mapped at 1:25,000 scale by J. Theissen during the period 22-27 September. Project Geologists C. Vieru and G. Gee also spent short periods of time on radiometric prospecting in the general area. This area was targeted due to its proximity to YAMBLA.

The mapping and prospecting work concentrated on several stratigraphic and structural elements as follows:
• Definition of the upper Riddock Amphibolite/ Irindina Gneiss (Boots Member) contact
• Investigating the structurally modified EW contact along the Yambla Creek valley
• Prospecting the major NW-SE structure named the Boots Fault (see Figure 4)
• Prospecting the minor EW splays and conjugate faults associated with the Boots Fault

The upper Riddock/ Irindina contact is generally gradational from para amphibolite into biotite rich felsic gneiss; there is often a narrow sillimanite rich unit above this gradational contact. The sequence grades further upwards into more felsic and garnetiferous biotite gneiss (Boots Member) with sporadic and discontinuous lenses of marble and hessianite bearing calc-silicate gneiss. The latter units are associated with minor Cu-Ag-Zn mineralization in the area of the Boots Costeans (200m north of the Claraville-Hardings Spring track, 2km west of Yambla). Small ultramafic plugs (Pgb?) commonly intrude the sequence, particularly in an EW belt just south of Yambla Creek.

The structurally modified EW contact along the Yambla Creek valley is characterised by spectacular isoclinal drag folds within the Riddock para amphibolite which is in places structurally superimposed onto the younger felsic units of the Boots Member; south directed thrusting is indicated and is likely to be of Alice Springs Orogeny age. Just north of this contact, and within the para amphibolite, are a series of EW trending quartz-limonite veins which are more less continuous for 2km from just south of Yambla Dam.

Prospecting of the NW-SE trending Boots Fault failed to locate any significant alteration; minor epidote and chlorite was however noted adjacent to the fault within garnetiferous felsic gneiss 100m north of the Claraville-Hardings Spring track. Sample HR05880 was collected from quartz-limonite gossan (56% Fe) within an EW splay off the Boots Fault 1.5km SW of Yambla Dam. Anomalous assays of 2500ppm Co, 970ppm Cu, 25ppb Pt and 2500ppm Ba were recorded as well as weakly elevated V, Ni. No sulphides were visible in the hand specimen.

Brief prospecting of EW structures was also carried out, particularly in areas of distinctly white airphoto tones. Approximately along strike from the Karly Fault, and within the Boots Member, one such EW structure was filled with calcite veining up to 1m wide over a strike length of several hundred metres. Other similar EW structures further to the west contained sugary white siliceous alteration associated with massive chaledony lenses: no significant radiometrics were recorded over these alteration zones.

No significant radiometric anomalies were located during this prospecting phase of exploration. Background radiometrics were recorded throughout, typically 40-60cps in amphibolitic and calc-silicate/marble lithologies, 80-100cps in garnet-biotite gneiss and up to 150cps in sillimanite schist.

4.6 Other Work

4.6.1 Age Dating

During 1995 PNC entered into an agreement with J. Mawby of the Department of Geology at the University of Adelaide, whereby J. Mawby in collaboration of A. Kennedy of the Department of Applied Physics, Shrimp Lab of the Curtin University analysed 13 samples of mineralization from various prospects in the Harts Range area for lead isotopes to establish SHRIMP microprobe Pb-Pb age dates for the mineralization.
These results have been presented in summarized form under the discussion of targets. Appendix 8 contains the summarized measurement, plus brief discussions by Mawby plus petrological reports of the dated specimens supplied by PNC and some information of Harts Range monzonite of regional implications.

4.6.2 Yambla Model - Uraninite Distribution Assessment
Snowden and Associate of Perth were contracted to assess the distribution of uraninite "eggs" both from the plotted locations of "eggs" found during mapping and from the distribution of "eggs" within Trench 4 at Yambla. The surface hotspots exhibit clustering of 20m along strike and 12m across strike and a high (70%) nugget effect. The distribution of "eggs" in the trench wall was totally random.

A "clustered drillhole approach" was recommended to further test the prospect; i.e. clusters of 4-5 holes would be drilled to test the close order continuity of mineralization. Appendix 9 contains the full report.
5.0 DISCUSSION and CONCLUSION

5.1 Aims
The main aims for 1995 were:

- to interpret and follow-up the results of the WGC airborne survey,
- to drill test the YAMBLA prospect,
- to do detailed assessment of the following prospects; BONNIE, PONY, BRUMBY, HADDOCK and TORBERNITE,
- to investigate minor showings located during 1994; e.g. HOF, BRONZE, VIMY RIDGE etc,
- to investigate new prospects located during 1995; e.g. PACER, BRUMBY extensions etc.

5.2 Airborne Reconnaissance Work

5.2.1 WGC Airborne Survey
A total of 213 airborne anomalies generated by the WGC survey were checked. No major anomalies were discovered during ground follow-up however several anomalies related to the TORBERNITE anomaly and extensions were located (TORBERNITE NW). The most significant new anomaly was FRENZY, an epidote type anomaly that does not warrant detailed follow-up at this stage.

5.2.2 Previous Surveys
A total of 63 anomalies that had remained unchecked from the previous Kevron and Geoterrex surveys were checked during heliborne follow-up. No significant anomalies were generated.

5.3 Prospection
Apart from the BRUMBY and BANTAM areas, which were extensively prospected, only a moderate amount of prospecting work was carried out. The main success were the discovery of numerous uraninite and U-allanite anomalies in the BRUMBY and BRUMBY NORTH areas and the location of the retrogressed fault showings/prospects near GOSSPOT, CHARGER (near BRUMBY) and PACER (near PONY).

The prospection of the immediate surrounds of known anomalies; e.g. FLOATER, KIEFER, VIMY RIDGE, HUCK FINN etc, was not very successful in locating additional mineralization. Hence downgrading the potential of such areas.

5.4 Prospect Work
Detailed work was carried out on 17 prospects and/or showings during 1995. The focus of the work was the YAMBLA prospect which remains the number one priority. Other prospects which received a major amount of work were PONY, HOF, BONNIE, BRUMBY and HADDOCK. Lesser amounts of
work on new grids were undertaken at TORBERNITE, ZEPHYR, BRONZE, PACER and YAMBLA SW. Minor amounts of grid based work was done at ONO and KONGO. Infill and follow-up work on old grids was done at CULAY, GARNET, SWALLOW, MOONDYNE and RYOMA.

5.4.1 Yambla (EL 7967 Mt Muriel)
The drill programme at YAMBLA failed to locate economic mineralization. The alteration envelope was intersected in all holes (13 in all) but sub-economic radiometric anomalies were only intersected in three holes. Of these, one was near surface and only two confirmed the existence of sub-surface mineralization. However, the grades and continuity of the anomalies in both, only indicated scattered nodular mineralization as already known from outcrop and trench exposures.

Positive factors to emerge from the drilling were:

- confirmation of the white alteration envelope and its continuity within the Yambla Amphibolite down dip,

- confirmation of the scapolite-albite-quartz mineralogy of the white alteration with associated accessory sphene, apatite, ilmenite, pyrite, pyrrhotite and trace chalcopyrite,

- indications that that the rocks in the footwall to the Yambla Amphibolite also show albite-carbonate and scapolite-diopside-sulphide alteration along shear zones; possibly related to the white alteration of the Yambla Amphibolite,

- it was established that the TRENCH FAULT post dated the mineralization,

- indications of sub-surface mineralization are open to the west down dip.

The amount of drilling to date has not adequately tested the 1.5 km length of surface mineralization. Only about 150m of the mineralized strike length has been tested to a vertical test of 50m. Viable mineralization may well exist within the untested portions of the alteration envelope. Figure 136 illustrates the present understanding of the YAMBLA mineralization and the distribution of the alteration envelope. The main elements being:

i. brittle amphibolite unit structurally prepared by low angle fracturing,
ii. permeation of metasomatic fluids (Na, CO₂ rich) generated during a metamorphic heat pulse along this fracture system,
iii. alteration of insitu rock generating white and dark alteration,
iv. precipitation of uraninite due to reduction effects associated with the mobilization of amphibole.

Mapping was carried out on the YAMBLA SW grid but the results were essentially negative.

5.4.2 Pony, Bonnie and Hof (EL 7967 Mt Muriel)
These three prospects all represent examples of significant mineralized retrogressed faults and hence have been grouped together.
Detailed work, including an additional five trenches, at PONY confirmed the presence of moderate uranium mineralization associated with apatite-zeolite veining in a zone of clay alteration along an E-E fault. Unfortunately, detailed mineralogical work (SEM, autoradiograph) could not establish the presence of primary uranium. The best guess is that a U-apatite (U-collophane) is host to the uranium. These may or may not be a secondary effect.

The 700m long anomalous zone represents a viable drill target even though the surface indications do not show economic grades or confirm the nature of the primary mineralization.

Detailed grid work and trenching (total 3) at BONNIE has substantiated the presence of a 100m long surface anomaly within a retrogressed fault that represents a viable drill target.

The anomaly at HOF did not prove to be as persistent or as strong as at either PONY or BONNIE hence only a low order drill target exists.

5.4.3 Brumby (EL 7990 Maud Creek)
Detailed mapping and trenching (total 9) around the BRUMBY uranium showings failed to establish any radiometric, stratigraphic or structural continuity between them. Unfortunately the surface allanite/uraninite and uraninite occurrences do not appear to have a recognisable and traceable alteration halo as at YAMBLA. At best only minor white alteration was noted. Generally, the mineralization control seems to be pressure shadows around sweets of aplitic material and/or boudins of granitic gneiss and orthoamphibolite that occur within a strongly tectonized granite/amphibolite mixture. That is, fluid flow was concentrated during a regional shear event around the boudins with uranium being precipitated in pressure shadows or perhaps due to fluid changes due to the contrast in lithologies.

Only in two trenches did minor convolute aplitic veins/sweats(?) in a near vertical orientation within a subsidiary shear zone(?) give some support for a host structure and the potential for more substantial mineralization. Weathered and leached uraninite eggs were found in these trenches (Tr 1 and 2). It is conceivable that the mineralization in these two trenches and the mineralization in Tr 4 is associated with the same shear that has been displaced by the later NW-SE faulting (see Plate 23).

Hence a limited amount of drilling is recommended to test the mineralization exposed on the surface and in the trenches and to test the continuity of the shear.

5.4.4 Haddock (EL 7967 Mt Muriel)
Grid work, including three trenches, showed the presence of a thin sheet of radioactive epidosite within felsic gneiss. A mineralized zone approximately 150m long has been identified. This represents a viable drilling target even though the surface indications of thickness and grade do not reach economic proportions.

5.4.5 Torbernite (EL 8220 Entia)
At TORBERNITE, mapping and prospecting located numerous scattered secondary uranium showings over a strike length of 450 m within clay altered, sheared and brecciated rock associated with a
indurated fault. This represents a substantial drill target. The postulated drill target is illustrated in Figure 89.

5.4.6 Zephyr (EL 7967 Mt Muriel) and Bronze (EL 8220 Entia)
These two epidote type anomalies were covered with grids and the surface anomalies tested by two trenches each. At ZEPHYR, epidote shoots in carbonate altered rock represent at viable drill target. At BRONZE, a low angled shear hosts moderate epidote alteration and discontinuous uranium mineralization which does not represent a target for further work.

5.4.7 Pacer (EL 8220 Entia)
At PACER a small grid was mapped and one trench dug. A thin and moderate anomaly located in a minor swell structure in a retrogressed fault was identified. This anomaly was regarded as too small to be ranked as a drill target.

5.4.8 Ono and Kongo (EL 7992, Kong Bore)
The uraninite mineralization at ONO does not represent a viable target for detailed work. The Cu-Au showing at KONGO probably represents a viable drill target.

5.4.9 Moondyne-Swallow-Garnet (EL 7967 Mt Muriel)
These epidote type occurrences have been investigated in detail during 1994 and further followed up 1995. A moderately rated drill target was identified at SWALLOW. The MOONDYNE and GARNET anomalies are of lower potential.

5.4.10 Ryoma (EL 7991 Christmas Creek)
The uraninite showing at RYOMA was re-mapped but only a narrow target horizon could be identified. Immediate follow-up was not recommended.

5.4.11 Culay (EL 7967 Mt Muriel)
This Cu-Au prospect was further evaluated with the excavation of a trench along strike from the 1994 work but results were disappointing; significantly downgrading the prospect.
6.0 ASSESSMENT OF RESULTS AND RECOMMENDATIONS

It is recommended that the prospects, listed below in order of priority, be drill tested; YAMBLA (1), TORBERNITE, PONY (2), HADDOCK and BRUMBY (3). The following areas should be investigated in detail and gridded and mapped if necessary to enable an accurate assessment of their potential; BRUMBY NORTH, CHARGER and TORBERNITE NORTH WEST.
REPORT TITLE
Mineralogical Studies of Two Rock Samples

REPORT #
2158

CLIENT
PNC Exploration (Australia) Pty. Ltd.

ORDER NO.
7164

CONTACT
Mr. Costica Vieru

REPORT BY
Dr. Douglas R. Mason

SIGNED
for Mason Geoscience Pty. Ltd.

DATE
27 September 1995
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<th>Page</th>
</tr>
</thead>
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<td>9</td>
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<td>11</td>
</tr>
</tbody>
</table>
Mineralogical Studies of Two Rock Samples

SUMMARY

1. Rock Samples
   - Two (2) rock samples have been studied using petrography, mineragraphy, X-ray diffraction, and electron probe microanalysis.

2. Brief Results
   - Rock names are listed in Table 1 below.

TABLE 1: ROCK NAMES

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>ROCK NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR05908</td>
<td>Euxenite rock</td>
</tr>
<tr>
<td>HR05909</td>
<td>Euxenite(-allanite) rock</td>
</tr>
</tbody>
</table>

- X-ray diffraction studies were limited by the metamict nature of the radioactive minerals. However, sample heating and re-analysis suggests that euxenite, \((Y,Ce)(Nb,Ti)_2O_8\), is the principal mineral in both samples.

- Electron probe microanalysis reveals that the euxenite is U-euxenite, and minor small grains of uraninite are Th-uraninite. Both phases have suffered metamict alteration, which has caused hydration and crystal lattice destruction.
1. INTRODUCTION

Two (2) rock samples were received from Mr. Costica Vieru (PNC Exploration Australia Pty. Ltd., South Perth, Western Australia) on 21 August 1995.

Particular requests were:

i) To prepare a polished thin section and combined petrographic and mineralogic description for each sample.

ii) To determine the mineralogy of each sample by X-ray diffraction methods. If possible, the mineralogy of the fine-grained yellowish surface deposits on sample HR05909 should also be determined.

iii) To obtain chemical analyses of minerals in sample HR05909 using electron microprobe methods.

Preliminary mineralogical results by X-ray diffraction were provided to Mr. Vieru by facsimile on 19 September 1995. This report contains the full results of this work.

2. METHODS

The samples were examined in hand specimen, and marked for section preparation. Polished thin sections were obtained from an external commercial laboratory (Amdel Limited, Thebarton, South Australia).

Mineral identifications by X-ray diffraction methods were obtained from Amdel Limited. The full procedure and results are provided as Appendix 1.

Mineral analyses were obtained by electron microprobe at the Centre for Electron Microscopy and Microstructure Analysis at the University of Adelaide. The polished thin section of sample HR05909 was cut down to ~50mm long, and appropriate areas were circled to facilitate location of analytical sites. The section was carbon coated. A CAMECA SX-51 scanning electron microscope fitted with three automated spectrometers was used at 15 kV. Elements sought had been previously calibrated using appropriate standards, except for Ta which was calibrated at the commencement of the analytical session. Counting times were 10 seconds on peaks of all elements, except for U and Th which were counted for 20 seconds.

3. PETROGRAPHIC AND MINERALOGIC DESCRIPTIONS

The combined petrographic and mineralogic descriptions are provided in the following pages.
SAMPLE : HR05908
SECTION NO. : HR05908 (C64396)
HAND SPECIMEN : The rock sample is composed entirely of massive vitreous black material, with minor surface iron oxide coating.
ROCK NAME : Euxenite rock

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euxenite (yellow, metamict)</td>
<td>93</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>K-feldspar (microcline)</td>
<td>3</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Allanite</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>?Monazite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Goethite</td>
<td>1</td>
<td>Weathering</td>
</tr>
</tbody>
</table>

[NOTE: X-ray diffraction has identified euxenite and brannerite].

In polished thin section, this sample displays a massive crystalline metamorphic texture, modified by metamict alteration.

Euxenite is abundant, occurring as coarse-grained massive aggregates throughout the sample. All has suffered metamict alteration encroaching inwards from grain margins, producing very fine-grained material that is dark yellow-brown in plane transmitted light. Kernels remain virtually isotropic under plane light, but display no difference from the metamict material under reflected light.

K-feldspar (microcline) occurs in minor amount as small anhedral grains that occupy elongated sites located between euxenite aggregates. The microcline displays its typical "tartan" twinning, and some polycrystalline aggregates display well-developed granoblastic texture with 120° triple-point junctions, confirming equilibrium metamorphic crystallisation.

Quartz is present in minor amount, forming polycrystalline aggregates in patches scattered through the euxenite, and intergrown in some patches with K-feldspar.

Muscovite forms well-crystallised flakes and finer-grained aggregates, intergrown with microcline and quartz in the granular patches between massive euxenite aggregates.

Allanite is uncommon, forming stumpy subhedral prismatic crystals that display typical metamict features, including pale drab brown colour in plane transmitted light and isotropic optical behaviour under crossed polarisers.

Probable monazite occurs in rare euhedral stumpy colourless crystals that display typical high relief, moderate birefringence, and inclined extinction. They occur in the interstitial patches with quartz, K-feldspar and muscovite.

Goethite is present in minor amount, forming fine-grained dense aggregates that appear to fill minor solution cavities in the rock.
INTERPRETATION:

This sample represents a coarse-grained metamorphic deposit dominated by e xenite, with associated minor radioactive phases (allanite, monazite), and additional non-radioactive phases (microcline, muscovite, quartz).

Minor near-surface oxidation has affected the rock, producing minor goethite. Metamict alteration has affected the e xenite, but this may have occurred during the assumed long time interval since metamorphic crystallisation.
SAMPLE : HR05909

SECTION NO. : C64397 (portion HR05909A), C64938 (portion HR05909B)

HAND SPECIMEN : The rock sample is composed mostly of dense, massive, fine-grained, greenish grey material. Surface deposits of earthy, porous, pale yellowish material are present.

ROCK NAME : Euxenite(-allanite) rock

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euxenite (yellow, metamict)</td>
<td>89</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Allanite (metamict)</td>
<td>10</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Muscovite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>K-feldspar (microcline)</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>?Uraninite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
</tbody>
</table>

[NOTE: X-ray diffraction has identified euxenite, aeschynite, and other phases. See XRD report for details.]

In polished thin section, this sample displays a massive metamict texture in precursor coarsely crystalline material, with scattered patches of additional phases.

Euxenite occurs abundantly as very fine-grained, massive yellow metamict material that occupies precursor coarse anhedral euxenite crystal sites up to several mm in size. Irregular patches are isotropic, and small randomly oriented microcracks cut the material.

Allanite occurs in lesser amount, irregularly distributed through only portion of the sample (portion B, section C64398). It forms colourless to very pale yellow bladed crystals that interfinger with the darker yellow euxenite. All of the allanite is isotropic and therefore metamict.

Muscovite is present in trace amount as large flakes limited to portion of the sample.

K-feldspar (microcline) forms uncommon large grains up to several mm in size, displaying typical "tartan" twinning.

Quartz occurs as polycrystalline aggregates in interstitial patches between bladed euxenite crystals.

Possible uraninite occurs as small subhedral to equant crystals up to ~0.2 mm in size, very sparsely and irregularly scattered through the euxenite. It displays its typical opaque optical behaviour, with dull brownish grey colour in plane reflected light.

INTERPRETATION:

This sample represents a coarse-grained metamorphic deposit of euxenite + allanite + minor K-feldspar + quartz + muscovite + uraninite.
Since crystallisation, metamict alteration of the radioactive minerals has occurred.
4. Electron Probe Microanalysis

A total of thirteen spots were analysed (see Table 2). Most yield analyses which are appropriate for U-euxenite. They are approximately rich in Ta, Ti, Y, Nb, and U, with minor Th. All of the analyses display low totals, which reflects significant hydration during metamict alteration. Confirmation of the presence of volatile materials was provided by the presence of bubbling at the electron beam spots during analysis.

Examination of the metamict euxenite in the back-scattered electron image (Plate 1) reveals considerable heterogeneity. Pale patches are scattered through a medium-grey matrix within which darker patches are evident. Different perceived "brightness" in the back-scattered electron image is normally related to variable "average atomic number" (i.e. chemical composition) of phases. However, there appears to be little or no significant compositional variation within the metamict U-euxenite. One analysis (spot A2/2) is significantly different, with high Y and Nb, and low Ta, Ti, and U (also see Plate 2).

Two analyses (spots A1/9, A1/10) were obtained from a single crystal of uraninite. The analyses reveal it is a thorian uraninite, with ~10-12% ThO₂. Low totals again are consistent with metamict alteration and associated hydration.

**Table 2: Microprobe analyses (wt.%) from minerals of sample HR05909**

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>U-eux.</td>
<td>Bright</td>
<td>15.20</td>
<td>15.06</td>
<td>15.12</td>
<td>14.91</td>
<td>14.74</td>
<td>15.03</td>
<td>14.11</td>
<td>15.29</td>
<td>0.12</td>
<td>0.11</td>
<td>13.90</td>
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<td>19.02</td>
<td>19.06</td>
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<td>18.74</td>
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<td>18.96</td>
<td>0.07</td>
<td>0.09</td>
<td>18.33</td>
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<tr>
<td>U-eux.</td>
<td>Bright</td>
<td>1.58</td>
<td>1.41</td>
<td>1.49</td>
<td>1.59</td>
<td>1.52</td>
<td>1.54</td>
<td>1.60</td>
<td>1.49</td>
<td>11.57</td>
<td>10.21</td>
<td>1.82</td>
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<tr>
<td>U-eux.</td>
<td>Grey</td>
<td>17.53</td>
<td>17.08</td>
<td>17.83</td>
<td>17.96</td>
<td>17.21</td>
<td>17.20</td>
<td>17.20</td>
<td>17.59</td>
<td>0.66</td>
<td>0.69</td>
<td>17.10</td>
</tr>
<tr>
<td>U-eux.</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.10</td>
<td>0.03</td>
<td>0.00</td>
</tr>
<tr>
<td>U-eux.</td>
<td>Grey</td>
<td>12.28</td>
<td>12.36</td>
<td>10.84</td>
<td>10.61</td>
<td>12.16</td>
<td>12.25</td>
<td>10.49</td>
<td>12.19</td>
<td>75.72</td>
<td>73.99</td>
<td>12.32</td>
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<tr>
<td>U-eux.</td>
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<td>78.67</td>
<td>78.04</td>
<td>77.25</td>
<td>76.70</td>
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<td>77.81</td>
<td>76.61</td>
<td>77.91</td>
<td>90.40</td>
<td>87.31</td>
<td>75.75</td>
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</table>

**Table 2: Microprobe analyses (wt.%) from minerals of sample HR05909**

<table>
<thead>
<tr>
<th>PHASE*</th>
<th>BSE COLOUR</th>
<th>A2/1</th>
<th>A2/2</th>
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<tr>
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<td>Grey</td>
<td>14.51</td>
<td>3.70</td>
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<td>U-eux.</td>
<td>Darker</td>
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<td>U-eux.</td>
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<td>U-eux.</td>
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<td>37.01</td>
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<td>U-eux.</td>
<td>U-eux.</td>
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<td>0.11</td>
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<td>U-eux.</td>
<td>U-eux.</td>
<td>0.00</td>
<td>0.00</td>
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<td>U-eux.</td>
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<td>12.68</td>
<td>5.52</td>
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<td>U-eux.</td>
<td>U-eux.</td>
<td>3.22</td>
<td>1.31</td>
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<tr>
<td>U-eux.</td>
<td>U-eux.</td>
<td>1.13</td>
<td>0.00</td>
</tr>
<tr>
<td>U-eux.</td>
<td>U-eux.</td>
<td>81.73</td>
<td>72.29</td>
</tr>
</tbody>
</table>

*NOTES:*
- U-eux. = uranian euxenite (metamict)
- Th-uran. = thorian uraninite
- Low totals attributable to hydration during metamict alteration.
PLATE 1: Back-scattered electron image (area 1, sample HR05909)
An angular grain of Th-uraninite (white, bottom) lies in a matrix of metamict U-euxenite. White scale bar (bottom left) is 200 μm (0.2 mm). Small ragged patches (pale grey, grey, darker grey) in the metamict U-euxenite yield very similar analyses (see Table 2).

PLATE 2: Back-scattered electron image (area 2, sample HR05909)
Metamict U-euxenite (grey, right) contains small ragged white patches of similar composition. Darker patches at left are Y- and Nb-rich (Table 2, spot A2/2).
APPENDIX 1: X-RAY DIFFRACTION STUDY
19 September 1995

Dr. D. R. Mason
Mason Geoscience Pty Limited
PO Box 78
GLENSIDE SA 5065

REPORT_G889700G/96
MINERALOGY OF RADIOACTIVE ROCK SAMPLES

YOUR REFERENCE: Letter 21/8/95
SAMPLE IDENTIFICATION: HR05908, HRO5909A, HRO5909B
MATERIAL: Three rock samples
DATE RECEIVED: 21 August 1995

Investigation and Report by: Michael Till

Dr Keith J Henley
Manager, Mineralogical Services

The results contained in this report relate only to the sample(s) submitted for testing. Amdel Ltd accepts no responsibilities for the representivity of the sample(s) submitted.

btw
MINERALOGY OF RADIOACTIVE ROCK SAMPLES

1. INTRODUCTION

Three rock samples were received from Dr. D. R. Mason of Mason Geoscience Pty Limited with a request for section preparation and mineral identification by X-ray diffraction.

2. PROCEDURE

The rocks required vacuum impregnation before sectioning. A portion of each rock was pulverised and analysed by X-ray diffraction. In addition, pale greenish-yellow material in sample HRO5909B and yellow powder in a cavity in HRO5909B were analysed by X-ray diffraction. The pale greenish-yellow material and yellow powder were then combined, and heated at 1000°C for 1 hour. The pulverised material was similarly treated. They were then analysed by X-ray diffraction.

3. RESULTS

The polished sections (PTS74396-8) were despatched to the client on 8/9/95. The pulverised rock and material extracted from HRO5909B was mainly amorphous, with a minor amount of poorly crystalline phase(s). Table 1 shows the minerals detected in the heated material which are listed in approximate decreasing order of abundance.
TABLE 1: MINERALOGY OF THREE RADIOACTIVE SAMPLES

<table>
<thead>
<tr>
<th></th>
<th>HRO5908</th>
<th></th>
<th>HRO5909A</th>
<th></th>
<th>HRO5909B</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Euxenite D</td>
<td>Euxenite D</td>
<td>Euxenite D</td>
<td>Liandrite D</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brannerite Tr-A</td>
<td>Aeschnyte Tr-A</td>
<td>Aeschnyte SD</td>
<td>Thorite SD</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>?Uraninite or ?cerianite Tr</td>
<td>Petscheckite A</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Euxenite Tr-A</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Aeschnyte Tr</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The formulae of these minerals are:

- Aeschynite: YTiNbO₆
- Brannerite: UTi₂O₆
- Cerianite: CeO₂
- Euxenite: (Y, Ce)(Nb, Ti)₂O₆
- Liandrite: U(Nb, Ta)₂O₆
- Petscheckite: UFe(Nb, Ta)₂O₆
- Thorite: ThSiO₄
- Uraninite: UO₂⁺

Semi-quantitative Abbreviations

D = Dominant. Used for the component apparently most abundant, regardless of its probable percentage level.

CD = Co-dominant. Used for two (or more) predominating components, both or all of which are judged to be present in roughly equal amounts.

SD = Sub-dominant. The next most abundant component(s) providing its percentage level is judged above about 20.

A = Accessory. Components judged to be present between the levels of roughly 5 and 20%.

Tr = Trace. Components judged to be below about 5%.
**REPORT TITLE**  Petrographic Descriptions for a Collection of Four Rock Samples

**REPORT #**  2123

**CLIENT**  PNC Exploration (Aust.) Pty. Ltd.

**ORDER NO.**  6930

**CONTACT**  Mr. Costica Vieru

**REPORT BY**  Dr. Douglas R. Mason

**SIGNED**  

for Mason Geoscience Pty. Ltd.

**DATE**  12 July 1995
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Petrographic Descriptions for a Collection of Four Rock Samples

SUMMARY

1. Rock Samples

- A collection of four (4) rock samples has been studied using petrographic, mineralographic, X-ray diffraction and electron microprobe methods.

2. Brief Results

- The rock names given to the samples are listed in Table 1 below.

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>ROCK NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR05556</td>
<td>Allanite-zircon metasomatite</td>
</tr>
<tr>
<td>HR05572</td>
<td>Allanite-quartz-feldspar(-zircon) metasomatite</td>
</tr>
<tr>
<td>HR05574</td>
<td>Allanite-zircon-thorite metasomatite</td>
</tr>
<tr>
<td>HR05575</td>
<td>Allanite(-zircon) pegmatoid</td>
</tr>
</tbody>
</table>

- Petrographic and mineralographic study suggests that the samples represent metasomatic metamorphic rocks with mineralogies dominated by metamict allanite, partly metamict zircon, quartz, plagioclase, microcline, apatite, and metamict thorite (replaced by thorogummite), with minor uraninite, pyrite, biotite, epidote, and chalcopyrite.

- X-ray diffraction studies provide particular information:
    - Pale yellow thorogummite is confirmed. It has replaced precursor thorite.
    - Zircon is identified in one sample, but not in samples that may contain up to ~20% zircon. This is attributable to metamict alteration of the zircon arising from its high U content.

- Electron microprobe studies indicate the following:
    - Uraninite is confirmed, and it contains ~5% ThO₂.
    - Thorogummite is confirmed, and it contains ~17% U₂O₅.
    - Zircon has been confirmed. U-free cores are overgrown by thick rims that may contain up to ~0.16% U₂O₅.
    - Allanite is confirmed, and it contains ~3.3% ThO₂.
1. INTRODUCTION

A collection of four (4) rock samples was received from Mr. Costica Vieru (PNC Exploration Aust. Pty. Ltd., South Perth, WA) on 6 June 1995.

Specific requests were to prepare a polished thin section, and combined petrographic and mineragraphic description, for each sample.

Preliminary results were conveyed to Mr. Vieru by facsimile on 26 June 1995. This report contains the full results of this work.

2. METHODS

The samples were examined in hand specimen, and section lines were marked. Polished thin sections were obtained from an external laboratory (Amdel Limited, Thebarton, SA).

Confirmatory mineral identifications by X-ray diffraction (XRD) methods were obtained from the same laboratory. The full XRD report is provided as Appendix 1, and results are also integrated with the petrographic descriptions.

Electron microprobe studies were performed on sample HRO5556, in order to confirm the identity of particular phases and to identify the presence of U-bearing minerals. At the University of Adelaide Centre for Electron Microscopy and Microstructure Analysis, the Cameca SX-51 electron microprobe with wavelength dispersive spectrometers was used to obtain quantitative analyses for the elements U, Th, La, Ce, Y, Zr, Si, Ca, Fe, P, and Pb. Standards had previously been used to standardise for these elements. The machine was operated at 15kV, and counting times of 10 seconds were used for all elements except for U and Th, for which counting times of 20 seconds were used.

Selected colour photomicrographs were taken to illustrate the minerals for which microprobe analyses had been obtained.

3. PETROGRAPHIC AND MINERAGRAPHIC DESCRIPTIONS

The combined petrographic and mineragraphic descriptions are provided in the following pages.
SAMPLE : HR05556
SECTION NO. : HR05556 (C64036)
HAND SPECIMEN : The rock sample abundant large black vitreous crystals with fewer small grey blocky crystals. The texture is best observed in the sawn section.
ROCK NAME : Allanite-zircon metasomatite
PETROGRAPHY AND MINERALOGY :
A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allanite</td>
<td>64</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Zircon</td>
<td>20</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Quartz</td>
<td>10</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Apatite</td>
<td>2</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Epidote</td>
<td>1</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Biotite</td>
<td>Tr</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>Tr</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Unknown opaque (uraninite by e-probe)</td>
<td>Tr</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>?Thorogummite (yellow, metamict)</td>
<td>2</td>
<td>Metamict alteration</td>
</tr>
</tbody>
</table>

[N.B.: XRD has identified the scattered small yellow grains as thorogummite, with trace quartz. Electron microprobe results identify the opaque as Th-uraninite, and confirm the identification of Th-allanite and U-thorogummite].

In polished thin section, this sample displays a phenoblastic metamorphic texture, with interstitial minerals filling interstices between randomly oriented large allanite prisms.

Allanite is abundant, forming large euhedral prismatic crystals commonly ~1 cm long. They are randomly oriented, and distributed more-or-less uniformly through the rock. Cores of all crystals are uniformly drab brownish green, and perfectly isotropic. Minute flecks of replacement carbonate are distributed in minor amount in restricted patches in each crystal. Mantles of weakly birefringent allanite project into interstices, where they are intergrown in amoeboid manner with interstitial quartz grains.

Zircon forms euhedral stumpy prismatic crystals ~0.5-1.0 mm in size, filling interstices between larger allanite crystals. The zircon is pale brown, with colourless cores in some crystals indicating that compositional growth zoning was present. This is confirmed in crossed polarised light, where delicate growth zoning is observable in most crystals.

A metamict phase formed euhedral equant prismatic crystals ~1 mm in size, occurring in interstices in association with zircon, quartz and apatite. The phase is now completely metamict, being composed of very fine bright yellow grains that are virtually isotropic. This is the phase identified as thorogummite by XRD.

Quartz forms anhedral interstitial grains between allanite crystals. Apatite also occurs in these sites, but forms stumpy prismatic crystals with uniaxial negative optic figures (compared with the uniaxial positive figures from quartz). Closely-spaced expansion cracks are present throughout the quartz.
Epidote is rare, forming pleochroic dark yellow grains in some interstices. It may be accompanied by small flakes of biotite that are strongly pleochroic from chocolate brown to pale yellow.

Chalcopyrite is very rare, forming tiny anhedral grains in some allanite crystals.

Rare opaque grains occur in the interstitial areas, and have suffered partial alteration to dark reddish brown material around their margins. Most are too small for positive identification, but one grain ~0.4 mm in size displays cubic morphology.

INTERPRETATION:

This sample most likely formed as a metasomatic rock in a medium to high grade regional metamorphic terrain. Large crystals of randomly oriented allanite formed as large porphyroblastic crystals, and interstices were filled by zircon, another radioactive phase (possibly thorite, now replaced by thorogummite), quartz, apatite, minor epidote and biotite.

PLATE 1: SAMPLE: HRO5556 (Transmitted plane polarised light, x5, 1/1)
This view illustrates the bladed allanite crystals (drab brownish green, left, right), with interstitial zircon crystals (pale buff brown, centre).
PLATE 2: SAMPLE HRO5556 (Transmitted plane polarised light, x5, 2/1)
A cubic crystal of metamict thorite (centre) has been completely replaced by thorogummite (pale yellow). Note the microcracks that radiate from the metamict thorite. Crystals of partly metamict zircon (pale brown, right) and metamict allanite (drab greenish brown, left) are also present.

PLATE 3: SAMPLE HRO5556 (Transmitted light, crossed polarisers, x5, 3/1)
This view illustrates compositional growth zoning in a euhedral zircon crystal. The higher-birefringent core is U-poor (Table 2, analysis 7), whereas the rim at upper right of the crystal (Table 2, analysis 8) contains 0.16% U₂O₅. Note the lower birefringence of the partly metamict U-rich zircon.
PLATE 4: SAMPLE HRO5556 (Reflected plane polarised light, x5, 4/1)
This view illustrates the single large uraninite crystal (cream) observed in the section. Analysis 1 (Table 2) was obtained from the centre of the crystal, and analysis 2 was obtained from the upper right projection of the crystal. The uraninite contains ~4% ThO₂.

PLATE 5: SAMPLE HRO5556 (Reflected plane polarised light, x20, 7/1)
Tiny cubic crystals of Th-uraninite (pale grey) are scattered through metamict allanite (upper left) and a ragged patch of carbonate (cleaved patches, centre and right). The small triangular-shaped crystal at centre right provided analysis 4 (Table 2).
SAMPLE : HR05572

SECTION NO. : HR05572 (C64037)

HAND SPECIMEN : The rock sample is composed of abundant black vitreous crystals that are randomly oriented in a paler felsic matrix.

ROCK NAME : **Allanite-quartz-feldspar(-zircon) metasomatite**

PETROGRAPHY AND MINERALOGY :

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allanite</td>
<td>50</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Quartz</td>
<td>20</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>K-feldspar (microcline)</td>
<td>15</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>5</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Biotite</td>
<td>4</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Apatite</td>
<td>2</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Zircon</td>
<td>3</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Zircon</td>
<td>Tr</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Pyrite</td>
<td>Tr</td>
<td>Alteration</td>
</tr>
<tr>
<td>Opaques (unidentified)</td>
<td>Tr</td>
<td>Alteration (in allanite)</td>
</tr>
</tbody>
</table>

[N.B.: XRD has identified abundant amorphous material, quartz, apatite, mica, plagioclase and K-feldspar. After heating, phases identified were amorphous material, quartz, plagioclase, and uraninite.]

In polished thin section, this sample displays a porphyroblastic metamorphic texture, with large randomly oriented allanite crystals and interstices filled mainly by granoblastic quartz and K-feldspar.

Allanite occurs abundantly as euhedral prismatic crystals ~1-2 mm long. They are randomly oriented, forming a bladed network throughout the rock. They are uniformly drab brownish green in colour, with diffuse patches containing minute carbonate patches and tiny unidentified opaque granules of micron size. All of the apatite is uniformly isotropic.

Quartz forms anhedral interstitial grains that range widely in size, ~0.1 mm up to ~1 mm. Where smaller grains occur in polycrystalline aggregates, they display 120° triple junctions, confirming that they formed by recrystallisation under equilibrium metamorphic conditions.

K-feldspar is moderately abundant, also occurring in interstices between allanite crystals. It forms larger anhedral grains, and finer-grained granoblastic mosaics. The presence of "tartan" twinning (i.e. combined pericline and albite twinning) confirms the identification of microcline.

Plagioclase is uncommon, forming anhedral large grains in some interstices or small anhedral grains in polycrystalline mosaics. The presence of polysynthetic (albite) twinning and faint buff brown incipient alteration confirms the identification.

Biotite forms small ragged flakes, pleochroic from dark chocolate brown to straw yellow. It tends to occur in interstices, where it may be uniformly intergrown as small flakes in similarly fine-grained K-feldspar mosaics.
Apatite occurs as small colourless subhedral equant grains that tend to form dense aggregates in interstices.

Zircon is moderately abundant, forming colourless euhedral small prismatic crystals up to ~0.4 mm long. They mostly occur within interstices, but also may be enclosed as inclusions within large allanite crystals.

Zircon is rare, forming equant stumpy crystals with brownish colour.

Pyrite is present in trace amount, forming tiny anhedral ragged grains that tend to build small filamentous aggregates. They are sparsely and irregularly scattered through the rock.

INTERPRETATION:

This sample has formed under medium to high grade regional metamorphic conditions, forming the porphyroblastic assemblage observed above. The textural relationships suggest that allanite formed first with minor zircon, and interstices were then filled by the remaining minerals.

Metamict alteration generated the perfectly isotropic appearance of the allanite, with minor carbonate, pyrite, and opaque granules.
SAMPLE : HR05574
SECTION NO. : HR05574 (C64038)

HAND SPECIMEN : The rock sample is composed of abundant small lustrous black vitreous crystals that display a preferred orientation observable on the weathered surface and in the sawn section. Interstices are filled by paler material.

ROCK NAME : Allanite-zircon-?thorite metasomatite

PETROGRAPHY AND MINERALOGY :

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allanite</td>
<td>61</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Zircon</td>
<td>20</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Quartz</td>
<td>3</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Apatite</td>
<td>5</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Pyrrhotite</td>
<td>Tr</td>
<td>?Metamorphic / ?metasomatic</td>
</tr>
<tr>
<td>Metamict (yellow, ?thorogummite)</td>
<td>10</td>
<td>Metamict alteration</td>
</tr>
<tr>
<td>Pyrite</td>
<td>Tr</td>
<td>Alteration</td>
</tr>
</tbody>
</table>

In polished thin section, this sample displays a porphyroblastic metamorphic texture.

Allanite is abundant, forming randomly oriented prismatic crystals ~1-2 mm long. They are uniformly drab brownish green in colour, and perfectly isotropic from incipient metamict alteration. Some contain tiny (micron-sized) lobate grains of anisotropic pyrrhotite, which is interpreted to represent a genuine metamorphic inclusion phase rather than alteration.

Zircon is moderately abundant, forming buff brown equant crystals ~0.4-1.0 mm in size, distributed more-or-less uniformly throughout the rock in interstices between allanite crystals. Some have been overgrown by allanite, forming inclusions.

A primary phase formed equant blocky crystals ~0.5 mm in size. It was scattered uniformly through the rock, mostly in close association with zircon. It is now completely replaced by dense pale yellow metamict material (cf. thorogummite in sample HR05556). The primary phase most likely was thorite. Closely-spaced radiating expansion cracks emanate from all of the altered ?thorite crystals.

Quartz occurs in minor amount as angular, anhedral interstitial grains that are moulded on allanite, zircon and ?thorite crystals.

Apatite is present in minor amount in close association with quartz. It forms fine-grained polycrystalline aggregates in the interstices between euhedral allanite, zircon and thorite crystals.

Pyrite is present in trace amount, forming tiny ragged grains and thin fillings in microcracks in some crystals, especially allanite.
INTERPRETATION:

This sample has formed under medium to high grade regional metamorphic conditions, generating the observed porphyroblastic assemblage of larger allanite crystals with smaller zircon and ?thorite crystals, with interstitial fillings of apatite and quartz grains.

Metamict alteration generated isotropic amorphous material after allanite, and thorogummite after ?thorite.
SAMPLE : HR05575

SECTION NO. : HR05575 (C64039)

HAND SPECIMEN : The rock sample is composed of abundant coarse felsic pale orange-pink matrix, through which are distributed bladed lustrous vitreous black crystals. The rock has a pegmatoidal appearance.

ROCK NAME : Allanite(-zircon) pegmatoid

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>52</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>35</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Allanite (incl. alteration)</td>
<td>8</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Apatite</td>
<td>3</td>
<td>Metamorphic / metasomatic</td>
</tr>
<tr>
<td>Zircon</td>
<td>2</td>
<td>Metamorphic / metasomatic</td>
</tr>
</tbody>
</table>

In polished thin section, this sample displays a coarse-grained pegmatoidal texture.

Quartz is abundant, forming large anhedral grains several mm in size. Most grains display a slight to moderate degree of shadowy strain extinction.

Plagioclase is moderately abundant. It forms large anhedral grains several mm in size, but also forms smaller equant grains that form even-grained granoblastic aggregates in limited areas. The presence of albite twinning and incipient pervasive buff alteration provides identification and distinction from the quartz.

Allanite builds elongate prismatic crystals ~3-10 mm long. It is uniformly drab brownish green in core areas, but has suffered replacement by very fine-grained orange-brown material along crystal margins.

Apatite forms small euhedral stumpy prismatic crystals ~0.2-0.4 mm long. They are sparsely disseminated throughout the rock, commonly within the plagioclase and quartz.

Zircon is present in minor amount, forming euhedral stumpy prismatic crystals up to ~1 mm in size. They are sparsely scattered through the rock. Optical features include pale brown non-pleochroic colour, high relief, moderate birefringence, and poorly developed compositional growth zoning.

No additional phases were observed in reflected light.

INTERPRETATION:

This sample represents a pegmatoidal rock that formed under medium to high grade regional metamorphic conditions. This is supported by the well-developed 120° triple grain junctions observed in polycrystalline plagioclase areas.
4. MINERAL ANALYSES BY ELECTRON MICROPROBE

The results of the electron microprobe work on sample HRO5556 are summarised in Table 2.

TABLE 2: MINERAL ANALYSES BY ELECTRON MICROPROBE (Sample HRO5556)

<table>
<thead>
<tr>
<th>SPOT #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>0.00</td>
<td>0.00</td>
<td>30.55</td>
<td>0.00</td>
<td>16.77</td>
<td>17.06</td>
<td>31.31</td>
<td>30.16</td>
</tr>
<tr>
<td>CaO</td>
<td>0.49</td>
<td>0.45</td>
<td>11.87</td>
<td>0.15</td>
<td>2.83</td>
<td>3.29</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>FeO</td>
<td>0.04</td>
<td>0.01</td>
<td>12.66</td>
<td>0.04</td>
<td>0.24</td>
<td>0.21</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.17</td>
<td>0.25</td>
<td>0.00</td>
<td>0.05</td>
</tr>
<tr>
<td>La₂O₃</td>
<td>0.01</td>
<td>0.00</td>
<td>3.11</td>
<td>0.00</td>
<td>0.09</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Ce₂O₃</td>
<td>0.00</td>
<td>0.09</td>
<td>7.20</td>
<td>0.01</td>
<td>0.00</td>
<td>0.19</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Y₂O₃</td>
<td>6.44</td>
<td>7.30</td>
<td>1.21</td>
<td>6.94</td>
<td>0.21</td>
<td>0.11</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>ZrO₂</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>65.77</td>
<td>62.95</td>
</tr>
<tr>
<td>PbO</td>
<td>3.56</td>
<td>3.54</td>
<td>0.00</td>
<td>4.08</td>
<td>4.68</td>
<td>1.99</td>
<td>0.07</td>
<td>0.16</td>
</tr>
<tr>
<td>U₂O₃</td>
<td>74.08</td>
<td>72.20</td>
<td>0.00</td>
<td>74.28</td>
<td>17.89</td>
<td>16.30</td>
<td>0.00</td>
<td>0.16</td>
</tr>
<tr>
<td>ThO₂</td>
<td>5.01</td>
<td>4.54</td>
<td>3.30</td>
<td>4.27</td>
<td>46.90</td>
<td>46.33</td>
<td>0.00</td>
<td>0.08</td>
</tr>
</tbody>
</table>

TOTAL 89.63 88.13 69.90 89.77 89.78 85.73 97.21 93.61

Notes:
1. Alumina was not analysed, and should be ~17% in allanite spot 3.
2. Slightly low totals in most cases is attributable to volatile components of metamict phases.
3. Identification of spots:
   - Spot 1: Th-uraninite, centre of large crystal (see Plate 4).
   - Spot 2: Th-uraninite, near margin of large crystal (see Plate 4).
   - Spot 3: Allanite, within large bladed crystal.
   - Spot 4: Th-uraninite, small crystal (see Plate 5).
   - Spot 5: U-thorogummite, metamict replacement material in equant thorite crystal site (see Plate 2).
   - Spot 6: U-thorogummite, as for spot 5.
   - Spot 7: Zircon, core of large zoned crystal (see Plate 3).
   - Spot 8: U-zircon, rim of large zoned crystal (see Plate 3).

Particular points arising from the results are as follows:

i) Uraninite is the principal U-bearing phase. It contains ~74% U₂O₃, and ~4% ThO₂.

ii) Zircon contains a significant amount of U in the pale brownish rims, where ~0.16% U₂O₃ may be present. U is absent from the colourless zircon cores.

iii) Thorogummite as identified by XRD (metamict after thorite) has been confirmed. It contains ~46% ThO₂ and ~17% U₂O₃.

iv) Allanite (large bladed vitreous metamict crystals) is confirmed, and contains ~3.3% ThO₂.
APPENDIX 1: X-RAY DIFFRACTION STUDY
26 June 1995

Dr. D. R. Mason
Mason Geoscience Pty Limited
PO Box 78
GLENSIDE SA 5065

REPORT G882000G/95
MINERAL IDENTIFICATION IN FOUR ROCKS

YOUR REFERENCE: Letter 6 June 1995
SAMPLE IDENTIFICATION: HRO5556 to HRO5575
MATERIAL: 4 rock samples
DATE RECEIVED: 7 June 1995
WORK REQUIRED: Polished thin section preparation and mineral identification

Investigation and Report by: Michael Till

Dr Keith J Henley
Manager, Mineralogical Services

The results contained in this report relate only to the sample(s) submitted for testing. Amdel Ltd accepts no responsibilities for the representivity of the sample(s) submitted.

btw
MINERAL IDENTIFICATION IN FOUR ROCKS

1. INTRODUCTION

Four rock samples were received from Dr. D. R. Mason of Mason Geoscience Pty Limited, with a request for section preparation and mineral identification by X-ray diffraction.

2. PROCEDURE

Polished thin sections were prepared by standard procedures. The X-ray diffraction procedures are as follows:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>HRO5556</td>
<td>yellow grains were extracted and analysed by XRD</td>
</tr>
<tr>
<td>HRO5572</td>
<td>a pulverised portion of the bulk rock was analysed by XRD, and after heating at 1000°C for 1 hour</td>
</tr>
<tr>
<td>HRO5574</td>
<td>same as HRO5572</td>
</tr>
<tr>
<td>HRO5575</td>
<td>the material under the red X was drilled. Also, cream-coloured earthy patches were extracted. The black vitreous veins were extracted, and analysed before and after heating at 1000°C for 1 hour</td>
</tr>
</tbody>
</table>

3. RESULTS

The sections (TS64036-39) were collected by the client.

The minerals detected by X-ray diffraction are listed in approximate decreasing order of abundance.
<table>
<thead>
<tr>
<th>HRO5556</th>
<th>HRO5572</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thorogummite - (Th, U, Ce) (SiO₄)ₓ₋₄(OH)ₓ⁻₄</td>
<td>as received</td>
</tr>
<tr>
<td>Quartz</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HRO5574</th>
</tr>
</thead>
<tbody>
<tr>
<td>as received</td>
</tr>
<tr>
<td>Amorphous</td>
</tr>
<tr>
<td>Apatite</td>
</tr>
<tr>
<td>Quartz</td>
</tr>
<tr>
<td>Zircon</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HRO5575</th>
</tr>
</thead>
<tbody>
<tr>
<td>material under red X</td>
</tr>
<tr>
<td>Amorphous</td>
</tr>
<tr>
<td>Plagioclase</td>
</tr>
<tr>
<td>Quartz</td>
</tr>
<tr>
<td>Mica</td>
</tr>
</tbody>
</table>

Semi-quantitative Abbreviations

D = Dominant. Used for the component apparently most abundant, regardless of its probable percentage level.

CD = Co-dominant. Used for two (or more) predominating components, both or all of which are judged to be present in roughly equal amounts.

SD = Sub-dominant. The next most abundant component(s) providing its percentage level is judged above about 20.

A = Accessory. Components judged to be present between the levels of roughly 5 and 20%.

Tr = Trace. Components judged to be below about 5%.
REPORT TITLE: Petrographic Descriptions for Sixteen Rock Samples

REPORT #: 2183

CLIENT: PNC Exploration (Aust.) Pty. Ltd.

ORDER NO.: 7199

CONTACT: Dr. Joe Drake-Brockman

REPORT BY: Dr. Douglas R. Mason

SIGNED: [Signature]

for Mason Geoscience Pty. Ltd.

DATE: 21 November 1995
Petrographic Descriptions for Sixteen Rock Samples

SUMMARY

1. Rock Samples
   - A suite of sixteen (16) surface and drill core rock samples has been studied using petrographic, mineragraphic, and limited X-ray diffraction methods.

2. Brief Results
   - Rock names are listed in Table 1.

<table>
<thead>
<tr>
<th>TABLE 1: ROCK NAMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE</td>
</tr>
<tr>
<td>HR05474</td>
</tr>
<tr>
<td>HR05875</td>
</tr>
<tr>
<td>HR05879</td>
</tr>
<tr>
<td>HR06801 (HRD1, 70.5-70.6)</td>
</tr>
<tr>
<td>HR06802 (HRD1, 72.1-72.2)</td>
</tr>
<tr>
<td>HR06803 (HRD8, 47.6-47.7)</td>
</tr>
<tr>
<td>HR06804 (HRD8, 41.6-41.7)</td>
</tr>
<tr>
<td>HR06805 (HRD8, 42.8-42.9)</td>
</tr>
<tr>
<td>HR06806 (HRD9, 49.4-49.5)</td>
</tr>
<tr>
<td>HR06807 (HRD9, 37.2-37.3)</td>
</tr>
<tr>
<td>HR06808 (HRD9, 50.2-50.3)</td>
</tr>
<tr>
<td>HR06809 (HRD9, 54.9-55.0)</td>
</tr>
<tr>
<td>HR06810 (HRD9, 66.3-66.4)</td>
</tr>
<tr>
<td>HR06811 (HRD9, 78.6-78.7)</td>
</tr>
<tr>
<td>HR06812 (HRD9, 79.9-80.0)</td>
</tr>
<tr>
<td>HR06865 (Torbrélníte)</td>
</tr>
</tbody>
</table>

- Calc-silicate meta-sedimentary rocks dominate the suite:
  - They are banded mafic gneisses composed of lineated granoblastic assemblages dominated by hornblende, plagioclase, and scapolite, with accessory ilmenite and sphene. Uncommonly, diopside may be abundant in some samples, and accessory sulphides (pyrrhotite + chalcopyrite) form part of the metamorphic granoblastic assemblage in some samples. The mineralogies and textures are consistent with dynamic regional metamorphism in the amphibolite facies.
  - Felsic banding and veining of some samples developed during or before the principal metamorphic event. This is confirmed by the presence of granoblastic metamorphic assemblages, which are composed of assemblages of scapolite, quartz, and plagioclase, with or without pyrrhotite, chalcopyrite, hornblende, ilmenite, and sphene.
  - Fracturing and retrogressive alteration has variably affected some samples. Particular effects include replacement assemblages of albite, chlorite, pyrite, tremolite, calcite, prehnite, and chalcopyrite, as well as strain shadowing and fragmentation of local wall rock. Note that sulphides may be part of this assemblage, and appear to represent redistributed metamorphic sulphide.
1. INTRODUCTION

A collection of sixteen (16) rock samples was received from Dr. Joe Drake-Brockman (PNC Exploration Aust. Pty. Ltd., South Perth, WA) on 17 October 1995.

Particular requests were noted on sample tags, and included thin section preparation and routine or brief petrographic description, or polished block preparation and mineragraphic description. Two fine-grained samples were submitted for whole-rock mineral confirmation by X-ray diffraction methods.

Preliminary petrographic comments were provided by facsimile to Dr. Drake-Brockman on 18 November 1995. Telephone discussion of the results confirmed that a selection of colour photomicrographs should be included in the report, particularly to illustrate relationships between mafic gneiss and felsic veins. They have been included as Appendix 1. This report contains the full results of this work.

2. METHODS

The samples were examined in hand specimen, and marked for section preparation. The sections were obtained from an external commercial laboratory (Amdel Limited, Thebarton, SA).

At Amdel Limited, three samples (bulk HR05875, bulk HR05879, and green coatings from HR06865) were analysed by X-ray diffraction methods for positive mineral identification. A portion of each sample was finely crushed, mounted in the X-ray diffractometer, and scanned over the range 3-70° two theta. Phases were identified using computer-based mineral search-match software. The results were provided by facsimile from Amdel Limited on 20 November 1995, and are incorporated in the petrographic descriptions.

Also at Amdel Limited, an autoradiograph was prepared for one sample (HR06865). Film was taped to the section offcut, and allowed to auto-irradiate for 5 days. The results are discussed in the petrographic description.

At Mason Geoscience Pty. Ltd., conventional transmitted and reflected light microscopy was used appropriately to prepare the petrographic and mineragraphic descriptions.

3. PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages. Where a polished block or a polished thin section was prepared, appropriate mineragraphic observations are provided.

X-ray diffraction results are incorporated in the descriptions for samples HR05875 and HR05879, and the autoradiograph result is incorporated in the description for sample HR06865.
SAMPLE : HR05474

SECTION NO. : HR05474

HAND SPECIMEN : The rock sample is composed of subequal proportions of large (cm-sized), randomly oriented, dark greenish black prismatic crystals between which occurs pink oxide-stained translucent quartz.

ROCK NAME : Epidote-quartz vein rock

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidote</td>
<td>50</td>
<td>Vein-filling</td>
</tr>
<tr>
<td>Quartz</td>
<td>50</td>
<td>Vein-filling</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>Tr</td>
<td>Vein-filling</td>
</tr>
<tr>
<td>Muscovite</td>
<td>Tr</td>
<td>Vein-filling</td>
</tr>
<tr>
<td>?Zeolite</td>
<td>Tr</td>
<td>Late vugh-filling</td>
</tr>
</tbody>
</table>

In thin section, this sample displays a coarse-grained vein-filling texture.

Epidote is abundant, occurring as large, randomly oriented, euhedral prismatic crystals of centimetre size. Particular optical observations confirm the identification of epidote: high relief, weak cleavage, weak pleochroism in drab pale brownish yellow, and biaxial negative interference figures with high 2V. All crystals display strong growth zoning, with large unzoned core regions overgrown by thinly layered growth zoning.

Quartz is the other principal mineral, forming subhedral equant crystals and angular interstitial grains between the epidote crystals. The quartz is unstrained.

Traces of other minerals are present. Plagioclase occurs as rare small anhedral grains in some interstices, and it may be associated with muscovite flakes. Rare subradiating aggregates of a zeolite mineral are present, and appear to represent white interstitial patches sparsely scattered through the hand specimen.

INTERPRETATION:

This sample represents a coarse-grained vein rock composed of epidote + quartz + trace plagioclase + muscovite + zeolite. Although no deformatonal effects are observable in the rock, it is possible that the rock formed under low-grade regional metamorphic conditions. The coarse-grained, vugly texture of the rock strongly suggests it formed by open space-filling conditions, rather than replacement processes.
SAMPLE : HR05875
SECTION NO. : HR05875
HAND SPECIMEN : The rock sample is composed of thinly laminated materials with local discordant disruptions. Colours range from translucent grey, through cream to white.

ROCK NAME : Bladed quartz-apatite rock

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>57</td>
<td>Alteration</td>
</tr>
<tr>
<td>Apatite</td>
<td>40</td>
<td>Alteration</td>
</tr>
<tr>
<td>Clays (dark green)</td>
<td>3</td>
<td>Vugh-fillings (weathering)</td>
</tr>
<tr>
<td>Carbonate (calcite)</td>
<td>Tr</td>
<td>Vugh-fillings (weathering)</td>
</tr>
</tbody>
</table>

In thin section, this sample displays a relict primary bladed structure that has been replaced by massive secondary minerals.

Quartz is abundant, occurring as massive space-filling deposits between bladed crystal structures. The quartz is fine-grained where it has nucleated on apatite-altered blades, and grows into the space fillings with coarser elongated crystals oriented perpendicular to walls. In places, quartz terminates in euhedral crystals in central vughy areas.

Apatite is subequal in abundance to quartz. It occurs as small, randomly oriented prismatic crystals that occupy thin bladed crystal sites several mm to centimetres in length, and also occupy central areas in quartz-filled vughs. In thicker blades, a relict laminated structure can be discerned in the fine-grained replacement apatite. The size, shape and distribution of the apatite strongly suggests it has formed by replacement of a precursor bladed phase that has not been preserved.

A clay phase occurs as dark green isotropic fillings in scattered vughy areas and small discontinuous veinlets.

A trace amount of carbonate (calcite) occurs as fine-grained diffuse patches, commonly located within the greenish clay patches.

X-RAY DIFFRACTION:

The minerals determined by X-ray diffraction are listed below:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Relative abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apatite</td>
<td>Dominant</td>
</tr>
<tr>
<td>Quartz</td>
<td>Accessory</td>
</tr>
<tr>
<td>Calcite</td>
<td>Trace</td>
</tr>
</tbody>
</table>

The XRD work has confirmed the optical identification of the fine-grained apatite.
INTERPRETATION:

The bladed structure suggests that the precursor rock was composed of long bladed crystals, possibly anhydrite or similar mineral, with quartz infillings. The thin bladed structure is reminiscent of evaporite-type sedimentary deposits, but a vein-type deposit cannot be discounted.

The rock body has suffered pervasive alteration under low-temperature conditions. This resulted in complete replacement of the primary bladed phase by fine-grained, randomly oriented apatite crystals. Identical apatite also filled some remnant vugly cavities. The presence of apatite in both vugly cavities and as randomly oriented crystals in bladed structures strongly supports a replacement origin for the apatite.

More recent near-surface weathering has generated minor clays + calcite.
SAMPLE : HR05879

SECTION NO. : HR05879

HAND SPECIMEN : The rock sample is a pale massive rock composed of translucent grey and white materials. Small solution cavities are scattered throughout, and lend a vughy appearance to the rock.

ROCK NAME : Brecciated laminated quartz-apatite rock

PETROGRAPHY : A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>64</td>
<td>Alteration</td>
</tr>
<tr>
<td>Apatite</td>
<td>20</td>
<td>Alteration</td>
</tr>
<tr>
<td>Zeolite</td>
<td>1</td>
<td>Alteration</td>
</tr>
<tr>
<td>Clays</td>
<td>10</td>
<td>Vughy-filling</td>
</tr>
<tr>
<td>Opaques (?Fe-oxide)</td>
<td>Tr</td>
<td>Vughy-filling</td>
</tr>
<tr>
<td>Voids</td>
<td>5</td>
<td>Remnant vughs</td>
</tr>
</tbody>
</table>

In thin section, this sample displays a disrupted laminated structure, with late clay-rich vughy fillings.

Quartz is abundant. It occurs in a bladed network structure that is disrupted to different degrees in different areas of the rock. In detail, quartz occurs as fine-grained oriented crystals that replaced and nucleated on a precursor bladed structure. Crystals grew perpendicular to the bladed substrate, terminating in well-formed crystals. Disruption of the rock has generated small comb-structured fragments of the quartz-rich bladed structure.

Apatite is moderately abundant, occurring as small elongated prismatic crystals of random orientation. It occurs mostly in interstices between disrupted bladed quartz fragments. Although fine-grained, uniaxial negative interference figures have been obtained, supporting the identification of apatite.

A zeolite mineral occurs as colourless, subhedral bladed crystals up to ~0.4 mm long. They are quite large compared with quartz and apatite grain sizes. They display parallel extinction to cleavage and prismatic faces, suggesting an orthorhombic crystal system.

A clay mineral occurs as dense, cryptocrystalline to isotropic, massive, dark green vuggy fillings scattered through the rock.

X-RAY DIFFRACTION:

The minerals identified by X-ray diffraction are listed below:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Relative abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>Dominant</td>
</tr>
<tr>
<td>Apatite</td>
<td>Accessory</td>
</tr>
<tr>
<td>Smectite</td>
<td>Accessory</td>
</tr>
<tr>
<td>Stilbite</td>
<td>Trace</td>
</tr>
</tbody>
</table>
The XRD result has confirmed the optical identifications. Further, it has provided more accurate identification of the clay mineral (smectite) and the zeolite mineral (stilbite).

INTERPRETATION:

This sample has a similar genesis to the previous sample, HR05875. A bladed mineral structure developed, but was completely replaced by quartz, apatite and minor zeolite (stilbite). The textures are compatible with either an altered evaporitic deposit or low-temperature vein deposit. Smectite clay filled solution cavities in the near-surface environment.
SAMPLE : HR06801 (HRD1, 70.5-70.6)

SECTION NO. : HR06801

HAND SPECIMEN : The drill core rock sample is a mafic gneiss in which white felsic grains of variable size are distributed through more abundant dark greenish black ferromagnesian grains. Preferred orientation and variable abundance of minerals produces a weak layering through the rock. A minor amount of metallic brown sulphide (?pyrrhotite) is concentrated in mm-sized patches aligned in the trace of the foliation.

ROCK NAME : Metamorphic sulphide-bearing rock

MINERAGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrrhotite</td>
<td>10</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>3</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Pyrite</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Non-opaque gangue</td>
<td>86</td>
<td>Metamorphic</td>
</tr>
</tbody>
</table>

In polished block, this sample displays a lineated granoblastic metamorphic texture in which sulphide grains appear to be in textural equilibrium with non-opaque gangue phases.

Pyrrhotite is the dominant sulphide mineral. It occurs as anhedral grains that range in size from ~0.2 up to ~4 mm (average size ~2 mm). It tends to be concentrated in polycrystalline aggregates elongated within the trace of the foliation defined by this and other oriented mineral grains. The pyrrhotite displays its typical pale brownish cream colour with weak bireflectance. Under crossed polarisers, anisotropic optical behaviour clearly displays the relatively coarse grain size of the pyrrhotite.

Chalcopyrite is present in minor amount, forming large patches up to ~2 mm in size, in close association with larger pyrrhotite aggregates. No intergrowth textures are evident.

Pyrite occurs in minor amount as subhedral blocky crystals ~0.2-2.0 mm in size. The larger crystals tend to be closely associated with the larger aggregates of pyrrhotite and chalcopyrite, but smaller grains are discretely disseminated through the rock.

Non-opaque gangue minerals are abundant. Lozenge-shaped crystal forms and moderate reflectivity of some crystals suggest they are sphene, but other phases are difficult to identify in reflected light.

INTERPRETATION:

The sample is inferred to represent a mafic gneiss with accessory sulphide (pyrrhotite > chalcopyrite > pyrite). The granoblastic textural relationships between sulphides and non-opaque gangue minerals strongly suggests that all of the sulphide phases equilibrated with the principal non-opaque phases during metamorphism. There are no textural indications that the sulphides formed by a later replacement event.
SAMPLE : HR06802 (HRD1, 72.1-72.2)

SECTION NO. : HR06802

HAND SPECIMEN : The drill core rock sample represents a medium-grained banded crystalline rock in which banding is defined by variable abundances of white and waxy greenish grey grains.

ROCK NAME : Diopside-scapolite calc-silicate gneiss

BRIEF PETROGRAPHY :

In thin section, this sample displays a medium-grained granoblastic metamorphic texture with indistinct mineral layering.

Diopside is moderately abundant, occurring as anhedral equant grains (average size ~1 mm) scattered throughout the rock. They display the typical pale green, non-pleochroic colour, moderate relief, and moderate birefringence that are characteristic of the mineral. A trace of pleochroic green actinolite occurs as small ragged replacement patches in some, but not all, grains.

Scapolite is subequal in abundance to diopside, building anhedral grains ~0.2-1.0 mm in size. They display the typical optical features of this mineral: colourless, low relief, parallel extinction to cleavage traces. The moderate birefringence suggests it is a Ca-rich scapolite (i.e. meionitic in composition). Some grains display incipient alteration in the form of dull brownish clouding, but most grains are quite fresh.

K-feldspar occurs in minor amount as small anhedral grains that are concentrated in a particular band. They display incipiently developed "tartan" twinning typical of microcline.

Accessory phases include subhedral sphene grains, foliated biotite flakes, and uncommon scattered aggregates of intergrown opaques and pale yellow epidote. The nature of the latter two minerals suggests a retrogressive alteration origin.

INTERPRETATION:

This sample represents a calc-silicate meta-sedimentary rock that has suffered dynamic regional metamorphism to generated diopside + scapolite + minor K-feldspar + biotite + sphene. Minor retrogressive alteration generated traces of actinolite + opaques + epidote.
SAMPLE: HR06803 (HRD8, 47.6-47.7)
SECTION NO.: HR06803

HAND SPECIMEN: The drill core rock sample is composed of indistinctly laminated mafic gneiss, cut by a felsic band. Sulphide grains and aggregates are most abundant in the felsic band, but some also occur as concentrations along the contact between the mafic gneiss and felsic band. Lustrous brownish metallic colour suggests that pyrrhotite is the most abundant sulphide phase, but lustrous silvery pyrite also appears to be present.

ROCK NAME: Altered metamorphic sulphide-bearing rock

MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrrhotite</td>
<td>5</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>&lt;1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Pyrite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Non-opaque gangue</td>
<td>91</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Pyrite</td>
<td>2</td>
<td>Retrogressive alteration</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>Tr</td>
<td>Retrogressive alteration</td>
</tr>
</tbody>
</table>

In polished section, this sample displays a granoblastic metamorphic texture that has suffered minor retrogressive alteration.

Pyrrhotite is the principal sulphide phase. It occurs as large anhedral grains ~1-2 mm in size, in granoblastic relationship with abundant non-opaque gangue grains. The pyrrhotite tends to be concentrated in sulphide-rich aggregates.

Two types of pyrite are distinguished:

i) Some occurs as euhedral small cubic crystals enclosed within pyrrhotite. These appear to be in textural equilibrium with the pyrrhotite.

ii) A larger amount occurs as very fine-grained rugged aggregates that have partly replaced pyrrhotite around pyrrhotite grain margins. It has also partly replaced some non-opaque gangue grains around their margins and along cleavage traces. The fine grain size and distribution of this pyrite strongly indicates it is of replacement origin.

Chalcopyrite also occurs in two textural occurrences. A small amount occurs as angular grains in textural equilibrium with pyrrhotite and blocky pyrite crystals. A trace amount occurs as tiny anhedral grains concentrated along cleavages in some altered non-opaque grains.

Ilmenite forms anhedral grains in close association, and in textural equilibrium, with pyrrhotite and coarser pyrite.

Non-opaque minerals dominate the rock. They form large anhedral grains that appear to be in equilibrium with pyrrhotite and coarser-grained pyrite and chalcopyrite.
INTERPRETATION:

The rock is inferred to represent a metamorphic rock in which sulphide minerals (pyrrhotite > pyrite = chalcopyrite) formed in textural equilibrium with the metamorphic non-opaque minerals. Subsequently, a mild degree of retrogressive alteration resulted in minor replacement of pyrrhotite and other minerals by pyrite + chalcopyrite. The fine-grained nature and distribution of the retrogressive sulphide minerals clearly set them apart from the coarser-grained metamorphic sulphides.
SAMPLE: HR06804 (HRD8, 41.6-41.7)

SECTION NO.: HR06804

HAND SPECIMEN: The drill core rock sample is composed of medium-grained lineated dark greenish black hornblende grains, and white felsic minerals, whose variable distribution defines mineralogical layering subparallel to the preferred orientation of the grains. Accessory lustrous silvery metallic sulphide patches (probably pyrite) are scattered through the rock.

ROCK NAME: Banded hornblende-plagioclase-scapolite calc-silicate gneiss

PETROGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornblende</td>
<td>80</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>10</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Scapolite</td>
<td>3</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>K-feldspar</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Opaques (?ilmenite)</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Sphene (incl. ?rutile)</td>
<td>&lt;1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Apatite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Opaques (?sulphide)</td>
<td>&lt;1</td>
<td>Retrogressive alteration</td>
</tr>
<tr>
<td>Calcite</td>
<td>Tr</td>
<td>Retrogressive alteration</td>
</tr>
</tbody>
</table>

In thin section, this sample displays a lineated granoblastic metamorphic texture with mineralogical layering. Minor retrogressive alteration has affected the rock.

Hornblende is abundant, occurring as anhedral elongated grains whose preferred orientation defines a lineation subparallel to layering. Hornblende is particularly abundant in some layers (~96%), and is less abundant in other layers (down to ~1-5% in some felsic layers). Average hornblende grain size is larger (~1 mm) in hornblende-rich bands compared with felsic bands (<0.2 mm), but all hornblende displays similar pleochroism, from pale drab brown to dark green, suggesting there is no compositional difference from band to band.

Plagioclase occurs as anhedral grains commonly ~0.2-0.4 mm in size in plagioclase-rich layers. Less commonly it forms larger grains ~1-2 mm in size in felsic layer that contains scapolite. All of the plagioclase is fresh, and most grains display its typical multiple twinning.

Scapolite builds anhedral ragged grains up to ~1 mm in size. They are restricted to particular felsic bands, and are absent from most of the rock. The moderate birefringence suggests it is a Ca-rich variety (i.e. meionitic). All grains display incipient replacement; most grains have suffered turbid incipient alteration along cleavage traces, and some have suffered partial replacement by ragged clear calcite patches.

Quartz occurs in minor amount as small anhedral grains that are most abundant in some felsic layers. Tiny ragged grains occur around margins of hornblende grains in the hornblende-rich layers.
Opaques of two types are distinguished:

i) Most occurs as small lath-like to subrounded grains ~0.2 mm long. They are sparsely disseminated through the rock, and display a preferred orientation subparallel to layering. They most likely are ilmenite. Uncommon larger grains ~1-2 mm long are intimately associated with pleochroic sphene, and minor ?rutile grains (weakly pleochroic dark reddish brown, high birefringence).

ii) A small amount of opaque grains occur as small ragged granular aggregates, in places within the scapolite-bearing layers. These opaques are closely associated with traces of epidote and chlorite.

K-feldspar is uncommon, forming small anhedral grains with weak "tartan" twinning that are concentrated in particular felsic layers.

Apatite is rare, forming small equant anhedral grains in particular plagioclase-rich layers.

INTERPRETATION:

This sample is considered to represent a calc-silicate meta-sedimentary rock. It has suffered dynamic regional metamorphism, generating the lineated granoblastic assemblage of hornblende + plagioclase + minor scapolite + quartz + K-feldspar + opaques (?ilmenite) + sphene + apatite. Retrogressive alteration generated trace amounts of opaques (?pyrite) + epidote + calcite + chlorite.

The hornblende in the hornblende-rich layers and the felsic layers appears to have formed synchronously. All hornblende grains display the same pleochroism and granoblastic relationship with other metamorphic phases, and therefore crystallised synchronously during the metamorphic event. The origin of the layering is conjectural, but it may reflect primary sedimentary layering with local modification by metamorphic segregation processes.
SAMPLE: HR06805 (HRD8, 42.8-42.9)

SECTION NO.: HR06805

HAND SPECIMEN: The drill core rock sample is composed of alternating felsic and mafic layers with variable thicknesses suggestive of boudinage-type structure. Felsic layers contain white mineral grains suggestive of scapolite, and mafic layers contain abundant dark greenish black grains of hornblende.

ROCK NAME: Sericitised hornblende-scapolite calc-silicate gneiss

PETROGRAPHY:
A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornblende</td>
<td>50</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Scapolite</td>
<td>30</td>
<td>Relict metamorphic</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>10</td>
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</tr>
<tr>
<td>Quartz</td>
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<td>Metamorphic</td>
</tr>
<tr>
<td>Opaques (?ilmenite)</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Biotite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Sphene</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>?Allanite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Sericite</td>
<td>5</td>
<td>Retrogressive alteration</td>
</tr>
<tr>
<td>Calcite</td>
<td>Tr</td>
<td>Retrogressive alteration</td>
</tr>
</tbody>
</table>

In thin section, this sample displays a granoblastic metamorphic texture, with mineralogical layering, modified by mild retrogressive alteration of scapolite.

Hornblende is abundant in mafic layers, where it forms anhedral grains ~0.2-3.0 mm in size. They display a preferred orientation (lineation) subparallel to layering, and their pleochroism ranges from pale drab brown to dark green.

Scapolite is the other principal mineral. It is the dominant mineral in felsic layers, where it forms anhedral equant grains that range widely in size ~0.2-4.0 mm in size. It is moderately abundant through most of the rest of the rock, forming smaller anhedral grains ~0.2 mm in size in granoblastic relationship with hornblende. Many scapolite grains display partial replacement by tiny, randomly oriented sericite flecks that tend to form dense replacement aggregates.

Plagioclase forms clear, twinned, fresh grains ~0.2-0.4 mm in size. It is most abundant in some horizons, but is distributed more-or-less throughout the rock except in the most scapolite-rich layers.

Quartz is uncommon, forming large anhedral grains in the scapolite-rich layers, and smaller ragged grains elsewhere through the rock.

Opaques occur mostly as small lath-like to subrounded grains ~0.2 mm in size. They are distributed through most layers, and their preferred orientation contributes to the lineation subparallel to layering. The form and distribution suggests these grains are ilmenite. Uncommon larger opaque grains (also probably ilmenite) occur sparingly in the scapolite-rich layers, and also are concentrated in thinner quartz-scapolite layers.

Biotite occurs as rare small flakes, pleochroic in orange-browns, suggestive of a phlogopitic composition.
Sphene forms small ragged grains, pleochroic in their typical brownish colours.

* Allanite is rare, forming subhedral crystals of dull yellowish brown colour and anomalous bluish-grey interference colours. They occur only in the scapolite-ilmenite-quartz layer.

INTERPRETATION:

This sample is inferred to represent a calc-silicate sedimentary rock that has suffered dynamic regional metamorphism in the amphibolite facies, generating the granoblastic metamorphic assemblage of hornblende + scapolite + plagioclase + minor quartz + opaques (?ilmenite) + biotite + allanite + sphene. Retrogressive alteration has resulted in selective partial replacement of scapolite by fine-grained massive sericite.
SAMPLE: HR06806 (HRD9, 49.4-49.5)
SECTION NO.: HR06806
HAND SPECIMEN: The drill core rock sample is composed of weakly layered mafic gneiss, in which layering is defined by minor subparallel felsic layers in an otherwise mafic (hornblende-rich) rock. A coarse-grained quartz-rich vein cuts the layering, and wall rock adjacent to the vein contains fine- to coarse-grained white grains (scapolite).

ROCK NAME: Veined hornblende-plagioclase calc-silicate gneiss

BRIEF PETROGRAPHY:
In thin section, this sample displays a lineated granoblastic metamorphic texture, with coarse-grained texture in a discordant quartz vein.

Hornblende is abundant in the host rock, occurring as anhedral ragged grains ~1 mm in average grain size, pleochroic in drab pale browns and dark greens. A preferred orientation (lineation) is subparallel to weak mineralogical layering.

Plagioclase is moderately abundant, forming anhedral grains ~0.4 mm in average size. More-or-less straight plagioclase-plagioclase grain boundaries indicate equilibrium crystallisation under metamorphic conditions. All of the plagioclase is fresh.

Scapolite is moderately abundant, forming anhedral grains in granoblastic metamorphic relationship with hornblende and plagioclase in the wall rock. It is confined to the selvedge of the quartz-rich vein, but does not appear to have replaced precursor material.

Quartz occurs mainly as large anhedral grains ~1-6 mm in size in the discordant quartz-rich vein. It is quite unstrained. Rare small hornblende crystals occur within some large quartz grains near the wall rock margin. Smaller grains occur in the wall rock, in granoblastic relationship with hornblende, plagioclase and scapolite.

Opaques (probably ilmenite) form small elongate and subrounded grains ~0.1-0.2 mm in size, distributed more-or-less uniformly throughout the wall rock. It most likely is ilmenite. Similar opaque grains are concentrated in a thin laminae of wall rock that projects as a lamina into the quartz-rich vein, subparallel to the wall rock.

Sphene forms small accessory subrounded grains, and zircon is very rare as small subrounded grains.

Apatite occurs as moderately large equant grains in aggregates within the quartz-rich vein, near the wall rock contact.

INTERPRETATION:
The sample is inferred to represent a calc-silicate meta-sedimentary rock that has suffered dynamic regional metamorphism of medium grade (amphibolite facies), generating the observed granoblastic assemblage of hornblende + plagioclase + minor quartz + opaques (ilmenite) + sphene.

Veining developed during the metamorphic event, allowing equilibrium crystallisation of vein selvedge alteration (scapolite) with wall rock minerals. The uniformly granoblastic texture of the scapolite is notable: it is in equilibrium with the metamorphic wall rock minerals, yet its distribution is controlled by the discordant quartz vein margins. The veining did not occur after the metamorphic event.
SAMPLE : HR06807 (HR9, 37.2-37.3)  

SECTIOON NO. : HR06807

HAND SPECIMEN : The drill core rock sample is composed of medium to coarse-grained, banded to spotted mafic gneiss in which banding is defined by variable abundances of dark greenish black hornblende and translucent grey and white felsic minerals. A coarse quartz patch lies discordant to banding, but an anastomosing shear band contains drab green alteration materials.

ROCK NAME : Sheared, veined hornblende-plagioclase calc-silicate gneiss

BRIEF PETROGRAPHY :

In thin section, this sample displays a medium-grained, lineated granoblastic metamorphic texture that has been severely modified by fracturing, cataclastic deformation, granulation and retrogressive alteration along shear planes in a shear zone.

The fresh wall rock is composed of abundant anhedral hornblende grains ~1 mm in size, pleochroic drab pale brown to dark green, and lesser fresh, weakly zoned plagioclase grains ~0.4 mm in size. Minor quartz forms small anhedral clear grains, opaques (ilmenite) form small lath-like grains that contribute to the lineation, and sphene occurs as small subrounded grains.

Cutting the lineation in the wall rock is a quartz-rich vein (or patch, as observed in hand specimen) composed almost entirely of large anhedral quartz grains that are notably unstrained. Uncommon large opaque crystals display prismatic forms appropriate to ilmenite. Biotite occurs as ragged flakes near margins of the quartz vein, and carbonate occurs as fine-grained granular aggregates that in places partly replace quartz. A shear zone (see next) has caused fracturing and shadowy strain extinction where it impinges against the margin of the vein.

Cutting the wall rock is a shear zone oriented discordant to lineation. Significant deformational effects in the shear zone include fractures that anastomose through the rock, fragments of wall rock that display moderately severe shadowy strain extinction, and pervasive and patchy alteration that has generated carbonate, chlorite, and sericite.

INTERPRETATION:

The rock sample represents a calc-silicate meta-sedimentary rock that has suffered the following events:

1) Dynamic regional metamorphism in the amphibolite facies.

2) Syn-metamorphic patchy veining generated coarse veins of quartz + minor ilmenite. A trace of biotite formed along margins of the quartz-ilmenite vein.

3) Fracturing and shearing occurred in a shear zone of centimetre width. This allowed development of the retrogressive alteration assemblage of carbonate + sericite + chlorite.
SAMPLE : HR06808 (HRD9, 50.2-50.3)
SECTION NO. : HRD9, 50.2-50.3

HAND SPECIMEN : The drill core rock sample is composed of relatively uniform medium-grained hornblende mafic gneiss, with thin pale bands richer in felsic minerals.

ROCK NAME : Hornblende-plagioclase(-scapolite) calc-silicate gneiss

BRIEF PETROGRAPHY :

In thin section, this sample displays a medium-grained lineated granoblastic metamorphic texture.

Hornblende dominates the rock, forming anhedral grains pleochroic from pale brown to dark brownish green. Most are ~0.6-2.0 mm long, and display a preferred orientation which defines a lineation subparallel to weak mineralogical layering. The hornblende is abundant throughout the rock, but occurs in minor amount in the felsic (plagioclase-scapolite-quartz) bands.

Plagioclase forms small twinned anhedral grains ~0.4 mm in size, filling interstices between hornblende grains. In places it is concentrated in thin bands, and the contacts between these and the hornblende-rich bands are gradational granoblastic contacts (i.e. they are in equilibrium, not sharp discordant contacts).

Scapolite occurs in minor amount as equant to subrounded grains ~0.2-1.0 mm in size. They are concentrated in the thin felsic bands, and clearly are in equilibrium granoblastic relationship with plagioclase and hornblende. Most of the scapolite is quite fresh.

Quartz occurs in minor amount as small grains in the felsic bands, and as tiny grains around margins of large hornblende grains in the hornblende-rich areas of the rock. In some felsic bands, quartz tends to form larger grains concentrated in thin indistinct veinlets subparallel to the banding.

Accessory phases include opaques (probably ilmenite), and pleochroic sphene, both of which are disseminated more-or-less uniformly through the rock, including the felsic bands.

INTERPRETATION:

The rock is inferred to represent a calc-silicate sediment that has suffered dynamic regional metamorphism in the amphibolite facies, generating the observed lineated granoblastic assemblage. It is unclear whether the felsic bands represent relict primary sedimentary layering, or localised metamorphic segregation of more mobile felsic components. It is clear, however, that the felsic banding formed before or during (not after) the metamorphic event, because the felsic bands display identical metamorphic textures to the main hornblende-rich portions of the rock.
SAMPLE: HR06809 (HRD9, 54.9-55.0)

SECTIONS: HR06809

HAND SPECIMEN: The drill core rock sample represents a banded gneissic rock, in which two distinct bands are distinguished: one is composed of lineated mafic gneiss, and the other is composed of felsic gneiss. Sparsely scattered through the rock (especially in the felsic band) are small ragged sulphide phases composed of lustrous metallic brown pyrrhotite and trace lustrous yellow chalcopyrite.

Cutting the rock is a thin shear zone slightly discordant to layering, near the contact between the two bands. Fine-grained silvery pyrite fills thin fractures within the shear zone.

ROCK NAME: Fractured, banded calc-silicate gneiss

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornblende-scapolite calc-silicate gneiss (mafic band)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hornblende</td>
<td>65</td>
<td>Metamorphic</td>
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<tr>
<td>Scapolite</td>
<td>25</td>
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<tr>
<td>Plagioclase</td>
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<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>3</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Sphene</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Scapolite gneiss (felsic band)</td>
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<td></td>
</tr>
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<tr>
<td>Hornblende</td>
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<tr>
<td>Sphene</td>
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<tr>
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</tr>
<tr>
<td>Pyrrhotite</td>
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</tr>
<tr>
<td>Pyrite</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Chalcopyrite</td>
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<td>Metamorphic</td>
</tr>
<tr>
<td>Apatite</td>
<td>Tr</td>
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</tr>
<tr>
<td>Calcite</td>
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<td>Alteration / fracture-filling</td>
</tr>
<tr>
<td>Chlorite</td>
<td>Tr</td>
<td>Alteration / fracture-filling</td>
</tr>
<tr>
<td>Pyrite</td>
<td>Tr</td>
<td>Alteration / fracture-filling</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>Tr</td>
<td>Alteration / fracture-filling</td>
</tr>
</tbody>
</table>

In polished thin section, this sample displays a lineated medium-grained granoblastic texture in the mafic band, and a massive (i.e. non-lineated, non-foliated) granoblastic texture in the felsic band.

Hornblende-scapolite calc-silicate gneiss (mafic band) is dominated by anhedral hornblende grains ~0.2-2.0 mm in size and pleochroic from drab pale brown to dark green, whose preferred orientation defines a lineation. Smaller anhedral grains of moderately birefringent scapolite (i.e. meionite) are moderately abundant, and large anhedral porphyroblastic grains occur near the contact with the scapolite-rich band. Lesser twinned plagioclase with lower birefringence also occurs between the hornblende grains. Quartz is uncommon, and tends to
occur in minor thin quartz-rich veins subparallel to lineation. Ilmenite forms small elongated grains aligned in the trace of the lineation, and sphene forms uncommon small anhedral grains.

Scapolite gneiss (felsic band) is composed mostly of large anhedral scapolite grains that range up to ~4 mm in size. Hornblende forms ragged grains of slightly paler green pleochroism compared with that in the mafic band, and plagioclase forms small anhedral twinned grains intergrown with scapolite. Sphene and ilmenite are moderately abundant for minor phases, the former occurring as ragged pleochroic pinkish brown grains and the latter form ragged anhedral grains. Both of these phases appear to be in textural equilibrium with each other and other principal metamorphic phases. Apatite builds stumpy prismatic clear crystals.

Scattered through the felsic band are anhedral grains of pyrrhotite, and associated angular grains of chalcopyrite and subhedral to euhedral pyrite crystals. All appear to be in granoblastic equilibrium relationship with each other and the other metamorphic phases.

Cutting the felsic band is a fracture zone composed of thin subparallel fractures. Nearby scapolite displays shadowy strain extinction, and alteration minerals concentrated in and between the fractures include fine-grained calcite, small chlorite flakes, and dense fine-grained elongated aggregates of pyrite. Tiny ragged grains of chalcopyrite also occur in the fractures.

INTERPRETATION:

This sample is interpreted in the following manner:

1) Dynamic regional metamorphism in the amphibolite facies generated granoblastic assemblages in layered calc-silicate sedimentary rocks: relatively Fe- and Mg-rich calc-silicate bands generated the lineated assemblage of hornblende + scapolite + minor plagioclase + quartz + ilmenite + sphene. In contrast, bands poor in Fe- and Mg- and rich in Cl, CO$_3$ and SO$_4$ recrystallised to coarser-grained assemblages of scapolite + minor hornblende + plagioclase + sphene + ilmenite + sulphides (pyrrhotite > chalcopyrite = pyrite).

Note that some sulphide appears to have formed as part of the metamorphic assemblage. Also note that the textures of the mafic and felsic bands suggest they formed synchronously.

2) Deformation affected the rock body. A thin fracture zone developed closely-spaced fractures. Deposited along and between the fractures was the retrogressive alteration assemblage of pyrite + calcite + chlorite + chalcopyrite.

Note that a second generation of sulphides (pyrite >> chalcopyrite) is represented in this assemblage.
SAMPLE : HR06810 (HRD9, 66.3-66.4)

SECTION NO. : HR06810 (HRD9, 66.3-66.4)

HAND SPECIMEN : The drill core rock sample is composed of weakly banded mafic gneiss, which contains a vein or band rich in felsic minerals and dense sulphide patches which displays lustrous brownish metallic colours (pyrrhotite) and lustrous yellow metallic colours (chalcopyrite).

ROCK NAME : Veined hornblende-plagioclase-scapolite calc-silicate gneiss

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornblende-plagioclase-scapolite calc-silicate gneiss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hornblende</td>
<td>42</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>35</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Scapolite</td>
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<td>Ilmenite</td>
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</tr>
<tr>
<td>Sphene</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Pyrrhotite</td>
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</tr>
<tr>
<td>Chalcopyrite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz-scapolite-sulphide vein</td>
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<td></td>
</tr>
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<td>Quartz</td>
<td>39</td>
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<tr>
<td>Prehnite</td>
<td>5</td>
<td>Alteration</td>
</tr>
</tbody>
</table>

In polished thin section, this sample displays a granoblastic metamorphic texture in the principal host rock, and both granoblastic and vein textures in the felsic, sulphide-rich vein. Mild retrogressive alteration has affected only portions of the felsic vein.

Hornblende-plagioclase-scapolite calc-silicate gneiss is composed of a weakly lineated granoblastic assemblage of anhedral pleochroic pale brown to green hornblende up to ~1 mm in size, and smaller interstitial grains of twinned plagioclase and moderately birefringent (meionitic) scapolite.

Accessory phases are scattered through the rock. Ilmenite forms ragged grains commonly mantled by sphene. Less commonly, anhedral pyrrhotite grains and chalcopyrite grains are disseminated through the rock, and occur in textural equilibrium with the other metamorphic phases. Note that no replacement phenomena are observable between these sulphide phases and the associated metamorphic minerals.

Quartz-scapolite-sulphide vein displays a discordant contact with respect to the weak lineation in the wall rock. The vein contains an heterogeneous mineral distribution and variable textures. Quartz is abundant, but is concentrated in a single coarse-grained band or vein. Coarse-grained scapolite is sparsely distributed through the quartz-rich vein, but is most abundant as smaller
granoblastic mosaics along margins of the vein which generates a banded vein structure. Minor hornblende occurs as ragged dark green grains and sphene forms ragged grains.

Sulphides are moderately abundant. Pyrrhotite occurs as large ragged patches, and may be accompanied by large ragged patches of chalcopyrite. The latter also occurs as tiny ragged grains concentrated in granular aggregates of prehnite which appears to have formed by replacement of nearby scapolite. Pyrite occurs as subhedral cubic crystals, concentrated in incipiently altered areas and particularly concentrated along a sulphide-rich lamina which contributes to the banded structure of the vein.

Importantly, tiny grains of chalcopyrite also occur along a closely-spaced fracture set which cuts the quartz-rich band in the vein. Clearly, this fine-grained chalcopyrite formed subsequent to development of the felsic vein.

INTERPRETATION:

This sample displays mineralogical and textural features consistent with the following interpretation:

1) Calc-silicate sedimentary materials were deposited as part of a sedimentary sequence.

2) Following deep burial and diagenesis, the rock body suffered dynamic regional metamorphism in the amphibolite facies. This had the following effects:

   - The main body of the rock recrystallised to a lineated granoblastic assemblage of hornblende + plagioclase + scapolite + minor ilmenite + sphene + pyrrhotite + chalcopyrite. Note that the accessory sulphide minerals formed in equilibrium with the other principal metamorphic phases. This suggests that sulphide components were introduced during or before the metamorphic event. The latter would suggest that the sedimentary sequence contained primary components of sulphur and metals.

   - Discordant veins recrystallised to granoblastic and banded vein assemblages of quartz + scapolite + plagioclase + pyrrhotite + chalcopyrite + minor hornblende + sphene. The vein structures formed either during or before the metamorphic event, because they display mineralogical and textural similarities with enclosing wall rock.

3) Mild retrogressive alteration affected the sulphide-rich areas of the vein. Some chalcopyrite was redistributed along a fracture set, cutting the banded vein structure. Prehnite formed by replacement of scapolite, and pyrite formed as a replacement phase.

This sample is important, because it contains textural evidence to suggest that sulphides of metamorphic origin (pyrrhotite, chalcopyrite) have suffered mild redistribution under retrogressive conditions.
SAMPLE : HR06811 (HRD9, 78.6-78.7)  
SECTION NO. : HR06811  
HAND SPECIMEN : The drill core rock sample is a banded gneissic rock in which banding is defined by variable abundances of pale green and white grains. One large patch is composed of a large white grain of cm size (albite) and dense dark aggregate of green material (chlorite).  
ROCK NAME : Altered banded calc-silicate gneiss  
BRIEF PETROGRAPHY : In thin section, this sample displays a massive granoblastic metamorphic texture that has been modified by pervasive alteration. Plagioclase is abundant, forming anhedral twinned grains ~0.2-0.4 mm in size. All display partial alteration by minute sericite flecks. One large plate of twinned albite has been captured as part of the white and black patch observed in hand specimen. Quartz forms anhedral plates ~1-2 mm in size. One plate contains small grains of pale green pleochroic actinolite, but actinolite has not been observed elsewhere in the rock. Calcite occurs as large angular plates scattered through the rock, but also forms thin discontinuous veinlets. Chlorite is moderately abundant, forming radiating sprays in patches scattered throughout the rock. Sphene occurs as large ragged grains ~1-2 mm in size. Most display partial replacement along cleavage traces by very fine-grained diffuse lamellae of indeterminate material (probably leucoxene). Opaques form elongate disseminated grains. They may be ilmenite.  
INTERPRETATION: This sample is inferred to represent a banded calc-silicate gneiss of meta-sedimentary origin. It suffered a regional metamorphic event of presumed medium grade (amphibolite facies), generating plagioclase + quartz + calcite + ferromagnesian grains + sphene + opaques (?ilmenite). Subsequently the rock body suffered a low-grade retrogressive alteration event which resulted in alteration of plagioclase to albite + sericite, and alteration of ferromagnesian grains to chlorite.
SAMPLE : HR06812 (HRD9, 79.9-80.0)
SECTION NO. : HR06812 (HRD9, 79.9-80.0)
HAND SPECIMEN : The drill core rock sample is composed of mafic gneiss with lineated dark green hornblende and bleached white felsic minerals, cut by intersecting thin veins filled by fine-grained pale grey material.
ROCK NAME : Veined, tremolite-albite-altered hornblende-plagioclase calc-silicate gneiss

BRIEF PETROGRAPHY :

In thin section, this sample displays a lineated granoblastic metamorphic texture that has been modified by fracturing, vein-filling and pervasive retrogressive alteration.

Hornblende occurs as ragged grains ~1 mm in size, pleochroic from pale brown to dark greenish brown. A preferred orientation of the hornblende defines a lineation through the rock.

Plagioclase occurs as smaller anhedral grains ~0.2-0.6 mm in size, forming a granoblastic mosaic between the larger hornblende grains. All plagioclase has suffered alteration in the form of replacement by optically continuous albite, and the development of tiny indeterminate alteration specks.

Colourless tremolite occurs as well-crystallised blades of random orientation, concentrated in ragged patches with coarser ragged calcite grains. Finer-grained tremolite forms dense fillings in veins up to several mm wide that cut the rock, and larger calcite patches may occur in these veins.

Opaques of two types are distinguished:

i) Ragged aggregates (possibly pyrite) occur as irregular replacement patches in some hornblende grains. These opaques clearly belong to the alteration assemblage.

ii) Some opaques occur as disseminated small subhedral grains. These may be ilmenite crystals of metamorphic origin.

INTERPRETATION:

This sample represents a calc-silicate meta-sedimentary rock that has suffered dynamic regional metamorphism, generating the lineated granoblastic assemblage of hornblende + plagioclase + minor sphene + opaques (?ilmenite).

The rock body suffered a retrogressive alteration event, with the following consequences:

i) Veins were filled by fine-grained tremolite + coarse calcite patches.

ii) Coarser-grained prisms of tremolite + calcite filled solution cavities and replacement patches scattered through the rock.

iii) Plagioclase was replaced by albite + indeterminate specks.

iv) Minor opaques (?pyrite) formed by replacement of hornblende grains.
SAMPLE : HR06865

SECTION NO. : HR06865

HAND SPECIMEN : The surface rock sample represents a banded gneiss which has suffered moderately severe weathering, producing pervasive pale brown discoloration and darker brown oxidation in particular bands.

ROCK NAME : Weathered banded gneiss

PETROGRAPHY AND MINERAGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>20</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Hornblende</td>
<td>Tr</td>
<td>Relict metamorphic</td>
</tr>
<tr>
<td>Zircon</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Pyrrhotite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Unknown</td>
<td>Tr</td>
<td>Altered metamorphic accessory phase</td>
</tr>
<tr>
<td>Quartz</td>
<td>67</td>
<td>Weathering</td>
</tr>
<tr>
<td>Clays (?kaolinite)</td>
<td>5</td>
<td>Weathering</td>
</tr>
<tr>
<td>Goethite</td>
<td>5</td>
<td>Weathering</td>
</tr>
<tr>
<td>Leucoxene</td>
<td>2</td>
<td>Weathering (after ?ilmenite)</td>
</tr>
</tbody>
</table>

In polished thin section, this sample displays a relict lineated granoblastic metamorphic texture with weak mineralogical layering, modified by strong pervasive alteration of weathering origin.

Quartz is abundant, and occurs in two distinctly different sites:

i) Some occurs as anhedral grains mostly ~0.2-0.6 mm in size, whose preferred orientation is subparallel to weak mineralogical layering, and therefore contributes to the structure through the rock. Clearly, this quartz represents relict metamorphic quartz.

ii) Much quartz occurs as very small anhedral grains that form massive microcrystalline replacements in precursor elongated subhedral prismatic crystals (possibly a ferromagnesian phase such as hornblende). This quartz clearly is of low-temperature alteration origin (weathering).

Hornblende occurs as small euohedral prismatic crystals <0.2 mm in size, pleochroic in greens. The small crystals occur as inclusions in quartz grains, and represent a relict primary metamorphic phase. They have been preserved because they were "shielded" by their enclosing host quartz from near-surface waters. It is likely that much of the quartz-altered lineated crystals were also hornblende.

Zircon forms small subhedral crystals sparsely scattered through the rock. They remain quite fresh.

An accessory metamorphic phase built small disseminated subhedral to euhedral blocky prismatic crystals up to ~0.4 mm in size. Their identity is uncertain, as they have suffered severe alteration. Most, however, retain some birefringent materials which appear to generate anomalous interference colours, and may therefore belong to the epidote mineral group.

Pyrrhotite occurs very rarely as small inclusions in quartz.
Clays occur as finely fibrous replacements of precursor crystals that were aligned within the structure of the rock. The lack of colour and low birefringence suggest the clay belongs to the kaolinite group, but the identity of the precursor phase is uncertain (possibly biotite or feldspar).

Iron oxides occur as very fine-grained, dense aggregates and patches. Some of the patches are elongated subparallel to the metamorphic structure, but others occur in discordant discontinuous veinlets.

Leucocene occurs as very fine-grained, dense replacement aggregates that are pseudomorphous after a precursor phase that formed lath-like and anhedral grains elongated in the trace of the banding. The phase most likely was ilmenite.

AUTORADIOGRAPH:

The autoradiograph (Fig. 1) generated two types of response:

i) Disseminated dark spots of variable intensity occur in small discrete radioactive grain sites. The response is attributed to the presence of small accessory phases of metamorphic origin that have been observed optically: zircon, and an unidentified phase that formed small subhedral crystals (possibly an epidote-group mineral such as allanite).

ii) A weak response has been generated by some of the dark brown iron oxide aggregates that have formed along precursor metamorphic banding and in thin discontinuous veins.

Fig 1: Autoradiograph of sample HR06865
The autoradiograph has been made from the section offcut. The principal radioactive response (small black spots) arises from accessory grains of zircon and an altered accessory phase of uncertain nature. A weak diffuse response arises from the iron oxide-rich patches and veinlets, which may contain meta-autunite mineral (see XRD below).
X-RAY DIFFRACTION:

The green surface coating was analysed by X-ray powder photography. The phase was identified as a meta-autunite group mineral, very probably meta-uranocircite Ba(UO$_2$)$_2$(PO$_4$)$_2$.6H$_2$O.

INTERPRETATION:

This sample is interpreted in the following manner:

1) Sedimentary deposition of siliceous and calc-silicate materials.

2) Following burial and diagenesis, the rock body suffered dynamic regional metamorphism (probably in the amphibolite facies), which generated a lineated, banded, granoblastic metamorphic assemblage which included quartz, hornblende, zircon, epidote-group mineral, and other phases too weathered for identification.

3) Following uplift and erosion, the rock body suffered near-surface oxidation and alteration, generating the assemblage quartz + clays + goethite + trace meta-autunite. The only metamorphic phases to survive this weathering event were quartz and its inclusions (hornblende, zircon, pyrrhotite).
APPENDIX 1: PHOTOMICROGRAPHS

A selection of colour photomicrographs is provided in following pages. They are ordered by sample number, and display particular mineralogical and microtextural features relating to mineral paragenesis and felsic banding.
PLATE 1: SAMPLE HR06803 (Reflected plane polarised light, x5, S1/F1)  
Coarse-grained pyrrhotite (pale brown, upper right), chalcopyrite (yellow) and pyrite (white cube in chalcopyrite) display textural equilibrium between each other and with other metamorphic grains (dark grey). Fine-grained pyrite (white) of retrogressive alteration origin has partly replaced non-opaque gangue.

PLATE 2: SAMPLE HR06805 (Transmitted light, crossed polarisers, x5, S1/F4)  
Fine-grained sericite (pale yellow flecks) of retrogressive alteration origin has replaced scapolite grains, but other principal metamorphic minerals remain fresh (hornblende, lineated orange-red grains; plagioclase, grey grains).
PLATE 3: SAMPLE HR06806 (Transmitted plane polarised light, x5, S1/F6)
This view shows the contact between mafic hornblende-rich gneiss (left) and a felsic band rich in scapolite (right). Both bands display equilibrium metamorphic textures.

PLATE 4: SAMPLE HR06806 (Transmitted light, crossed polarisers, x5, S1/F5)
This is the same field of view as PLATE 3 above. Note the uniform grain size of hornblende (left, dark colours) and scapolite (right, yellows). There is no textural distinction between the mafic and felsic bands.
PLATE 5: SAMPLE HR06807 (Transmitted light, crossed polarisers, x5, S1/F7)
A shear zone (right half of view, oriented NW-SL) related to the retrogressive alteration event contains granulated wall rock fragments and carbonate alteration. Gneissic wall rock (left) is relatively fresh, with lineated hornblende (orange, red, yellow) and finer-grained plagioclase (grey).

PLATE 6: SAMPLE HR06808 (Transmitted light, crossed polarisers, x5, S1/F10)
This typical view of a mafic gneiss displays larger ragged lineated hornblende grains (orange, reds, blues, greens), and finer-grained scapolite (bright reds, yellows, across centre of view) and plagioclase (greys). The granoblastic metamorphic texture appears to have formed during a single metamorphic event.
PLATE 7: SAMPLE HR06809 (Reflected plane polarised light, x5, S1/F11)
Primary metamorphic ilmenite (brownish grey) and sulphide (left, mainly creamish brown pyrrhotite with a trace of yellow chalcopyrite) lie in textural equilibrium with coarse-grained scapolite (rest of view) in a felsic scapolite-rich band.

PLATE 8: SAMPLE HR06809 (Transmitted light, crossed polarisers, x5, S1/F12)
Fractured scapolite (reds, oranges) lie in a felsic band near a shear zone (left) containing abundant fine-grained pyrite (opaque material) and small ragged calcite grains (high pastel colours). The scapolite clearly predates the retrogressive alteration event, and formed part of the principal metamorphic assemblage.
PLATE 9: SAMPLE HR06810 (Transmitted light, crossed polarisers, x5, S1/F15)
This view shows part of a felsic band in mafic gneiss. Note the abundant scapolite (bright colours) and minor interstitial plagioclase (grey twinned grains, top left, centre right). The moderate birefringence of the scapolite suggests it is a Ca-rich variety (i.e. meionitic).

PLATE 10: SAMPLE HR06810 (Reflected plane polarised light, x5, S1/F14)
This is the same field of view as PLATE 9 above. Note the presence of disseminated grains of pyrrhotite (pale brownish cream) and minor chalcopyrite (near centre), which are in textural equilibrium with the metamorphic assemblage.
PLATE 11: SAMPLE HR06810 (Transmitted light, crossed polarisers, x5, S1/F16)
Coarse scapolite (green, top) in a felsic band has been partly replaced by fine-grained prehnite and sulphides. Coarse quartz grains (white, yellow) are cut by thin fractures lined by tiny chalcopyrite grains (trails of opaque grains). The felsic band phases clearly predate the retrogressive alteration event.

PLATE 12: SAMPLE HR06811 (Transmitted light, crossed polarisers, x5, S1/F17)
Retrogressive alteration has generated turbid albite (grey colours) after plagioclase and subradiating aggregates of chlorite (centre, dark anomalous khaki colour). In hand specimen, the turbid albite is superficially similar to white scapolite.
PLATE 13: SAMPLE HR06812 (Transmitted light, crossed polarisers, x5, S1/F18)
A replacement patch oriented NE-SW is composed of small tremolite blades (bright blue, orange, yellow) coarse calcite (high pastel colour, centre), and opaque aggregates (centre right). Relict metamorphic hornblende (orange, right; dull colours, top left) and plagioclase (turbid dark grey, bottom left) are preserved in the wall rock mafic gneiss.
REPORT TITLE: Petrographic Descriptions and Mineralogical Studies for a Suite of Five Rock Samples

REPORT #: 2171

CLIENT: PNC Exploration (Aust.) Pty. Ltd.

ORDER NO.: 7194

CONTACT: Mr. Costica Vieru

REPORT BY: Dr. Douglas R. Mason

SIGNED: for Mason Geoscience Pty. Ltd.

DATE: 18 October 1995
Petrographic Descriptions and Mineralogical Studies for a Suite of Five Rock Samples

SUMMARY

1. Rock Samples

- A suite of five (5) surface rock samples has been studied using petrographic, mineragraphic, and X-ray diffraction methods.

2. Brief Results

- Rock names are given in Table 1.

TABLE 1: ROCK NAMES

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>ROCK NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR05910</td>
<td>Monazite crystal</td>
</tr>
<tr>
<td>HR05911</td>
<td>Quartzo-feldspathic magnetite-bearing gneiss (meta-granitoid)</td>
</tr>
<tr>
<td>HR05912</td>
<td>Banded quartzo-feldspathic gneiss (meta-granitoid)</td>
</tr>
<tr>
<td>HR05913</td>
<td>Mylonitic quartzo-feldspathic gneiss (meta-granitoid)</td>
</tr>
<tr>
<td>HR05914</td>
<td>Quartzo-feldspathic gneiss (meta-granitoid)</td>
</tr>
</tbody>
</table>

- Comments

- Sample HR05910 represents portion of a single monazite crystal, with minor inclusions of quartz, hornblende, xenotime and a metamict phase.

- All other samples are quartzo-feldspathic gneissic rocks which appear to have formed by dynamic regional metamorphism of granitoid precursor rocks. Large blocky plagioclase crystals (and less common K-feldspar crystals) are interpreted to represent relict igneous phenocrysts. All samples have suffered variable degrees of recrystallisation. A mild degree of metasomatism during the metamorphic event has generated a diverse range of minor minerals including biotite, muscovite, garnet, epidote, magnetite, ilmenite, scapolite, zircon, xenotime, allanite, and small metamict unknown grains.

- X-ray diffraction studies provide the following results:

  i) Confirmation of monazite and possible trace xenotime in sample HR05910.

  ii) Identification of mafic patches of magnetite, ilmenite and hematite in sample HR05911.

  iii) Identification of yellow patches of beta-uranophane, Ca(UO₂)₂(SiO₃OH)₂.5H₂O, in sample HR05914.
1. INTRODUCTION

A suite of five (5) rock samples was received from Mr. Costica Vieru (PNC Exploration Aust. Pty. Ltd., South Perth, Western Australia) on 26 September 1995.

Particular requests were:

i) To prepare a polished thin section and combined petrographic and mineragraphic description for each sample.

ii) To obtain mineral identifications by X-ray diffraction for samples HR05910 (bulk sample), HR05911 (mafic patches), and HR05914 (yellow mineral).

The summary of this report was provided to Mr. Vieru in the Perth office of PNC Exploration by facsimile on 18 October 1995. This report contains the full results of this work.

2. METHODS

The samples were examined in hand specimen, and marked for section preparation. Polished thin sections were obtained from an external commercial laboratory (Amdel Limited, Thebarton, South Australia). Mineral identifications by X-ray diffraction were also obtained from Amdel, and the full results of that work are provided as Appendix 1.

At Mason Geoscience Pty. Ltd., conventional transmitted and reflected polarised light microscopy was used to prepare combined petrographic and mineragraphic descriptions.

3. PETROGRAPHIC AND MINERAGRHIC DESCRIPTIONS

The combined petrographic and mineragraphic descriptions are provided in the following pages.
SAMPLE : HR05910
SECTION NO. : C64636 (HR05910)
HAND SPECIMEN : The sample represents portion of a single large crystal, with planar crystal faces bounding part of the sample. The crystal displays a dark resinous greenish-black colour, with diffuse pale cream fibrous patches distributed along cleavage planes.

ROCK NAME : Monazite crystal

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monazite</td>
<td>95</td>
<td>?Metamorphic pegmatoid</td>
</tr>
<tr>
<td>Quartz</td>
<td>2</td>
<td>Metamorphic (inclusions in monazite)</td>
</tr>
<tr>
<td>Hornblende</td>
<td>&lt;1</td>
<td>Metamorphic (inclusions in monazite)</td>
</tr>
<tr>
<td>?Xenotime</td>
<td>Tr</td>
<td>Metamorphic (inclusions in monazite)</td>
</tr>
<tr>
<td>Metamict phase</td>
<td>&lt;1</td>
<td>Metamorphic (inclusions in monazite)</td>
</tr>
<tr>
<td>Goethite</td>
<td>1</td>
<td>Alteration (weathering)</td>
</tr>
</tbody>
</table>

[NOTE: XRD has identified monazite, with possible trace xenotime.]

In polished thin section, this sample displays a coarsely crystalline texture, with minor inclusions of other minerals.

Monazite completely dominates the sample, occurring as portion of an optically continuous crystal throughout the section. It is very pale brown in colour, with subparallel partings concentrated in thin zones. Thin, widely spaced twin planes occur in places.

Quartz occurs in minor amount as angular grains concentrated in limited areas. It is intergrown with pleochroic dark brown hornblende in one finer-grained aggregate.

Xenotime occurs in trace amount as subhedral grains ~0.2 mm in size, concentrated in one particular area of the sample. The grains are colourless and display the typical high birefringence of this phase.

A metamict phase built subhedral small crystals ~0.2-0.6 mm in size, concentrated in limited areas and also along parting planes through the monazite. Radiating expansion cracks emanate from each of the crystals, which are completely replaced by cryptocrystalline colourless alteration material.

Iron oxides (goethite) occur in minor amount, concentrated along thin partings in zones through the crystal.

INTERPRETATION:

This sample represents portion of a single crystal of monazite, which grew to many centimetres in size. It may have grown in a metamorphic environment, as supported by the presence of inclusions of quartz, hornblende, xenotime, and an unidentified metamict phase.
SAMPLE : HR05911
SECTION NO. : HR05911
HAND SPECIMEN : The rock sample is a felsic, cream-coloured, strongly foliated rock composed of aligned subhedral large feldspar crystals in a finer-grained crystalline matrix. Black aggregates in places are drawn out in the trace of the foliation, and their strong response to the hand magnet confirms the presence of magnetite.

ROCK NAME : Quartzo-feldspathic magnetite-bearing gneiss

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plagioclase</td>
<td>20</td>
<td>Relict ?phenocrysts</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>44</td>
<td>Metamorphic matrix</td>
</tr>
<tr>
<td>Quartz</td>
<td>25</td>
<td>Metamorphic matrix</td>
</tr>
<tr>
<td>Magnetite (incl. trace hematite)</td>
<td>5</td>
<td>Metamorphic /alteration</td>
</tr>
<tr>
<td>K-feldspar (microcline)</td>
<td>1</td>
<td>Metamorphic matrix</td>
</tr>
<tr>
<td>Garnet (almandine)</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Biotite</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Muscovite</td>
<td>&lt;1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>Tr</td>
<td>Metamorphic</td>
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<tr>
<td>Allanite (partly metamict)</td>
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<td>Apatite</td>
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</tr>
<tr>
<td>Zircon (partly metamict)</td>
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<td>Metamorphic</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>Tr</td>
<td>Relict metamorphic</td>
</tr>
<tr>
<td>?Uraninite (mostly metamict)</td>
<td>Tr</td>
<td>Relict metamorphic</td>
</tr>
<tr>
<td>Iron oxides (goethite, hematite)</td>
<td>&lt;1</td>
<td>Alteration (after ?sulphide)</td>
</tr>
</tbody>
</table>

[NOTE: XRD of mafic patches has identified magnetite, ilmenite, and hematite.]

In polished thin section, this sample displays a relict porphyritic texture that has been severely modified by strong deformation and recrystallisation.

Plagioclase is abundant, and occurs in two forms:

i) Large anhedral crystals of plagioclase several mm to ~1 cm in size are distributed through the rock. They commonly display signs of deformation (bent twinning), and may contain small ragged patches of crystallographically oriented K-feldspar (i.e. anti-perthitic texture).

ii) A higher proportion of the plagioclase occurs as small anhedral grains ~0.1-0.2 mm in size that form an even-grained granoblastic matrix. In most places it is virtually monomineralic.

Quartz is the other principal mineral, occurring as anhedral grains of wide size range concentrated in sutured polycrystalline aggregates elongated in the trace of the foliation. All grains display a significant degree of shadowy strain extinction. Only a small amount of quartz occurs as small anhedral grains intergrown with the matrix plagioclase.
Magnetite is present in moderate amount, concentrated in ragged patches and stringers elongated in the trace of the foliation. Most grains display a small degree of replacement by hematite along crystallographic planes. The magnetite occurs almost entirely intergrown with the matrix plagioclase, but rare small ragged magnetite patches occur as replacements along thin alteration zones in some of the larger plagioclase crystals.

K-feldspar is uncommon, forming anhedral grains concentrated in tension gashes where large plagioclase crystals have pulled apart. The presence of combined pericline and albite twinning ("tartan twinning") confirms the identification of microcline.

Garnet occurs in minor amount as subhedral to anhedral pale pink subhedral crystals and anhedral, amoeboid grains. Most are closely intergrown with magnetite aggregates or trails.

Both biotite and muscovite occur in minor amount as well-crystallised flakes that are concentrated with magnetite along thin trails and shear planes. The biotite is pleochroic from dark reddish brown to straw yellow, and is quite fresh (i.e. not chloritised).

Ilmenite occurs in minor amount as angular grains intimately intergrown with magnetite in larger magnetite-rich aggregates. The ilmenite is readily distinguished from magnetite by its pinkish brown colour in plane reflected light and anisotropy under crossed polarisers, and lack of hematitic alteration along crystallographic planes.

Zircon occurs in significant accessory amount, forming euhedral stumpy prismatic crystals ~0.2-0.4 mm long. Most display zoning and partial metamict alteration, especially of outermost zones, suggesting a U-rich composition.

Apatite forms sparsely and irregularly distributed anhedral grains that range up to ~1 mm in size. They occur within the polycrystalline plagioclase matrix.

Allanite occurs in trace amount as subhedral prismatic crystals enclosed within one large plagioclase crystal. The allanite displays a pale brownish green colour and its isotropic optical behaviour suggests complete metamict alteration; marginal zones of the allanite are partly replaced by bright orange-yellow alteration materials.

An unknown phase (possibly uraninite) occurs as small (<0.2 mm), sparsely disseminated grains that have suffered partial to complete replacement around margins by deep orange alteration materials.

Chalcopyrite occurs as tiny ragged disseminated grains. In places, small ragged relict grains occur in dense goethite replacement patches.

INTERPRETATION:

This sample appears to represent a coarsely plagioclase-phryic igneous rock that has suffered severe dynamic regional metamorphism. This has resulted in deformation of the large phenocrysts, recrystallisation of the groundmass mainly to fine-grained granoblastic plagioclase, and development of quartz-rich polycrystalline aggregates by partial recrystallisation of precursor quartz in the foliated matrix.

A wide range of minor phases formed during this event, including magnetite, ilmenite, garnet, biotite, muscovite, zircon, apatite, allanite, and possibly uraninite. The presence of small replacement magnetite grains in some large plagioclase crystals confirms that the large crystals formed at an earlier time than the metamorphic phases, providing support for a phenocrystic origin in precursor granitoid.
SAMPLE : HR05912
SECTION NO. : C64638 (HR05912)

HAND SPECIMEN : The rock sample contains scattered large blocky white feldspar crystals (some as large as ~2 cm) set in a banded matrix of white feldspar and translucent grey quartz.

ROCK NAME : Banded quartzo-feldspathic gneiss

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plagioclase</td>
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<td>Relict igneous / metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
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<td>Relict igneous / metamorphic</td>
</tr>
<tr>
<td>Epidote</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Scapolite (incl. sericite)</td>
<td>1</td>
<td>Metamorphic (incl. alteration)</td>
</tr>
<tr>
<td>Muscovite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Biotite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Hornblende</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Magnetite</td>
<td>Tr</td>
<td>Metamorphic</td>
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<tr>
<td>Unknown (metamict)</td>
<td>Tr</td>
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</tbody>
</table>

In polished thin section, this sample displays a relict flow-aligned granitoid texture that has been modified by metamorphic recrystallisation and minor replacement.

Plagioclase dominates the rock, occurring as subhedral aligned prismatic crystals ~1-2 mm long, and smaller anhedral grains in granoblastic texture. Slight compositional zoning is evident in larger crystals.

Quartz is the other principal phase, occurring as anhedral grains of variable size, all of which display strong shadowy strain extinction and local recrystallisation to sutured granoblastic aggregates. The quartz is concentrated in quartz-rich bands which contain minor plagioclase prisms oriented subparallel with the banding.

Epidote forms small subhedral prismatic to anhedral ragged grains ~0.2-0.4 mm in size. They occur as replacement grains in larger plagioclase grains, at margins of some plagioclase grains, and locally form poikiloblastic aggregates that partly enclose small plagioclase grains. The lack of colour and inclined extinction support an identification of clinzoisite (Fe-poor epidote) rather than epidote sensu stricto.

Scapolite is uncommon, forming subhedral equant grains and poikiloblastic interstitial patches that partly enclose some smaller plagioclase grains. Identification of the scapolite is aided by its lack of colour, moderately high birefringence (Ca-rich, meionitic scapolite), good cleavage, and parallel extinction. The scapolite occurs in limited areas, and all grains display partial replacement by fine fibrous sericite.

Muscovite and biotite occur as ragged small flakes, in close association with epidote and magnetite.

Magnetite occurs as anhedral grains up to ~0.4 mm in size, concentrated within the foliation plane in limited areas of the rock.
Hornblende is rare, forming small subhedral crystals, strongly pleochroic in dark greens to pale browns.

An unknown phase (possibly uraninite) built small equant to stumpy prismatic crystals sparsely scattered through the rock, commonly in association with epidote. All of the grains have suffered complete replacement by indeterminate orange-brown to opaque materials.

INTERPRETATION:

This sample is interpreted to represent a porphyritic leuco-granitoid that was originally composed of large plagioclase phenocrysts in a finer-grained groundmass of plagioclase and quartz. The bulk composition was trondhjemitic (K-poor granitoid).

The rock has suffered metamorphic deformation, partial replacement, and minor recrystallisation. Lack of deformation in the aligned plagioclase crystals suggests that the granitoid may have been emplaced during the metamorphic event. Development of replacement phases (including epidote, scapolite, magnetite) indicates that some degree of metasomatism affected the rock during the metamorphic event.
SAMPLE : HR05913
SECTION NO. : C64639 (HR05913)
HAND SPECIMEN : The rock sample is a uniformly fine- to medium-grained felsic crystalline rock with a strong foliation defined by foliated thin dark micaceous laminae. Weak mineral layering is defined by lower abundance of dark flecks in cm-thick felsic bands.
ROCK NAME : Mylonitic quartzo-feldspathic gneiss (meta-granitoid)

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>30</td>
<td>Metamorphic / ?relict igneous</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>28</td>
<td>Metamorphic / ?relict igneous</td>
</tr>
<tr>
<td>K-feldspar (microcline)</td>
<td>35</td>
<td>Metamorphic / ?relict igneous</td>
</tr>
<tr>
<td>Zircon</td>
<td>Tr</td>
<td>?Metamorphic / ?relict igneous</td>
</tr>
<tr>
<td>Biotite</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Epidote</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Magnetite (incl. trace hematite)</td>
<td>1</td>
<td>Metamorphic (incl. oxidation)</td>
</tr>
<tr>
<td>Sphene</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Muscovite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
</tbody>
</table>

In polished thin section, this sample displays a granoblastic metamorphic texture with strong foliation and mylonitic lineation, with possible faint relict igneous texture.

K-feldspar is abundant, occurring both as larger subhedral to anhedral grains ~1 mm in size, and smaller anhedral grains in the granoblastic matrix. In places, polycrystalline lenticles of K-feldspar are drawn out in the trace of the foliation. All of the K-feldspar displays "tartan" twinning characteristic of microcline.

Plagioclase, like K-feldspar, occurs both as larger crystals and smaller matrix grains. The larger crystals are ~1-2 mm in size, and have retained their blocky primary crystal forms better than the K-feldspar. Some of the larger crystals display minor compositional zoning, which may represent relict primary igneous zoning. In the matrix, small anhedral plagioclase grains lie in granoblastic relationship with K-feldspar and quartz.

Quartz occurs as small anhedral strained grains ~0.2-0.4 mm in size. They commonly are concentrated in thin, highly elongated lenticles or discontinuous laminae subparallel to the foliation.

Biotite builds small flakes pleochroic from very dark chocolate brown to drab straw yellow. They tend to be concentrated in thin laminae; the strong foliation of the biotite within the laminae contributes to the strong foliation and lamination through the rock. Well-crystallised flakes of muscovite may be closely associated with biotite in the laminae.

Epidote forms subhedral crystals and ragged grains scattered through the rock. Some are entrained in phyllosilicate-rich laminae.
Sphene forms subhedral grains that display typical weak pale brown pleochroism and strong birefringence. They may form discrete grains and small granular aggregates, and tend to be aligned in the trace of the foliation.

Magnetite occurs as small ragged grains, some with thin hematite replacements along crystallographic planes. It is sparsely and irregularly disseminated through the rock, and in places is closely associated with sphene.

Ilmenite is uncommon, forming small ragged grains disseminated through the rock.

INTERPRETATION:

This sample represents a quartzo-feldspathic rock that has suffered severe deformation and recrystallisation during a dynamic regional metamorphic event. The rock clearly occurred within a zone of high strain, possibly in or near a fault zone. This generated the strongly foliated, weakly laminated, mylonitic assemblage described above.

Although the rock is extensively recrystallised, some of the larger feldspar grains (both plagioclase and K-feldspar) may represent relict crystals in the precursor rock. In particular, the larger plagioclase crystals display blocky subhedral crystal forms and compositional zoning that is reminiscent of an igneous origin. A felsic igneous precursor rock is further supported by the abundances of the feldspars and quartz. If it is assumed that the present mineralogy reflects the primary mineralogy of a felsic granitoid rock, then the primary composition was broadly monzogranitic. This contrasts with the K-feldspar-poor mineralogies of meta-granitoid samples HR05911 and HR05912 described earlier in this report.
SAMPLE : HR05914

SECTION NO. : C64640 (HR05914)

HAND SPECIMEN : The rock sample is composed of large subhedral to anhedral white feldspar crystals in a finer-grained white matrix that also contains translucent grey quartz grains elongated in the plane of a foliation. Pale earthy yellow secondary U-bearing mineral forms diffuse patches in parts of the rock.

ROCK NAME : Quartzo-feldspathic gneiss (meta-granitoid)

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plagioclase</td>
<td>47</td>
<td>?Relict igneous / metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>30</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>K-feldspar (microcline)</td>
<td>20</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Muscovite</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Xenotime</td>
<td>&lt;1</td>
<td>?Relict igneous / ?metamorphic</td>
</tr>
<tr>
<td>Zircon</td>
<td>Tr</td>
<td>?Relict igneous / monazite</td>
</tr>
<tr>
<td>Magnetite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Allanite (incl. metamict alteration)</td>
<td>Tr</td>
<td>Metamorphic (incl. alteration)</td>
</tr>
</tbody>
</table>

[NOTE: XRD has identified the yellow secondary patches as beta-uranophane.]

In polished thin section, this sample displays a poorly-preserved relict granitoid texture that has been severely modified by metamorphic deformation, recrystallisation, and minor replacement.

Plagioclase is abundant, and occurs in two forms:

i) Some occurs as large anhedral crystals ~2-4 mm in size. Some display mild shadowy strain extinction, and small replacement patches of microcline may be present. No compositional zoning is evident. These large grains appear to represent relict primary crystals, probably of igneous origin.

ii) Much of the plagioclase occurs as small anhedral equant grains ~0.1-0.4 mm in size. They form a granoblastic mosaic through the rock, in places with a sutured texture but elsewhere displaying a better-formed polygonal granoblastic texture suggestive of an approach to equilibrium during recrystallisation. In zones of higher strain, grains of plagioclase are elongated within the trace of the foliation.

Quartz is moderately abundant. Some occurs as large anhedral grains several mm in size, with strong shadowy strain extinction in variable degrees of intensity. In places, the larger grains have recrystallised to sutured granoblastic mosaics. Small anhedral quartz grains are intergrown with granoblastic plagioclase in the matrix.

K-feldspar (microcline) occurs mostly as small anhedral grains in granoblastic relationship with finer-grained quartz and plagioclase. Large subhedral crystals of K-microcline are uncommon. Small replacement patches of microcline have partly replaced some of the larger plagioclase crystals.
Muscovite occurs as ragged small flakes ~0.2-0.4 mm in size, sparsely scattered through the rock. Some display ragged poikiloblastic shapes, and some appear to have formed by replacement of plagioclase grains.

Xenotime builds euhedral blocky crystals ~0.1-0.2 mm in size. They tend to occur within polycrystalline quartz, where they may form granular aggregates. The xenotime is restricted to particular areas in the rock, and in places is concentrated along foliation planes and intimately intergrown with magnetite. Identification of the xenotime is supported by its optical properties (colourless, equant euhedral crystal forms, high birefringence, association with zircon). Radiation cracks emanate from most crystals.

Magnetite occurs as anhedral grains, concentrated in granular aggregates or patches, and as trails elongated along foliation planes.

Zircon forms euhedral stumpy prismatic crystals with a somewhat turbid pale brown colour suggestive of incipient metamict alteration. They tend to be closely associated with the xenotime crystals.

Allanite occurs in trace amount as subhedral elongated crystals that display a drab greenish brown colour. They occur within polycrystalline plagioclase mosaics. Some retain anisotropic cores (i.e. not fully metamict), but bright yellow-orange marginal replacements are common.

INTERPRETATION:

This sample is inferred to represent a porphyritic granoid that was originally composed of large crystals of plagioclase, quartz and K-feldspar in a somewhat finer-grained groundmass. Dynamic regional metamorphism caused deformation and partial recrystallisation.

Timing of the development of xenotime and zircon is a little unclear. In places they are intimately intergrown with magnetite, which clearly is a metasomatic metamorphic phase. It is likely, therefore, that all of the minor phases formed during the metamorphic event rather than as primary accessory phases.
APPENDIX 1: X-RAY DIFFRACTION STUDY

[This report has been transcribed from a facsimile report received from Amdel Limited on 13 October 1995.]

INTRODUCTION

Five rock samples were received from Dr. D. Mason of Mason Geoscience Pty. Ltd. with a request for section preparation and XRD mineral identification.

PROCEDURE

The bulk sample of HR05910 and mafic patches in HR05911 were analysed by X-ray diffraction. The yellow mineral in sample HR05914 was analysed by X-ray powder diffractometry.

RESULTS

The minerals detected by X-ray diffraction are listed in approximate decreasing order of abundance.

Sample HR05910 (bulk): Monazite D
?Xenotime Tr

Sample HR05911 (mafic patches) Magnetite D
Hematite A
Ilmenite Tr

Sample HR05914 (yellow mineral) Beta-uranophane D
Ca(UO₂)₂(SiO₃OH)₂·5H₂O

Semi-quantitative abbreviations:
D = Dominant. Used for the component apparently most abundant, regardless of its probably percentage level.
CD = Co-dominant. Used for two (or more) predominaing components, both or all of which are judged to be present in roughly equal amounts.
SD = Sub-dominant. The next most abundant component(s) providing its percentage level is judged above about 20.
A = Accessory. Components judged to be present between the levels of roughly 5 and 20%.
Tr = Trace. Components judged to be below about 5%.
Petrographic Descriptions for a Suite of Seventeen Rock Samples

SUMMARY

1. Rock Samples
   - A suite of seventeen (17) rock samples has been studied using petrographic and limited mineragraphic and X-ray diffraction methods.

2. Brief Results
   - Rock names are listed in Table 1 below.

<table>
<thead>
<tr>
<th>TABLE 1: SUMMARY OF ROCK NAMES</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAMPLE</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>HR05951</td>
</tr>
<tr>
<td>NA01851</td>
</tr>
<tr>
<td>NA01852</td>
</tr>
<tr>
<td>NA02786</td>
</tr>
<tr>
<td>NA02787</td>
</tr>
<tr>
<td>NA02788</td>
</tr>
<tr>
<td>NA02789</td>
</tr>
<tr>
<td>NA02791</td>
</tr>
<tr>
<td>NA02792</td>
</tr>
<tr>
<td>NA02793</td>
</tr>
<tr>
<td>NA02794</td>
</tr>
<tr>
<td>NA02795</td>
</tr>
<tr>
<td>NA02796</td>
</tr>
<tr>
<td>NA02797</td>
</tr>
<tr>
<td>NA02798</td>
</tr>
<tr>
<td>NA02799</td>
</tr>
<tr>
<td>NA02800</td>
</tr>
</tbody>
</table>

- Sample HR05951 is a trondhjemitic gneissic granitoid. It contains accessory uraninite, which occurs as small cubic crystals ~0.2-0.4 mm in size. They are irregularly distributed throughout the rock, occurring in plagioclase, quartz, and the mafic aggregates. All of the uraninite grains display variable degrees of metamict alteration. The uraninite has been identified by optical and X-ray diffraction methods.
1. INTRODUCTION

A suite of seventeen (17) rock samples was received from Mr. John Thevissen (PNC Exploration Aust. Pty. Ltd., South Perth, WA) on 10 July 1995.

Particular requests were to provide a thin section and routine petrographic description for each sample.

This report contains the full results of this work.

2. METHODS

The samples were examined in hand specimen, and section lines were marked. Thin sections were obtained from an external commercial laboratory (Amdel Limited, Thebarton, SA).

At Mason Geoscience Pty. Ltd., conventional transmitted and reflected light microscopy was used to prepare the petrographic descriptions.

Confirmatory X-ray diffraction studies were undertaken on sample HROS951, in order to identify the mineralogy of the mafic aggregates. This work was provided by Amdel Mineral Services Laboratory (Thebarton, SA), and the results are provided in full in Appendix 1.

3. PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages.
SAMPLE: HR05951
SECTION NO.: HR05951 A (C64141) and HR05951 B (C64142)

HAND SPECIMEN: The rock sample is composed mainly of large ragged pale yellowish feldspar grains in a translucent grey quartzose matrix. Scattered mafic aggregates occur in minor amount, and their preferred orientation defines a foliation through the rock.

Some of the mafic aggregates respond to the hand magnet, suggesting minor magnetite is present.

ROCK NAME: Uraninite-bearing trondhjemitic gneissic granitoid

PETROGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plagioclase</td>
<td>40</td>
<td>?Igneous / metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>56</td>
<td>?Igneous / metamorphic</td>
</tr>
<tr>
<td>Biotite</td>
<td>2</td>
<td>?Igneous / metamorphic</td>
</tr>
<tr>
<td>Hornblende</td>
<td>Tr</td>
<td>?Igneous / metamorphic</td>
</tr>
<tr>
<td>Magnetite</td>
<td>1</td>
<td>?Igneous / metamorphic</td>
</tr>
<tr>
<td>Zircon</td>
<td>&lt;1</td>
<td>?Igneous / metamorphic</td>
</tr>
<tr>
<td>Uraninite (incl. metamict alteration)</td>
<td>Tr</td>
<td>?Igneous / metamorphic</td>
</tr>
</tbody>
</table>

[NOTE: X-ray diffraction study of mafic aggregates confirms the presence of mica, quartz, plagioclase, chlorite, amphibole, and uraninite.]

In thin section and polished thin section, this sample displays a relict coarse-grained granitoid texture, modified by metamorphic deformation and partial recrystallisation.

Quartz is abundant, occurring as anhedral grains ~0.2-2.0 mm in size. All display a significant degree of shadowy strain extinction, and quartz-quartz grain boundaries are sutured.

Plagioclase occurs in two forms:

i) Much occurs as large subhedral prismatic crystals and anhedral grains ~2-4 mm long. Their preferred orientation contributes to the structure through the rock. All display weakly developed polyscale (albite) twinning. Many contain crystallographically oriented patches of microcline indicative of slow cooling from high temperatures causing exsolution (antiperthitic texture) of the minor K from the plagioclase lattice.

ii) Some occurs as smaller anhedral grains ~0.1-0.2 mm in size, concentrated in granoblastic plagioclase-rich aggregates in the quartz-rich matrix. The aggregates may be elongated within the trace of the foliation.

Biotite is the principal ferromagnesian phase. It occurs as well-crystallised ragged flakes that range widely in size, from <0.1 mm up to ~2 mm. They tend to be concentrated in ragged aggregates that are aligned in the trace of the foliation, and individual biotite flakes similarly are foliated. All are pleochroic from dark chocolate brown to straw yellow, a scheme suggestive of an oxidised biotite composition.
Hornblende is uncommon, forming small anhedral grains within the biotite-rich aggregates. Its pleochroism from dark brownish green to pale brown indicates an Al- and Ti-rich composition, appropriate to a high metamorphic grade.

Magnetite forms small cubic crystals sparsely scattered through the rock, and uncommon large ragged grains within the biotite-rich aggregates. Most crystals have suffered incipient replacement by hematite along crystallographic planes.

Zircon occurs as small stumpy crystals ~0.1-0.2 mm in size. They are zoned, and display features suggestive of partial metamict alteration (viz. anomalously low interference colours in outer zones, and radiating microcracks) attributable to a high U content. The zircon crystals occur within the biotite-rich aggregates, but also occur disseminated throughout the rock, in places forming small aggregates.

Uraninite occurs as small cubic crystals ~0.2-0.4 mm in size. They are irregularly distributed throughout the rock, occurring in plagioclase, quartz, and the mafiic aggregates. All of the uraninite grains display variable degrees of metamict alteration.

INTERPRETATION:

This sample is considered to represent a relatively coarse-grained felsic granitoid of trondhjemitic composition (i.e. K-feldspar poor). Microtextures suggest the rock formed as an intrusive magmatic igneous rock, with modification by partial recrystallisation during a dynamic regional metamorphic event. A high grade is inferred from the colour of the hornblende and the antiperthitic texture in the plagioclase. Relatively oxidising conditions are inferred from the dark brown colour of the biotite, and the presence of magnetite.
REPORT TITLE  Petrographic and Mineralogical Studies of Ten Rock Samples

REPORT #  2132

CLIENT  PNC Exploration (Aust.) Pty. Ltd.

ORDER NO.  7060

CONTACT  Dr. Joe Drake-Brockman

REPORT BY  Dr. Douglas R. Mason

SIGNED  

for Mason Geoscience Pty. Ltd.

DATE  10 August 1995
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Petrographic and Mineralogical Studies of Ten Rock Samples

SUMMARY

1. Rock Samples

- A suite of ten (10) rock samples has been studied using petrographic, mineralographic, autoradiographic, X-ray diffraction and electron-probe microanalytical methods.

2. Results

- Rock names given to the samples are listed in Table 1 below.

TABLE 1: ROCK NAMES

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>ROCK NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR05541</td>
<td>Banded amphibolite</td>
</tr>
<tr>
<td>HR05579</td>
<td>Quartzo-feldspathic hypersthene gneiss (charnockite)</td>
</tr>
<tr>
<td>HR05580</td>
<td>Allanite-zircon metasomatite</td>
</tr>
<tr>
<td>HR05585</td>
<td>Deformed quartzo-feldspathic biotite gneiss</td>
</tr>
<tr>
<td>HR05668</td>
<td>Apatite-calcite rock</td>
</tr>
<tr>
<td>HR05669</td>
<td>Apatite-calcite-quartz rock</td>
</tr>
<tr>
<td>HR05670</td>
<td>Quartz-apatite-zoisite boxwork</td>
</tr>
<tr>
<td>HR05671</td>
<td>Calcite-apatite rock</td>
</tr>
<tr>
<td>HR05677</td>
<td>Hornblende-plagioclase(-scapolite) amphibolite</td>
</tr>
<tr>
<td>HR05679</td>
<td>Epidote rock (pegmatoidal epidote metasomatite)</td>
</tr>
</tbody>
</table>

- Autoradiography produced the following results:
  - In the quartz-apatite rocks, diffuse radiogenic responses are generated from patches and colloform bands of fine-grained apatite (which contains variable Th and U by electron-probe analysis). Rare tiny radiogenic specks may be attributed to Ba-rich Mn-oxide grains (psilomelane), as no other radiogenic minerals were identified.
  - In the amphibolite (HRO5677), a strong radiogenic response was produced by tiny grains concentrated in a scapolite-rich band subparallel to foliation in portion of the rock. The response is attributed to tiny grains of Th-uraninite identified by electron-probe microanalysis.

- X-ray diffraction confirmed the presence of abundant quartz and apatite in the fine-grained phosphatic boxwork rocks. In addition, small amounts of calcite were identified in several samples, and stilbite (a Ca-zeolite mineral) was identified in sample HRO5671.

- Electron-probe microanalysis provided useful results as follows:
  - Fine-grained turbid apatite in the quartz-apatite rocks contains variable amounts of trace radiogenic elements (Th, U, La, Ce). These components are responsible for the diffuse radiogenic response observed in the autoradiograph.
- Other minerals identified by EPMA in the quartz-apatite rocks include stilbite (an hydrated Ca-zeolite mineral) and psilomelane (an hydrated Mn-Ba oxide mineral). The high Ba content of the latter might be responsible for rare tiny dark radiogenic specks in the autoradiographs of these rocks, as no other radiogenic minerals were identified.

- Tiny grains of Th-uraninite in the amphibolite (HRO5677) contain ~79% U₂O₃ and ~8% ThO₂.
1. INTRODUCTION

A collection of ten (10) rock samples was received from Dr. Joe Drake-Brockman on 3 July 1995.

Requested petrographic and mineralogical work was noted on the sample number tickets in each sample bag. The work requested included standard thin section preparation and routine petrographic description, polished thin section preparation and combined petrographic and mineragraphic description, and more detailed mineralogical studies that may require X-ray diffraction work and electron microprobe studies.

Preliminary X-ray diffraction (XRD) results for five samples were conveyed to Dr. Drake-Brockman by facsimile on 31 July 1995. Results of the electron-probe microanalytical (EPMA) work were provided by facsimile on 9 August 1995. This report contains the full results of this work.

2. METHODS

The samples were examined in hand specimen, and marked appropriately for section preparation. Some samples had been marked by the client for attention (e.g. small areas circled for XRD study).

The work requirements for each sample are set out in Table 2 below.

**TABLE 2: WORK REQUIREMENTS**

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>SECTION TYPE*</th>
<th>PETROGRAPHY/ MINERAGRAP**</th>
<th>BULK XRD</th>
<th>AUTO- RADIOGRAPH</th>
<th>ELECTRON PROBE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR05541</td>
<td>TS</td>
<td>PETRO 2.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HR05579</td>
<td>PTS</td>
<td>PETRO 3.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HR05580</td>
<td>PTS</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HR05585</td>
<td>PTS</td>
<td>PETRO 3.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HR05668</td>
<td>PTS</td>
<td>PETRO 3.1 YES</td>
<td>YES</td>
<td>YES</td>
<td>POSSIBLY</td>
</tr>
<tr>
<td>HR05669</td>
<td>PTS</td>
<td>PETRO 3.1 YES</td>
<td>YES</td>
<td>YES</td>
<td>POSSIBLY</td>
</tr>
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<td>HR05670</td>
<td>PTS</td>
<td>PETRO 3.1 YES</td>
<td>YES</td>
<td>YES</td>
<td>POSSIBLY***</td>
</tr>
<tr>
<td>HR05671</td>
<td>PTS</td>
<td>PETRO 3.1 YES</td>
<td>YES</td>
<td>YES</td>
<td>POSSIBLY</td>
</tr>
<tr>
<td>HR05677</td>
<td>PTS</td>
<td>PETRO 3.1 YES</td>
<td>-</td>
<td>YES</td>
<td>POSSIBLY***</td>
</tr>
<tr>
<td>HR05679</td>
<td>PTS</td>
<td>PETRO 3.1 YES</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**NOTES:**
*: TS = standard thin section;
PTS = polished thin section
**: PETRO 2.1 = routine petrographic description;
PETRO 3.1 = combined petrographic and mineragraphic description.
***: EPMA work carried out on these samples.

Thin sections, X-ray diffraction, and autoradiograph work were obtained from an external commercial laboratory (Amdel Mineral Services Limited, Thebarton, SA).

At Mason Geoscience Pty. Ltd., conventional transmitted and reflected light microscopy was used to prepare the petrographic and mineragraphic descriptions.
EPMA work was carried out at the University of Adelaide Centre for Electron Microscopy and Microtextural Analysis. A Cameca SX-51 electron microprobe, fitted with three spectrometers, was used in wavelength-dispersive mode at 15 kV. Elements sought were varied according to the phase being analysed:

- U, Th, Pb, La, Ce, Y, P, Ca, and Si were sought for apatite;
- Si, Ti, Al, Cr, Mg, Ca, Mn, Fe, Zn, Na, K, F, and Cl were sought for stilbite;
- Si, Th, U, Mn and Ba were sought for psilomelane.
- P, Si, Th, Y, La, Ce, U, Ca, and Pb were sought for uraninite.

Counting times were 10 seconds on peaks and 5 seconds on background each side of the peak for all elements, except for U and Th for which counting times of 30 seconds were used on peaks to enhance accuracy. On-line data reduction was performed immediately following acquisition of the intensities.

3. PETROGRAPHIC DESCRIPTIONS

The petrographic descriptions are provided in the following pages. Where a polished thin section was prepared, the mineragraphic description is incorporated with the petrographic description.
SAMPLE : HR05541

SECTION NO. : HR05541

HAND SPECIMEN : The rock sample is a uniformly medium-grained amphibolite, composed of uniformly distributed lineated dark greenish black hornblende crystals and lesser interstitial felsic grains. Subparallel to the foliation is a felsic band ~3-4 mm thick.

ROCK NAME : Banded amphibolite

PETROGRAPHY :

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibolite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hornblende</td>
<td>57</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>35</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>5</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Opaques (?ilmenite)</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Apatite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Allanite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Felsic band</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plagioclase</td>
<td>94</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Hornblende</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Apatite</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Sphene</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Opaques (?ilmenite)</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Epidote</td>
<td>Tr</td>
<td>Alteration</td>
</tr>
<tr>
<td>Sericite</td>
<td>Tr</td>
<td>Alteration</td>
</tr>
</tbody>
</table>

In thin section, this sample displays a strongly lineated granoblastic metamorphic texture.

**Amphibolite** is dominated by hornblende and plagioclase. The hornblende forms pleochroic dark green or brownish green, elongated subhedral grains whose strong preferred orientation defines the structure through the rock. They range widely in grain size (<0.1 mm up to ~2 mm, average ~1 mm). They are irregularly distributed, being particularly abundant in selvages marginal to the felsic band. Plagioclase occurs as anhedral grains ~0.1-0.6 mm in size (average ~0.4 mm), with larger grains elongated within the trace of the lineation. Quartz is minor, forming anhedral grains similar in size to plagioclase, and in granoblastic relationship with the plagioclase and hornblende. Opaques (probably ilmenite) occur as small elongate grains oriented within the trace of the lineation. Apatite is uncommon, forming subrounded grains elongated within the trace of the lineation, and allanite is rare, occurring as anhedral grains with dark orange-yellow marginal alteration.

**Felsic band** is dominated by plagioclase, which occurs as anhedral equant grains ~0.6 mm in size, with uncommon larger grains up to ~2 mm. The larger grains may contain cores, zoned outward to less calcic rims. Cores of some grains display replacement by epidote granules and sericite flecks. A well-developed granoblastic metamorphic texture is displayed by the plagioclase grains, with 120° triple junctions indicative of equilibrium metamorphic recrystallisation. Minor phases in the felsic band include anhedral green hornblende, clear subrounded apatite, and granular sphene, all of which tend to be concentrated in trails aligned parallel to the trace of the lineation in the enclosing amphibolite. Small ragged opaque cores
(probably ilmenite) may occur within the sphene grains, suggesting replacement of ilmenite by sphene.

INTERPRETATION:

This sample has suffered dynamic regional of medium to high grade, producing the lineated granoblastic assemblage of hornblende + plagioclase + minor quartz + opaques (?ilmenite) + apatite + allanite. The dark green to brownish green absorption colour of the hornblende supports a grade of upper amphibolite facies.

The felsic band is interpreted to have formed during the principal metamorphic event, probably by metamorphic segregation processes involving local migration of more mobile felsic components (Si, Al, Na, Ca). This is supported by the mafic-rich selvedge (the ferromagnesian complement of the felsic segregation), and the similar metamorphic textures of the felsic band and enclosing amphibolitic host. Such metamorphic segregation processes would be expected to occur in the upper amphibolite facies.
SAMPLE : HR05579
SECTION NO. : HR05579

HAND SPECIMEN : The rock sample is a medium- to coarse-grained, massive, felsic rock with a waxy brownish grey colour. Small ragged dark ferromagnesian grains are sparsely scattered through the rock.

ROCK NAME : Quartzo-feldspathic hypersthene gneiss (charnockite)

PETROGRAPHY AND MINERAGRAPHY:
A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plagioclase</td>
<td>65</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>30</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Orthopyroxene (hypersthene)</td>
<td>3</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Biotite</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Hornblende</td>
<td>&lt;1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>?Uraninite (opaque to brown)</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Zircon</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Metamict ?thorite (yellow)</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
</tbody>
</table>

In polished thin section, this sample displays a coarse-grained granitoid texture that has been modified by metamorphic deformation and partial recrystallisation.

Plagioclase is abundant, forming anhedral large grains ~1-3 mm in size. Many contain relatively large, crystallographically-aligned grains of K-feldspar exsolution patches, lending an anisotropically texture to the grains. Most grains display albite polysynthetic twinning. Deformational effects are evident: twin lamellae are curved, and strain shadowing is common in most grains.

Quartz occurs as small grains in sutured granoblastic mosaics between the larger plagioclase grains. The interstitial nature of the quartz, and its partial recrystallisation to sutured granoblastic mosaics, indicates it initially formed as coarse anhedral interstitial grains.

Orthopyroxene is the principal ferromagnesian phase. It occurs as ragged anhedral grains up to ~1 mm in size, displaying the typical pleochroism of hypersthene (pale green to pale pink). It is irregularly scattered through the rock, mostly occurring with quartz in the interstices between large plagioclase grains, but also occurring less commonly as equant subhedral inclusions within plagioclase.

Biotite and hornblende occur in close association. Pleochroic dark chocolate brown biotite flakes are intergrown with ragged anhedral hornblende (pleochroic in dark greens and brownish greens), in ragged aggregates that occur interstitially to the large plagioclase grains.

Uraninite is tentatively identified as equant subrounded grains ~0.2-0.4 mm in size, very sparsely and irregularly scattered through the rock. They tend to occur mainly in the recrystallised interstitial quartz. Some are perfectly opaque, but others appear to have suffered partial metamict alteration to isotropic dark brownish materials.

Zircon is rare, forming small equant prismatic crystals in close association with biotite, hornblende, and uraninite. Its somewhat turbid appearance and low birefringence suggest it is partly metamict, and therefore may have been a high-U zircon.
Thorite may have occurred in trace amount, but now occurs as small equant cubic crystals that have been completely replaced by isotropic yellow secondary materials.

INTERPRETATION:

This sample represents a quartzo-feldspathic rock that has suffered recrystallisation under conditions of dynamic regional metamorphism, producing the assemblage plagioclase + quartz + minor hypersthene + biotite + hornblende + accessory ?uraninite + zircon + thorite. The presence of the anhydrous orthopyroxene phase confirms that recrystallisation occurred at a high grade (granulite facies). The rock has charnockitic affinities, as indicated by the metamorphic assemblage and the modified granitoid texture.

The U-bearing phases (uraninite, zircon, thorite) appear to be part of the principal metamorphic assemblage.
SAMPLE: HR05580

SECTION NO.: HR05580

HAND SPECIMEN: The rock sample is composed of abundant vitreous black material, which appears to be concentrated in large subparallel elongate crystals in the sawn section. Small yellowish grains are disseminated through the interstices.

ROCK NAME: Allanite-zircon metasomatite

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allanite</td>
<td>55</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Zircon (turbid, partly metamict)</td>
<td>25</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>?Thorite (yellow, metamict)</td>
<td>10</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>5</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Apatite</td>
<td>4</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Pyrite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Chalcopyrite</td>
<td>Tr</td>
<td>Metamorphic (inclusions in pyrite)</td>
</tr>
</tbody>
</table>

In polished thin section, this sample displays a granular metamorphic texture that has been modified by metamict alteration of some phases.

Allanite is abundant, occurring as large bladed crystals ~1.5 mm long, and also as large anhedral areas that appear to lack crystal forms. The different forms of the allanite introduce a banded appearance to the rock, which can be observed in the sawn section. The allanite is uniformly pale brown in colour, and is almost completely isotropic except for some uncommon margins that display low-order anomalous interference colours.

Zircon is abundant, displaying two distinct forms:

i) Equant subhedral grains ~0.2-0.6 mm in size are abundant in interstices between the large allanite blades.

ii) Fine-grained granular zircon, concentrated in trails subparallel to the banding, are moderately abundant in the more massive allanite-rich band.

All of the zircon displays a turbid brownish colour, indicating a significant degree of metamict alteration. It may therefore be U-rich zircon.

Thorite may have formed subhedral equant crystals ~0.6 mm in average size. They all have suffered complete metamict alteration to fine isotropic yellowish material, and radiating microcracks project into nearby allanite, quartz and apatite.

Quartz occurs as angular interstitial grains that form granoblastic mosaics in interstices between the large allanite grains.

Apatite accompanies the quartz, forming equant subhedral grains and granular aggregates.
Pyrite is present in accessory amount, forming tiny ragged grains within the allanite grains, and larger equant crystals in interstices between the allanite grains. Tiny ragged grains of chalcopyrite accompany the larger pyrite grains.

INTERPRETATION:

This sample represents a metasomatic metamorphic rock that recrystallised under high-grade regional metamorphic conditions, producing the assemblage allanite + zircon + \( \theta \) thorite + minor quartz + apatite + trace pyrite + chalcopyrite. Metamict alteration has destroyed the allanite and \( \theta \) thorite, and has partly destroyed the zircon. It may be inferred that all three phases are U and/or Th rich.

No uraninite has been observed in this section, but the sample is closely similar in mineralogy and texture to previous samples in which uraninite has been identified (e.g. sample HR05556, Mason Geoscience Report #2123, 12 July 1995).
SAMPLE : HR05585
SECTION NO. : HR05585

HAND SPECIMEN : The rock sample represents a quartzo-feldspathic gneiss, in which the preferred orientation of moderately abundant ferromagnesian grains defines a foliation and a lineation. Small diffuse patches of pale yellow secondary U-bearing minerals are sparsely scattered through the rock.

ROCK NAME : Deformed quartzo-feldspathic biotite gneiss

PETROGRAPHY AND MINERALOGY:
A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plagioclase</td>
<td>60</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>35</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Biotite</td>
<td>4</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Apatite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Zircon (metamict)</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>?Uraninite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Epidote</td>
<td>Tr</td>
<td>Alteration</td>
</tr>
</tbody>
</table>

In polished thin section, this sample displays an inequigranular metamorphic granoblastic texture with deformational effects.

Plagioclase is abundant. It occurs in two forms:

i) Large anhedral grains ~2-3 mm in size are elongated within the trace of the foliation. Bending of twin lamellae is evident in some grains. Most contain tiny, randomly oriented acicular inclusions of apatite.

ii) Smaller anhedral grains ~0.2-0.5 mm in size form a finer-grained granoblastic mosaic with quartz.

Quartz is moderately abundant, forming anhedral grains ranging widely in size, from <0.2 mm up to ~2 mm. They form a sutured granoblastic matrix to the larger plagioclase grains. Their sutured granoblastic texture, shadowy strain extinction, and elongation in the trace of the foliation plane indicates that they have suffered a significant degree of deformation.

Biotite forms small ragged flakes ~0.2 mm in size, concentrated in aggregates within the granoblastic matrix with quartz and finer-grained plagioclase. The biotite is pleochroic from dark chocolate brown to straw yellow, suggesting it has a relatively oxidised composition.

Apatite occurs in trace amount as small equant grains ~0.1-0.2 mm in size, commonly concentrated in small trails aligned within the foliation, in close association with zircon, ?uraninite, and biotite.

Zircon forms sparsely scattered equant prismatic crystals ~0.2-0.4 mm in size. Their turbid, brownish colour indicates a significant degree of metamict alteration, and they therefore may be U-rich zircons.
Possible uraninite occurs as small equant cubic grains ~0.2 mm in size, partly to completely replaced by dark turbid brownish metamict materials. They occur within the finer-grained matrix materials.

Epidote forms small subhedral prismatic grains, in close association with biotite flakes and also sparsely distributed through some large plagioclase grains.

INTERPRETATION:

This sample is inferred to represent a quartzo-feldspathic rock, possibly of granitoid origin, that has suffered severe deformation and recrystallisation under conditions of high grade regional metamorphism. This has generated the foliated granoblastic assemblage of plagioclase + quartz + minor biotite + accessory apatite + zircon + ?uraninite. The trace amount of epidote is considered to have formed by slight retrogressive alteration of biotite and plagioclase.
SAMPLE: HR05668

SECTION NO.: HR05668

HAND SPECIMEN: The rock sample is very fine-grained and pale creamish grey in colour. It is generally massive in structure, with indistinct white patches and discontinuous veinlets which effervesce in reaction with dilute HCl (and therefore are likely to be calcite).

ROCK NAME: Apatite-calcite rock

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apatite</td>
<td>73</td>
<td>Low-T alteration</td>
</tr>
<tr>
<td>Calcite</td>
<td>10</td>
<td>Low-T alteration</td>
</tr>
<tr>
<td>Clays</td>
<td>2</td>
<td>Low-T alteration</td>
</tr>
<tr>
<td>Voids</td>
<td>15</td>
<td>Remnant open space</td>
</tr>
</tbody>
</table>

[NOTE: X-ray diffraction has identified apatite, calcite, and quartz.]

In polished thin section, this sample displays a fine-grained, massive, vugly texture suggestive of deposition under low-temperature conditions in an open space-filling environment.

Apatite is abundant, occurring mostly as tiny, randomly oriented prismatic crystals ~75 μm in average size. They appear to have formed by open space-filling processes, as there are abundant voids (remnant open space) between the apatite crystals. Many of the small apatite crystals appear to contain minute dark inclusions of unidentifiable nature: they may be fluid or mineral inclusions in hollow cores of the apatite crystals. Their presence contributes to a somewhat turbid appearance of the apatite-rich areas. A trace amount of apatite occurs as relict large crystals ~1 mm in size: kernels of apatite have been severely replaced by optically continuous calcite.

Calcite occurs mostly as ragged large anhedral plates on the mm scale, as well as discontinuous veinlets. A trace amount has replaced large apatite crystals.

Clays are uncommon, forming dense massive patches of microcrystalline clay flecks. Larger clay plates are sparsely scattered through the fine-grained aggregates.

No additional minerals were identified by reflected light observations.

INTERPRETATION:

This sample is considered to represent low-temperature deposition of apatite, with associated minor calcite and clays, in a near-surface environment. There is textural evidence that larger apatite crystals formed first, but were subsequently replaced by calcite.
SAMPLE : HR05669
SECTION NO. : HR05669
HAND SPECIMEN : The rock sample has an overall creamish grey colour, somewhat similar to the previous sample (HR05668), but a more blocky or breccia structure is faintly evident.
ROCK NAME : Apatite-calcite-quartz rock

PETROGRAPHY AND MINERAGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apatite</td>
<td>45</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Calcite</td>
<td>35</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Quartz</td>
<td>20</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>?Hematite</td>
<td>Tr</td>
<td>Low-temperature alteration</td>
</tr>
</tbody>
</table>

[NOTE: X-ray diffraction has identified apatite, calcite, quartz, and smectite clay.]

In polished thin section, this sample displays a heterogeneous open space-filling texture.

Apatite is abundant, forming tiny randomly oriented prismatic crystals ~75-100 μm long. In places they are distributed through large sparry calcite plates, but elsewhere they form a latticework with open void interstices. Tiny unidentifiable dark inclusions occur in cores of some apatite crystals, lending a somewhat turbid appearance to apatite-rich areas. Ragged patches of dense, very fine-grained apatite is nearly isotropic, and has the appearance of collophane.

Calcite mostly occurs as large ragged sparry patches several mm in size. They may contain small apatite crystals. Elsewhere, calcite forms clear patches and veins that locally cut other structures.

Quartz occurs in two forms:

i) Some occurs as very fine-grained chalcedonic silica, which forms elongated blade-like aggregates disrupted by later calcite veinlets.

ii) Some occurs as large, well-crystallised, euhedral quartz crystals which form aggregates intergrown with large calcite plates. This quartz is remarkably clear, being virtually devoid of fluid inclusions (which are very rare and quite small, with a tiny vapour bubble).

Hematite occurs in trace amount as small blades within the dense brownish collophane aggregates.

INTERPRETATION:

This sample has formed by near-surface, low-temperature alteration processes. There is no evidence of the nature of the precursor rock, as the minerals appear to have formed by space-filling processes involving development of thin layers of chalcedonic silica, disruption of
these, and further deposition of layered to massive collophane, better-crystallised apatite and calcite.
SAMPLE : HR05670

SECTION NO. : HR05670

HAND SPECIMEN : The rock sample is composed of a thin bladed boxwork of waxy translucent grey material (quartz), with vuggy interstitial voids and fine-grained interstitial white material (mainly apatite).

ROCK NAME : Quartz-apatite-zeolite boxwork

PETROGRAPHY AND MINERAGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>47</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Apatite</td>
<td>25</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Zeolite mineral</td>
<td>5</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Clays</td>
<td>3</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Calcite</td>
<td>Tr</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Unknown opaques (?Mn-phase)</td>
<td>Tr</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Voids</td>
<td>20</td>
<td>Remnant open space</td>
</tr>
</tbody>
</table>

[NOTE: XRD has identified apatite and quartz. EPMA has identified apatite, a Ca-zeolite mineral (stilbite), and Mn-Ba oxide phase (psilomelane).]

In polished thin section, this sample displays a thinly bladed boxwork structure that has been partly filled by weakly colloform deposits.

Quartz is abundant, occurring in different forms:

1) A small amount occurs as very fine-grained, microcrystalline quartz that has replaced thin blades ~50-100μm wide. Onto these blades are coated different layers.

2) Most quartz occurs as somewhat coarser-grained granular aggregates which have nucleated on the thin blades of 1) above, and have grown outwards to fill available space.

A zeolite mineral occurs mostly as stumpy prismatic crystals ranging up to ~1 mm long. They fill or partly fill the interstitial cavities between thin quartz blades, and may be intergrown with the coarser-grained quartz.

Apatite occurs as dense, turbid, massive fine-grained material that forms poorly-defined colloform layers. It may contain larger, well-crystallised bladed zeolite crystals.

Clays of two types are distinguished. Dense, cryptocrystalline, pale yellow clay forms diffuse, discontinuous laminae up to ~0.4 mm thick, deposited on apatite and quartz crystals. Elsewhere, turbid clays occur as dense void-filling deposits.

Calcite is uncommon, forming sparsely scattered microcrystalline void-filling deposits.

Tiny angular opaque grains occur sparsely intergrown within turbid apatite. They are strongly anisotropic, and may be a Mn-oxide phase. This is confirmed by EPMA work, with has identified a Mn-Ba oxide phase (psilomelane).
INTERPRETATION:

This sample formed by near-surface, low-temperature processes that involved repeated dissolution and deposition of quartz and apatite, with minor clays and calcite. This generated the bladed, boxwork structure with weakly developed coloform structure.

PLATE 1: SAMPLE HRO5670 (Transmitted plane polarised light, x5, 10A/1)
Blades of zeolite (stilbite, colourless) are intergrown with a colloform band of turbid brownish fine-grained apatite. A band of fine-grained quartz (top) contributes to the colloform structure. The opaque circle (left, right) is a pen marking for EPMA purposes.
PLATE 2: SAMPLE HRO5670 (Reflected plane polarised light, x20, 11A/1)
Micron-sized grains (pale grey) are intergrown with the fine-grained turbid apatite (see PLATE 1). EPMA indicates the phase to be a Mn-Ba oxide (psilomelane).
SAMPLE : HR05671

SECTION NO. : HR05671

HAND SPECIMEN : The rock sample is composed of dense, fine-grained, pale brownish cream materials with thin tortuous veinlets. The presence of large, anhedral grains is evident where light reflects from cleavage surfaces. A more porous, white weathering rind has developed on the active weathering surface.

The sample effervesces in reaction with dilute HCl, suggesting calcite is present in significant amount.

ROCK NAME : Calcite-apatite rock

PETROGRAPHY AND MINERALOGGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcite</td>
<td>60</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Apatite</td>
<td>30</td>
<td>Low-temperature alteration</td>
</tr>
<tr>
<td>Voids</td>
<td>10</td>
<td>Remnant open space</td>
</tr>
</tbody>
</table>

[NOTE: X-ray diffraction has identified calcite and apatite.]

In thin section, this sample displays a vugly massive poikiloblastic texture, with large sparry calcite grains enclosing tiny apatite crystals.

Calcite is abundant, forming large ragged grains ~4-6 mm in size. Most grains are peppered with tiny, randomly oriented apatite crystals ~50 μm long which may contain minute turbid inclusions in their cores. In some areas, calcite is absent, leaving a meshwork of randomly oriented apatite crystals.

No additional phases were identified using reflected light.

INTERPRETATION:

This sample represents near-surface deposition of calcite and apatite, in a calcrete-type environment. This has generated the massive association of intergrown calcite and apatite, with a significant amount of remnant open space.
SAMPLE: HR05677

SECTION NO.: HR05677

HAND SPECIMEN: The rock sample represents a strongly foliated, lineated amphibolite in which discontinuous, indistinct subparallel laminae are composed alternately of dark greenish black elongated hornblende grains and white felsic grains.

ROCK NAME: Hornblende-plagioclase(-scapolite) amphibolite

PETROGRAPHY AND MINERALOGY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol.%</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornblende</td>
<td>69</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>20</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Scapolite</td>
<td>5</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Quartz</td>
<td>3</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>2</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Sphene</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Goethite</td>
<td>Tr</td>
<td>Alteration (weathering)</td>
</tr>
</tbody>
</table>

[NOTE: EPMA has identified trace Th-uraninite not observed in section.]

In polished thin section, this sample displays a lineated granoblastic metamorphic texture.

Hornblende is abundant, forming anhedral grains of variable size, ranging from ~0.1 mm up to ~2 mm. The longer grains display a strong preferred orientation subparallel to the weak mineralogical layering. Although distributed throughout the rock, the hornblende is more abundant in some indistinct bands than in others which are rich in felsic minerals. Pleochroism of the hornblende is dark brownish green to pale fawn, indicative of high Al and Ti contents, and therefore supportive of a relatively high grade of metamorphism.

Plagioclase is the other principal phase, occurring as anhedral twinned grains ~0.1-0.4 mm in size. It is more abundant in some indistinct, discontinuous felsic laminae.

Quartz is present in minor amount, forming anhedral grains similar in size to plagioclase. It is readily distinguished by its lack of twinning, slightly higher birefringence, and tendency to display a significant degree of shadowy strain extinction.

Scapolite occurs in minor amount. It forms anhedral equant grains, similar in size, shape and occurrence to plagioclase with which it is intergrown in granoblastic texture in indistinct felsic laminae. Together with plagioclase, the scapolite tends to form indistinct laminae. The scapolite is readily distinguished from plagioclase and quartz by its distinct cleavage, medium birefringence (suggestive of a meionitic composition, i.e. Ca-rich), and parallel extinction.

Ilmenite is present in minor amount, forming small anhedral grains mostly ~0.05-0.1 mm in size, but in places ranging up to ~0.2-0.4 mm. Most occurs within hornblende, but some occurs in plagioclase.

Sphene forms small anhedral grains that display the typical turbid pale brownish colour with slight pleochroism. Like ilmenite, it occurs mainly in hornblende, but also in plagioclase.
Goethite forms small equant crystals of cubic morphology, mostly ~50-100 \( \mu m \) in size. It occurs almost exclusively within the scapolite, which has suffered some ferruginous alteration within the vicinity of the grains. The phase appears to have been a cubic opaque phase, but has suffered significant alteration. It may have been pyrite. EPMA confirms only Fe is present in the analysis.

INTERPRETATION:

This sample represents a basic rock of possible calc-silicate chemical sedimentary origin. It has suffered dynamic regional metamorphism of relatively high grade (upper amphibolite to granulite facies), producing the foliated granoblastic assemblage of hornblende + plagioclase + quartz + scapolite + minor ilmenite + sphene + trace pyrite (+ trace uraninite from EPMA work).

PLATE 3: SAMPLE HRO5677 (Reflected plane polarised light, x10, 7A/1)
This view illustrates accessory ilmenite grains (pale pinkish grey, left, top) that are common as an accessory phase in amphibolitic rocks. Note the goethite-altered opaque grain (pale bluish grey, upper left), possibly pseudomorphous after pyrite.
SAMPLE : HR05679

SECTION NO. : HR05679

HAND SPECIMEN : The rock sample is composed entirely of vitreous black material, very similar to allanite-rich rocks described previously.

ROCK NAME : Epidote rock (pegmatoidal epidote metasomatite)

PETROGRAPHY AND MINERACOGRAPHY:

A visual estimate of the modal mineral abundances gives the following:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Vol. %</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epidote (yellow)</td>
<td>96</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Epidote (colourless)</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>1</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Phlogopite</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Unknown (?uraninite)</td>
<td>Tr</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Ferruginous material</td>
<td>2</td>
<td>Alteration (fracture alteration)</td>
</tr>
</tbody>
</table>

[NOTE: X-ray diffraction has identified epidote only.]

In polished thin section, this sample displays a massive crystalline texture with minor small mineral inclusions, veins, and fracture alteration.

Epidote completely dominates the sample. The section is occupied by portion of a single optically continuous crystal whose boundaries have not been captured. The epidote is weakly pleochroic in pale yellow with a dull brownish tinge, and displays typical anomalous interference colours. This epidote is somewhat similar to the allanite of sample HR05580 (allanite-zircon metasomatite), but the allanite of that sample is browner and isotropic. A trace amount of colourless epidote forms thin optically continuous margins on the dominant yellow epidote.

Plagioclase is present in minor amount, forming small angular grains included within the yellow epidote. It also fills thin, widely-spaced (i.e. uncommon) veinlets that cut the epidote.

Phlogopitic mica forms small but well-crystallised flakes, weakly pleochroic in colours from very pale orange to colourless. It is closely associated with small grains of plagioclase in small inclusion aggregates in the epidote.

An unknown phase occurs as rare tiny equant grains ~100 μm in size. Only one such grain was observed in the section. It occurs in close association with plagioclase and phlogopite in small patches within the epidote host. In reflected light, the phase has the somewhat turbid dull grey appearance of parti'll metatmic uraninite.

Ferruginous reddish brown, very fine-grained material of unidentifiable mineralogy has incipiently replaced epidote along irregular fractures and microcracks.

INTERPRETATION:

This sample represents portion of a coarse, pegmatoidal rock that is composed almost entirely of pale yellow epidote. Small amounts of late-forming colourless epidote, plagioclase,
phlogopite and an unknown opaque phase (possibly uraninite) comprise small polycrystalline inclusions and vein-fillings in the main epidote phase.

The rock is considered to have formed as a pegmatoidal metasomatic rock during a metamorphic event. Minor recent alteration in the zone of oxidation has generated thin ferruginous fracture alteration.
4. AUTORADIOGRAPHY

The autoradiographs are displayed in PLATE 4.

In quartz-apatite rocks (samples HRO5668, -669, -670, -671), darker patches and indistinct bands represent a mild radiogenic response from trace U and Th in fine-grained turbid apatite. Tiny black specks may be a response from the Ba-bearing Mn-oxide grains (psilomelane). Colourless areas mainly represent quartz.

In the amphibolite sample (HRO5677), strong radiogenic responses arise from small specks that yield dark patches in a thin band subparallel to the foliation through the rock. The band is also rich in scapolite. EPMA has identified tiny grains of Th-uraninite, which are responsible for the radiogenic response.

Autoradiographs provided by Amdel Mineral Services Laboratory.
5. ELECTRON-PROBE MICROANALYSIS

5.1 Minerals in quartz-apatite rock (HRO5670)

Apatite occurs as fine-grained turbid brownish colloform bands and patches. Analyses from this apatite are provided in Table 3.

<table>
<thead>
<tr>
<th>TABLE 3: APATITE ANALYSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>OXIDE</td>
</tr>
<tr>
<td>P_2O_5</td>
</tr>
<tr>
<td>SiO_2</td>
</tr>
<tr>
<td>ThO_2</td>
</tr>
<tr>
<td>Y_2O_3</td>
</tr>
<tr>
<td>La_2O_3</td>
</tr>
<tr>
<td>Ce_2O_3</td>
</tr>
<tr>
<td>U_2O_3</td>
</tr>
<tr>
<td>CaO</td>
</tr>
<tr>
<td>PbO</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

One analysis (1, Table 3) clearly contains trace amounts of Th, U, La and Ce. The peak counts for these elements were well above background, and therefore are considered real. The presence of these trace components is responsible for the diffuse radiogenic response of the apatite in the autoradiograph (see PLATE 4).

One analysis of stilbite is provided in Table 4. The analysis is close to a stoichiometric stilbite analysis free of Na and K (SiO_2=59.68%, Al_2O_3=14.47%, CaO=7.96%, H_2O=17.90%). Stilbite has been identified by XRD in another quartz-apatite rock (sample HRO5671).

<table>
<thead>
<tr>
<th>TABLE 4: STILBITE ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>OXIDE</td>
</tr>
<tr>
<td>SiO_2</td>
</tr>
<tr>
<td>TiO_2</td>
</tr>
<tr>
<td>Al_2O_3</td>
</tr>
<tr>
<td>Cr_2O_3</td>
</tr>
<tr>
<td>MgO</td>
</tr>
<tr>
<td>CaO</td>
</tr>
<tr>
<td>MnO</td>
</tr>
<tr>
<td>FeO</td>
</tr>
<tr>
<td>ZnO</td>
</tr>
<tr>
<td>Na_2O</td>
</tr>
<tr>
<td>K_2O</td>
</tr>
<tr>
<td>F</td>
</tr>
<tr>
<td>Cl</td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>O=\text{F}</td>
</tr>
<tr>
<td>O=\text{Cl}</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>
Analyses of the tiny opaque grains intergrown with apatite are provided in Table 5. They represent a Mn-Ba oxide phase (psilomelane).

**TABLE 5: ANALYSES OF Mn-Ba OXIDE PHASE (PSILOMELANE)**

<table>
<thead>
<tr>
<th>OXIDE</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>1.83</td>
<td>0.57</td>
</tr>
<tr>
<td>ThO₂</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>U₂O₃</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>MnO</td>
<td>59.26</td>
<td>59.44</td>
</tr>
<tr>
<td>BaO</td>
<td>14.86</td>
<td>16.38</td>
</tr>
<tr>
<td>Total</td>
<td>75.97</td>
<td>76.39</td>
</tr>
</tbody>
</table>

**5.2 Uraninite in Amphibolite (HRO5677)**

One tiny grain of uraninite has been located and analysed (Table 6). It represents a Th-uraninite composition.

**TABLE 6: URANINITE ANALYSIS**

<table>
<thead>
<tr>
<th>OXIDE</th>
<th>WT.%</th>
</tr>
</thead>
<tbody>
<tr>
<td>P₂O₅</td>
<td>0.00</td>
</tr>
<tr>
<td>SiO₂</td>
<td>4.83</td>
</tr>
<tr>
<td>ThO₂</td>
<td>8.28</td>
</tr>
<tr>
<td>Y₂O₃</td>
<td>0.86</td>
</tr>
<tr>
<td>La₂O₃</td>
<td>0.00</td>
</tr>
<tr>
<td>Ce₂O₃</td>
<td>0.22</td>
</tr>
<tr>
<td>U₂O₃</td>
<td>78.72</td>
</tr>
<tr>
<td>CaO</td>
<td>0.26</td>
</tr>
<tr>
<td>PbO</td>
<td>4.13</td>
</tr>
<tr>
<td>Total</td>
<td>92.47</td>
</tr>
</tbody>
</table>
PLATE 5: SAMPLE HRO5677 (Backscattered electron image, scale bar = 10μm).
This view shows the analysed grain of Th-uraninite (white). It lies at the margin of an ilmenite grain (grey, top), and clearly is in equilibrium with the ilmenite. The uraninite is therefore considered to have formed during the metamorphic recrystallisation of the calc-silicate host rock.
APPENDIX 1: X-RAY DIFFRACTION STUDY
27 July 1995

Dr. D. R. Mason
Mason Geoscience Pty Limited
PO Box 78
GLENSIDE SA 5065

REPORT G884700G/96
MINERALOGY OF ROCK SAMPLES

YOUR REFERENCE: Letter 3/7/95
SAMPLE IDENTIFICATION: HR05541 to HR05679
MATERIAL: 10 rock samples
DATE RECEIVED: 4 July 1995
WORK REQUIRED: Section preparation, XRD analysis and autoradiographs

Investigation and Report by: Michael Till

Dr Keith J Henley
Manager, Mineralogical Services

The results contained in this report relate only to the sample(s) submitted for testing. Amdel Ltd accepts no responsibilities for the representivity of the sample(s) submitted.

btw
MINERALOGY OF ROCK SAMPLES

1. INTRODUCTION

Ten rock samples were received from Dr. D. R. Mason of Mason Geoscience Pty Limited, with a request for thin section, XRD and autoradiograph work.

2. PROCEDURE

Polished thin sections were prepared of the rocks by appropriate procedures, including vacuum impregnation of two samples. A portion of each of five samples was pulverised and analysed by X-ray diffraction. Autoradiographs were prepared of sectioned surfaces of five rocks by exposing X-ray film to the sectioned surfaces for ten days.

3. RESULTS

The sections (TS64120 to 64129) were despatched on 12/7/95. The minerals detected in the samples by X-ray diffraction are as follows:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>HR05668</th>
<th>HR05669</th>
<th>HR05670</th>
<th>HR05671</th>
<th>HR05679</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apatite</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>-</td>
</tr>
<tr>
<td>Calcite</td>
<td>Tr</td>
<td>Tr-A</td>
<td>-</td>
<td>Tr-A</td>
<td>-</td>
</tr>
<tr>
<td>Quartz</td>
<td>Tr-A</td>
<td>Tr-A</td>
<td>A</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Stilbite</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Tr</td>
<td>-</td>
</tr>
<tr>
<td>Epidote</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>D</td>
</tr>
<tr>
<td>Smectite</td>
<td>- Tr</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Semi-quantitative Abbreviations

D = Dominant. Used for the component apparently most abundant, regardless of its probable percentage level.

CD = Co-dominant. Used for two (or more) predominating components, both or all of which are judged to be present in roughly equal amounts.

SD = Sub-dominant. The next most abundant component(s) providing its percentage level is judged above about 20.

A = Accessory. Components judged to be present between the levels of roughly 5 and 20%.

Tr = Trace. Components judged to be below about 5%. 

_Amde Report G884700G/95_ 27 July 1995
The autoradiographs of the rock sections of HR05668, HR05669, HR05670 and HR05671 contain broad areas of low-level radioactivity. The autoradiograph of HR05667 contains a number of dark spots on one side of the sectioned surface and these probably correspond to off-white fracture in-fillings in a dark green rock. The spots are considered too small to be examined by X-ray photography.