FINAL REPORT 1978 FIELD INVESTIGATION

EXPLORATION LICENCE NO. 1235

BENMARA, NORTHERN TERRITORY

OPEN FILE

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Mines Administration Pty. Limited have held the Benmara area under Exploration Licence 1235 since 1976. Field programmes carried out since then have outlined four radiometrically anomalous areas in Lower Proterozoic Murphy Metamorphics associated with intrusions of the later Lower Proterozoic Nicholson Granite.

Geological mapping at scales of 1:5,000 and 1:2,500 have been carried out over the area containing the four anomalies and an alphameter survey over the same area has yielded further interesting radon anomalies.

No successful investigation has been carried out below the surface extent of these anomalies, and the area awaits a drilling programme planned for early April 1979.
# TABLE OF CONTENTS

1. INTRODUCTION. ............................ 1
2. GEOGRAPHY ................................. 1
  2.1 Location ................................ 1
  2.2 Climate and Topography ................. 1
  2.3 Communications and Accommodation. .... 2
3. TITLES .................................... 2
  3.1 Exploration Licence 1235 N.T. ......... 2
  3.2 Additional Ground Available. .......... 2
4. GEOLOGY .................................. 2
  4.1 Stratigraphy - Benmara EL 1235 ....... 2
  4.2 Structure ................................ 3
  4.3 Mineralization. ......................... 3
5. PREVIOUS WORK. ............................ 4
  5.1 Exploration Prior to Minad Acquisition of EL 1235. 4
  5.2 Previous Exploration by Minad. ........ 4
    (a) Stream Sediment Geochemistry. ....... 5
    (b) Rock Geochemistry. .................. 5
    (c) Geological Mapping. ................. 5
    (d) Ground Radiometrics. ............... 5
6. RESULTS OF FIELDWORK 1978 ............. 5
  6.1 Airborne Geophysics. ................. 6
  6.2 Photogeological Interpretation ...... 7
    (a) Basement Rocks. .................... 7
    (b) Cover Rocks. ....................... 8
  6.3 Geological Mapping at 1:5,000 approximately. 8
  6.4 Grid Survey. ........................... 8
  6.5 Contract Drilling. ................. 9
  6.6 Ground Geophysics. ............... 9
    (a) Alphameter Survey. ................. 9
    (b) Magnetometer Survey. ............. 10
  6.7 Geological Mapping at 1:2,500 scale. 11
    (a) Anomaly I. ......................... 11
    (b) Anomaly II ......................... 14
    (c) Anomaly III ......................... 15
    (d) Anomaly IV ......................... 17
7. CONCLUSIONS. ............................. 18
  7.1 Alphameter Survey ..................... 18
  7.2 Contract Drilling ................... 18
7.3 Geological Mapping

(a) 1:2,500 Mapping.  
(b) 1:5,000 Mapping.

8. RECOMMENDATIONS.
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Location Map EL 1235 Benmara N.T.</td>
</tr>
<tr>
<td>2.</td>
<td>Location and Access Benmara.</td>
</tr>
<tr>
<td>4.</td>
<td>Drill Hole Section BNM DDH-1.</td>
</tr>
<tr>
<td>5.</td>
<td>Drill Hole Section BNM DDH - 2.</td>
</tr>
<tr>
<td>6.</td>
<td>Alphameter Repeatability Test Line 5100E.</td>
</tr>
<tr>
<td>7.</td>
<td>Alphameter Survey Anomaly I.</td>
</tr>
<tr>
<td>8.</td>
<td>Alphameter Survey Anomaly II.</td>
</tr>
<tr>
<td>9.</td>
<td>Alphameter Survey Anomaly III.</td>
</tr>
<tr>
<td>10.</td>
<td>Alphameter Survey Anomaly IV.</td>
</tr>
<tr>
<td>11.</td>
<td>Magnetometer Survey Anomaly I.</td>
</tr>
<tr>
<td>12.</td>
<td>Magnetometer Survey Anomaly III.</td>
</tr>
<tr>
<td>13.</td>
<td>Magnetometer Survey Anomaly IV.</td>
</tr>
<tr>
<td>15.</td>
<td>Geological Map Anomaly II.</td>
</tr>
<tr>
<td>16.</td>
<td>Geological Map Anomaly III.</td>
</tr>
<tr>
<td>17.</td>
<td>Geological Map Anomaly IV.</td>
</tr>
</tbody>
</table>
APPENDICES

APPENDIX 1  Interpretation of radiometric and magnetic data by Loxton Hunting and Associates, Canberra.

APPENDIX 2  Anomaly follow-up Benmara.

APPENDIX 3  Photogeological map 1:27,000 by Loxton Hunting and Associates, Canberra.

APPENDIX 4  Petrography reports by CMS Adelaide.

APPENDIX 5  Proposed 1979 field programme and budget.
LOCATION MAP
E.L. 1235 BENMARA N.T.
1. **INTRODUCTION.**

Mines Administration Pty. Limited has carried out exploration programmes on EL 1235 since June 1976. Previous work carried out by Minad had located four radiometrically anomalous areas in the northern part of the Exploration Licence. A suite of anomalous areas identified from mini-plots of airborne radiometric and magnetic surveys were also investigated.

The 1978 exploration programme had the following aims:-

(i) Evaluation (mainly by drilling) of the four radiometrically anomalous areas (Anomalies, I, II, III and IV).

(ii) Follow-up ground investigation of other anomalous areas located from mini-plots of airborne radiometric and magnetic surveys.

(iii) To carry out mapping of an area containing the four major anomalies at 1:5,000 scale.

Unfortunately, due to drilling contractor and drill machine difficulties a major part of the 1978 programme had to be abandoned. As a consequence, this Report covers details and results of work carried out during 1978 as well as information on the results of work previously carried out by Minad.

It is anticipated that the conclusions and recommendations outlined in this report will form the framework for an exploration programme to commence in April 1979.

2. **GEOGRAPHY**

2.1 **Location.**

Exploration Licence 1235 (Benmara) is 890 road kilometres northwest from Mt Isa. The road is bitumen for 640 km and the remainder is formed gravel. A location map is shown in Fig. 1. Access within the Exploration Licence is reasonable providing a four wheel drive vehicle is available.

Benmara Station, predominantly a cattle ranch, is situated just within the Exploration Licence and a permanent campsite has been prepared by Minad some 12 kilometres north of Benmara Station. Location details are shown in Fig. 2.

2.2 **Climate and Topography**

The Benmara Exploration Licence area has a semi-arid to subhumid tropical climate. The weather is seasonal, with a short wet summer and a long dry winter. Rain, mainly from thunderstorms and tropical depressions associated with a northwest monsoonal influence, averages 500 mm to 700 mm per year. In general, all non-bituminized roads are non-trafficable during the wet summer season. Temperatures in the region are moderate to high all year.

Two physiographic regions extend across the area. In the western part strike ridges of the South Nicholson Group of rocks and lateritized cover rocks form the undulating Barkly Tablelands.
In most other regions within the Exploration Licence low undulating hills with occasional remnants of South Nicholson Group rocks rise to 300 m above sea level.

The region is drained by the Nicholson River, a broad deeply incised river with a regional north easterly flow. One major tributary, the Buddycurrawa Creek drains the South-western portion of the area.

2.3 Communications and Accommodation.

No regular air services link the isolated homesteads in proximity to the Exploration Licence. However, air charter at Moderate cost is available from Mt. Isa. No telephone or mail facilities are available and during field programmes, communications with Brisbane are conducted through the Royal Flying Doctor Outpost Radio Network which has a base at Mt. Isa.

A permanent campsite area has been prepared some twelve kilometres north of Benmara Homestead. Camping and ancillary equipment are stored in Mt. Isa.

3. TITLES.

3.1 Exploration Licence 1235 N.T.

Exploration Licence NO. 1235 was granted to Minad by the Northern Territory Mines Branch to explore for uranium and base metals on June 18th 1976. Title was renewed in full for a further twelve months on June 8th 1977.

A fifty percent relinquishment and renewal was approved for a further twelve months from June 18th 1978. The current Exploration Licence has an area of 544 square kilometres (210 sq miles). Under the terms and conditions of the Mining Ordinance of the Northern Territory of Australia, reports on work carried out on EL 1235 are required every three months.

In January 1978, Union Oil Development Corporation formally entered into a joint-venture with Minad whereby Union Oil could earn a 50% interest in EL 1235 by funding exploration costs to $250,000.

3.2 Additional Ground Available.

Immediately to the east of EL 1235 an area of 200 sq kilometres is held by Minad (EL 1234 Calvert Hills). To the west of EL 1235 an area of 240 sq kilometres is also held by Minad under an Exploration Licence (EL 1427 Bowgan Creek). To the north and south of EL 1235 the ground is untememented and displays no significant geological reasons to warrant acquisition.

4. GEOLOGY.

4.1 Stratigraphy - Benmara EL 1235

The oldest rocks outcropping on EL 1235 are the Lower Proterozoic Murphy Metamorphics. The rocks are typically volcanics and quartz-feldspathic sediments metamorphosed to the quartz-albite-epidote-biotite subfacies of the greenschist facies (Robert's et al 1963).
Within the Exploration Licence, the Murphy metamorphics are typically altered sericitic acid volcanics, kaolinitized sericitic metasediments and gneisses. In places, a ferruginous metaquartzite (Metajasplilite) has been found and is considered to belong to the Murphy Metamorphics.

Roberts et al (1963) noted the difficulty in distinguishing between the Murphy Metamorphics and the Nicholson Granite within the Calvert Hills 1:250,000 geological sheet area. Within the Benmara region similar gradational contacts exist between the above two rock types. Additionally, it appears that at the present time, the Murphy Metamorphics include a broad range of metamorphosed lithologies (including a sheared altered plutonic rock) ranging from acid volcanics and tuffs through to calcareous metasediments and gneisses.

Local contact metamorphic rocks are also developed as a result of the intrusive Nicholson Granite. Further regional mapping is required to separate the vast variety of rock types currently included in the Murphy Metamorphics.

The Nicholson Granite Complex is also of Lower Proterozoic age and intrudes the Murphy Metamorphics. Within the Benmara region the lithology of the Nicholson Granite is a reasonably consistent medium grained biotite-rich granite with occasional finer grained aplitic intrusions occurring in particular, in the northern part of the Benmara area. In places, assimilation of the overlying Murphy Metamorphics has produced biotite-rich rocks of dioritic composition.

Unconformably overlying the Murphy Metamorphics and the Nicholson Granite are the Lower Proterozoic Benmara Beds, a series of greywacke, tuffs and rhyolites. In turn, unconformably overlying the Benmara Beds are the Upper Proterozoic Constance Sandstone and the Mullera Formation respectively. For more detailed description of the stratigraphy of the Benmara region, the reader is referred to the report by J.G. Clavarino (1978) titled "Interim progress report, Exploration Licence No. 1235 (Benmara) N.T."

4.2 Structure.

The Murphy Metamorphics appear to have been isoclinal folds and metamorphosed to greenschist facies rocks in the Lower Proterozoic. Three later stages of deformation are visible within the Benmara region (Clavarino 1978), these are:

(a) Gently folding trending 030° to 040° parallel to the Murphy Tectonic Ridge.
(b) East-north-east trending faults (070° to 080°) (include Benmara Fault).
(c) South-east trending fractures (130°).

4.3 Mineralization

No economic mineralization has been defined within the Benmara Exploration Licence. A piece of float found adjacent to Anomaly I assayed 0.74% U₂O₃ and 0.10% Th with visible secondary uranium mineralization. The extent of possible mineralization awaits testing.
Mineralization targets within the Licence are expected to be localized in and around faults and shears within the Murphy Metamorphics.

Two alternative mechanisms of mineralization emplacement are as follows:-

(a) Primary vein mineralization precipitated from hydrothermal solutions mobilized along fracture zones adjacent to the Nicholson Granite.

(b) Leaching uranium from the source Nicholson Granite followed by concentration of mineralization into favourable structural traps.

5. PREVIOUS WORK

5.1 Exploration Prior to Minad Acquisition of EL 1235

Livingstone (1957) carried out an airborne scintillograph survey over a small portion of the northern part of EL 1235 during a survey of the Nicholson River Region. However, no areas of anomalous radioactivity were discovered on the Exploration Licence.

Noranda (Peitsch and Tucker, 1972) flew an airborne radiometric survey north of 18°S and east of 137°E which included parts of EL 1235. Follow-up drilling of an airborne anomaly east of EL 1235 intersected weak uranium mineralization.

Esso Australia Ltd (Nasca, 1972) carried out a low-level close spaced airborne radiometric survey over the southern half of EL 1235 in conjunction with geological reconnaissance. In addition geochemical sampling of drill cuttings and water from water bores was undertaken.

Although both Company found encouraging signs, no significant uranium mineralization was located.

To date the overall area has been mapped by the Bureau of Mineral Resources on a scale of 1:250,000, however, no detailed mapping of the study area has yet been done by the B.M.R. BMR geochemical surveys of the Murphy Tectonic Ridge in the south-eastern quarter of the Calvert Hills 1:250,000 sheet revealed an area of anomalous uranium in sediments coinciding with a ring fracture in a high level stock of the Nicholson Granite Complex. This led Clavarino (1978) to believe the granitic rocks on EL 1235 had a significant potential for a source of uranium.

5.2 Previous Exploration by Minad.

Following the granting of EL 1235, a study of Open File Company Reports on the Calvert Hills: Mt Drummond area was made in Darwin. Emphasis during this work was placed on reports of work by Esso and Noranda who had explored for uranium over parts of the Licence.

A photogeological interpretation of the Licence was made by Loxton Hunting and Associates, Canberra with a photo scale of 1:83,000 and using National Mapping RC9 black and white aerial photographs.
Following agreement between the Joint Venture partners, Union Oil Development Corporation and Mines Administration Pty. Limited, office preparations for a late 1977 field programme were carried out.

The field programme is summarized under the following headings:-

(a) **Stream Sediment Geochemistry.**

Approximately 450 stream sediment samples were collected during combined sampling/ground radiometric/geological traverses totalling 350 kilometres. Assay results were disappointing and it was concluded that, due to climatic and physiographic conditions, stream sediment geochemistry was an unsuitable exploration method for uranium and base metals exploration within the Exploration Licence.

(b) **Rock Geochemistry.**

Approximately 300 rock samples were collected and a total of 68 were submitted for assay. When compared to world averages, metal contents were generally low except samples X1 to X30 from Anomaly I which contained anomalous uranium and copper.

(c) **Geological Mapping.**

Geological reconnaissance was undertaken during the fieldwork simultaneously with stream sediment sampling/ground radiometric traversing.

The traverses totalled in excess of 350 km and additional mapping/radiometric traverses totalled more than 140 km.

The aims of the mapping were to check unit boundaries, structure and lithologies interpreted by Loxton Hunting and Associates. The reconnaissance mapping for the most part, confirmed the photo-interpretation.

(d) **Ground Radiometrics.**

A total of 500 km of ground radiometric surveys were undertaken during the stream sediment sampling and mapping surveys. In this way two anomalies, Anomaly I and Anomaly II were discovered. In addition, background radiation levels for the various lithologies were established. Selected areas delineated by previous airborne surveys (Nasca, 1972) were covered by ground radiometric traverses.

6. **RESULTS OF FIELDWORK 1978**

Exploration activities for 1978 comprised the following. An airborne geophysical survey was completed by Geometrics International Corp and the results interpreted by a consultant geophysicist from Loxton Hunting and Associates. Ground follow-up of airborne radiometric anomalies was then carried out by Mines Administration Pty. Limited.
Colour aerial photography was flown over the northern part of the licence by B.K.S. Surveys Ltd at scale 1:27,000. Loxton Hunting and Associates carried out a Photogeological study using these colour aerial photographs.

During the main field programme the areas around Anomalies I, II, III and IV were gridded and grid mapped at 1:2,500 scale. Ground geophysics comprised an alpha meter survey and magnetics coverage. Union Oil Development Corporation geologist, P. Goldner was seconded to the project during this phase of exploration.

Two diamond drill holes were drilled at Anomaly I. Drilling proved difficult however and BNM DDH I reached 52.45m whilst BNM DDH-2 was aborted at approximately 10 m.

6.1 Airborne Geophysics.

Geometrics Inc. of Sydney, were contracted to conduct an airborne geophysical survey using a differential gamma-ray spectrometer with a 2000 cubic inch Sodiumiodide crystal and a proton precession magnetometer. Data was collected in both digital and analog forms, while navigation was accomplished by a photographic tracking camera.

The survey which was carried out during January 1978, flew over 5,000 line kilometres where line spacing was 250 metres and the mean terrain clearance 80 metres. At the same time, anomaly follow-up was carried out on 40 anomalies selected from analog data available during the survey.

The survey data was processed by Geometrics Inc. in the USA and was corrected for altitude, background and Compton Scatter. Processed data was presented as:-

(a) 1:25,000 planimetric base maps showing recovered flight path.
(b) 1:25,000 computer generated contour map of total radiation intensity.
(c) 1:25,000 computer generated contour map of total magnetic intensity.
(d) Computer generated mini-plots (profiles) showing U, Th, K40, U/Th, U'/Th, U/K40.

The processed data was forwarded to a consultant geophysicist from Loxton Hunting and Associates, Canberra, who carried out a detailed interpretation of magnetic and radiometric data, with particular emphasis on radiometric anomalies and their geological setting.

A report and recommendations of this work is included (Appendix I).

During April 1978, following recommendations by the consultant geophysicist from Loxton Hunting and Associates, Canberra, Thirty-one radiometric anomalies were selected as worthy of ground follow-up. These were subsequently checked in the field. The anomalies generally reflected changes in rock type rather than mineralization and UO2 assays confirmed this with a range of 1 - 10 ppm.
The airborne radiometric survey detected anomalies III and IV as well as anomalies I and II which were initially detected by a ground radiometric survey. Description of each anomaly located is given with corresponding assay results in Appendix II.

Additional anomalies selected by field geologists and subsequently located and checked during the main field programme are listed and described with their corresponding assay values also shown in Appendix II.

In the southern portion of the Exploration Licence investigation of several point source radiometric anomalies located from mini plots were examined. In all cases the cause of the anomaly was determined to be surficial scavenging of minor uraniferous concentrations. No economic significance could be associated with the anomalies and it is recommended that this southern portion of the EL be relinquished in due course.

6.2 Photogeological Interpretation.

Colour aerial photography was flown over the northern retained area of EL 1235 (north of 18°S) by B.K.S. Surveys Ltd during May 1978 (Refer Fig. 2).

The photogeological study at aerial photo scale 1:27,000 involved 80 photographs with 80 per cent overlap and was carried out by Loxton Hunting and Associates, Canberra. The results were presented as a photogeological work-sheet and a brief report (Appendix III).

Detailed photogeological interpretation has resulted in the delineation of 18 lithological units subdivided into 2 categories. A summary is set out below:

(a) Basement Rocks.

(i) Murphy Metamorphics.

These rocks cover an area in the south bounded by the Benmara Fault to the north and faulted out to the south beneath cover rocks. Arenites dominate the 4 lithological units recognized which include pelites and volcanics. It is thought the metamorphosed volcanics (Plm-V) overlie the arenites and pelites, hence there is no correlation between these and the volcanic Benmara Beds to the south.

(ii) Nicholson Granite Complex.

Three granitic phases were recognized in the central and northern part of the area studied.

(i) A "pink-orange" phase in the north-western and central areas.

(ii) A weathered "yellow" phase in the central and eastern areas.

(iii) A "grey-pink" phase of the northern part cut by acid dykes.
(b) **Cover Rocks.**

These rocks crop out particularly in the northern and southern parts of the area studied. A new arenitic and pelitic formation has been interpreted in the central part of the area (Ps1; Psq, and Psqg) in an elongate basin cut to the south by the Benmara Fault.

Changes in the aerial extent of the Constance Sandstone (Ps) and in interpretation of the structure deforming it have resulted in changes to the original photointerpretation map near the Benmara Fault.

6.3 **Geological Mapping at 1:5,000.**

During November 1978 Messrs K.J. Ridge and R. Mosig spent five days at Benmara compiling of geological map at a scale of approximately 1:5,000. The map base was a colour photograph enlargement and lithological boundaries were plotted as accurately as practicable on a transparent overlay. Frequent rain showers augmented the mapping difficulties and prevented access to the thicker (and boggy) soil plains areas.

The mapping clearly shows the large areal extent of the Nicholson Granite within the mapped area. Lineaments such as faults and shear zones within the granite all favour a NW - SE trend. Associated with the granite are relics of Murphy Metamorphics of varying lithology and varying degrees of contact metamorphism. Generally, these remaining metamorphics outcrop as low resistant hills. The thickness of metamorphics varies and is expected to be thin.

The metamorphics were mapped as two main lithologies; the first rock type exhibited no fabric *in hand specimen* and was mapped as sericitized metavolcanic rock. The second (and more prolific rock type) exhibited a strong fabric (comparable to the CMS "micogneiss, Fander 1978) and was mapped as undifferentiated metasedimentary rock.

The map (Fig. 3) is a preliminary edition and requires further field examination and structural information. As yet this mapping has not outlined any major structural trends connecting the Anomalies. Anomalies I, and III are associated with zones of faulting but Anomalies II and IV are not associated with any regional structural feature. Further infill mapping will be initiated during the 1979 drilling programme.

6.4 **Grid Survey.**

A grid was established over all four anomalies to facilitate detailed geological mapping and geophysical investigation including radiometrics, magnetics and alphameter survey. The grid based on 50 metre centres has a north-south magnetic orientation.

The origin of the grid over Anomaly I was 5000N, 5000E with the baseline along 5000N. In the case of the grid over Anomalies II, III and IV the baseline is 7000E with origin at 3000N, 7000E. Survey instruments used were a compass and Topolite, and no correction for topography was applied.
6.5 Contract Drilling.

A Mindrill 10-L truck mounted diamond drilling rig supplied by Associated Diamond Drillers Pty. Ltd., Mt Isa was located at grid co-ordinates 4971E, 5037N (BNM DDH - 1) on the Anomaly 1 grid. The drill hole was inclined at 55° from horizontal and aligned on 160° m azimuth. The purpose of the hole was to intersect at depth the south-western portion of radiometric anomaly 1. The drill hole was abandoned at 52.45 m in strongly indurated metasedimentary rock after unsuccessful attempts to clear the hole of drilling debris which had caused the rods to stick. No mineralization was encountered over the drilled interval and from the idealized drill hole section of BNM DDH - 1 (Fig. 4) the hole appeared to intersect the hanging wall fault associated with the surface radiometric anomaly.

The rig was moved to co-ordinates 4991E, 5070N on the anomaly 1 grid (BNM DDH - 2 (Fig. 5). The drill hole was inclined at 60° from horizontal and aligned at 160° m azimuth. The purpose of the drill hole was again to intersect the down dip extension of the surface radiometric anomaly.

The drillhole and subsequent drilling programme were abandoned when machine difficulties occurred at a depth of 10 metres. The drill hole intersected a continuous sequence of relatively soft slightly kaolinitic metasedimentary rock.

Drill hole logging sheets are contained in (Fig. 4 and 5).

6.6 Ground Geophysics.

(a) Alphameter Survey.

Ten alpha meters were hired from Geometrics International Corp, Sydney, for the radon gas detection survey. These meters were alpha nuclear meters with a silicon diffused junction detector of active area, 400 sq mm.

Field procedures for the survey were as follows:-

Holes were dug on 50 metre centres with a portable posthole digger and left open for 24 hours. The alpha meters were then placed in the holes packed around with soil and left for 20 - 24 hours. For each alpha meter the total counts recorded and elapsed time readings were taken and expressed as counts per hour (cph). Readings were corrected by use of a base station alphameter.

A Repeatability Test was undertaken by repeat readings on line 5200E (4900N - 5100N) (Fig. 6). From this, repeatability of low alpha meter values (less than 500 cph) is considered acceptable. Anomalous values (greater than 500 cph) were characterized by erratic although anomalous repeat readings. A background value of 200 cph was selected and significant anomalies are those greater than 4 times background. Details of the alphameter surveys over the four anomalies are given below.
ALPHAMETER REPEATABILITY TEST

Line 5100 E

Black values reduced using 4850N as a base station (granite soil)
Anomaly I (Fig. 7)

The main alpha meter anomaly, 7300 cph is at 5000N, 5000E. From here two trends of anomalies strike in an easterly direction to 4900N, 5800E and a northeasterly direction to 5400N 5600E. The northeasterly anomaly trend does not persist beyond 5700E while the easterly trend has not been closed at 5800 E.

Anomaly II (Fig. 8)

A single point anomaly of 2390 cph was detected at 2800N, 6700E. The anomaly is in an area of fine red-brown soil with sparse granite scree and is immediately north of the fault scarp on which the ground radiometric Anomaly II is located.

Anomaly III. (Fig. 9)

Six point source anomalies were encountered, and all of these are located in granitic soils overlying granite. The three main anomalies at 3450N, 7000E, 3400 - 3350N, 6800E, 3300N, 7000E all occur in soil covered areas adjacent to the ground radiometric anomaly III which occurs in outcrop at approximately 3350N, 6950E. Although these anomalies are as yet untested it is suspected they are due to concentration of radioactive minerals in the soil profile.

Anomaly IV (Fig. 10)

A number of anomalous (up to 20 times background) were detected during the alpha meter survey. Two anomalies just south of 2900N are immediately south of the ground radiometric Anomaly IV over the faulted hematitic shale outcrop. The other anomalies are in areas of soil covered granite (CZS/Pgr).

During this survey alphameter results were gathered in two geological environments and these may affect interpretation of anomalies detected.

Alphameter anomalies were detected in areas of outcrop and may have been produced by radon gas emanating from the immediate vicinity of the sample point. Radon anomalies were also detected in areas of soil cover and are more difficult to interpret; radon gas is able to travel along structural features such as joints and faults not visible on the surface and can offset the detected surface anomaly from the alpha source below. In addition, radon gas detection methods are unable to distinguish between alpha sources in the rocks at depth and those produced by scavenged enrichment in the soil profile.

The significance of alphameter anomalies will be tested by a drilling programme of shallow holes in the vicinity of each anomaly.

(b) Magnetometer Survey.

A portable proton precession magnetometer (G-816) was hired from Geometrics International Corp. With this instrument ground magnetic surveys were carried out over the grids covering Anomalies I, III and IV (see Fig. 11, 12, 13).
In general the survey produced disappointing results, where neither structural features nor lithological variation produced anything better than a vague magnetic signature.

At Anomaly I, "streaking" of the magnetic contours into a series of elongate negative anomalies west of 5000E parallels the strike direction of mapped faults. A positive anomaly centred on 5350N, 5700E is in response to laterite development.

Magnetics results for Anomalies III and IV are inconclusive.

6.7 Geological Mapping at 1:2,500

Geological mapping at 1:2,500 scale was carried out by P. Goldner of Union Oil Development Corporation on Anomalies I, III and IV. On anomaly II mapping at the same scale was carried out by R. Mosig of Minad.

(a) Anomaly I.

Detailed Geology.

The high radioactivity in this area is associated with a north easterly trending fault within the Murphy Metamorphics near the contact of this unit with the Nicholson Granite.

The area is deeply weathered making rock identification both in hand specimen and thin section extremely difficult and of necessity therefore some of the identifications and groupings into units is at present tentative (see Fig. 14). Petrological work was undertaken by W. Fander of CMS Laboratories and petrological reports are included in Appendix IV.

The Murphy Metamorphics are represented by a sequence of generally fine grained metasediments ranging from siltstones to fine grained quartzites. Depending on iron oxide content the rocks vary from light brown to red. In the north eastern section of the grid laterite is developed on low ridges. Some of the laterite is pisolitic, however, more commonly it occurs as a massive blocky unit which is considered to be lateritised metamorphics.

The metasediments have been divided into two units. The first is a generally fairly well cleaved unit of siltstone and quartz siltstone which petrologically consists largely of quartz and sercite. In some rocks a two stage process has occurred in which feldspar developed initially and was later replaced by sercite. Minor minerals noted in thin section included hematite, goethite, green tourmaline and zircon.

Two samples of relatively fresh metasediment were collected from the north eastern corner of the grid (BG 35 and 36 see Appendix IV).
The coarser sample consisted of a biotite bearing sandstone exhibiting some remnant bedding. The second sample BG 36 is similar in composition although much finer grained. Both exhibit evidence of hornfelsing.

The second unit distinguished within the metasediments is a spotted fine grained quartzite. Cleavage is generally poorly developed or absent and the rock has a generally more massive appearance than the siltstone unit. The unit is most prominently developed near the granite contact (see Fig. 14) although it has occasionally been noted in other sections of the grid. The spotting is thought to possibly be a contact metamorphic effect and although the spots now consist almost entirely of sericite they probably originally consisted of porphyroblasts of cordierite and feldspar.

Near the zone of high radioactivity an elongate "plug" of acid volcanic composition has been mapped. While the field term plug has been used the intrusive could be either a sill or a dyke. As can be seen similar, although smaller, outcrops of the same unit have been mapped to the east of the main body. The uniform distance between the granite and the volcanic is striking and may suggest a relationship between the two units.

In hand specimen the volcanic is composed of relatively large irregular patches of cream coloured clay set in a pale brown matrix. In some samples small altered plagioclase laths are present. In thin section the rock is composed of shapeless patches of kaolinite possibly after large orthoclase crystals with some smaller plagioclase laths now altered to a claygoethite mixture set in a groundmass of micrographically intergrown quartz and feldspar. They have been termed granophyres by W. Fander and this name is adopted for the purpose of this report.

The granophyre is highly fractured and faulted throughout, in places, small veinlets of kaolinite produced by hydrothermal alteration.

Both the southern and northern boundaries of the granophyre appear to be, at least in part, fault controlled and it is within the southern boundary fault that the zone of high radioactivity occurs.

Between the granophyre and the Nicholson Granite contact a number of small granitic intrusions have been mapped within the metamorphics, some of these have been intruded along a prominent fault zone. The faulting in the area is described in more detail below.
Structure

The area covered by the Anomaly I grid is intensely faulted, containing a major zone of faulting bounded by two prominent subparallel fault scarps striking northeast-southwest and dipping dominantly to the north-west. Numerous smaller faults, particularly within the granophyre, occur within the area bounded by the subparallel scarps. The southern-most fault scarp is the most prominent and has been intruded by granite along part of its length. This southern fault generally dips 70-85° to the northwest, however, a possible dip reversal to the southeast has been noted in one locality. The other prominent fault scarp occurs along the northern boundary of the granophyre. Fault breccia (consisting of large angular fragments of granophyre) has been developed within this fault which dips about 35° NW.

Most of the smaller faults within the area bounded by the scarp are oriented in a northeasterly direction and dip to the northwest. There appears to be a tendency for the fault dips to be steep in the vicinity of the southerly fault scarp and to gradually become more shallow towards the northern fault scarp. The smaller faults are generally less than ½ metre in width, filled with a siliceous ferruginous material and cannot be traced along strike for more than a few metres.

A larger fault occurs on the southern flank of the granophyre and this can be traced for over 70 metres. It is along part of this fault that the zone of high radioactivity is located. No dips were obtained from this fault however, the limited drilling information suggests it has a dip of 60° to the NW.

Cleavage in the metasediments is well developed to the northwest of the granophyre. Cleavage strike is dominantly in a northeast - southwest direction with dips varying from 50° NW to vertical. A crenulated cleavage has been noted in a number of places.

Bedding within the metamorphics has only been tentatively recognised in two adjacent localities. Here again dips are steeply to the northwest.

Zone of High Radioactivity.

The zone of high radioactivity occurs within a fault zone possibly up to 5 metres wide on the southern boundary of the granophyre. The high radioactivity response is only obtained over a limited strike fault length and is certainly not present along the entire length of the fault.

The material within the fault consists of a siliceous ferruginous rock generally with a rather vuggy appearance. Numerous irregular veinlets of a white amorphous material occur throughout the rock. This material exhibits a bright green fluorescence under ultra-violet light and is only found where the radioactivity is anomalously high. It has been identified in thin section as opaline silica.
During the 1977 field programme some torbernite mineralization was found in a specimen of fault material occurring as float in a small creek draining the area of anomaly. No other uranium mineralization has been found in the area.

Sample BG 17 (see Appendix IV) was taken from the area of high radioactivity and is described by Central Mineralogical Services, Adelaide, as a sheared quartz clay rock containing silica, clay and goethite with possibly some jarosite thought to be after pyrite. Fluorescent opaline silica occurs in fractures in this rock. An autoradiograph indicated that the radiation is correlatable with veins of limonitic argillaceous material with opaline silica. The jarosite (?) was found not to be radioactive.

A sample of this fault material was submitted to the CSIRO in Perth for investigation by a scanning electron microscope. This revealed a number of phases containing heavy metals all of which are radioactive.

The phases detected were:-

(a) U + Ca + P Probably autenite.
(b) U + Cu + P Probably torbernite.
(c) U + Si + Cu Probably the fluorescent silica.
(d) Ce + P Probably monazite.
(e) Th + Si + Ca + P + Fe + (trace Ce) possibly some Cu.

In addition iron oxides are common throughout the sample.

The grains were found to be generally very fine - less than 30 microns and often about 10-20 microns and because of this the energy dispersive spectra have Si, Cu, and Fe peaks which probably relate to the iron oxide - clay matrix in which the minerals of interest lie.

The phase which probably equates to the fluorescent silica ((c) above) appears to occur in two forms, namely as grains up to 100 microns and as very small grains of less than 10 microns. The latter appear to be rather more copper rich. The observations are strictly qualitative and only tentative as far as correct mineral composition is concerned.

While the controls of mineralization are not understood at present it would appear that structural preparation in the form of faulting and possibly the granophyre intrusive (as well as the granite) may both be important in the localisation of the radioactive material.

(b) Anomaly II.

Anomaly II, located a short distance south-west of Anomaly III (Figure 15) was detected by the 1978 airborne radiometric survey.
(b) The grid area covers a broad washplain containing basement granite with minor roof pendants of metamorphic rock. A prominent ridge of ferruginous metaquartzite outcrops in three places. Where the granite does not outcrop, distinctive yellow brown granitic soil is apparent.

The metamorphic rocks in the vicinity were mapped as contact metamorphosed acid volcanics, however, the rocks appear very similar to the argillized-ferruginous-microgneisses described by Central Mineralogical Services, Adelaide (refer Appendix IV). Sericite is found as small flecks throughout the metamorphics and probably represents replacements of felspar. In general large amounts of biotite are present in the metamorphics, however, gneissosity is not obvious in most hand specimens.

Faulting is somewhat obscured for the main area of Anomaly II. This is primarily due to the lack of outcrop and the relatively thick washplain gravel developed on the non-outcrop areas. A definite fault trend is exemplified along the metaquartzite ridge in the northern portion of the map (Fig. 15).

Anomalously high radiometric readings were located along the face of the prominent fault scarp of ferruginous metaquartzite. The readings were generally restricted to a point source area of 5 square metres. No visible mineralization was encountered although a significant alphasitet anomoly was recorded on the hanging wall side of the ferruginous metaquartzite.

(c) Anomaly III.

**Introduction.**

This anomaly is located approximately 5 kilometres south of Anomaly I. The area appears to have a similar geological framework to Anomaly I as the zone of anomalous radioactivity is associated with a fault zone within low grade metasediments close to the contact with the Nicholson Granite (see Plan 16).

**Detailed Geology.**

The Murphy Metamorphics in the area consist, in hand specimen, as a brownish red laminated tuffaceous (?) metasandstones. Fracturing is intense and numerous small faults are present throughout the area. In thin section, however, the rocks have been termed microgneiss and were found to consist of granular feldspars, quartz, stubby biotite and hornblende in varying proportions. Alteration is usually intense. The term microgneiss refers to the textures developed in this unit and does not imply a grade of metamorphism.
In the original field mapping a second lithological unit (red hematitic siltstone) had been distinguished and this was mapped largely in the area around the major north-south fault zone which in part occurs along the granite metamorphic contact. Thin section examination of rocks from this "unit" has indicated that it is in fact the same as the microgneiss unit although possibly finer grained and more ferruginous. This is probably due to shearing and alteration associated with the fault.

A possible volcanic rock (BG 73 see appendix IV) is located around 3650N/6925E. The thin section description is rather similar to that of the microgneiss with the exception of the presence of subhedral K-feldspar crystals which were possibly phenocrysts. While this is shown as a separate unit on (Fig. 16) it could easily be a variety of the microgneiss. It is located some distance from the area of high radioactivity.

In the western and south western sections of the grid granite has also been mapped largely on the basis of soil type. While the occasional piece of granite float is found, generally, the area is entirely covered by soil and laterite.

Granite intrusions occur throughout the metamorphics and it is felt that this area is very close to the roof of the main granite intrusive.

Structure

Extensive faulting is present throughout the metamorphic sequence with fault planes generally being filled with a siliceous hematitic material. The faults are generally small and discontinuous and only a small number of the faults present are shown on (Fig. 9). The most prominent fault zone occurs in the eastern section of the grid and in part forms the contact between the granite and the metamorphics. The zone strikes north/south and dips 45-55° generally to the east. In general the rocks are not cleaved (unlike at Anomaly I) however, they are often characteristically finely laminated and this was thought to represent original bedding.

Petrological examination of the rocks suggests that the lamination is in fact a metamorphic layering. As can be seen from (Fig. 16) the dip of the lamination is generally shallow averaging about 25°. The predominant strike direction is north to north-northwest and the lamination dips are predominantly to the east.

Zone of High Radioactivity.

The zone of high radioactivity occurs near the southern end of the prominent north/south trending fault which is part forms the boundary between the granite and metamorphics in the eastern section of the grid (grid reference 3450N/6940E).
The radioactivity cannot be traced for any significant length along the fault and appears to be a very localised feature. Minor amounts of fluorescent silica have been detected by ultraviolet light in the immediate area of radioactivity however no uranium mineralization has been noted.

(d) Anomaly IV

Introduction.

Anomaly IV located a short distance south-southeast of Anomaly III (see Fig. 17) was detected by the airborne radiometric survey flown in early 1978. On initial ground follow-up, the outcrop exhibiting the anomalous radiation was found to be marked with paint indicating previous investigation. In all probability a field assistant attached to the 1977 programme may have marked the anomaly and then been unable to relocate it for follow up investigation. No other companies are known to have been active in this area.

Detailed Geology.

The grid area covers a number of prominent en-echelon fault scarps consisting largely of hematitic quartzite, often with an irregular vuggy appearance, which is extensively invaded by irregular masses of granite and some vein quartz. The vein quartz most typically occurs along the fault planes.

It appears that the Anomaly IV area represents a small remnant roof pendant of faulted and silicified Murphy Metamorphics within the Nicholson Granite. The granite does not outcrop, however, distinctive granite soil surrounds the hematitic quartzite.

In the northeast corner of the grid an outcrop of a spotted metasediment is present, however, this is separated from the area of faulting by granite. The spotted metasediment is similar in appearance to the fine grained spotted sandstone unit mapped at Anomaly I.

Sample BG82 (see Appendix IV) from this unit was thin sectioned and this work has confirmed that the rock is a metasediment consisting largely of quartz and sericite and there is some evidence that sillimanite may have been present.

Zone of High Radioactivity.

Anomalously high radioactivity occurs along the face of the prominent fault scarp in the centre of the grid. The fault dips at varying angles to the northeast and the high radioactivity is found along both sides of the rather sharp fault ridge in isolated small patches.
The radioactivity is not continuous over the length of the exposed fault. There is no visible mineralization associated with the areas of high radioactivity.

7. CONCLUSIONS.

7.1 Alphameter Survey.

Anomalies located by the alphameter survey were generally small localised areas of thick soil cover. In places, the anomalies occur in transported soils, whilst the majority of anomalies appear in residual granitic sand/soil over Nicholson Granite basement. To some extent, the significance of these anomalies with regards to their mineralization potential will be a function of evaluation by drilling. Repeatability of alphameter readings (within statistical significance) was attained, however, no surface mineralization exists over the anomalies. It is expected that drilling these alphameter anomalies will yield detailed information on the interpretation of surface alphameter readings.

7.2 Contract Drilling.

To date no conclusive drilling results are available for the four Benmara anomalies. Two incomplete diamond drillholes were attempted on Anomaly I and results of DDH-1 suggest that there is a reasonable thickness of Murphy Metamorphics overlying the Nicholson Granite within the anomaly I area. Mineralization was not intersected in either drillhole.

7.3 Geological Mapping.

(a) 1:2,500 Mapping.

The four anomalous areas have been mapped in reasonable detail at the above scale. In terms of the anomalies magnitudes, Anomaly I appears to be of higher radiometric magnitude and broader anomalous area than the other three. Indeed, in terms of geology, Anomaly I occupies a large brecciated zone separating the Murphy Metamorphics from the Nicholson Granite. The other three radiometric anomalies are of small areal extent with less obvious structural controls.

(b) 1:5,000 Mapping.

The four anomalous areas are located in or associated with Murphy Metamorphic rocks, underlain by the Nicholson Granite. Within the mapped area, the metamorphics occupy a small areal extent when compared with the ubiquitous granite. Mapping appears to show the metamorphics as relict blocks of variable thickness within the granite.

8. RECOMMENDATIONS

A further field programme for 1979 is recommended. Essentially, the programme should be based on drilling the four radiometric anomalies with detailed core and rock chip examination in order to identify the below-ground representation of the surface anomalies.
Alphameter anomalies outlined during the 1978 field programme should be further investigated by rotary/percussion drilling, however, further use alphameters - at Benmara is not recommended until the significance of the present anomalies are determined by drilling.

The structure and lithology of the Murphy Metamorphics is complex, and further investigations are required. Further infill geological mapping at 1:5,000 scale is recommended concurrent with the 1979 field programme.

Details of specific drill sites and the 1979 field programme budget are included in Appendix 5.

A fifty percent relinquishment is required on the Benmara Exploration Licence before June 1979, and in view of the negative response to geological follow up on airborne anomalous areas in the southern portion of the EL. This area should be relinquished when required.
BIBLIOGRAPHY


APPENDIX 1

Interpretation of radiometric and magnetic data by Loxton Hunting and Associates, Canberra.
R. F. Loxton, Hunting and Associates

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Photogrammetric Mapping and Computation

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Our Ref. RKJ/n1/36/78
Your Ref.

13th April, 1978

Mr. G. Evans
Mines Administration Pty. Limited
G.P.O. Box 880
BRISBANE, Qld 4001

Dear Garth,

SPECTROMETER SURVEY : BENMARA, QUEENSLAND
JOB NO. GA.22/78

Please find enclosed a letter report on the anomaly selection work undertaken on the Benmara geophysical data. Also included are provisional diagrams which hopefully will be of use during the field checking stage.

I hope that this work will be of assistance to you in evaluating the Benmara area and look forward to further discussions following your planned field trip.

Yours sincerely,

R.K. Jones

Encls:
The Exploration Manager  
Mines Administration Pty. Limited  
G.P.O. Box 880  
BRISBANE, Qld 4001  

Attention: Mr. G. Evans  

Dear Sir,

SPECTROMETER SURVEY; BENMARA, QUEENSLAND  
JOB NO. GA.22/78

Introduction

At the request of Mines Administration Pty. Limited a total of approximately 5000 line kilometres of airborne spectrometer data has been analysed with a view to the selection of anomalies for ground follow-up work. For this study the original analogue tapes, computer processed "mini-plots" and flight path recovery maps were provided. A photogeological map prepared for Mines Administration Pty. Limited by R.F. Loxton, Hunting and Associates in 1976 has also been available.

It is stressed that this work does not constitute a full and rigorous interpretation of the entire geophysical data but merely a selection of areas of anomalous uranium radioactivity.

Criteria adopted for the selection of anomalies.

The first and most obvious requirement for selection is a response in the uranium channel. The other criteria for selection include amplitude width, strike length and geological setting. The latter is of particular importance as it dictates to a large extent the importance attached to features such as amplitude and width.
In the present survey the presence of granites and acid volcanic rocks (tuffs) suggests that areas of high radioactivity (relatively) might be recorded over these units compared to areas of metamorphics and sediments. This in fact is borne out in the recorded data and the problem becomes one of selecting anomalies rather than geological effects on the level of radioactivity.

Bearing in mind the type of deposit being sought by Mines Administration Pty. Limited, i.e. "vein type" of relatively high grade, particular attention has been given to anomalies which have sharp response (generally less than 10 fiducials) and moderate to high amplitude. Care must however be given to amplitudes due to the masking effects of surficial deposits and possible surface leaching of uranium.

**Anomalies selected for ground follow-up work.**

**1st Order Priority Targets**

<table>
<thead>
<tr>
<th>Fl Line</th>
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<th>Comments</th>
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<tbody>
<tr>
<td>10/1 *</td>
<td>02277</td>
<td>Outside of survey area. Sharp uranium channel response occurs in area of relatively high K/U backgrounds within a magnetically active area mapped as granite Pgr.</td>
</tr>
<tr>
<td>11/1 *</td>
<td>01968</td>
<td>Continuation of 10/1.</td>
</tr>
<tr>
<td>33/1</td>
<td>09139</td>
<td>Local K/U anomaly on a broad K/Th high background.</td>
</tr>
<tr>
<td>36/1 *</td>
<td>10140</td>
<td>Minad's Anomaly III. In area of extensive faulted granite and Murphy Metamorphics.</td>
</tr>
<tr>
<td>37/1 *</td>
<td>10472</td>
<td>Minad's Anomaly I. In Murphy Metamorphics close to contact with granite.</td>
</tr>
<tr>
<td>38/1</td>
<td>10932</td>
<td>K/U anomaly.</td>
</tr>
<tr>
<td>39/1</td>
<td>11335</td>
<td>Minad's Anomaly II. In metamorphics and granite and possible B.I.F.</td>
</tr>
<tr>
<td>Fl Line</td>
<td>Fiducial</td>
<td>Comment</td>
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<tr>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>53/1</td>
<td>17159</td>
<td>K/U anomaly with high K; corresponding anomalies on lines 54 (16640) and 55 (16214). Within granite?? but Plm outcrops to the north and numerous dykes and faults are indicated on the photogeological map.</td>
</tr>
<tr>
<td>64/1</td>
<td>44348 $^+5$ fcds</td>
<td>K/U anomalies with Th anomaly immediately to the north. Probable granite but numerous dykes and faults.</td>
</tr>
<tr>
<td>65/1</td>
<td>44974</td>
<td></td>
</tr>
<tr>
<td>66/1</td>
<td>45334</td>
<td></td>
</tr>
<tr>
<td>128/1</td>
<td>56254</td>
<td>K/U response in area mapped as Murphy Metamorphics.</td>
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<tr>
<td>150/1 *</td>
<td>68229</td>
<td>Only uranium response. In Murphy Metamorphics and close to drainage channel (possible calcrite anomaly). At nose of fold structure. Regional ENE and NNE faults indicated.</td>
</tr>
<tr>
<td>160/1</td>
<td></td>
<td>Close to drainage channel; broad increase in uranium channel - possible calcrite.</td>
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<tr>
<td>193/1 *</td>
<td>87989</td>
<td>High amplitude K/U/Th anomaly with significant uranium response in Benmara Beds.</td>
</tr>
<tr>
<td>200/1</td>
<td>91162</td>
<td>Low amplitude uranium on broad Th - no potassium.</td>
</tr>
<tr>
<td>200/2</td>
<td>91173</td>
<td>K/U on decreasing Th - Psa.</td>
</tr>
<tr>
<td>200/3</td>
<td>91123</td>
<td>Within Ps1 - low amplitude but definite uranium response.</td>
</tr>
<tr>
<td>201/1</td>
<td>91408</td>
<td>K/U broad U - Psa.</td>
</tr>
<tr>
<td>201/2</td>
<td>91432</td>
<td>Broad K/U/Th with U peak in Th low.</td>
</tr>
<tr>
<td>202/1</td>
<td>92058-92075</td>
<td>K/U/Th high in Ptb. Benmara Beds.</td>
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<tr>
<td>202/2</td>
<td>92119</td>
<td>K/U - very low amplitude. Ps1 - Mullera Formation.</td>
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.../...
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<tr>
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<td>204/1</td>
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<td>K/U/Th with considerable U response. Benmara Beds.</td>
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<td>204/2</td>
<td>93726</td>
<td>Ps1?? - Mulera Formation.</td>
</tr>
<tr>
<td>248/1</td>
<td>94354</td>
<td>Sharp U peak within broad Thorium anomaly. Mapped as Constance Sandstone but high local Thorium values suggest possibly incorrect.</td>
</tr>
<tr>
<td>253/1</td>
<td>12731</td>
<td>K/U anomaly within possible Murphy Metamorphics.</td>
</tr>
<tr>
<td>230/1)</td>
<td>2284</td>
<td>Low amplitude K/U anomalies in close proximity to linear magnetic anomaly.</td>
</tr>
<tr>
<td>236/1)</td>
<td>4287</td>
<td></td>
</tr>
<tr>
<td>244/1)</td>
<td>6849</td>
<td></td>
</tr>
</tbody>
</table>

* Anomalies included in Minad's Provisional Test.

In addition to the above anomalies, the following lists anomalies which are considered to be a lower priority which cannot be entirely explained by the presently available geological maps:

8 (26013); 12 (18022); 25 (6417); 29 (77025); 31 (84504); 34 (93609); 43 (13023); 44 (13560); 54 (16640); 60 (22296); 61 (42962); 72 (48366); 73 (48852); 123 (53904); 130 (57246); 142 (64180 - 64186); 176 (79842).

Discussion of anomalies.

At first glance there appear to be a considerable number of priority anomalies selected for ground follow-up work, thirty in all. If however the spatial positions of the anomalies are considered it can be readily seen that many of these group together in definite areas thus reducing considerably the actual field checking stage.

Prior to a discussion of the anomalies selected it should be noted that some uranium anomalies were observed on the analogue tapes which are not included on the computer processed mini-plots. In two instances
interesting anomalies were recorded during turns between flight lines when the camera would not have been functioning. Attempts should be made to relocate these anomalies as they occur in an area where metamorphic and granitic rocks are indicated on the photogeological map. The anomalies referred to are as follows:

(1) On the turn between FL's 10 and 9.
(2) On the turn between FL's 12 and 11.
(3) On the aborted start to FL. 2 fiducial 18014.

It may be possible to relocate (3) from the tracking film.

For ease of discussion the anomalies have been grouped in units:

Group A (Anomalies 10/1, 11/1)

Anomalies 10/1 and 11/1 are associated with relatively high amplitude magnetic anomalies in an area mapped photogeologically as granite (Pgr) and some possible metamorphic units. The granites within the main survey area are not however magnetic and with possible local exceptions neither are the Murphy Metamorphics. A swarm of dykes or B.I.F.'s may be the cause. Detailed ground work is necessary to determine the cause of both the spectrometer and magnetic anomalies.

Group B (Anomalies 36/1, 37/1, 38/1, 39/1).

The anomalies grouped as B are of considerable interest. Ground checking has confirmed an area of high interest in the area of 37/1. Much of the area appears from the radiometric results to be granite but faulted blocks of Murphy Metamorphics are indicated on the geological map and this area lies within a major WNW zone of faulting. Field checking of Minad's Anomaly II revealed a possible B.I.F. and the magnetic results would appear to confirm this possibility as two distinct magnetic anomalies occur directly to the east of Anomaly II and approximately 3 kms to the NE. Approximately 1.5 kms north of Minad's Anomaly I (37/1) there occurs an east-west striking zone of low amplitude magnetic anomalies. The source of the magnetic anomalies is not clear but extensive laterite and ferruginous surficial material is noted on the photogeological maps.
Group C (Anomalies 64/1, 65/1, 66/1)

Group C is most probable due to granite but numerous faults and dykes are mapped and the presence of localised anomalies within a broader high background warrants investigations.

Group D (Anomalies 200/1, 202/1, 204/1/2)

Some of these anomalies are almost certainly the result of acid volcanics (Tuffs) within the Benmara Beds but a number of anomalies occur within units mapped as U Proterozoic sedimentary rocks. In this category are anomalies 200/2 (91173) and 201/1 (91408) which from the photogeology occur with the Constance Sandstone. Anomalies 200/3 (91123), 202 (92119) and 204 (93726) are located in unit Psl, the Mullera Formation and are very low in amplitude and of doubtful significance.

Group E (Anomalies 230/1, 236/1, 244/1, 253/1)

This group of anomalies forms a linear zone which is associated with a distinct linear magnetic anomaly. It is for this reason and the presence of Murphy Metamorphics that this group of low amplitude K/U anomalies has been selected. The magnetic anomaly may possibly be caused by a dyke intruded along a fault or shear zone. Numerous major faults and lineaments paralleling the magnetic anomaly can be seen on the geological map.

Individual anomalies which warrant comment are as follows:

**FL. 248/1 (14354)**

This anomaly lies within a broad thorium high in an area mapped as Constance Sandstone. A broad arcuate high amplitude thorium channel anomaly is recorded over a wide area and is not consistent with the response of a sandstone unit unless heavy minerals in the form of monazite and zircon are present. It is important to note that the thorium response coincides with slight depression or hollow which corresponds on the photogeological map to an area of surficial deposits. It is recommended that the area be carefully investigated as other possible low amplitude uranium anomalies were noted (e.g. 257/1 (11599)).
FL. 160 (73238)

This anomaly occurs close to a drainage feature and may possibly be associated with calcrete, although this needs to be confirmed by ground checking.

FL. 150 (68229)

A pure uranium response of low amplitude is recorded at this locality within Murphy Metamorphics. The structural location of the anomaly may be important as it occurs at the nose of a fold structure.

Yours faithfully,

R. F. LOXTON, HUNTING AND ASSOCIATES

R.K. Jones
APPENDIX 2.

Anomaly follow-up Benmara
<table>
<thead>
<tr>
<th>LINE</th>
<th>FIDUCIAL</th>
<th>TOTAL COUNT</th>
<th>K</th>
<th>U</th>
<th>Th</th>
<th>TOPOGRAPHIC LOCATION</th>
<th>GEOLOGY</th>
<th>BACKGROUND cps</th>
<th>PEAK cps</th>
<th>CONCLUSIONS</th>
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<tr>
<td>7</td>
<td>2665</td>
<td>2X</td>
<td>2X</td>
<td>2X</td>
<td>1.25X</td>
<td>Flat cut by Creek</td>
<td>Granite O/C</td>
<td>15</td>
<td>60</td>
<td>No further work.</td>
</tr>
<tr>
<td>10</td>
<td>02277</td>
<td>2kX</td>
<td>3X</td>
<td>3X</td>
<td></td>
<td>Near old station track.</td>
<td>poor granite O/C</td>
<td>40</td>
<td>70</td>
<td>No further work.</td>
</tr>
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APPENDIX 3.

Photogeological map 1:27,000 by Loxton Hunting and Associates, Canberra.
Dear Sir,

LETTER REPORT : PHOTOGEOLOGICAL STUDY
BENMARA AREA, N.T. (JOB NO. GA.30/78).

Using colour aerial photographs on the scale of 1:27 000, a detailed photogeological study of the Benmara area (EL 1235) was carried out during June 1978 by M.M. Coupard of R.F. Loxton, Hunting and Associates on behalf of Mines Administration Pty. Limited.

A larger area, which includes in its northern part the present study-area, was mapped on a photogeological reconnaissance basis by the writer in December 1976, using small-scale (1:83 000) black and white photographs. No field work was done. The general comments made in the previous report (Job no. GA.36/76) regarding earlier mapping in the area, the physiography, regional geology, structural features and previous mineral exploration, are unchanged.

The present large-scale photogeological mapping has definitely improved on the previous limited understanding of the nature, distribution, lithological differentiation and structural relationships of the basement and cover rocks, and has therefore fully justified our early recommendation...
for the stereoscopic study of large-scale colour photography (page 14, report GA. 36/76). Errors in previous interpretation, that on re-evaluation, were found to be inherent in the 1:83 000 scale photography when related to local landform, and therefore apparently not to be disputed under the stereoscope, were actually obvious, and were corrected, during annotation of the larger-scale colour photographs. Even a limited field-visit by the photogeologist would have eliminated the problem. (see later).

Field-mapping was carried out by MINAD's geologists and was designed to investigate the accuracy and applicability of our earlier small-scale photogeological mapping. A copy of the resulted "corrected" generalised map was made available to the writer (who was also responsible for the previous work) together with four oblique low level 35 mm colour slides of relevant outcrops, and areas with radioactive anomalies.

Once again the writer was not allowed any field work during execution of the photogeological mapping. This is naturally detrimental to the outcome of the stereoscopic work, and to the resultant conclusions.

The results of the detailed photogeological mapping are incorporated in one provisional work-sheet map (scale 1:27 000) which represents the most important outcome of the study. This letter-report is merely intended to supplement the map-sheet.

The aim of the detailed photogeological study was to map the lithology and structure in relation to potential uranium mineralisation, with special emphasis on the basement rocks. Attempts to recognise and trace the different units beneath shallow soil cover were made and the resultant interpretations are shown on the accompanying map.

The study involved a total of 80 colour photographs (80 per cent overlap) on the approximate scale of 1:27 000, which were interpreted by means of a Zeiss mirror stereoscope, using 1x and 6x magnification. Annotation of photogeological detail was done directly in ink onto a transparent drainage acetate base that was derived from a self-made lay-down of the aerial photographs. The effects of mosaic distortion are negligible except along Run 1 where offsets are up to 200 m. The location of the radioactive anomalies II and III was plotted on the colour photographs by visual comparison with the small-scale black and white photographs and the accuracy of location is therefore not great. Reference was made frequently to the black and white photographs (scale 1:83 000) and to two LANDSAT scenes (scale 1:1 000 000) in order to provide a large overview of the area.
One coloured version of the provisional photogeological work-sheet map is enclosed with this letter-report.

The detailed photogeological study has resulted in the differentiation of 18 lithological units which form two broad classes referred to here as the basement rocks and the cover rocks.

The basement rocks underlie about 70 per cent of the area mapped. Whilst little information on their presence (often inferred) and nature could be obtained from the small-scale black and white photographs, their relative lithological differentiation was made easier with the large-scale colour photography; it must be stressed however that some limitations on their identification still exist and the problem will be solved only by field-mapping. Another restriction is imposed by the soil cover which is extensive in the central part of the area, and although the identity of the underlying rock type can occasionally be inferred, the soil cover is commonly sufficiently thick to even camouflage regional fractures. The basement rocks have been divided into two units.

(a) The Murphy Metamorphics

The southern part of the study-area is occupied by an exposed belt of various metamorphic rocks up to 4.5 km wide. The metamorphic rocks are largely bound to the north by the Benmara Fault; to the south they disappear owing to faulting, beneath the cover rocks (Psp, Psa, Ps1). Four distinct lithological units may be recognised on the basis of photogeological criteria, (tone, texture and morphology) owing to the relatively good exposure in this area; these have been labelled Plm - a, p, v and x. These units are suspected to include pelitic, arenitic and possible volcanic lithologies, with the arenitic phase being predominant in outcrops.

The photogeological evidence indicates that the volcanic-derived metamorphic rocks (Plm-v), conformably overlie those of arenitic and pelitic affiliation. This fact negates a possible correlation with the volcanic Benmara Beds mapped previously farther south.

Undifferentiated metamorphic rocks (Plm) form small exposures surrounded by granitic rocks in the northern and eastern parts of the area. These are generally covered by soil or laterite, and their foliation is often obscured.
(b) The Nicholson Granite Complex

Much of the central and northern part of the study-area is underlain by granitic rocks, subdivided into three lithological phases on the grounds of tone and morphological expression. This breakdown includes the following:

- a well-exposed pinkish-to-orange granitic phase in the northwestern part of the area; in the central part it forms isolated rugged hills exhibiting a bouldery topography.

- a probable highly-weathered, yellowish, granitic phase which occupies the central and eastern part of the area; low hills and allied residual soil are characteristic of this phase.

- a well-exposed greyish- to pinkish granitic phase in the northern part of the area containing numerous dyke rocks (mostly aplite, micro-granite, pegmatite), which is interpreted to represent a high-level phase of the pinkish to orange granite phase. It was previously unrecognised because the resolution of the black and white photographs on the scale of 1:83 000 was too low to detect these dykes whose width rarely exceed 1 m along a lateral extent of 100 m.

This high-level granite outcrops along a block which is bound by two large faults trending 300°. Two radioactive anomalies (numbered II and III) appear to be linked with the granite rather than with its contact with the Murphy Metamorphics (as for anomaly I).

Cover rocks are extensively developed in the northern and southern part of the study-area. The detailed photogeological study has definitely improved on the previous mapping, providing many refinements and has led to the recognition of a new formation in the central part of the area, consisting of three units (Psq1, Psq2 and Psqq) which form an elongated basin truncated by the Benmara Fault to the south. The stratigraphy is mostly arenitic in character with some quartzitic members in the lower half; the upper half of the sequence has a more weathered (? pelitic) character.

The outcrop area of the Constance Sandstone (Psa) has been significantly modified from the previous mapping, which assigned to it a dome structure. The present mapping indicates that the beds of the Constance Sandstone have been subjected to considerable deformation, including over-turning and later arching, and that they form a basin structure with numerous warps, with the central part of the basin occupied by the lower member of the Mullera Formation (Ps1). This error of interpretation in the previous mapping has many implications from a stratigraphic and structural viewpoint:

.../...
the unit north of the Constance Sandstone cannot be assigned to
the Mullera Formation (Psl) but must be correlated with a unit older
than the Constance Sandstone; it has been provisionally equated
with the Pandanus Siltstone Member (Psp);

Units Psq1 and Psq2 may represent a time-stratigraphic equiva-
 lent of the Constance Sandstone, separated by a horst composed of
Murphy Metamorphics.

the basin structure outlined by the outcrop of the Constance
Sandstone and Mullera Formation was formed by Lower Cambri-
times, providing a site for the deposition of the Bukalara Sandstone
(Elb).

The areal extent of surficial deposits has been reduced by a significant
amount and where possible attempts have been made to identify the rock type
beneath.

Although the major structural features identified during the earlier
mapping remain unchanged, the present mapping has elucidated some
relevant details, such as isoclinal folding in the metamorphic rocks and
high-level granites trending approximately 300°, whilst also eliminating
some errors such as the dome structure affecting the Constance Sandstone.

In conclusion the present photogeological mapping using colour aerial
photographs on the scale of 1:27 000 has led to a substantial improvement on
the previous mapping, despite the fact that no field checking was allowed.
The basement rocks have been divided into six units, whilst the cover rocks
into twelve units. It is recommended that field checking of all units be
carried out, particularly of the metamorphic terrain displaying complex
folding, and that the results be combined with geochemical and geophysical
data to allow a satisfactory appraisal of the area.

Yours faithfully,

R. F. LOXTON, HUNTING AND ASSOCIATES

M. M. Coupard
# LIST OF AERIAL PHOTOGRAPHS USED

### Colour photographs on the approximate scale of 1:27,000

Source: Mines Administration Pty. Limited BKS Surveys

<table>
<thead>
<tr>
<th>Job Name</th>
<th>Job No.</th>
<th>Date</th>
<th>Run No.</th>
<th>Photo Nos.</th>
<th>Quality *</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL 1235 Benmara</td>
<td>BKS 5</td>
<td>5.5.78</td>
<td>1</td>
<td>3408-3435</td>
<td>Fair</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>2</td>
<td>3382-3407</td>
<td>&quot;</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>3</td>
<td>3356-3381</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

80% overlap - 20-30% sidelap

* The printing quality included an undesired dark blue tone (poor colour balance); numerous spots and scratches (retouched during printing) are visible under high magnification (6x).

### Black and white photographs on the approximate scale of 1:83,000

Source: Division of National Mapping

<table>
<thead>
<tr>
<th>Job Name</th>
<th>Job No.</th>
<th>Date</th>
<th>Run No.</th>
<th>Photo Nos.</th>
<th>Quality **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calvert Hills</td>
<td>CAG 324</td>
<td>2.6.68</td>
<td>7</td>
<td>54-60</td>
<td>Very poor</td>
</tr>
<tr>
<td>&quot;</td>
<td>&quot;</td>
<td>&quot;</td>
<td>8</td>
<td>182-189</td>
<td>Poor</td>
</tr>
</tbody>
</table>

** Owing to much marking (including pinholes).

### LANDSAT non digitally enhanced colour composite scenes on the scale of 1:1,000,000

Source: NASA

<table>
<thead>
<tr>
<th>Job No.</th>
<th>Date</th>
<th>Band</th>
</tr>
</thead>
<tbody>
<tr>
<td>E 1029-00233</td>
<td>21.8.72</td>
<td>4 + 5 + 7</td>
</tr>
<tr>
<td>E 1029-00231</td>
<td>21.8.72</td>
<td>4 + 5 + 7</td>
</tr>
</tbody>
</table>
APPENDIX 4.

Petrography reports by CMS Adelaide.
Central Mineralogical Services

8th August 1978

Mr. Garth Evans,
Geologist,
Mines Administration Pty. Ltd.,
GPO Box 880,
BRISBANE. Q. 4001

REPORT CMS 78/7/30

YOUR REFERENCE: Letter, 25.7.78
DATE RECEIVED: 26.7.78
SAMPLE NOS.: BG 1, 8, 11, 12,
           , 15, 17, 18, 20, 24,
           , 28, 29, 32, 34
SUBMITTED BY: G. Evans
WORK REQUESTED: Petrology/Mineralogy

Copy to:

Mr. P. Goldner,
Union Oil Development Corporation,
8 - 12 Bridge Street,
SYDNEY. N.S.W. 2000
Thirteen samples were received for thin-section preparation and descriptions, and comparison with previous samples.

Almost all the rocks are severely altered, making interpretation difficult, and, in many cases, tentative; this applies especially to sheared or brecciated material. In some instances there is difficulty even in determining whether the rock is igneous or sedimentary. The descriptions are presented in the accompanying tables.

Comments

Several of the rocks are fairly clearly of igneous origin, though precise classification is no longer possible because of the total kaolinisation of the feldspars. They are believed to be feldspar-rich types, perhaps originally composed of large orthoclase crystals, smaller laths of plagioclase (represented by clay-goethite pseudomorphs) and interstitial micrographically intergrown quartz-feldspar. These rocks have been termed granophyres (because of recognisable, distinctive textures) and include BG 8, BG 15, BG 29 and possibly BG 32 as a finer-grained equivalent.

Some of the other rocks are recognisable as former sediments; they seem to have been siltstones and sandy siltstones which were subjected to very low-grade hydrothermal alteration, principally sericitisation, with the development of fine and coarser sercite-hyromuscovite. In some rocks this may have been a two-stage process, in which feldspar developed initially, to be replaced subsequently by sercite; there is some textural evidence to support this. This group includes BG 11, 12, 20, 34 and 24.

Samples BG 1 and BG 18 are of doubtful origin; though they have been termed aplites, they may in fact be sericitised feldspathic hornfelses and thus be assigned to the group of metasediments.

BG 17 is so altered that it cannot be satisfactorily classified. The mineralisation in this rock (and in BG 24) occurs as strongly fluorescent opaline silica veneers on fracture-surfaces. A mineral which is believed to be jarosite, is also present in BG 17 and 18, having formed from the oxidation of pyrite; it will be rechecked when the autoradiographs are ready.

Few comparisons were possible, since in the previous work only x-4, -12, -25 and x-28 were examined. The granophyres are correlatable with x-4 and possibly x-12, and the metasediments with x-25, x-28.

H.W. Fander, M.Sc.
<table>
<thead>
<tr>
<th>Sample Details</th>
<th>Rock Type</th>
<th>Composition</th>
<th>Fabric</th>
<th>Minor Minerals</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG 8</td>
<td>Argillised ?Granophyre. Dominantly shapeless patches fine semi-amorphous and coarser flaky kaolinite; relict patches of quartz with micrographic textures. Re-stained.</td>
<td>Very poor fabric, some doubtful feldspar outlines (phenocrysts).</td>
<td>Shapeless, diffuse leucoxene patches. Kaolinite veins cut rock.</td>
<td>Could have been feldspathic granophyre, with large feldspar crystals (two species) and interstitial micrographic quartz/feldspar. Quartz not common.</td>
<td></td>
</tr>
<tr>
<td>BG 12</td>
<td>Spotted Hornfels. Very small, stubby, random and subparallel sericite flakes, fine interstitial quartz; void spots of fine sericite = altered zandulite/cordierite.</td>
<td>Typical fine hornfelsic fabric; homogeneous; spots randomly distributed.</td>
<td>Extensive goethite-staining in places.</td>
<td>Original rock was argillaceous siltstone; subjected to low-grade contact metamorphism. Far more argillaceous than x25.</td>
<td></td>
</tr>
<tr>
<td>BG 20</td>
<td>Sericitised Sandy Siltstone. Scattered sericite &quot;spots&quot; in silt and fine-sand size clastic quartz, abundant interstitial fine sericite and earthy hematite.</td>
<td>Clastic textures obvious. Some grading from fine silt to coarser silt.</td>
<td>Detrital green tourmaline, muscovite flakes. Quartz veins.</td>
<td>May be related to BG 11. Clearly a low grade contact-metamorphosed sediment. Relationship to BG 17, 18 not clear.</td>
<td></td>
</tr>
<tr>
<td>BG 24</td>
<td>Sheared Ferruginised Quartzite. Angular fragments and mylonitised fine quartz, with earthy, argillaceous limonite; mostly ultrafine quartz.</td>
<td>Preferred orientation due to strong shearing crushing.</td>
<td>Quartz veins. Goethite patches &amp; veins. Fluorescent opaline S10g on surfaces.</td>
<td>Original rock was quartzite/meta-quartzite. No relict clastic features but probably sedimentary, perhaps argillaceous.</td>
<td></td>
</tr>
<tr>
<td>Sample Details</td>
<td>Rock Type</td>
<td>Composition</td>
<td>Fabric</td>
<td>Minor Minerals</td>
<td>Comments</td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>-----------------------------------------</td>
<td>-----------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fe-oxide pigment in feldspar. Small hematite spots in argillised feldspar.</td>
<td>Selective argillisation of plagioclase and feldspathisation, with hueic acularia overgrowths on orthoclase.</td>
<td></td>
</tr>
<tr>
<td>BG 29</td>
<td>Kaolinite 7Granophyre. Dominantly large shapeless patches of kaolinite flakes, interstitial clay-goethite, minor quartz, with micrographic textures.</td>
<td>Poorly preserved feldspar pseudomorphs; probably strongly porphyritic.</td>
<td>Diffuse leucocene patches. Goethite patches and veins.</td>
<td>Similar to BG 8, BG 15. Interpreted as porphyritic, feldspathic rock with interstitial granophytic patches.</td>
<td></td>
</tr>
<tr>
<td>BG 34</td>
<td>Sericitised Quartzite. Subangular, sand- 6 silt-grade quartz grains, with interstitial fine sericite and coarser, random hydromuscovite flakes, earthy goethite patches.</td>
<td>Relict clastic textures and poor bedding preserved.</td>
<td>Detritally-rounded zircon. Healed quartz veinlets.</td>
<td>Reasonably similar to BG 20 but not 24. (though 24 could be sheared equivalent). This rock also vaguely resembles BG 1.</td>
<td></td>
</tr>
</tbody>
</table>
Central Mineralogical Services

21st August 1978

Mr. G.R. Evans,
Senior Geologist,
Mines Administration Pty. Ltd.,
31 Charlotte Street,
BRISBANE. QLD. 4000

REPORT CMS 78/8/8

YOUR REFERENCE: Letter, 2.8.78, G.R. Evans

DATE RECEIVED: 7.8.78

SAMPLES: 14 specimens prefixed "BG"

SUBMITTED BY: G.R. Evans

WORK REQUESTED: Petrology

Copy to:

Mr. P. Goldner,
Union Oil Development Corporation,
8 - 12 Bridge Street,
SYDNEY. N.S.W. 2000

H.W. Fander, M.Sc.
Fourteen rocks were received for sectioning, examination and comparison with the previous suite (CMS 78/7/30). The rocks are briefly described in the accompanying tables, including appropriate comments. As in the previous suite, alteration (particularly ferruginisation) has obscured or obliterated many critical details, but on the whole the rocks are in a better state of preservation and thus interpreted with greater confidence.

N.B.: Autoradiographs of BG 17 and 18 from the previous suite, showed diffuse radiation in BG 17 correlatable with veins of limonitic, argillaceous material with opaline silica. The "jarosite" is not radioactive (i.e. not a jarosite-like uranium mineral).

Summary The largest group comprises BG 62, 64, 66, 68, 71, 72, and 74; BG 73 may be assigned to this group but is doubtful. This is a series of rocks termed "microgneisses", since they are neither schists (too little mica) nor gneisses (too fine and homogeneous) and no other, more appropriate term is available. These rocks are composed of generally granular feldspars, quartz, stubby biotite, and hornblende in varying proportions, mostly severely altered. There is no evidence to suggest the nature of the original rocks and at this stage this problem must remain open. They are regionally metamorphosed but with some tendency to be hornfelsic, i.e. thermal influences were stronger than directed pressure.

This group is not really correlatable with any of the earlier series of rocks.

The "granophyre" can be correlated with BG 8, 15 and 29; relict textures are better-preserved because the rock is not sheared, and some features suggest that it may possibly have been more in the nature of a diorite, with interstitial graphic quartz/feldspar patches, i.e. oversaturated; however, this interpretation is tentative.

H.W. Fander, M.Sc.
<table>
<thead>
<tr>
<th>Sample Details</th>
<th>Rock Type</th>
<th>Composition</th>
<th>Fabric</th>
<th>Minor Minerals</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG 39</td>
<td>Argillised 7Granophyre. Clear evidence of two types of feldspar, as random prismatic crystals, both argillised, one ferruginised. Interstitial micrographic quartz patches.</td>
<td>Random medium/coarse fabric, consistent with a minor intrusive texture.</td>
<td>Patches of degraded, iron-stained mica.</td>
<td>Correlates with BG 8, 15, 29, with better preserved textures. Possibility that original rock was perhaps more dioritic than granitic?</td>
<td></td>
</tr>
<tr>
<td>BG 36</td>
<td>Fine Micaceous Hornfels. Very fine sub-rounded flakes of degraded biotite intimately intergrown with quartz and sericite, with a few spots of altered Toccordelite.</td>
<td>Very fine-grained, partly schistose, partly hornfelsic.</td>
<td>Weakly ferruginous throughout, due to partial decomposition.</td>
<td>Really a cross between schist and hornfels of low metamorphic grade. Possibly correlateable with BG 12.</td>
<td></td>
</tr>
<tr>
<td>BG 64</td>
<td>Argillised Microgneiss/Schist. Finely granular quartz, kaolinitised feldspar patches, sub-parallel stubby altered mica flakes, all finely strongly ferruginised.</td>
<td>More granular than schistose; distinctly banded. Ave grain size = 0.1 mm.</td>
<td>Small hematite flakes. Quartz-hematite veins (crosscutting).</td>
<td>Clearly a low-grade regionally metamorphosed semipelitic sediment. Bleached patches are later, unrelated cavity-fillings.</td>
<td></td>
</tr>
<tr>
<td>BG 74</td>
<td>Banded, Argillised Microgneiss. Alternating thin bands of feldspars, quartz, biotite, dark ferruginous altered hornblende. Feldspars &amp; biotite altered.</td>
<td>Fine compositional banding. Ave grain size = 0.1 mm.</td>
<td>Fine hornblende inclusions in quartz, projected from alteration.</td>
<td>Closely similar to BG 62 in particular, &amp; probably more amphibolitic, of sedimentary origin. No evidence of pyroclastic material.</td>
<td></td>
</tr>
<tr>
<td>Sample Details</td>
<td>Rock Type - Composition</td>
<td>Fabric</td>
<td>Minor Minerals</td>
<td>Comments</td>
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<tr>
<td>----------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>----------------------------------------------------</td>
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<td></td>
</tr>
<tr>
<td>BG 71</td>
<td>Argillised Micogneiss. Finely granular argillised feldspar, quartz, fine micaceous hematite; probably two feldspar varieties originally presented.</td>
<td>Fine-grained; finely banded in places; distinct preferred orientation.</td>
<td>Occasional 7feldspar porphyroblasts, and hematite-goethite veinlets.</td>
<td>Closely similar to BG 72 and others in this group, though biotite not detected. Fabric not markedly lined.</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 5.

Proposed 1979 field programme and budget.
1. **DIAMOND DRILLING.**

A programme of 200 metres core drilling has been proposed at Anomaly I only. It is considered that adequate drill testing can be carried out using open hole/percussion methods. Set out below are details outlining the reasons for locating the drill holes at their respective position.

(a) **Geological Information Available.**

Anomaly I is situated within the confinements of a fault zone between Nicholson Granite and Murphy Metamorphics. The Murphy Metamorphics have been studied petrographically and may be a granophyre.

(b) **Drilling Information Available.**

Diamond hole BNM DDH - 1 drilled in August 1978 and abandoned at 53 metres offers a limited amount of information. From the drill hole section, it can be seen that the fault zone $F_1$ cannot be dipping towards the north at an angle of less than $78 {}^\circ$. DDH-1 also intersected a fault zone however, not mineralization was encountered. Accordingly the mineralization:

(i) Follows the fault plane dip and has been leached from the intersected depth.

(ii) Follows the fault plane dip of vertical or at some angle dipping to the south.

(iii) Does not follow the fault plane dip but is confined to the faulted zone between $F_1$ and $F_2$.

To test (i) above (although it seems highly unlikely) a vertical hole at BNM DDH - 1 is proposed. This hole could be core and to 70 m depth would be No. 4 on the priority.

To test (ii) above (which seems likely) diamond hole DDH-A would be inclined at $60 {}^\circ$ and depth 50 m.

To test (iii) above (which also seems likely) two diamond holes DDH-B DDH-C are proposed.

PROPOSED

(c) **Diamond Drilling Summary.**
<table>
<thead>
<tr>
<th>PROPOSED DIAMOND DRILL HOLE</th>
<th>AZIMUTH °</th>
<th>DIP °</th>
<th>DEPTH m</th>
<th>PRIORITY</th>
<th>CO-ORDINATES m</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDH-A</td>
<td>160</td>
<td>60</td>
<td>50</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>DDH-B</td>
<td>160</td>
<td>60</td>
<td>70</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>DDH-C</td>
<td>-</td>
<td>Vert</td>
<td>70</td>
<td>3</td>
<td>(4971E 5037N)</td>
</tr>
<tr>
<td>DDH-D</td>
<td>-</td>
<td>Vert</td>
<td>70</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL** 260 metres

2. **PERCUSSION DRILLING.**

It is proposed that anomalies II, III and IV be tested by percussion drilling. In addition, alphameter anomalies will also be investigated by lines of percussion drill holes. Details are set out in Table I.
<table>
<thead>
<tr>
<th>DRILL HOLE</th>
<th>LOCATION</th>
<th>CO-ORDINATES</th>
<th>AZIMUTH</th>
<th>DIP</th>
<th>CORE/PERCUSION</th>
<th>ESTIMATED DEPTH</th>
<th>AIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDH-3</td>
<td>Anomaly I</td>
<td>4978E 4985N</td>
<td>160°M</td>
<td>60°</td>
<td>Core</td>
<td>50m</td>
<td>To intersect mineralization, associated with dip of fault plane F₁.</td>
</tr>
<tr>
<td>DDH-4</td>
<td>Anomaly I</td>
<td>5000E 4950N</td>
<td>160°M</td>
<td>60°</td>
<td>Core</td>
<td>70m</td>
<td>To test area between Metamorphics and granite.</td>
</tr>
<tr>
<td>DDH-5</td>
<td>Anomaly I</td>
<td>5012E 4985N</td>
<td>-</td>
<td>-</td>
<td>Core</td>
<td>70m</td>
<td>as above.</td>
</tr>
<tr>
<td>DDH-6</td>
<td>Anomaly I</td>
<td>4971E 5037N</td>
<td>-</td>
<td>-</td>
<td>Core</td>
<td>70m</td>
<td>To intersect Fault plane F₁ at large vertical depth.</td>
</tr>
<tr>
<td>PDH-1</td>
<td>Anomaly II</td>
<td>6727E 2810N</td>
<td>160°M</td>
<td>60°</td>
<td>Percussion</td>
<td>60m</td>
<td>Investigation source of Anomaly II.</td>
</tr>
<tr>
<td>PDH-2</td>
<td>Anomaly II</td>
<td>6705E 2800N</td>
<td>160°M</td>
<td>60°</td>
<td>Percussion</td>
<td>60m</td>
<td>As above.</td>
</tr>
<tr>
<td>PDH-3</td>
<td>Anomaly II</td>
<td>6675E 2787N</td>
<td>160°M</td>
<td>60°</td>
<td>&quot;</td>
<td>60m</td>
<td>&quot;</td>
</tr>
<tr>
<td>PDH-4</td>
<td>Anomaly II</td>
<td>6700E 2810N</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
<td>50m</td>
<td>Investigate alphameter anomaly.</td>
</tr>
<tr>
<td>PDH-5</td>
<td>Anomaly II</td>
<td>6720E 2820N</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
<td>40m</td>
<td>As above.</td>
</tr>
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<td>PDH-6</td>
<td>Anomaly III</td>
<td>6964E 3470N</td>
<td>295°M</td>
<td>60°</td>
<td>&quot;</td>
<td>60m</td>
<td>Investigate Anomaly III</td>
</tr>
<tr>
<td>PDH-7</td>
<td>Anomaly III</td>
<td>6952E 3450N</td>
<td>295°M</td>
<td>60°</td>
<td>&quot;</td>
<td>60m</td>
<td>As above.</td>
</tr>
<tr>
<td>PDH-8</td>
<td>Anomaly III</td>
<td>6946E 3425N</td>
<td>295°M</td>
<td>60°</td>
<td>&quot;</td>
<td>60m</td>
<td>As above.</td>
</tr>
<tr>
<td>PDH-9</td>
<td>Anomaly III</td>
<td>7000E 3300N</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
<td>40m</td>
<td>Investigate alphameter anomaly.</td>
</tr>
<tr>
<td>PDH-10</td>
<td>Anomaly III</td>
<td>6975E 3300N</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
<td>60m</td>
<td>As above.</td>
</tr>
<tr>
<td>PDH-11</td>
<td>Anomaly III</td>
<td>6800E 3350N</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
<td>40m</td>
<td>Investigate alphameter anomaly.</td>
</tr>
<tr>
<td>PDH-12</td>
<td>Anomaly III</td>
<td>6825E 3350N</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
<td>40m</td>
<td>Investigate alphameter anomaly.</td>
</tr>
<tr>
<td>PDH-13</td>
<td>Anomaly III</td>
<td>6600E 3750N</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
<td>40m</td>
<td>Investigate alphameter anomaly.</td>
</tr>
<tr>
<td>PDH-14</td>
<td>Anomaly III</td>
<td>6625E 3725N</td>
<td>-</td>
<td>-</td>
<td>&quot;</td>
<td>40m</td>
<td>Investigate alphameter anomaly.</td>
</tr>
</tbody>
</table>
EXPENDITURE BENMARA FIELD PROGRAMME $979

(i) Technical Salaries.
1 Supervising geologist @ 6 days @ $230/day. $1,380
1 Geologist @ 35 days @ $175/day. $6,125
1 Field Assistant @ $90 day @ 35 days. $3,150
Total: $10,655

(ii) Drilling.
Location and disestablishment. $1,500
150 m diamond drilling @ $50/m $8,250
1000 m non-core drilling @ $20/m $20,000
Water carting. $400
Casing, reaming. $200
Total: $30,350

(iii) Analyses/Petrography
5 Petrographic thin sections @ $14/section. $70
Analysis 200 samples @ $8.00/analysis. $1600
Total: $1,670

(iv) Geophysics
Down hole logging unit 4 weeks @ $300/week. $1,200
Spectrometer @ $200/month. $200
1 scintillometer @ $120/month. $120
1 magnetometer @ $600/month. $600
Total: $2,120

(v) Air Charter
3 flights @ $400/flight. $1,200
Total: $1,200

(vi) Vehicle Hire
1 x 4WD @ $800/month. $800
Running costs and spares @ $500/month. $500
Total: $1,300

(vii) Communication.
Correspondence, telegrams. $500
(viii) **Accommodation/Camping/Travel.**

Accommodation Mt Isa. $300

Food/cooking/lighting etc. $70/wk/man. 2 men x 4 weeks. $560

2 airfares Brisbane - Mt Isa - Brisbane. $400

**1260**

$1,260

(ix) **Freight**

Samples, equipment, stores, fuel. $500

(x) **Office.**

Reporting and assessment. 30 days @ $175/day. $5,250

Commercial Salary 400/month x 1 month. $400

Communications. $300

**5750**

$5,950

$55,505

+ 7½%

$59,668

**Say**

$60,000
<table>
<thead>
<tr>
<th>INTERVAL FROM</th>
<th>INTERVAL TO</th>
<th>RECOVERY</th>
<th>GEOLOGICAL LOG</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>16.45</td>
<td>7m (43%)</td>
<td>Strongly weathered kaolinitic rock in places heavily fractured and clayey (kaolinitic). Rock type probably weathered volcanics. Diamond drilling abandoned at 16.45 m and open hole drilling recommenced at hole collar. Open hole drilling continued to depth of 33.65 m.</td>
</tr>
<tr>
<td>0</td>
<td>33.65</td>
<td></td>
<td>Roller bit used. Strongly weathered ferruginous volcanic rock. Relict kaolinitized felspathic blebs in an aphanitic ferruginous groundmass. No recovery data collected. Rock shows some evidence of induration and alteration due to intrusion of underlying granite. Some fragments show relict granitic textures and volcanics may just be a thin veneer or roof pendant above a large granite intrusion.</td>
</tr>
<tr>
<td>33.65</td>
<td>34.35</td>
<td>0.53m (76%)</td>
<td>NQW diamond drilling recommenced. Recovery 0.53m. Strong ferruginous staining on? slickensided metavolcanic rock suggesting commencement of fault zone. Small pieces exhibit parascissosity parallel to longitudinal axis of core.</td>
</tr>
<tr>
<td>INTERVAL</td>
<td>RECOVERY</td>
<td>GEOLOGICAL LOG</td>
<td>GEOPHYSICAL LOG</td>
</tr>
<tr>
<td>----------</td>
<td>----------</td>
<td>----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>FROM</td>
<td>TO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34.35</td>
<td>35.95</td>
<td>0.9m (56%)</td>
<td>Meta-basic volcanic rock: strongly metamorphosed and granitised basic volcanic rock exhibiting taliosis and fine chlorite and magnetite groundmass. May be normal metabasic volcanic which has suffered local metamorphism due to faulting.</td>
</tr>
<tr>
<td>35.95</td>
<td>37.45</td>
<td>1.35m (90%)</td>
<td>Core loss at top of run. Small fractured areas exhibiting green talcose serpentine mineral in anastomosing veins throughout a metamorphosed basic? volcanic. At 37.45 m, rock loses schistosity and local intense metamorphic effects, and becomes moderately siliceous (secondary) but primarily basic fine grained volcanic with fine magnetite crystals and some manganese staining evident.</td>
</tr>
<tr>
<td>37.45</td>
<td>39.10</td>
<td>0.75m (45%)</td>
<td>Fractured metabasic volcanic</td>
</tr>
<tr>
<td>39.10</td>
<td>40.45</td>
<td>1.05m (78%)</td>
<td>Transition from metabasic to indurated metasediment with fine quartz veining at about 40 m.</td>
</tr>
<tr>
<td>40.95</td>
<td>43.45</td>
<td>2.4m (80%)</td>
<td>Indurated metasediment with manganese staining and high silica content with Beta quartz filling vughs.</td>
</tr>
<tr>
<td>43.45</td>
<td>44.71</td>
<td>0.88m (70%)</td>
<td>Purple brown metasediment.</td>
</tr>
<tr>
<td>44.71</td>
<td>46.45</td>
<td>0.96m (55%)</td>
<td>Metasediment with pytymatic quartz veins.</td>
</tr>
<tr>
<td>46.45</td>
<td>47.72</td>
<td>0.43m (34%)</td>
<td></td>
</tr>
<tr>
<td>47.72</td>
<td>49.14</td>
<td>1.23m (87%)</td>
<td></td>
</tr>
<tr>
<td>49.14</td>
<td>52.45</td>
<td>2.50m (76%)</td>
<td></td>
</tr>
</tbody>
</table>

END OF HOle
MINES ADMINISTRATION PTY. LIMITED

Benmara E.L.1235 N.T.
Alphameter Survey
Anomaly II

AUTHOR G. EVANS
DATE DEC. 1978

CONTOUR INTERVAL 300 c.p.h.
SCALE 1:2500

NOTE
×8 = 8 times background
300 c.p.h.
MINES ADMINISTRATION PTY LIMITED

Benmarra E.L.1235 N.T.
Alphameter Survey
Anomaly IV

AUTHOR G. EVANS
DATE DEC. 1978
CONTOUR INTERVAL 300 c.p.h.
SCALE 1:2500
NOTE 49000'b HAS BEEN SUBTRACTED FROM ALL READINGS

MINES ADMINISTRATION PTY LIMITED

Benmara E.L.1235 N.T. Magnetometer Survey Anomaly IV

AUTHOR G. EVANS SCALE 1:2500
DATE JAN 1979

20425 - V21
MINES ADMINISTRATION PTY. LIMITED

Benmara E.L. 1235 N.T.
Geological Map
Anomaly IV

AUTHOR: P. GOLDNER    SCALE: 1:2500
DATE: DEC. 1978