UTAH DEVELOPMENT COMPANY
SOUTH ALLIGATOR JOINT VENTURE

1979 SUMMARY REPORT ON JOINT VENTURE AREAS
IN THE
SOUTH ALLIGATOR RIVER VALLEY
NORTHERN TERRITORY
AUSTRALIA

REPORT NO. 325
February 1980

CR 1980-0253
UTAH DEVELOPMENT COMPANY
SOUTH ALLIGATOR JOINT VENTURE

1979 SUMMARY REPORT ON JOINT VENTURE AREAS
IN THE
SOUTH ALLIGATOR RIVER VALLEY
NORTHERN TERRITORY
AUSTRALIA

REPORT NO. 325

ALASTAIR A. BRICKELL
FEBRUARY 1980
BRISBANE
AUSTRALIA
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>LOCATION AND ACCESS</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>SUMMARY AND CONCLUSIONS</td>
<td>2</td>
</tr>
<tr>
<td>3.1</td>
<td>GENERAL SUMMARY</td>
<td>2</td>
</tr>
<tr>
<td>3.2</td>
<td>MAJOR CONCLUSIONS</td>
<td>2</td>
</tr>
<tr>
<td>3.2.1</td>
<td>Window I</td>
<td>2</td>
</tr>
<tr>
<td>3.2.2</td>
<td>Skull II</td>
<td>2</td>
</tr>
<tr>
<td>3.2.3</td>
<td>Saddle Ridge</td>
<td>3</td>
</tr>
<tr>
<td>3.2.4</td>
<td>Sleisbeck</td>
<td>3</td>
</tr>
<tr>
<td>3.2.5</td>
<td>B. Medium Priority Areas</td>
<td>3</td>
</tr>
<tr>
<td>3.2.6</td>
<td>Palette</td>
<td>3</td>
</tr>
<tr>
<td>3.2.7</td>
<td>Window II</td>
<td>3</td>
</tr>
<tr>
<td>3.2.8</td>
<td>Coronation Hill</td>
<td>3</td>
</tr>
<tr>
<td>3.2.9</td>
<td>C. Low Priority Areas</td>
<td>3</td>
</tr>
<tr>
<td>3.2.10</td>
<td>Anomaly 3-171</td>
<td>3</td>
</tr>
<tr>
<td>3.2.10</td>
<td>Rockhole Reverse Fault Extension</td>
<td>4</td>
</tr>
<tr>
<td>3.2.10</td>
<td>Anomaly 105/110</td>
<td>4</td>
</tr>
<tr>
<td>4.</td>
<td>GENERAL GEOLOGY OF THE SOUTH ALLIGATOR RIVER VALLEY</td>
<td>5</td>
</tr>
<tr>
<td>4.1</td>
<td>STRATIGRAPHY</td>
<td>5</td>
</tr>
<tr>
<td>4.1.1</td>
<td>Lower Proterozoic</td>
<td>5</td>
</tr>
<tr>
<td>4.1.2</td>
<td>Transitional Igneous Activity</td>
<td>6</td>
</tr>
<tr>
<td>4.1.3</td>
<td>Middle Proterozoic</td>
<td>6</td>
</tr>
<tr>
<td>4.1.4</td>
<td>Mesozoic</td>
<td>6</td>
</tr>
<tr>
<td>4.1.5</td>
<td>Cenozoic</td>
<td>6</td>
</tr>
<tr>
<td>4.2</td>
<td>STRUCTURE AND METAMORPHISM</td>
<td>7</td>
</tr>
<tr>
<td>4.3</td>
<td>MINERALISATION</td>
<td>7</td>
</tr>
<tr>
<td>5.</td>
<td>INDIVIDUAL PROSPECT DESCRIPTIONS</td>
<td>9</td>
</tr>
<tr>
<td>5.1</td>
<td>A. High Priority Areas</td>
<td>9</td>
</tr>
<tr>
<td>5.1.1</td>
<td>WINDOW I</td>
<td>10</td>
</tr>
<tr>
<td>5.1.2</td>
<td>Alternative Designations</td>
<td>10</td>
</tr>
<tr>
<td>5.1.3</td>
<td>Location &amp; Access</td>
<td>10</td>
</tr>
<tr>
<td>5.1.4</td>
<td>Illustrations</td>
<td>10</td>
</tr>
<tr>
<td>5.1.5</td>
<td>Tenement Status</td>
<td>10</td>
</tr>
<tr>
<td>5.1.6</td>
<td>Introduction</td>
<td>11</td>
</tr>
<tr>
<td>5.1.6.1</td>
<td>Geology</td>
<td>11</td>
</tr>
<tr>
<td>5.1.6.2</td>
<td>Stratigraphy</td>
<td>11</td>
</tr>
<tr>
<td>5.1.6.2</td>
<td>Structure</td>
<td>11</td>
</tr>
</tbody>
</table>
# TABLE OF CONTENTS (Cont'd.)

<table>
<thead>
<tr>
<th>5.1.7</th>
<th>Exploration Prior to 1980</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.7.1</td>
<td>Geological Mapping</td>
<td>12</td>
</tr>
<tr>
<td>5.1.7.2</td>
<td>Radiometrics</td>
<td>12</td>
</tr>
<tr>
<td>5.1.7.3</td>
<td>Geophysics and Geochemistry</td>
<td>13</td>
</tr>
<tr>
<td>5.1.7.4</td>
<td>Diamond Drilling</td>
<td>15</td>
</tr>
<tr>
<td>5.1.7.5</td>
<td>LANDSAT and Aerial Photography</td>
<td>18</td>
</tr>
<tr>
<td>5.1.8</td>
<td>Conclusions and Recommendations</td>
<td>18</td>
</tr>
<tr>
<td>5.1.8.1</td>
<td>Previous Track Etch and Geochemical Surveys</td>
<td>18</td>
</tr>
<tr>
<td>5.1.8.2</td>
<td>Previous Diamond Drilling at TE 9750W - TE 10725W</td>
<td>18</td>
</tr>
<tr>
<td>5.1.8.3</td>
<td>Proposed Diamond Drilling at TE 9750W - TE 10725W</td>
<td>19</td>
</tr>
<tr>
<td>5.1.8.4</td>
<td>Proposed Diamond Drilling at TE 7950W - TE 8250W</td>
<td>19</td>
</tr>
<tr>
<td>5.1.8.5</td>
<td>Radon Anomaly TE 2250W - TE 3675W</td>
<td>19</td>
</tr>
<tr>
<td>5.1.8.6</td>
<td>Anomaly R10</td>
<td>19</td>
</tr>
<tr>
<td>5.1.8.7</td>
<td>Anomaly TE 1050W / OON</td>
<td>19</td>
</tr>
<tr>
<td>5.1.8.8</td>
<td>General</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.2</th>
<th>SKULL II</th>
<th>21</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.2.1</td>
<td>Alternative Designations</td>
<td>21</td>
</tr>
<tr>
<td>5.2.2</td>
<td>Location and Access</td>
<td>21</td>
</tr>
<tr>
<td>5.2.3</td>
<td>Illustrations</td>
<td>21</td>
</tr>
<tr>
<td>5.2.4</td>
<td>Tenement Status</td>
<td>21</td>
</tr>
<tr>
<td>5.2.5</td>
<td>Introduction</td>
<td>22</td>
</tr>
<tr>
<td>5.2.6</td>
<td>Geology</td>
<td>22</td>
</tr>
<tr>
<td>5.2.6.1</td>
<td>Stratigraphy</td>
<td>22</td>
</tr>
<tr>
<td>5.2.7</td>
<td>Exploration Prior to 1980</td>
<td>24</td>
</tr>
<tr>
<td>5.2.7.1</td>
<td>Geological Mapping</td>
<td>24</td>
</tr>
<tr>
<td>5.2.7.2</td>
<td>Radiometrics</td>
<td>24</td>
</tr>
<tr>
<td>5.2.7.3</td>
<td>Geophysics and Geochemistry</td>
<td>24</td>
</tr>
<tr>
<td>5.2.7.4</td>
<td>Previous Drilling</td>
<td>25</td>
</tr>
<tr>
<td>5.2.7.5</td>
<td>LANDSAT Imagery</td>
<td>25</td>
</tr>
<tr>
<td>5.2.8</td>
<td>Conclusions and Recommendations</td>
<td>25</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5.3</th>
<th>SADDLE RIDGE</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.3.1</td>
<td>Alternative Designation</td>
<td>26</td>
</tr>
<tr>
<td>5.3.2</td>
<td>Location and Access</td>
<td>26</td>
</tr>
<tr>
<td>5.3.3</td>
<td>Illustrations</td>
<td>26</td>
</tr>
<tr>
<td>5.3.4</td>
<td>Tenement Status</td>
<td>26</td>
</tr>
<tr>
<td>5.3.5</td>
<td>Introduction</td>
<td>26</td>
</tr>
<tr>
<td>5.3.6</td>
<td>Geology</td>
<td>26</td>
</tr>
<tr>
<td>5.3.6.1</td>
<td>Stratigraphy</td>
<td>26</td>
</tr>
<tr>
<td>5.3.7</td>
<td>Mining and Associated Drilling</td>
<td>28</td>
</tr>
<tr>
<td>5.3.8</td>
<td>Exploration Prior to 1980</td>
<td>29</td>
</tr>
<tr>
<td>5.3.8.1</td>
<td>Geological Mapping</td>
<td>29</td>
</tr>
<tr>
<td>5.3.8.2</td>
<td>Radiometrics, Geophysics and Geochemistry</td>
<td>29</td>
</tr>
<tr>
<td>5.3.8.3</td>
<td>Air Photo Interpretation</td>
<td>30</td>
</tr>
<tr>
<td>5.3.9</td>
<td>Conclusions and Recommendations</td>
<td>30</td>
</tr>
<tr>
<td>Section</td>
<td>Title</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>5.4</td>
<td>SLEISBECK</td>
<td>31</td>
</tr>
<tr>
<td>5.4.1</td>
<td>Location and Access</td>
<td>31</td>
</tr>
<tr>
<td>5.4.2</td>
<td>Illustrations</td>
<td>31</td>
</tr>
<tr>
<td>5.4.3</td>
<td>Tenement Status</td>
<td>31</td>
</tr>
<tr>
<td>5.4.4</td>
<td>Introduction</td>
<td>31</td>
</tr>
<tr>
<td>5.4.5</td>
<td>Geology</td>
<td>32</td>
</tr>
<tr>
<td>5.4.5.1</td>
<td>Introduction</td>
<td>32</td>
</tr>
<tr>
<td>5.4.5.2</td>
<td>Stratigraphy</td>
<td>32</td>
</tr>
<tr>
<td>5.4.6</td>
<td>Mining</td>
<td>33</td>
</tr>
<tr>
<td>5.4.7</td>
<td>Exploration Prior to 1980</td>
<td>33</td>
</tr>
<tr>
<td>5.4.7.1</td>
<td>Introduction</td>
<td>33</td>
</tr>
<tr>
<td>5.4.7.2</td>
<td>Geological Mapping</td>
<td>34</td>
</tr>
<tr>
<td>5.4.7.3</td>
<td>Geophysics and Geochemistry</td>
<td>36</td>
</tr>
<tr>
<td>5.4.7.4</td>
<td>Drilling</td>
<td>36</td>
</tr>
<tr>
<td>5.4.7.5</td>
<td>Airborne Geophysical Survey</td>
<td>36</td>
</tr>
<tr>
<td>5.4.8</td>
<td>Conclusions and Recommendations</td>
<td>37</td>
</tr>
<tr>
<td>B.</td>
<td>Medium Priority Areas</td>
<td></td>
</tr>
<tr>
<td>5.5</td>
<td>PALETTE</td>
<td></td>
</tr>
<tr>
<td>5.5.1</td>
<td>Location and Access</td>
<td>37</td>
</tr>
<tr>
<td>5.5.2</td>
<td>Illustrations</td>
<td>37</td>
</tr>
<tr>
<td>5.5.3</td>
<td>Tenement Status</td>
<td>37</td>
</tr>
<tr>
<td>5.5.4</td>
<td>Introduction</td>
<td>37</td>
</tr>
<tr>
<td>5.5.5</td>
<td>Geology</td>
<td>37</td>
</tr>
<tr>
<td>5.5.6</td>
<td>Conclusions and Recommendations</td>
<td>37</td>
</tr>
<tr>
<td>5.6</td>
<td>WINDOW II</td>
<td></td>
</tr>
<tr>
<td>5.6.1</td>
<td>Location and Access</td>
<td>39</td>
</tr>
<tr>
<td>5.6.2</td>
<td>Tenement Status</td>
<td>39</td>
</tr>
<tr>
<td>5.6.3</td>
<td>Geology</td>
<td>39</td>
</tr>
<tr>
<td>5.6.4</td>
<td>Exploration Prior to 1980</td>
<td>39</td>
</tr>
<tr>
<td>5.6.5</td>
<td>Conclusions and Recommendations</td>
<td>40</td>
</tr>
<tr>
<td>5.7</td>
<td>CORONATION HILL</td>
<td></td>
</tr>
<tr>
<td>5.7.1</td>
<td>Location and Access</td>
<td>41</td>
</tr>
<tr>
<td>5.7.2</td>
<td>Tenement Status</td>
<td>41</td>
</tr>
<tr>
<td>5.7.3</td>
<td>Introduction</td>
<td>41</td>
</tr>
<tr>
<td>5.7.4</td>
<td>Geology and Mineralisation</td>
<td>42</td>
</tr>
<tr>
<td>5.7.5</td>
<td>Summary and Conclusions</td>
<td></td>
</tr>
<tr>
<td>C.</td>
<td>Low Priority Areas</td>
<td></td>
</tr>
<tr>
<td>5.8</td>
<td>ANOMALY 3 - 171</td>
<td></td>
</tr>
<tr>
<td>5.8.1</td>
<td>Summary</td>
<td>43</td>
</tr>
<tr>
<td>5.8.2</td>
<td>Recommendations</td>
<td>43</td>
</tr>
<tr>
<td>5.9</td>
<td>ROCKHOLE REVERSE FAULT EXTENSION</td>
<td></td>
</tr>
<tr>
<td>5.9.1</td>
<td>Summary and Recommendations</td>
<td>43</td>
</tr>
<tr>
<td>5.10</td>
<td>ANOMALY 105/110</td>
<td></td>
</tr>
<tr>
<td>5.10.1</td>
<td>Summary and Recommendations</td>
<td>43</td>
</tr>
</tbody>
</table>
### Table of Contents (Cont'd.)

| 6. | NOTES ON THE ALLIGATOR RIVERS URANIUM FIELDS | 45 |
| 6.1 | EAST ALLIGATOR RIVER FIELD | 45 |
| 6.2 | SOUTH ALLIGATOR RIVER FIELD | 45 |
| 6.3 | SUMMARY | 46 |

### Appendix I

**Descriptions of Two South Alligator River Valley Mine Areas**

1. **El Sherana and El Sherana West**
   - Illustrations | 1 |
   - Introduction | 1 |
   - Geology | 1 |
   - Mineralisation | 1 |

2. **Rockhole Mine**
   - Illustrations | 2 |
   - Introduction | 2 |
   - Geology | 2 |
   - Mineralisation | 3 |

### Appendix II

**Selected Bibliography**

### Appendix III

**Summarised Contents of Noranda Australia Reports on South Alligator Joint Venture**

### Appendix IV

**Lowder Geoscience Petrological Report on 33 South Alligator Samples**

### Appendix V

**Geoterrex Report on 1979 "Input" Airborne EM Survey of the Sleisbeck Area**
LIST OF ILLUSTRATIONS

FIGURES

FIGURE 1  Locality Map 1:1,000,000

"  2  Window I  Oblique aerial view of Window I and South Alligator River Valley looking SE

"  3  Photo 1  - Angular unconformity at Rockhole Mine between Lower Proterozoic Koolpin Formation and Middle Proterozoic Conglomerate

Photo 2  - Thrust fault in Middle Proterozoic sandstones at Koolpin Gorge

Photo 3  - Koolpin Formation at Rockhole Mine - Unit P15 showing interbedded chert and siltstone

Photo 4  - Koolpin Formation at Rockhole Mine - Unit P15 showing development of chert nodule

PLATES

PLATE 1  Regional Geological Plan 1:25,000

"  2  Scinto Plateau - Geological Plan 1:5,000

"  3  Scinto Plateau - Geological cross sections 1:5,000

"  4  Window I  - Geological Plan

"  5  Window I  - Detailed geology and Track Etch results 1:5,000

"  6  Window I  - Geological cross sections 1:500

"  7  Skull II  - Geological Plan 1:2,500

"  8  Skull II  - Schematic cross sections 1:2,500

"  9  Saddle Ridge  - Geological Plan 1:2,500

" 10  Saddle Ridge  - Schematic cross section 1:2,500

" 11  Sleisbeck  - Interpretation map - Airborne EM survey 1:15,800

" 12  Sleisbeck  - Structural interpretation of residual magnetic intensity 1:15,800

" 13  Sleisbeck  - Regional geological plan 1:16,800

" 14  Palette  - Geological plan 1:480

" 15  Palette  - Schematic cross section 1:960

" 16  El Sherana Mine  - Geological plan 1:480

" 17  El Sherana Mine  - Geological cross sections 1:480

" 18  El Sherana Mine  - Longitudinal section and composite level plan 1:1,200

" 19  Rockhole Mine  - Geological plan - Sheet A 1:480

Sheet B 1:480
<table>
<thead>
<tr>
<th>PLATE</th>
<th>Description</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>El Sherana Mine - Geological plan</td>
<td>1:480</td>
</tr>
<tr>
<td>&quot; 17</td>
<td>El Sherana Mine - Geological cross sections</td>
<td>1:480</td>
</tr>
<tr>
<td>&quot; 18</td>
<td>El Sherana Mine - Longitudinal section and composite level plan</td>
<td>1:1,200</td>
</tr>
<tr>
<td>&quot; 19</td>
<td>Rockhole Mine - Geological Plan - Sheet A</td>
<td>1:480</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sheet B 1:480</td>
</tr>
<tr>
<td>&quot; 20</td>
<td>Rockhole Mine - Geological cross sections</td>
<td>1:480</td>
</tr>
<tr>
<td>&quot; 21</td>
<td>Rockhole Mine - Longitudinal section and composite level plan</td>
<td>1:960</td>
</tr>
</tbody>
</table>
1. **INTRODUCTION**

This report is intended to briefly summarise the main exploration work carried out by the South Alligator Joint Venture to date and to suggest areas where further work is required to either prove or disprove their potential as uranium or gold producers.

The four high priority areas discussed in section 5A are considered to be prime exploration targets that must be examined in depth regardless of one's philosophy on ore genesis in this region of the Northern Territory. In fact, a proper exploration effort directed at these areas should go a long way towards resolving the economic potential of the South Alligator River Valley as compared to that of the East Alligator River Region.

The remaining prospective areas discussed in sections 5B and 5C are considered to be worthy exploration targets although their potential is not as immediately obvious as those in section 5A.

Exploration in the region will not be cheap due to the large numbers of prospects that require testing, many of which lie in rugged terrain with difficult access. However, these prospects must be worked through systematically if a proper assessment of the region is to be made ... discouraging results in one area must not be allowed to prevent the testing of the remaining prospects.

In the years ahead, environmental issues here including Aboriginal land rights and the Kakadu National Park, are bound to become increasingly important, as in the case throughout much of the world. The author feels that the Joint Venture must attempt to determine the potential of this region quickly so that we know exactly what mineral wealth we do or do not hold in order to better assess these environmental challenges.

2. **LOCATION AND ACCESS**

The South Alligator River Valley contains the bulk of the Joint Venture's mineral leases. It lies approximately 220 km SE of Darwin, the Northern Territory's largest city, and is provided with good bitumen and gravel access roads from Darwin during the dry season with the 100 km gravel road from Pine Creek being cut for only a few days at a time during the worst of the "wet" season, January to March.
Locality Map
South Alligator Joint Venture

- South Alligator J.V. leases, locations & names.
- Known uranium deposits

Scale in Kilometres

 compilation: A.A. Brickell
 drawn: P.R. Leonard
 scale: as shown
 figure 1
FIG. 2 Oblique aerial view of Window I and South Alligator River Valley looking SE.
3. SUMMARY AND CONCLUSIONS

3.1 GENERAL SUMMARY

(a) The East Alligator River Uranium Field and the South Alligator River Valley have striking similarities in many aspects of their geological environment, lithology and structure.

(b) The occurrence of uranium is widespread in the South Alligator River Valley and the presence of small orebodies over a strike length of at least 50 km demonstrates that lithologies and structures favourable for U\(_{38}\) concentration exist over a large area in this region.

(c) Exploration by the Joint Venture in the Window I and 3-171 areas has shown that the occurrence of ore grade uranium mineralisation in the region is not confined to the geographical South Alligator River Valley.

(d) Ore grade uranium has been found by drilling near the major fault zones at Window I and Saddle Ridge. Neither of these prospects has been adequately tested.

(e) Major faults at the Skull II prospect are strongly radioactive at surface and have not been tested at depth. Strong radon and soil U\(_{38}\) anomalies occur at this prospect over the fault zones.

(f) Strong EM conductors have been found along a zone at Sleisbeck that includes the old Sleisbeck Mine workings. These may indicate that a highly prospective graphitic zone extends beyond the central hills area where much of the exploration work to date has been concentrated.

3.2 MAJOR CONCLUSIONS

A. HIGH PRIORITY AREAS

3.2.1 Window I

The major reverse fault zone at Window I shows anomalous radioactivity, radon, and soil U\(_{38}\) over much of its length and should be tested at depth in at least two locations by drilling. A total of 400 m of diamond drilling in 4 holes inclined at -55° is proposed.

3.2.2 Skull II

The anomalously radioactive sections of the major faults should be tested at depth by drilling. A total of 700 m of percussion drilling inclined up to 15° from the vertical is proposed in two locations.
3.2.3 Saddle Ridge

The area of ore grade drill intersections below the Saddle Ridge open cut should be tested by a 250 m percussion drill hole. The fault to the south of the open cut that shows strong surface radioactivity requires testing by a 300 m percussion drill hole that should also interest the fault zone below the open cut.

3.2.4 Sleisbeck

The main EM conductor, SB1, should be tested by a radon survey with a concurrent soil geochemical and spectrometer survey. Any anomalous zones should be explored by percussion drilling.

B. MEDIUM PRIORITY AREAS

3.2.5 Palette

The major fault at Palette is an important control in localising ore deposition and requires testing at depth. A 250 m vertical percussion drill hole is proposed to check for mineralisation at the fault and the Lower/Middle Proterozoic unconformity above it, and also to assess the geological environment down dip from the Palette Mine.

3.2.6 Window II

The radon and geochemical anomalies located in previous surveys require further work to assess the thorium contribution in this area. A re-survey of the anomalous area located in the Track Etch survey is recommended by using either Track Etch cups or alphameters with "Thoron" filters. Concurrent soil geochemistry and spectrometer ratioing is also recommended.

3.2.7 Coronation Hill

The gold potential of Coronation Hill has not been adequately tested and, as a first stage, detailed geological mapping of the area surrounding the open cut is recommended. A program of rock chip sampling for Au and U,0 should be undertaken in the same area and the remaining core 3 from diamond drill core CH-DDH3 should be assayed for at least Au and U,0. Any anomalous areas detected during this program should be followed up with diamond drilling.

C. LOW PRIORITY AREAS

3.2.8 Anomaly 3-171

An alphameter survey with concurrent soil geochemistry is recommended in the area of costeans 1 and 5 to check out the broad radiometric anomaly there and both costeans should be extended.
3.2.9 Rockhole Reverse Fault Extension

Alphameter sampling of soil radon is recommended to locate any further mineralised sections of the fault zone along strike from Rockhole Mine.

3.2.10 Anomaly 105/110

Surface geological mapping, soil geochemistry, and radiometrics are recommended to determine the origin of the known radiometric anomaly.
4. GENERAL GEOLOGY OF THE SOUTH ALLIGATOR RIVER VALLEY

4.1 STRATIGRAPHY

4.1.1 Lower Proterozoic

In the South Alligator River Valley (SARV) the base of the 2.5 km thick Lower Proterozoic sequence is represented by sediments of the Masson Formation and Stag Creek Volcanics of the Namaoma Group. These are followed by the Mundogie Sandstone of the Mount Partridge Group, the Koollpin Formation of the South Alligator Group; and the Fisher Creek Siltstone of the Finnis River Group. The Lower Proterozoic sequence is considered to occupy a basement low - the South Alligator River Trough - formed by incipient rifting at an early stage in the development of the Pine Creek Geosyncline. The geology of the Central section of the SARV is shown on Plate 1.

The Masson Formation consists predominantly of various types of siltstone and shale with discontinuous bands of dolomitic and quartzitic sandstone.

The Stag Creek Volcanics consisting of tholeiitic basalts, basaltic andesites, flow breccias and pyroclastics were previously considered to represent the Archean basement in the SARV. However, drilling by the Joint Venture at anomaly 2J in 1973, showed that the Stag Creek Volcanics actually lie stratigraphically above most of the Masson Formation and are thus of Lower Proterozoic age.

The Mundogie Sandstone, previously called the Coirwong Greywacke, consists of very siliceous quartz sandstone and conglomeratic sandstone that forms a distinctive and prominent ridge in the Lower Proterozoic sequence in the SARV.

The Koollpin Formation consists of siltstone and shale which contain sections rich in chert bands, lenses and nodules. Horizons consisting predominantly of sandstone are present in some areas as are rare large lenses, several hundred metres thick, of stromatolitic (?) carbonate. This carbonate can be subdivided into dololitite, dolarenite and dolomite and is considered to represent a shallow water facies due to the presence of the probable stromatalites and small carbonate pseudomorphs of prismatic gypsum seen in some outcrops.

A very distinctive unit of the Koollpin Formation consists of thin interbeds up to a few centimetres thick of siltstone/shale and chert nodules and bands (Fig. 3 - photos 3,4). This is generally rich in hematite and has previously been referred to as BIF (banded iron formation) or CFS (cherty ferruginous siltstone). Drilling and underground workings carried out in many of the prospect areas in the SARV has shown much of the siltstone/shale to be carbonaceous and pyritic below the weathered zone. Graphite apparent forms most of the carbonaceous material although shungite, an algal coal, has been reported as well. The shale, siltstone, and sandstone beds in the Koollpin often contain a considerable amount of tuffaceous material.
PHOTO 1

ANGULAR UNCONFORMITY AT ROCKHOLE MINE BETWEEN LOWER PROTEROZOIC KOOLPIN FORMATION AND MIDDLE PROTEROZOIC CONGLOMERATE

PHOTO 2

THRUST FAULT IN MIDDLE PROTEROZOIC SANDSTONES AT KOOLPIN GORGE.
PHOTO 3

KOOLPIN FORMATION AT ROCKHOLE MINE - UNIT P15
SHOWING INTERBEDDED CHERT AND SILTSTONE.

PHOTO 4

KOOLPIN FORMATION AT ROCKHOLE MINE - UNIT P15
SHOWING DEVELOPMENT OF CHERT NODULE.
Fisher Creek Siltstone overlies the Koolpin Formation and consists mainly of siltstone, but minor micaceous greywacke and siltstone also occur in the formation.

4.1.2 Transitional Igneous Activity

The late Lower Proterozoic – Early Carpenterian period was a time of considerable igneous activity in the Pine Creek Geosyncline.

- Continental tholeiitic sills of Zamu Dolerite were intruded into the Lower Proterozoic succession prior to regional metamorphism and deformations. Quartz dolerite, syenite, microdiorite, and quartz monzonite differentiates have also been assigned to this formation.

- The Malone Creek Granite is one of several multiphase granites intruded in the area during this period. It is predominantly a medium to coarse grained biotite granite having some very strongly radioactive phases.

- The Edith River Volcanics consist of both sedimentary and volcanic units. The basal sandstones, the "Coronation" sandstone and "Palette" sandstones, range from massive quartz sandstones to pebbly and conglomeratic sandstones and frequently contain much volcanic detritus. Both basic and acid volcanic units have been recognised with the basic amygdaloidal flows and tuffs generally underlying the acid rhyolites and ignimbrites.

- The Oenpelli Dolerite, a suite of continental tholeiitic lopoliths, apparently post-dates the Edith River Volcanics and is seen in the Window II area. It appears to be less metamorphosed than the Zamu dolerite.

4.1.3 Middle Proterozoic

- The Kombolgie Formation is a plateau-forming sequence of siliceous quartz sandstone, pebble conglomerate, and conglomerate. These beds are frequently cross bedded on large and small scales and several volcanic units are found interbedded with the sediments.

4.1.4 Mesozoic

- Cretaceous sandstones and conglomerates of the Petrel Formation (Nullaman Beds) form a discontinuous capping over the Proterozoic sequence.

4.1.5 Cenozoic

- Soil and alluvium cover much of the region and laterite has developed over some of the area underlain by Koolpin and Petrel Formations.
4.2 STRUCTURE AND METAMORPHISM

While erosion and warping undoubtedly affected the Lower Proterozoic sequence several times during its formation, the first major metamorphic and tectonic event occurred at the end of Lower Proterozoic sedimentation and after the intrusion of the Zamu Dolerite. Tight folding and faulting of the sequence gave rise to the regional NW/SE strike of the Lower Proterozoic sequence that can be seen today throughout much of the SARV. Extensive strike-slip and low angle-ω bedding plane faulting in the Koolpin Formation probably occurred at this time as well. Metamorphism in this part of the Pine Creek Geosyncline was generally limited to lower greenschist facies although a somewhat higher grade does appear to have been attained in the Sleisbeck area - possibly upper greenschist facies or higher. This regional metamorphic event has been dated at 1800 m.y.

The intrusion of granite plutons such as the Malone Creek Granite is considered to have occurred in the 1730-1780 m.y. period and the Edith River Volcanics were probably formed at the end of, or after, this period. The emplacement of the Oenpelli dolerite at 1688 m.y. at a depth of 1-2 km must have been followed by a considerable period of erosion prior to the deposition of the Kombolgie Formation as these flat-lying sandstones appear to have been deposited around Oenpelli Dolerite ridges in some areas. An angular unconformity can often be seen between the Edith River Volcanics and the Kombolgie Formation.

Shallow folds and steep faults observed on the Scinto Plateau in the Kombolgie Formation sandstones testify to a later period of deformation. This Kombolgie Formation cover on the Scinto Plateau appears to have been down faulted in the Lower Proterozoic succession and steep major faults are present on the NE, SE, and SW edges of the plateau which lies approximately 5 km SE of El Sherana.

The major fault trend in the region is NW/SE, parallel to the South Alligator Fault Zone. While structures in the extreme NW of the SARV appear to be largely the result of tight folding, those in the area shown in Fig. 1 are more obviously related to steeply dipping faults, many of which have been active over a considerable time period during the Middle Proterozoic at least. The Middle Proterozoic succession to the NE of the fault zone consists of approximately 600 m of sandstone while on the SW side it consists of 1500 m of sandstone with two volcanic members suggesting more rapid subsidence of the SW side at that time.

Dips in the Lower Proterozoic units are very steep but do suggest a synclinal structure in the SARV, especially at the Scinto Plateau. The presence of apparently overturned beds as in the Rockhole mine area and the extensive faulting make precise structural interpretation somewhat hazardous at this stage. Dips in the Middle Proterozoic sandstones are generally shallow although gentle folding has occurred as mentioned above.

4.3 MINERALISATION

Uranium mineralisation in the SARV discovered to date has largely been confined to a few lithological units and is often associated with faulting and brecciation as discussed in sections 3 and 6. Koolpin Formation lithologies have been the host to most of the uranium exploited in the SARV although some of this was found in the Middle Proterozoic sandstones and volcanics either immediately above the Lower/Middle Proterozoic unconformity or along faulted contacts. Mineralisation at the Anomaly 3-171 prospect occurs in fault zones in the Fisher Creek Siltstones while the Masson Formation is host to mineralisation at the airstrip and 2J prospects and possibly Sleisbeck.
Gold occurs in economic quantities in the El Sherana, Palette, and Coronation Hill mines while copper has been found either as sulphides and/or oxides in some of the prospects in the SARV such as Palette, Coronation Hi, El Sherana, Saddle Ridge South, Scinto VI (originally called "Copper Find") and Painted Rock.

Lead mineralisation associated with fluorite veins in the Zamu Dolerite is known to occur some 17 km NE of the Scinto Plateau and tin has been found in alluvial samples from streams draining the Malone Creek Granite.
5. **INDIVIDUAL PROSPECT DESCRIPTIONS**

This section is intended to present a brief summary of those areas considered to be worthy of further exploration work at this stage. The reader should consult the references in Appendix II and especially Appendix III for further information on individual prospects.

**A. HIGH PRIORITY AREAS**

5.1 **WINDOW I**

**TABLE OF CONTENTS**

5.1.1 Alternative Designations  
5.1.2 Location and Access  
5.1.3 Illustrations List  
5.1.4 Tenement Status  
5.1.5 Introduction  
5.1.6 Geology  
5.1.6.1 Stratigraphy  
5.1.6.2 Structure  
5.1.7 Exploration Prior to 1980  
5.1.7.1 Geological Mapping  
5.1.7.2 Radiometrics  
5.1.7.3 Geophysics and Geochemistry  
5.1.7.4 Diamond Drilling  
5.1.7.5 LANDSAT and Aerial Photography  
5.1.8 Conclusions and Recommendations  
5.1.8.1 Previous Track Etch and Geochemical Surveys  
5.1.8.2 Previous Diamond Drilling at TE 9750W–TE 10725W  
5.1.8.3 Proposed Diamond Drilling at TE 9750W–TE 10725W  
5.1.8.4 Proposed Diamond Drilling at TE 9750W–TE 8250W  
5.1.8.5 Radon Anomaly TE 2250W–TE 3675W  
5.1.8.6 Anomaly R10  
5.1.8.7 Anomaly TE 1050W/CON  
5.1.8.8 General
5.1.1 Alternative Designations

Airborne radiometric anomalies R12, R10

5.1.2 Location & Access

17 air km NW of El Sherana Camp or 23 km by four wheel drive track through the Rockhole mine access road which enters the NW side of Window I at Waterfall Creek.

5.1.3 Illustrations

Figure 2 Oblique Aerial View of Window and South Alligator River Valley looking SE

Plate 4 Geological Plan 1:16,800

Plate 5 Detailed geology and Track Ex results 1:5,000

Plate 6 Geological cross sections 1:10,000

5.1.4 Tenement Status

The present tenement situation consists of 5 granted mineral leases and 15 mineral leases under application:

Granted mineral leases:

<table>
<thead>
<tr>
<th>Lease designation</th>
<th>Date of application</th>
<th>Date of granting</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML 594A</td>
<td>28/12/73</td>
<td>17/7/74</td>
</tr>
<tr>
<td>&quot; 595A</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>&quot; 596A</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>&quot; 597A</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>&quot; 598A</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

Leases under application:

<table>
<thead>
<tr>
<th>Lease designation</th>
<th>Year of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML 786A - ML800A inc.</td>
<td>1976</td>
</tr>
</tbody>
</table>

The 5 granted leases and 7 of the leases under application (ML 794A ML 800A inc.) lie within Stage 1 of the Kakadu National Park. The remaining 8 leases under application lie outside both Stage 1 and 2 of the Park but within an area suggested by the Second Fox Report ("Ranger Uranium Environmental Enquiry Second Report") as a possible Stage 3 of the Park.
5.1.5 Introduction

Window 1 is a NW trending flat bottomed topographical depression (approximately 13 X 2.5 km) in the Middle Proterozoic Kombolgie Formation of the Arnhem Land Plateau. The floor of the depression is formed of Lower Proterozoic rocks which are in faulted contact with the Kombolgie Formation along the SW rim while the NE contact appears to be normal although largely scree covered (Plate 4). A prominent but discontinuous escarpment up to 120 m high forms the rim of Window I (Fig.2).

5.1.6 Geology

5.1.6.1 Stratigraphy

(a) Lower Proterozoic

The Lower Proterozoic floor of Window I is comprised of slightly metamorphosed chloritic siltstones and tuffaceous metasediments of the Fisher Creek Siltstone Formation which have been intruded by quartz dolerites of the Zamu Complex. The siltstones, which contain altered basic tuffs and tuffaceousarkoses, strike north-westerly and dip 75°-85° NE (Plate 4). The dolerites usually contain quartz and alkali feldspar intergrowths and near the SW boundary fault are extensively chloritised, sericitised and carbonitised.

(b) Middle Proterozoic

The Middle Proterozoic Kombolgie Formation consists dominantly of flat lying medium to coarse grained quartz sandstones and conglomerate which lie unconformably above the Lower Proterozoic sequence. At the south eastern escarpment of Window I the Lower Proterozoic sequence is unconformably overlain by sericitised acid tuffs of the Edith River Volcanics which are succeeded by the Kombolgie Formation containing red tuffaceous sandstones and thin siltstone lenses. Along the SW escarpment the Kombolgie Formation is in faulted contact with the Lower Proterozoic sequence.

(c) Cenozoic

Most of the southeastern two thirds of the Window I area is covered by sandy soil derived from the Kombolgie Formation and by extensive alluvial and black soil deposits. A small section in the central part of the window contains remnants of a laterite cover.

5.1.6.2 Structure

At Window I the Lower Proterozoic rocks form an inlier in the Middle Proterozoic Kombolgie Formation which is bounded on its SW side by a major reverse fault trending 120° with a dip of 75°-80° NE. Upthrusting and tilting of the NE block, relative to the SW block, followed by erosion has formed the window exposing the Lower Proterozoic succession. On the NE side, and at both ends of the window, the Lower/Middle Proterozoic unconformity lies close to the floor of the depression, while near the SW reverse fault the unconformity was probably only a few tens of metres above the present land surface in the window.
North-south, east-west, and north-westerly trending joint sets are well developed in the Kombolgie Formation. In the south-western area of Window I, Waterfall Creek follows the trend of a well-developed joint in the Kombolgie Formation which can be traced NE to a large fault in the Window II area. The intersections of this joint and the reverse fault in Window I is the site of a weak radiometric and strong single point track etch anomaly (TE 2250W - 3675W).

5.1.7 Exploration Prior to 1980

5.1.7.1 Geological Mapping

Geological mapping at airphoto scale (1:16,800) in 1973 (Plate 4) covered the entire Window I area and was followed up in 1975 with more detailed mapping (1:5,000) along selected portions of the south west fault zone (Plate 5).

5.1.7.2 Radiometrics

In conjunction with the 1973 mapping a Scintrex BGS-IS broad band gamma ray scintillometer was used to record radiometric values. Background readings over the various lithologies are as follows in counts per second:

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Background Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Proterozoic:</td>
<td></td>
</tr>
<tr>
<td>Fisher Creek Siltstone</td>
<td>30-45 cps</td>
</tr>
<tr>
<td>Zamu Complex</td>
<td>18-25 cps</td>
</tr>
<tr>
<td>Middle Proterozoic:</td>
<td></td>
</tr>
<tr>
<td>Kombolgie Fm. - sandstone</td>
<td>15-20 cps</td>
</tr>
<tr>
<td>Kombolgie Fm. - tuffaceous sandstone</td>
<td>up to 60 cps</td>
</tr>
<tr>
<td>Edith River Volcanics</td>
<td>up to 100 cps</td>
</tr>
</tbody>
</table>

Low order anomalous readings were recorded in several localities on the reverse fault structure over a total distance of 2 km. Readings of 60-160 cps were recorded in a limonitic and hematitic shear zone in dolerite near the fault and rock samples nearby assayed up to 153 ppm U₄O₉. This area corresponds to an airborne radiometric anomaly located in 1972 during a survey conducted for United Uranium N.L. (UUNL) by Geophysical Resources Development Co. (GRD) using a magnetometer and spectrometer flown with a mean terrain clearance of approximately 90 m on lines approximately 300 m apart. This survey covered an area of some 2,880 sq. km. from north of the Arnhem Highway to Sleisbeck in the south.

Two low order anomalies were also located in this survey. Anomaly R10 is a weak uranium-thorium emitter and is located north of Waterfall Creek over alluvial soil cover. Anomaly R12, a weak thorium emitter, is near the area of laterite outcrop but neither anomaly was positively located on the ground.
5.1.7.3 Geophysics and Geochemistry

(a) Introduction

A limited Track Etch survey was carried out in 1974 utilising 264 Track Etch cups. The cups were placed at 150 m intervals, in staggered array along two lines, separated by 150 m, which followed the reverse fault zone for 12.6 km from its SW to NW limit in Window I. Track Etch stations were closed to a 75 m X 75 m grid for a distance of 3450 m to obtain greater resolution in the area along strike from the 1973 diamond drill sites discussed in Section 5.1.7.4.

A total of 264 soil samples were taken from the bottom of the Track Etch holes (average depth .53 m) and analysed for U\textsubscript{3}O\textsubscript{8}, Cu, Ni, Co, Pb, and Zn.

(b) Results

Results are summarised in Table 1 below and Plate 5. Track Etch readings ranged from 1.5 to 394 T/Sq.mm. (tracks per square millimetre) with a background mean of 21 T/Sq.mm. The survey defined 13 sites with radon levels greater than three times background. These are grouped in 4 areas ranging from a single station anomaly to an anomaly extending over 975 m in length.

Background and threshold values for the geochemical results were determined graphically and are shown below:

<table>
<thead>
<tr>
<th></th>
<th>U\textsubscript{3}O\textsubscript{8}</th>
<th>Cu</th>
<th>Ni</th>
<th>Co</th>
<th>Pb</th>
<th>Zn (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>3</td>
<td>16</td>
<td>20</td>
<td>11</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>Threshold</td>
<td>10</td>
<td>50</td>
<td>65</td>
<td>35</td>
<td>40</td>
<td>48</td>
</tr>
</tbody>
</table>

The soil sampling survey delineated 9 areas anomalous in one or more of the elements analysed. In 4 of these areas anomalous base metal values accompany anomalous radon levels, one area represents a single station carrying anomalous U\textsubscript{3}O\textsubscript{8}, and the remaining four areas carry anomalous base metal values only.
<table>
<thead>
<tr>
<th>Location</th>
<th>Length</th>
<th>Anomalous Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE 975m</td>
<td>975m</td>
<td>( Radon 7 anomalous stations, peak anomalous values</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( U₃Ο₈ 4 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Co 3 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Pb 2 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Ni 15 anomalous stations)</td>
</tr>
<tr>
<td>TE 10725W</td>
<td></td>
<td>( Cu 13 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Zn 6 anomalous stations)</td>
</tr>
<tr>
<td>TE 2250W</td>
<td>1425m</td>
<td>( Radon 3 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( U₃Ο₈ 2 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Co 8 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Pb 8 anomalous stations)</td>
</tr>
<tr>
<td>TE 3675W</td>
<td></td>
<td>( Ni 5 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Cu 2 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Zn Nil)</td>
</tr>
<tr>
<td>TE 7950W</td>
<td>300m</td>
<td>( Radon 2 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( U₃Ο₈ 1 anomalous station, peak anomalous value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Co 1 anomalous station)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Pb 5 anomalous stations)</td>
</tr>
<tr>
<td>TE 8250W</td>
<td></td>
<td>( Ni 8 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Cu 5 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Zn 2 anomalous stations)</td>
</tr>
<tr>
<td>TE 8550W/75N</td>
<td>Single Station</td>
<td>Radon anomalous</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Copper anomalous</td>
</tr>
<tr>
<td>TE 1050W/00N</td>
<td>Single Station</td>
<td>U₃Ο₈ anomalous</td>
</tr>
<tr>
<td>TE 12000W</td>
<td>375m</td>
<td>( Radon Nil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( U₃Ο₈ Nil)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Co 5 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Pb 5 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Ni Nil)</td>
</tr>
<tr>
<td>TE 12375W</td>
<td></td>
<td>( Cu 6 anomalous stations)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( Zn 5 anomalous stations)</td>
</tr>
<tr>
<td>Location</td>
<td>Length</td>
<td>Anomalous Values</td>
</tr>
<tr>
<td>-----------</td>
<td>--------</td>
<td>------------------</td>
</tr>
<tr>
<td>TE 11100W</td>
<td>150m</td>
<td>(Radon) Nil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(U₃O₈) Nil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Co) 2 anomalous stations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Pb) 1 anomalous station</td>
</tr>
<tr>
<td>TE 11250W</td>
<td></td>
<td>(Ni) 2 anomalous stations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Cu) 2 anomalous stations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Zn) 1 anomalous station</td>
</tr>
<tr>
<td>TE 8925W</td>
<td>225m</td>
<td>(Radon) Nil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(U₃O₈) Nil</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Co) 1 anomalous station</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Pb) Nil</td>
</tr>
<tr>
<td>TE 9150W</td>
<td></td>
<td>(Ni) 6 anomalous stations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Cu) 3 anomalous stations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Zn) Nil</td>
</tr>
<tr>
<td>TE 9375W</td>
<td></td>
<td>2 stations anomalous in copper</td>
</tr>
<tr>
<td>TE 9450W</td>
<td>75m</td>
<td></td>
</tr>
</tbody>
</table>

5.1.7.4 Diamond Drilling

(a) Introduction

A total of 245.65 m of diamond drilling in 3 holes was done by Longyear in 1973 using a Boyles BBS 1 drill rig in the area of the radiometric anomalies along a 550 m strike length of the SW fault zone. These holes were inclined at 55° towards the reverse fault with the deepest hole being 130.44 m.

The drill core was radiometrically logged in sections of 1.5 m with a Scintrex GIS-3 gamma ray spectrometer and sections with >40 cps were split and assayed by Geomin Laboratories in Darwin. No downhole logging was done but the core is stored at El Sherana Camp.

(b) Drilling Geology

The aim of the drilling program was to test the reverse fault zone between Lower Proterozoic dolerite and siltstone and Middle Proterozoic sandstone in the region of mildly anomalous surface radioactivity and rock geochemistry. Two of the holes did not pass through the fault and penetrated only medium to coarse grained dolerite and Gabbro that has been chloritised, carbonitised, and sericitised. Carbonate veining is common in all holes with occasional pyrite being reported. Analysis of a carbonate vein at 78.86 m in W1/DDH3 showed it to be composed of a mineral with a formula very close to Mg Co₂,Fe Co₃. The other hole (W1/DDH 1) encountered similar dolerite to a depth of 45 m then passed through a zone of shearing to intersect tuffaceous sandstone with chlorite bands. This sandstone was described in a
petrological report as a "quartz-feldspathic (kaolin) greywacke (?tuff)". Some previous writers classified this as part of the Kambolgie Formation (as shown on Plate 6) but the present writer considers the proof to be inconclusive and believes that it is possible that W1/DDH1 may not have completely penetrated the reverse fault zone.

A summarised diamond drill log for each of the holes is given below:

**W1/DDH1**
Collared 7/11/73  
Completed 14/11/73

| Co-ordinates   | 9968N 19292 E |
| Inclination    | -50° |
| Azimuth        | 215° M |
| Total depth    | 54.25 metres |

**W1/DDH1**

<table>
<thead>
<tr>
<th>Interval in Metres</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down Hole</td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td>No core</td>
</tr>
<tr>
<td>3.05</td>
<td>Weathered medium to coarse grained red brown rock - probably weathered dolerite. End of zone of maximum weathering at 20.73 metres.</td>
</tr>
<tr>
<td>20.73</td>
<td>Dark greenish grey altered dolerite injected by numerous thin carbonate veins. Petrological examination of the dolerite in thin section recorded extensive chloritisation, carbonitisation and sericitisation.</td>
</tr>
<tr>
<td>45.00</td>
<td>Brecciated and sheared dolerite, shearing at 65° to Long Core Axis (L.C.A)</td>
</tr>
<tr>
<td>45.00</td>
<td>Brecciated and sheared tuffaceous sandstone and deformed (?) dolerite.</td>
</tr>
<tr>
<td>46.72</td>
<td>Fractured tuffaceous sandstone with chloritised bands.</td>
</tr>
<tr>
<td>51.00</td>
<td>Moderately fractured pink tuffaceous sandstone with chlorite on fracture surfaces.</td>
</tr>
</tbody>
</table>

**W1 DDH 2**
Collared 18/11/73  
Completed 22/11/73

| Co-ordinates   | 9964 M 9750E |
| Inclination    | -55° |
| Azimuth        | 215° M |
| Total depth    | 60.96 metres |

**W1 DDH/2**

<table>
<thead>
<tr>
<th>Interval in Metres</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down Hole</td>
<td></td>
</tr>
<tr>
<td>0.00</td>
<td>No core</td>
</tr>
<tr>
<td>7.62</td>
<td>Heavily weathered red brown medium to coarse grained basic rock, probable dolerite. Zone of extreme weathering to 18.60 metres.</td>
</tr>
</tbody>
</table>
18.60 54.53 Greenish grey altered medium to coarse grained dolerite and gabbro. Carbonate veining widespread and the dolerite has been chloritised, carbonatised and sericitised. Trace pyrite.

54.53 60.96 Medium to coarse grained dolerite altered as above (18.60 - 54.53 metres) with progressively heavier iron staining grading into a reddish brown altered rock. Carbona veins common and a few thin haematit veinlets beyond 58.80 metres.

WI/DDH 3 Collared 24/11/73 Completed 30/11/73

Co-ordinates
Inclinations 10,000 N 10,000 E
Azimuth -55°
Total depth 215 M
130.44 metres

W1 DDH 3

0.00 6.09 No core
6.09 35.72 Heavily weathered medium and coarse grained basic rocks - (?) dolerite. Zone of extreme weathering ends at 35.72 metres.
35.72 101.92 Medium to coarse grained strongly altered dolerite or gabbro. Carbonate veining is common with trace pyrite. Petrological reports describe these rocks as being extensively chloritised, carbonatised and in places silicified
101.92 107.30 Sheared and in places iron stained altered dolerite. Alteration as above (35.72 - 101.92 metres). Shearing at 35-45° to L.C.A.
107.30 130.44 Medium to coarse grained altered dolerite or gabbro with many small shear zones. Fracturing and inject of carbonate veins is also common.

(c) Mineralisation

The only section of the total of 245.65 M of drill core to be assayed was 25.5 M at the bottom of W1/DDH 3.

The average grade for this core was .0193% U, 0.386 lb/short ton; with the highest 1.5 m section being .22% U, 4.41 lb/short ton; between 105.0 - 106.5 m downhole.
A very slight rise in radioactive background was noted near the bottom of W1/DDH 2 while W1/DDH 1 was not anomalous.

Detailed results are given on Plate 6 and summarised below:

<table>
<thead>
<tr>
<th>Depth in Metres</th>
<th>Assay Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Down Hole</td>
<td>Maximum</td>
</tr>
<tr>
<td>102.0 - 105.0</td>
<td>.0180%</td>
</tr>
<tr>
<td>105.0 - 106.5</td>
<td>.2240%</td>
</tr>
<tr>
<td>106.5 - 126.0</td>
<td>.0200%</td>
</tr>
<tr>
<td>126.0 - 127.5</td>
<td>not assayed</td>
</tr>
<tr>
<td>127.5 - 129.0</td>
<td>.0120%</td>
</tr>
</tbody>
</table>

5.1.7.5 LANDSAT and Aerial Photography

Examination of LANDSAT imagery and air photography at various scales revealed the presence of several major lineaments in Window I and surrounding area. Major NW/SE lineaments coincide with the SW fault zone and the major NW/SE drainage depression that occupies the centre of Window I. A major E-W lineament shown in Figure 2 coincides with the major valley at Window II and Waterfall Creek in Window I. The highest Track Etch count in the TE 2250W - TE 3675W area (Plate 5) lies at the intersection of the SW fault zone and the Waterfall Creek E-W lineament, and the airborne radiometric anomaly R10 is located on the NW bank of Waterfall Creek near the intersection of a major NW/SE lineament and the Waterfall Creek E-W lineament.

5.1.8 Conclusions And Recommendations

5.1.8.1 Previous Track Etch and Geochemical Surveys

The major SW reverse fault zone between Lower and Middle Proterozoic lithologies is very similar to major reverse fault zones in some of the East Alligator River deposits such as Koongarra. The main orebody at Koongarra occurs adjacent to a prominent faulted bluff of sheared Kombolgie sandstone very similar to that on the SW side of Window I. The Track Etch and geochemical results along the SW edge of Window I show that anomalous base metal and radon values extend over considerable strike lengths in 3 main zones: TE 9750W to TE 10725W; TE 7950W to TE 8250W; and TE 2250W to TE 3675W.

5.1.8.2 Previous Diamond Drilling at TE 9750W - TE 10725W

Some of the chlorite found in the dolerite and as bands in the tuffaceous siltstones may be related to the reverse faulting event and is considered to be an encouraging feature. The Mg/Fe carbonate veins also indicate that magnesium enrichment and/or redistribution have taken place near the fault structure here as has been reported from the East Alligator River deposits.
Diamond drilling has shown that economic mineralisation (up to 0.22% U₃O₈ or 4.41 lb/short ton) exists at depth near the major reverse fault zone in an area of strongly anomalous surface radon concentration. The mineralised drill hole (W1/DDH 3 and at least one of the other two holes did not pass through the fault zone so further drilling is required to test this fault zone adequately near the mineralised hole.

5.1.8.3 Proposed Diamond Drilling at TE 9750W - TE 10725W

Two inclined diamond drill holes are proposed with a total of 400 m (Plates 5, 6) to test the fault zone above and below the area of known mineralisation but sited between W1/DDH 2 and W1/DDH 3 at the centre of a prominent Track Etch anomaly. Downhole radiometric logging should follow this drilling.

5.1.8.4 Proposed Diamond Drilling at TE 7950W - TE 8250W

An additional 2 diamond drill holes with a total of 400 m are proposed to test the fault zone in a similar manner at radon anomaly TE 7950W - TE 8250W where a smaller, but pronounced, Track Etch anomaly was located in 1974 associated with strongly anomalous U₃O₈ values in soils. The highly weathered and sheared Lower Proterozoic Fisher Creek siltstone outcropping at the anomaly is considered to be a more favourable host for uranium mineralisation than the Zamu dolerite intersected in the diamond drill holes at TE 9750W - TE 10725W.

5.1.8.5 Radon Anomaly TE 2250W - TE 3675W

The radon anomaly at TE 2250W - TE 3675W occurs near the intersection of the Waterfall Creek/E-W lineament and the NW/SE fault zone. The only lithologies exposed here are Middle Proterozoic acid volcanics and sandstone. Radon values recorded near the acid volcanics here are strongly anomalous when compared with those obtained near basic volcanics 1.5 km to the south east. At least one of the radon highs here appears to be associated with late Tertiary but in view of the reverse fault and Waterfall Creek lineament intersection, the area is considered to have considerable potential for U₃O₈ mineralisation and warrants further investigation. It should be tested at depth by drilling but this may not be possible until the leases currently under application have been granted.

5.1.8.6 Anomaly R10

The airborne radiometric anomaly R10 occurs near the intersection of the Waterfall Creek lineament and a NW/SE lineament. This area should be tested initially by a radon survey with concurrent soil geochemistry to attempt to locate the source of the anomaly.

5.1.8.7 Anomaly TE 1050W / OON

The single point Track Etch anomaly with anomalous soil U₃O₈ at TE 1050W/OON should be subject to a mineral lease application when the government Mineral Reserve MR 563 in the area is repealed. If further economic mineralisation has been located following steps 3 - 6 above, the single point anomaly should be drilled after additional radon and geochemical sampling.
5.1.8.8 General

Selected samples of the 1973 diamond drill core stored at El Sherana should be assayed to determine if mineralised zones are more extensive than currently known.
5.2  **SKULL II**

**TABLE OF CONTENTS**

5.2.1  Alternative Designations
5.2.2  Location and Access
5.2.3  Illustrations
5.2.4  Tenement Status
5.2.5  Introduction
5.2.6  Geology
5.2.6.1  Stratigraphy
5.2.7  Exploration Prior to 1980
5.2.7.1  Geological Mapping
5.2.7.2  Radiometrics
5.2.7.3  Geophysics and Geochemistry
5.2.7.4  Previous Drilling
5.2.7.5  LANDSAT Imagery
5.2.8  Conclusions and Recommendations

5.2.1  **Alternative Designations:** Skull Line, Skull Southwest

5.2.2  **Location and Access:** 6.5 air km SE of El Sherana Camp. Vehicle access is by four wheel drive track from the El Sherana - Sleisbeck track.

5.2.3  **Illustrations:** Plate 7 - Geological Plan 1:2,500 Plate 8 - Schematic cross sections 1:2,500

5.2.4  **Tenement Status:**

The present tenement situation consists of 2 mineral leases under application:

ML 1414A  Year of application - 1975
ML 1415A  " " - "

Both leases lie outside Stage 1 and Stage 2 of the Kakadu National Park but within an area suggested by the Second Fox Report (Ranger Uranium Environmental Inquiry Second Report) as a possible stage 3 of the Park.

5.2.5  **Introduction**

The Skull II prospect lies on the NE slope of Scinto Plateau approximately 800 m SE of the Palette Mine. In 1961, a series of shallow percussion drill holes was drilled at the prospect by United Uranium N.L. (UUNL) but, as no intersections >2 lb/ton U₃O₈ (0.1%) which was then cut off grade were encountered, no further work was undertaken.
5.2.6 Geology

5.2.6.1 Stratigraphy

(a) Lower Proterozoic

Koolpin Formation

Pl 5b - Bleached shale and siltstone with sandstone and tuffaceous horizons - This unit is principally composed of a soft cream to pale green badly weathered and bleached shale to siltstone with some tuffaceous material and minor sandstone. Beds, where visible, are generally <1-1 cm thick and occasional chert beds 1-2 cm thick occur in the south of the mapped area. This unit has been shown to be carbonaceous at depth in underground workings of the old mines in the South Alligator River Valley.

Pl 5 - Interbedded shale and siltstone with chert horizons and nodules - This is the typical Koolpin Banded Iron Formation of earlier workers similar to that shown in Fig. 3 - Photos 3 & 4 from the Rockhole Mine area. It consists of varying proportions of interbedded siltstone and chert in horizons 1-10 cm thick. The siltstone is generally predominant and is often carbonaceous and pyritic at depth. Low angle faulting of the siltstone and chert layers and similar folding are common and frequently associated with brecciation. Dips are very steep to vertical.

Pl 5d - Rhyolitic to dacitic tuffs and flows - This massive hematitic reddish purple fine grained rock (B234, B249, Appendix IV) appears quite variable in thin section and both flows and tuffs have been identified. It is considered possible but unlikely that this unit could be part of the Middle Proterozoic Edith River Volcanics but field relationships show it to be underlain by tuffaceous shale of unit Pl 5b with no obvious sign of faulting or unconformity where the contact is exposed.

(b) Middle Proterozoic

The Middle Proterozoic units rest with pronounced angular unconformity on the Lower Proterozoic succession.

Edith River Volcanics:

Pm 1c - Massive coarse grained grey sandstone - This poorly sorted sandstone contains quartz grains that range from rounded to angular, and variable quantities of lithic material, mostly acid volcanics or chert, and is equivalent to the "Palette Sandstones" of earlier workers. Rounded grains of tourmaline are the predominant accessory mineral but zircon and rutile are often present. A notable feature of the rock is the presence of up to 20% brown phosphatic matrix in some samples (B200, B196 Appendix IV) while others have none. This is considered by Lowder to be a primary chemical sedimentary component but some phosphate veins do cut detrital quartz grains.
Fm; Pmlb - Basic volcanics with poorly sorted sandstone lenses - Purple or reddish purple flows that can contain up to 20% pale green or cream amygdales are frequently brecciated and veined with specular hematite and anomalously radioactive. Sandstone lenses 5-10\(^{\circ}\) long (B213, Appendix IV) are common (Pmlb) and consist of quartz sandstone similar to Pmae above but with considerable variations in the amount of lithic material present. Dips are generally moderate to steep (35\(^{\circ}\) - 85\(^{\circ}\)) to the southwest.

**Kombolgie Formation:**

The Kombolgie Formation rests with angular unconformity on the underlying units.

Pm4d; Pm4 - Cross bedded pinkish grey quartz sandstone; boulder conglomerate - This unit consists of coarse to medium grained grey or pinkish grey siliceous quartz sandstone with up to 10% of a black accessory mineral (tourmaline?) and is usually cross bedded on both small and large scales. Beds are generally only a few cm or less thick and dips range from 25 - 45\(^{\circ}\) unless local faulting has occurred. The boulder conglomerate at the base of the sandstone contains angular pebbles, cobbles, and boulders, mostly of sandstone but with occasional volcanic clasts in a sandy matrix.

(c) **Cenozoic**

Lt - Laterite - This unit consisting of subangular-quartz set in a yellow liminitic matrix was seen only in the northwest of the area and may have been developed over unit P15d (Lower Proterozoic volcanics).

(d) **Indefinite Age**

SB - Siliceous angular breccia - This breccia in the Skull II area is developed unconformably on the Koolpin Formation and contains angular fragments up to 30 cm long of chert and shale/siltstone similar to that found in the Koolpin Formation set in a matrix of finer fragments of the same material with rare specular hematite grains. A few clasts of red (hematitic?) quartz/jasper but none of Kombolgie sandstone were seen in this area. A few patches contain thin angular quartz fragments a few centimetres long as well, similar to that seen at El Sherana and Sleisbec in a siliceous breccia. It is considered probable that this unit could here represent a paleo-scree deposit developed on the Lower Proterozoic Koolpin Formation prior to the deposits of the Middle Proterozoic Kombolgie Formation.
5.2.7 Exploration Prior to 1980

5.2.7.1 Geological Mapping

Prior to preparation of the 1:5000 scale map of Scinto Plateau by Noranda in 1977 (Plate 3) and 1:2500 scale mapping carried out in 1979 (Plate 7); United Uranium N.L. had covered this region of the Scinto Plateau at scales of approximately 1:1200 and 1:4200 although some of this data has been lost.

5.2.7.2 Radiometrics

The Skull II prospect was covered by radiometric traverses during the 1977 and 1979 mapping program. Background and anomalous readings obtained with a Scintrex GIS-4 gamma ray spectrometer in 1979 are:

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Background Reading</th>
<th>Maximum Anomalous Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB Siliceous breccia</td>
<td>60 cps</td>
<td></td>
</tr>
<tr>
<td>LT Laterite</td>
<td>125 cps</td>
<td></td>
</tr>
<tr>
<td>Pn4d Kombolgie sandstone</td>
<td>30 cps</td>
<td></td>
</tr>
<tr>
<td>Pn4 Kombolgie conglomerate</td>
<td>70 cps</td>
<td></td>
</tr>
<tr>
<td>Pml Basic volcanics</td>
<td>85 cps</td>
<td>530 cps</td>
</tr>
<tr>
<td>Pmlb Sandstone lens in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>volcanics</td>
<td>60 cps</td>
<td></td>
</tr>
<tr>
<td>Pmle Palette sandstone</td>
<td>85 cps</td>
<td>710 cps</td>
</tr>
<tr>
<td>P15d Rhyolite flows</td>
<td>100 cps</td>
<td></td>
</tr>
<tr>
<td>P15 Koolpin siltstone/</td>
<td>65 cps</td>
<td>1200 cps</td>
</tr>
<tr>
<td>chert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P15b Koolpin shale/</td>
<td>140 cps</td>
<td></td>
</tr>
<tr>
<td>siltstone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The anomalous sites shown on Plate 7 are usually associated with faulting and/or brecciation.

5.2.7.3 Geophysics and Geochemistry

The BMR conducted an SP survey in 1961 that included the Skull Mine and Skull II areas. An anomaly detected in the centre of the Skull II area was percussion drilled by UUNL and results are discussed below.

An "alphalogger" survey was carried out by Geopeko for Noranda in 1977, which involved the exposure of an alpha particle sensitive film to soil gas to determine radon concentrations. Generally 3 sites were sampled down the scree slopes around Scinto Plateau on lines 100 m apart.

"Soil" samples of the scree material from the bottom of the alphalogger holes (20 cm deep) were analysed for Cu, Pb, Zn, Ni, Co, As, and U_{238}. The Skull II area produced anomalous results in Alphalogger readings, U_{238} and Pb geochemistry in the 1979 Noranda survey and was considered to contain the most significantly anomalous groupings of any area in the Scinto Plateau survey.
5.2.7.4 Previous Drilling

One drilling traverse of 11 (to 16?) shallow percussion drill holes was carried out by United Uranium N.L. in 1961 to test the main BMR SP anomaly. Maximum depth of the holes was 100 feet (30 m) and although the remaining records are incomplete and contradictory, some results of the radiometric logging of part of the holes are available and seem to indicate that sporadic weak mineralisation was detected in most of the holes. The highest results were 1 foot of .031% $UO_2$ (0.62 lb/t); 12 feet of .021% $UO_2$ (0.25 lb/t); and 8 feet of .015% $UO_2$ (0.33 lb/t) with all intersections being in Lower Proterozoic Koolpin Formation.

5.2.7.5 LANDSAT Imagery

Examination of computer enhanced LANDSAT photographs has revealed the presence of two NE-SW linear structures in the Skull II area that intersect the NW/SE major fault along the NE edge of Scinto Plateau in the Skull II area. The points of intersection of these linears may be sites of increased structural disturbance and potential sites for mineralisation.

5.2.8 Conclusions and Recommendations

(a) The major NW/SE fault zone on the NE edge of the Scinto Plateau mineralised at the Palette and Skull mines, passes through the Skull II area and separates Lower Proterozoic Koolpin Formation and Middle Proterozoic Edith River Volcanics. At Skull II it is the site of several strongly radioactive outcrops and concentrations of hematite and phosphate.

(b) This fault zone is cut by two NE/SW LANDSAT linear structures in the Skull II area.

(c) The Skull II area contains highly anomalous radon concentrations and anomalous uranium and lead in "soil" samples.

(d) Shallow percussion drilling in 1961 in this fault zone detected low grade $U_3O_8$ enrichment in the Koolpin Formation.

(e) The combination of favourable lithology, major faulting, and anomalous $U_3O_8$ and radon indicate that this area has considerable potential for the discovery of subsurface $U_3O_8$ mineralisation and should be investigated by drilling. A total of 700 m of percussion drilling is recommended as shown on Plates 7 & 8 to determine the location and extent of the source of the surface indications.
5.3 SADDLE RIDGE

TABLE OF CONTENTS

5.3.1 Alternative Designation
5.3.2 Location and Access
5.3.3 Illustrations
5.3.4 Tenement Status
5.3.5 Introduction
5.3.6 Geology
5.3.6.1 Stratigraphy
5.3.7 Mining and Associated Drilling
5.3.8 Exploration Prior to 1980
5.3.8.1 Geological Mapping
5.3.8.2 Radiometrics, Geophysics, and Geochemistry
5.3.8.3 Air Photo Interpretation
5.3.9 Conclusions and Recommendations

5.3.1 Alternative Designation: BMR No.2 Prospect

5.3.2 Location and Access: 7.5 air km south east of El Sherana Camp. Vehicle access is by four wheel drive track from the El Sherana-Sleisbeck road.

5.3.3 Illustrations: Plate 9 - Geological Plan 1:2500
Plate 10 - Schematic Cross Section 1:2500

5.3.4 Tenement Status

This prospect is covered by one mineral lease, ML119A, applied for on 26/7/47 and granted on 6/5/58.

This lease lies outside Stage 1 and Stage 2 of the Kakadu National Park but within an area suggested by the Second Fox Report ("Ranger Uranium Environmental Inquiry Second Report") as a possible Stage 3 of the Park.

5.3.5 Introduction

The Saddle Ridge prospect lies on a topographic saddle at the SE corner of the Scinto Plateau. It was the site of a small mining operation in 1960 following a BMR SP survey and costeasting.

5.3.6 Geology

5.3.6.1 Stratigraphy

(a) Lower Proterozoic

Mundogie Sandstone

P12 - Quartz sandstone - Formerly known as the Coirwong Greywacke this unit consists of hard pinkish grey, very fine grained siltstone and quartz sandstone. In this area it is strongly silicified and forms a prominent ridge to the south of the Saddle Ridge open cut.
Koolpin Formation

P13a - Pale sandstone and siltstones - These well sorted sandstone and siltstones contain large amounts of sericite (up to 40%) which may be the remnants of volcanic fragments or clasts. Hematitic spots form up to 10% of the rock and may be after pyrite (B316, Appendix IV).

P13 - Pale Shales - These are essentially a finer grained version of the P13a sandstones and siltstones and appear in hand specimen as white or cream highly sericitic rocks with up to 10% hematitic spots with a cubic form obviously after pyrite crystals. They are quite similar to bleached shales elsewhere in the region and may have a volcanic component (B301, Appendix IV).

(b) Middle Proterozoic

The Middle Proterozoic strata lie with pronounced unconformity on the underlying units although large scale faulting at Saddle Ridge has produced steep dips in the Middle Proterozoic sequence. An angular unconformity is also present in the Middle Proterozoic between units Pm3c and Pm4g.

Edith River Volcanics

Pm1, Pm1b - Basic volcanics with sandstone lenses - The volcanics are only poorly exposed on surface but have been found in drill core. They consist of variably amygdaloidal purple flows, often having pale green amygdalae in hand specimens. The sandstone lenses, seen in outcrop in the Skull II and Palette areas, have here been interpreted from drill hole data.

Pm3 - Ignimbrite - Massive pink or cream rhyolitic ignimbrite forms the prominent ridge immediately NE of the open cut at Saddle Ridge. It contains a variable amount of flattened shards of volcanic material up to 2-3 cm long as well as angular quartz fragments (1-3mm) probably of pyroclastic origin. In places the rock appears to grade into a true tuff. A few "sandstone dykes" have been observed filling steeply dipping joints a few centimetres wide.

Pm3b - Conglomerate - The irregular surface of the Pm3 ignimbrite and tuff has been covered by a conglomerate with a sedimentary matrix but contains almost exclusively volcanic pebbles and cobbles that are sub-rounded to angular. Some thin lithic sandstone horizons have also been observed interbedded in the conglomerate.

Pm3c Basalt - Strongly altered and oxidised basalt outcrops in a thin band above the conglomerate. It is heavily hematized having a purple colour and occasional quartz veins and eyes <1cm wide (B279, Appendix IV).
Kombolgie Formation

Pm4g - Quartz sandstone - Poorly sorted pinkish grey sandstone and rare siltstone outcrop extensively to the NW of the acid volcanics above Saddle Ridge Mine. Angular quartz grains form 80% of the rock and are set in a cream coloured sericitic (?) matrix. Cross bedding is common on medium and small scales and individual beds are generally a few mm or cm thick. Quartz pebbles are common in some beds.

(c) Indefinite Age

SB - Siliceous breccia - This rock, previously called "Scinto Breccia" consists almost entirely of quartz in several forms and is variably hematitic. Lowder has interpreted it to be a silicified volcanic (B304, B305; Appendix IV) and this seems reasonable in view of the known surface geology. The age of the silicification is not known but possibly occurred in the post-Pm1 to pre-Pm4g period. Similar rocks are described in 5.4.5 from Sleisbeck.

SF - Fault breccia - Known only from UUNL drilling, this "unit" consists of silicified sediments and "quartz breccia".

5.3.7 Mining and Associated Drilling

The Saddle Ridge Mine was discovered by UUNL prospectors using random radiometric traversing which located an area of secondary uranium mineralisation on the surface. Subsequent shallow diamond drilling by the BMR did not locate the orebody but later UUNL percussion drilling proved up enough reserves to commence mining. In 1960 between 60 and 82 tons of contained UO$_2$ were recovered from approximately 29,900 tons of ore mined completely by open cut methods. Estimates of ore grade range from 4 lb/ton UO$_2$ (0.2%) to 5.5 lb/ton UO$_2$ (0.275%) with the uranium being held entirely in secondary minerals. The cut off grade was probably 0.1% UO$_2$ (2lb/ton) in line with the other UUNL operations in the South Alligator River Valley, and this orebody extended to a depth of approximately 30 m (100 feet). The ore was trucked to Moline 45 km to the SW, for solvent extraction treatment.

Two "deep" diamond drill holes were drilled by UUNL (Plate 10) and intersected high grade mineralisation below the open cut. The best intersections obtained are summarised below and occur in volcanics and the reverse fault breccia.

**DDH SR 1**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Length</th>
<th>UO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>198'-201'</td>
<td>0.91 m</td>
<td>2.6 lb/ton (0.13%)</td>
</tr>
<tr>
<td>254'-257'</td>
<td>0.91 m</td>
<td>6.9 &quot; (0.34%)</td>
</tr>
<tr>
<td>275'-277'</td>
<td>0.61 m</td>
<td>4.7 &quot; (0.24%)</td>
</tr>
<tr>
<td>284'-291'</td>
<td>2.14 m</td>
<td>3.4 &quot; (0.17%)</td>
</tr>
</tbody>
</table>

**DDH SR 4**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Length</th>
<th>UO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>319'-344'</td>
<td>7.52 m</td>
<td>2.6 lb/ton (0.13%)</td>
</tr>
</tbody>
</table>
The best individual section was 319'-325' (37.23 - 99.06m) with 6.7 lb/ton U₃O₈ (0.34%) in SR 4 over 1.83m. The uranium is reported to occur as secondary uranium minerals and "sooty pitchblende".

5.3.8 Exploration Prior to 1980

5.3.8.1 Geological Mapping

The Saddle Ridge area was included in regional mapping by UUNL geologists at 1:6000 and 1:4200 scales and the open cut was mapped at 1:480. Noranda Australia Ltd. mapping of the Scinto Plateau at 1:5000 in 1977 (Plate 3) also included Saddle Ridge and the prospect area itself was also mapped by the BMR in 1961(?) prior to mining. Results of mapping in 1973 are shown on Plate 9.

5.3.8.2 Radiometrics, Geophysics and Geochemistry

(a) Radiometrics

A small radiometric survey was carried out by UUNL staff over the main reverse fault in the Saddle Ridge open cut area. The 1977 survey carried out by Noranda Australia Ltd. over the Scinto Plateau scree slopes located several anomalous sites but these are believed to be due to contamination from the mine workings.

Radiometric readings obtained with a Scintrex GIS-4 gamma ray spectrometer during the 1979 mapping are shown below:

<table>
<thead>
<tr>
<th>Lithology</th>
<th>Background Reading</th>
<th>Maximum Anomaly Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB</td>
<td>Siliceous Breccia</td>
<td>60 cps</td>
</tr>
<tr>
<td>Pm₄g</td>
<td>Kombalgie Sandstone</td>
<td>40 cps</td>
</tr>
<tr>
<td>Pm₃c</td>
<td>Basalt</td>
<td>130 cps</td>
</tr>
<tr>
<td>Pm₃b</td>
<td>Conglomerate</td>
<td>140 cps</td>
</tr>
<tr>
<td>Pm₃</td>
<td>Ignimbrite</td>
<td>180 cps</td>
</tr>
<tr>
<td>Pm₁</td>
<td>Basic volcanics</td>
<td>130 cps</td>
</tr>
<tr>
<td>P1₃</td>
<td>Shales</td>
<td>75 cps</td>
</tr>
<tr>
<td>P1₃a</td>
<td>Sandstone, siltstone</td>
<td>85 cps</td>
</tr>
<tr>
<td>P1₂</td>
<td>Sandstone</td>
<td>30 cps</td>
</tr>
</tbody>
</table>

The anomalies in the Scinto Breccia (SB) unit are related to the faulted contact between it and Lower Proterozoic shales (P1₃) and may indicate that economic mineralisation exists at depth near the fault.

(b) Geophysics and Geochemistry

An SP survey was carried out by the BMR in 1961 over a small area below the Saddle Ridge open cut but no significant anomalous zones were located.

Two soil radon sample sites of the 1977 survey described in section 5.2.7.3 were strongly anomalous. They are located close to the fault noted above as having anomalous surface radioactivity in the Scinto Breccia.
5.3.8.3  Air Photo Interpretation

Examination of colour air photography at a 1:26,000 scale revealed several structures corresponding with the major faults mapped on the ground. The radiometric hot spot SSW of the Saddle Ridge open cut occurs at the intersections of an ENE/WSW lineament and the NW/SE fault.

5.3.9  Conclusions and Recommendations

(a) Ore grade mineralisation is associated with a reverse fault zone at the Saddle Ridge Mine. This reverse fault was shown to be mineralised at depth in DDH SR 4.

(b) The reverse fault to the south west of the Saddle Ridge open cut is anomalously radioactive in at least two locations, the strongest of these being located at intersections of the fault and an ENE/WSW photo lineament.

(c) Two inclined percussion drill holes totalling 550 m are proposed to test these fault zones at depth (Plate 10).

(d) Remaining UUNL drill core at El Sherana should be reassayed and relogged.
5.4 SLEISBECK

TABLE OF CONTENTS

5.4.1 Location and Access
5.4.2 Illustrations
5.4.3 Tenement Status
5.4.4 Introduction
5.4.5 Geology
   5.4.5.1 Introduction
   5.4.5.2 Stratigraphy
5.4.6 Mining
5.4.7 Exploration Prior to 1980
   5.4.7.1 Introduction
   5.4.7.2 Geological Mapping
   5.4.7.3 Geophysics and Geochemistry
   5.4.7.4 Drilling
   5.4.7.5 Airborne Geophysical Survey
5.4.8 Conclusions and Recommendations

5.4 SLEISBECK

5.4.1 Location and Access - Sleisbeck lies 44 air km southeast of El Sherana Camp and 56 km by bulldozed track from El Sherana which is impassible during the wet season.

5.4.2 Illustrations - Plate 11 Interpretation Map - Airborne EM Survey 1:15840
                           Plate 12 Structural Interpretation of Residua Magnetic Intensity 1:15840
                           Plate 13 Regional Geological Plan

5.4.3 Tenement Status

The Sleisbeck Prospect is covered by 4 granted mineral claims and 29 mineral claims under application. All claims lie outside Stage 1, Stage 2, and the proposed Stage 3 of the Kakadu National Park as recommended by the Second Fox Report ("Ranger Uranium Environmental Inquiry Second Report").

<table>
<thead>
<tr>
<th>Lease</th>
<th>Date of Application</th>
<th>Date of Granting</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC 23A - MC 26A</td>
<td>9/10/56</td>
<td>11/1/57</td>
</tr>
<tr>
<td>ML 805A- ML 833A</td>
<td>1976</td>
<td>Pending</td>
</tr>
</tbody>
</table>

5.4.4 Introduction

The Sleisbeck Prospect was discovered in the early 1950's by Dr. G. Sleis and subsequently explored and mined by North Australian Uranium Corporation (NAUC) between 1954 and 1957. The NAUC field operations manager at the time was a Mr. E. Becker which explains the naming of the prospect. The exploration carried out by NAUC included over 50 diamond drill holes but unfortunately almost all records of this work have been lost.
5.4.5 Geology

5.4.5.1 Introduction

The Sleisbeck prospect lies at the southern edge of a large 70x30 km inlier of Lower Proterozoic metasediments and intrusives exposed through the Middle Proterozoic cover of arenites and volcanics.

5.4.5.2 Stratigraphy

(a) Lower Proterozoic

Surface exposures of Lower Proterozoic units are limited to 3 ridges at the Sleisbeck prospect and a few extensively weathered and silicified outcrops to the east and west. The Lower Proterozoic succession consists of an E-W striking steeply dipping (75° - 90°N) sequence of metasediments and tuffs. The metasediments are often described as schists and phyllites in hand specimens and drill core but petrological reports classify most of them as meta shales, meta siltstones and meta chert of upper greenschist to lower amphibolite facies. Dolomitic, chloritic, and graphitic rocks have been logged from drill core and cuttings. The dolomitic rocks may be true dolomites or dolomitised meta shales and while most of the chlorite in the area is undoubtedly primary, some of it may have been introduced at a later stage. The amount of graphite present in the Sleisbeck area seems to have been considerably overestimated by some previous workers although its presence in the prospect area is not denied. Units logged as "graphitic schist" from drill core are generally described as "carbonaceous shale" in thin sections and much of the dark material seen in hand specimens and called graphite is apparently finely disseminated hematite. A concentration of hematite several metres thick in these rocks immediately below the Lower/Middle Proterozoic unconformity has been noted in percussion drill holes that have penetrated the Middle Proterozoic cover at Anomaly SB.

These lithogies have been considered by recent workers to belong to the Hasson Formation rather than the Koolpin Formation as had been previously thought, although any classification must be considered to be tentative at present.

Dolerite and gabbro intersected in drill holes are believed to be of Lower Proterozoic age as well.

(b) Middle Proterozoic

The Lower Proterozoic succession is unconformably overlain by shallow dipping Middle Proterozoic Edith River Volcanics and Kombolgie Formation sandstones. The Lower/Middle Proterozoic contact to the south of the Sleisbeck workings appears to be faulted in some areas and a simple unconformity in other areas along strike.
The volcanics consist mainly of acid tuffs, flows, and volcanic conglomerate while the Kombolgie Formation consists of sandstone with quartz cobble conglomerate bands. Dips in the sandstone tend to be steep (up to 75°) near the faulted/unconformity contact but shallow out within a few tens of metres to 10° - 15°.

(c) Indefinite Age

A series of prominent hills and ridges composed of angular siliceous breccia were the site of examinations during the NAUC operations. This breccia consists of a white or pink siliceous matrix containing angular siliceous fragments (chert and/or sandstone) up to several centimetres long as well as thin disrupted quartz stringers and occasionally contains phosphate as apatite. The origin of this unit is an enigma that has had many possibilities put forward. Paleo scree deposits, core of anticline, core of syncline, fault breccia, sedimentary slump breccia, silicified limestone breccia, silicified regolith, etc. have been proposed but no definite conclusion has been reached. This unit does, however, appear to be very similar to siliceous breccias developed elsewhere in the South Alligator River Valley that can occasionally be seen as the end product of gradational silification of volcanics and sandstones. DDH53 at Sleisbeck passed under a large outcrop of this breccia and encountered mostly metashales and dolerite so the breccia may only be a relatively shallow feature related to surficial processes. It is probable that the Sleisbeck outcrops lie only a few tens of metres below the Lower/Middle Proterozoic unconformity so the breccia may have developed at that time on a paleo ridge as a scree or regolith. It is possible that the ridge may have resulted from faulting.

5.4.6 Mining

Estimates of total production at Sleisbeck range from 2.4-3.0 tons of contained U3O8 with an ore grade of approximately 0.4% U3O8 (8 lb/ton). The ore is believed to have been taken from 5° separate small excavations in or at the edge of the siliceous breccia ridges mentioned above. The largest open cut was 90x30 m with a maximum depth of about 12 m.

The ore consisted of secondary uranium minerals occurring associated with carbonaceous and chloritic schists but not actually in the carbonaceous "schists" and having phosphorous as an important component.

5.4.7 Exploration Prior to 1980

5.4.7.1 Introduction

Although a considerable amount of costeining and diamond drilling involving some 50 holes was done by NAUC, most of the drilling data has been lost, as mentioned above, and subsequent workers have had to repeat some of this work.

5.4.7.2 Geological Mapping

The major post-NAUC mapping projects include that by McManus in 1969 (1:1200); Miezitis in 1974 (1:2500) and Chapple in 1976 (1:16800). Plate 13 shows the Sleisbeck area at 1:16800
while more detailed maps of the granted leases can be found in Pietsch G., 1977 (Noranda Report 266) at 1:1000.

5.4.7.3 Geophysics and Geochemistry

(a) Radon Surveys

In 1974 a Track Etch survey was conducted along the fault/unconformity contact between Lower and Middle Proterozoic rocks to the south of the old workings. A total of 196 cups were placed in a staggered array at 150 m intervals along two lines 150 m apart which followed the fault from the EL 119 boundary, near Sleisbeck hut, west for a distance of 13.2 km. Four embayments in the fault line were tested south of the main survey lines.

A radon emanometer survey in 1974 using an Ekco Radon Monitor tested soil gas at an 18" depth in 626 holes on a 100 x 200 m grid along a 13 km baseline. Some anomalous areas were investigated at a closer spacing.

(b) Radiometric Surveys

Radiometric readings taken on a 50 x 25 m grid in conjunction with the 1976 geological mapping covered the area of leases under application, as well as those already granted, on lines 50 m apart. Total count gamma radiation readings were measured with Scintrex BGS-15 Scintillometers.

In 1977 radiometric readings using a similar instrument were taken every 5-10 m on lines 10 - 25 m apart over most of the area covered by the granted leases.

(c) Geochemical Surveys

A total of 196 soil samples were taken from the bottom of the Track Etch Cup holes (average depth 0.7m) during the survey mentioned above. Samples were analysed for $U_{308}$, Cu, Pb, and Zn. An auger geochemistry program using a Jacrö 100 auger drill involved sampling 104 holes at 1.5 m intervals down the hole. One bottom-of-hole sample from all drill holes was assayed for $U_{308}$ while the remaining samples down the hole were split, logged lithologically and radiometrically and retained. Drilling was carried out at 200 m intervals along N-S 1000 m cross lines on the Sleisbeck grid. Two areas were drilled in greater detail (8400W and 8000W/1080N).

(d) Summary of Survey Results

The radon and geochemical surveys delineated several anomalous zones some of which were percussion drilled in following years (Plate 13). However, results were disappointing with the highest analyses of drill cuttings being 177 ppm $U_{308}$ (.0117%) over 2 m in hole SPH2 of Anomaly SB. The anomalies appear to have resulted from small $U_{308}$ concentrations just below the unconformity surface. The source of the uranium is unknown but probably the overlying acid volcanics.
The radiometric survey outlined anomalous areas on the 3 hills at the Sleisbeck Prospect as well as a continuation of this trend to the west of the hills. These are due, at least in part, to contamination from the old workings and acid volcanic or laterite scree and soil. Nevertheless, anomalies were found to occur wherever Lower Proterozoic sediments are in contact with "siliceous hematite breccia" in the central hills area and also to the west of the granted lease area over patchy siliceous breccia outcrop.

5.4.7.4 Drilling

(a) Percussion Drilling

In 1975, 20 percussion holes, each between 40 and 64 m deep tested 3 of the 1974 Track Etch anomalies and an area along strike west of the Sleisbeck mineralised zones having weakly anomalous Radon Emanometer results and anomalous U$_{30}$g in an auger drill hole. The location of the holes is shown on Plate 13. Samples were collected every 2 m and every fifth sample, plus others suspected to contain anomalous U$_{30}$g, were analysed for U$_{30}$g, Cu, Ni, Co, Pb, and Zn. Samples from every 2 m drill run were logged radiometrically and a McPhar TV-5 down-the-hole spectrometer was used to probe as many holes as possible. Holes were sited 50 to 100 m apart and would probably not have given a complete cross section of the lithologies in each area due to steep dips in the Lower Proterozoic units.

In 1976 two areas were drilled - Anomaly SB where weak uranium mineralisation had been located in 1975 drilling, and Anomaly SG, a radon anomaly. A total of 574 m of drilling in 8 holes was completed and these were 100 m apart at Anomaly SB. Samples were collected across 2 metre intervals and lithologically and radiometrically logged. Anomalous samples and bottom-of-hole samples were assayed for U$_{30}$g.

(b) Diamond Drilling

Apart from the numerous diamond drill holes done by NAUC as mentioned above, whose records were largely lost, the only other diamond drilling at Sleisbeck has been 3 inclined holes totalling 594.3 m by Noranda Australia for the Joint Venture in 1977. These were sited to test 3 high priority radiometric anomalies; two of which had previously been reported as having mineralisation beneath them, and all 3 holes were sited at the central hills.

The core was radiometrically and lithologically logged on site, and selected anomalous samples were split and assayed for U$_{30}$g, Cu, Ni, Co, Pb, Zn, Au and Ag.
The lithologies intersected included:

(a) A series of chlorite "schists", chlorite-quartz "schists", graphitic "schists", and locally graphitic and schistose arenaceous dolomite and dolomite.

(b) Altered dolerite, doleritic granophyres, gabbro, and quartz gabbro.

(c) Volcanics - basalt or andesite flows (?) in the dolerite.

(d) Siliceous breccia - often hematitic and phosphatic. The best mineralised intersection was in DDH 54 (69.0 - 70.0 of 0.0052% U_3O_8 (52 ppm) in brecciated, altered dolerite. Up to 13.7% P_2O_5 is reported from some of the siliceous breccia. The presence of shear breccias in all 3 holes may indicate that the central hills lie along an E-W trending fault zone.

5.4.7.5 Airborne Geophysical Survey

An airborne INPUT EM survey was conducted by Geoterrrex over the area shown in Plate 11 in 1979. The report is attached as Appendix V and results shown on Plates 11 and 12. The survey located several E-W trending conductors which may be related to graphitic rocks are known to exist.

A simultaneous airborne magnetic survey was undertaken and results are shown on Plate 12.

5.4.8 Conclusions and Recommendations

(a) Lithologies at Sleisbeck have been metamorphosed to upper greenschist-lower amphibolite facies which is a higher metamorphic grade than found elsewhere in the South Alligator River Valley, and thus more similar to that found in the East Alligator River deposits.

(b) The outcropping Lower Proterozoic units probably lie only a few tens of metres below the Lower/Middle Proterozoic unconformity.

(c) Economic uranium mineralisation has been exploited from these metasediments in close proximity to carbonaceous horizons at Sleisbeck by NAUC.

(d) The INPUT airborne EM survey has located several conductors that may be related to carbonaceous horizons.

(e) A radon survey is recommended to test the EM conductors in the lease area. Any anomalous areas found should be tested by drilling especially if they lie along faults defined in the airborne magnet survey or along strike from the fault zone detected in 1977 drilling.

(f) A spectrometer and soil geochemical survey should be carried out concurrently with the radon survey.
B. MEDIUM PRIORITY AREAS

5.5 PALETTE

5.5.1 Location and Access

Palette Mine lies 6 air kilometres SE of the El Sherana Camp. Vehicle access is by 4 wheel drive track from the El Sherana-Sleisbeck road.

5.5.2 Illustrations

<table>
<thead>
<tr>
<th>Plate 14</th>
<th>Plate 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geological Plan 1:480</td>
<td>Schematic Cross Section 1:960</td>
</tr>
</tbody>
</table>

5.5.3 Tenement Status

The Palette area is covered by the following granted leases: GML 45A, GML 46A; which lie outside Stage 1 and Stage 2 of the Kakadu National Park but within an area suggested as a possible Stage 3 of the Park.

5.5.4 Introduction

The Palette Mine was operated by UUNL between 1958 and 1963 and is reported to have produced a total of 118 tons of U₃O₈ at an average grade of 2.45% U₃O₈ mostly from underground workings. The high grade figures for the ore probably reflects some hand sorting of the ore at the working face.

Palette was also one of the richest gold producers in the region but production figures are not available although assays of 2 - 6 dwt/t (3 - 9 g/t) and higher are reported from some sections of the underground workings.

5.5.5 Geology

This deposit is located on the NE side of Scinto Plateau at the faulted contact between Lower Proterozoic carbonaceous shales of the Koolpin Fm and Middle Proterozoic sandstones of the Edith River Volcanics (the "Palette Sandstone"). A large amount of ore was apparently produced from the sandstone in close proximity to these faulted contacts, as well as along the faults themselves, where it occurred in a very rich pod over 10 m long in the sandstone that contained nearly 2/3 of the total ore, as well as several small but rich pods a few metres long. Gold was occasionally found in "shoots" separate from the U₃O₈ ore and some mercury has also been recovered from Palette, possibly from the Coloradoite (HgTe) known to occur there. Chalcopryite has been reported as occurring in some of the ore as well.

5.5.6 Conclusions and Recommendations

The ore at Palette Mine was located near a major fault between Lowe and Middle Proterozoic strata. Little is known about the geology of the area down dip from this fault below the mine workings.
A percussion drill hole of 250 m is proposed from the top of Scinto Plateau to:

(1) Test for mineralisation at the Lower/Middle Proterozoic unconformity at depth.

(2) Test for mineralisation near the down dip extension of the fault that is richly mineralised at the surface.

(3) Gain a better understanding of the geology of the Scinto Plateau down dip from the Palette Mine.

Access for a drill rig to the drill site shown on Plates 14 and 15 would be by the track leading up past Cliff Face Prospect towards Scinto 1 Prospect (Plate 2) which would require some repair by bulldozer. A short track would then be bulldozed to the drill site near the edge of the Scinto Plateau.
5.6 WINDOW II

5.6.1 Location and Access

Lying 12km N of El Sherana and 10 km E of Window I, the Window II area can be reached by a 4 wheel drive track from the Rockhole Mine to the point at which Waterfall Creek crosses the SW boundary of Window I. The track must be left at this point but 4 wheel drive vehicles can continue N across the Window I depression until the escarpment above Barramundi Creek is reached. The descent and last 4 km up the creek valley can be covered by foot, or with difficulty, by motorcycle.

5.6.2 Tenement Status

The Window II area is covered by 44 Mineral Leases (ML 646A - 681A ML 776A - 783A inc.) all of which are under application and lie wholly or partly within Stage 1 of the Kakadu National Park.

5.6.3 Geology

The Window II area refers to a 6 km E-W section of the steep sided valley of the Barramundi and Koolpin Creek headwaters and an area extending approximately 5 km to the northwest. The floor of the valley is underlain by dolerite and quartz dolerite which is tentatively assigned to the Oenpelli Dolerite of Late Lower Proterozoic - Early Carpentarian age. This classification is supported by the low grade of metamorphism seen in the rock relative to that in dolerites of the Lower Proterozoic Zamu Dolerite at Window I. The walls of the valley and country to the NW are composed of grey to pink medium grained sandstone of flat-lying Middle Proterozoic Kombolgie Formation that contains several quartz pebble horizons. The sandstone seems to form a very shallow basin in the lease area. The sandstone appears to have been downfaulted against the dolerite on the south side of the Window II valley while the northern contact is a nonconformity.

5.6.4 Exploration Prior to 1980

The Window II area was investigated after a ground radiometric survey in 1972 located highly anomalous radioactivity over 1200 m of the valley. One stream sediment sample taken from a stream draining the area to the north of the valley analysed 17 ppm U_{3+} and 57 ppm Th, but this result could not be repeated in later work. Spectrometer readings in the area indicate a strong thorium component to the anomalies. Subsequent Track Etch sampling located 4 distinct anomalies trending NW from the valley floor over the sandstone plateau.

Soil samples taken from the Track Etch holes ranged from <1-12 pp U_{3+} and uranium and copper results defined 2 anomalous areas, one of which was associated with anomalous radon although in general correlation of anomalous uranium and radon was not very good. Soil samples do not appear to have been analysed for thorium, however.
A seismic survey in 1975 defined a NE/SW trending ridge in the lease area, with the seismic refractor surface lying 20 – 70 m below the present ground surface of the plateau.

5.6.5 Conclusions and Recommendations

It is considered possible that many of the anomalous results obtained to date in the Window II area might be due to a predominantly thorium rather than uranium source. Monazite concentrations in the Kombolgie sandstone or in a shallow granitic mass could be possible sources. Recent work by the BMR (Tucker, et al) suggests that a basement high links the Jim Jim and Malone Creek Granites and would pass through the Window II area at a relatively shallow depth.

The soil geochemical results indicate that some uranium is present in the area and although this could be due to acid volcanics at the base of the sandstones it is felt that further work is warranted at Window II.

A radon survey should be conducted over the area of Track Etch anomalies but "Thoron" filters should be used, either on Track Etch cups or alphameters. Soil samples should be collected from the bottom of each sample hole and subjected to multi-element analyses including thorium, and spectrometer ratios should be noted at each site. Particular attention should be paid during sampling and result interpretation to the topographic features of each site as the Window II plateau is highly dissected. Any anomalies found as a result of this work would considerably enhance the potential of the Window II area.
5.7 CORONATION HILL

5.7.1 Location and Access

Coronation Hill lies 14 km SE of El Sherana along the road to Sleisbeck.

5.7.2 Tenement Status

The Coronation Hill area is covered by 3 granted leases (GML 41A; 42A; ML 4A) and 8 leases under application (ML 1406A - ML 1409A, ML 801A - ML 804A). All leases lie outside Stage 1 and Stage 2 of the Kakadu National Park but within an area suggested as a possible Stage 3 of the park.

5.7.3 Introduction

The BMR discovery of Coronation Hill uranium mineralisation in 1953 was the first of the South Alligator River Valley uranium discoveries. Worked by United Uranium N.L. between 1961-1962 from open cut and underground workings it produced a total of 68 t of contained uranium. Uranium ore grade is reported to have averaged 0.26% U3O8 and a considerable amount of gold was extracted from ore said to average better than 5 - 7 dwt/t (8 - 11 g/t).

5.7.4 Geology and Mineralisation

The Coronation Hill Mine area on the NE slopes of Coronation Hill appears to have been the locus for volcanic activity in Middle Proterozoic time. A pale yellow to purple quartz and quartz-feldspar porphyry has intruded Middle Proterozoic green basic volcanics including flows and tuffs in the mine area. The contact appears to be faulted in places and a volcanic breccia or agglomerate can be seen in the open cut which contains some fragments of Lower Proterozoic carbonaceous shales and intrusive quartz porphyry.

Few records remain concerning the geological occurrence of the mineralisation but a diamond drill hole done by the Joint Venture in 1976 has helped to clarify the matter. Uranium mineralisation was probably localised in and around the intrusive (diatreme?) breccia, especially where carbonaceous fragments were present, while uranium/gold and gold mineralisation may have been more in the quartz porphyry and near its contacts with the green basic volcanics.

The uranium occurred both as sooty pitchblende and, in the weathered zones, as secondary uranyl phosphates.
Gold was found in the area of uranium mineralisation associated with hematite and the uranium minerals as well as in areas away from the richest uranium ore. Old mine plans of an area approximately 14 m NE of the open cut show analyses of up to 5.93 g/t over a 12 m length of adit with the best 3 m section being 10.54 g/t Au. The 1976 diamond drill hole, CH-DDH3, passed beneath this zone and the open cut and while less than half of the core was assayed, results are encouraging as shown below.

<table>
<thead>
<tr>
<th>Meterage</th>
<th>Assays</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>To</td>
<td>(U_{3.0}^\text{ppm})</td>
<td>Au ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A.A.S. Method</td>
<td>Oz/Short Ton</td>
</tr>
<tr>
<td>44</td>
<td>46</td>
<td>48</td>
<td>1.0</td>
</tr>
<tr>
<td>52</td>
<td>54</td>
<td>2</td>
<td>1.4</td>
</tr>
<tr>
<td>62</td>
<td>64</td>
<td>4</td>
<td>1.4</td>
</tr>
<tr>
<td>86</td>
<td>88</td>
<td>15</td>
<td>1.16</td>
</tr>
<tr>
<td>94</td>
<td>96</td>
<td>354</td>
<td>1.0</td>
</tr>
<tr>
<td>96</td>
<td>98</td>
<td>1240</td>
<td>0.14</td>
</tr>
<tr>
<td>98</td>
<td>100</td>
<td>27</td>
<td>1.04</td>
</tr>
<tr>
<td>114</td>
<td>116</td>
<td>1200</td>
<td>0.12</td>
</tr>
<tr>
<td>116</td>
<td>118</td>
<td>800</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Gold occurred in both basic volcanics and in the quartz porphyry, especially in chloritic sections where visible gold was seen in fractures in some of the core having films of chlorite.

Copper has been found by BMR drilling in a quartz vein 70 m N of the open cut where it occurs as copper carbonate and chalcocite. It was this quartz vein that drew the first prospectors to the Coronation Hill area.

5.7.5 Summary and Conclusions

While Coronation Hill remains an interesting uranium prospect it appears that it should be considered as a potential low grade gold producer as well. To enable better assessment of this potential the following steps are recommended:

- Detailed mapping in the vicinity of the Coronation Hill open cut.
- Rock chip sampling and analysis for at least Au and \(U_{3.0}\) of outcro of quartz porphyry and basic volcanics in this area.
- The remaining core from CH-DDH3 should be assayed for at least Au and \(U_{3.0}\).
- If any of these steps provide encouraging results a series of vertical diamond drill holes should be done to test the extensions of the gold mineralisation located to the NE of the open cut as we as any other anomalous areas.
C. LOW PRIORITY AREAS

5.8  ANOMALY 3 - 171

5.8.1 Summary

Uranium mineralisation was located in breccia zones in a series of Fisher Creek Siltstone-steeply dipping, lightly metamorphosed greywacke, siltstone, and shale. These have been intruded by dolerite of the Zamu Dolerite and quartz feldspar porphyry dykes possibly related to the nearby Malone Creek Granite.

While assays of near surface material gave results of up to 5.05% U(3)O(8), extensive costeasing and drilling did not locate significant mineralised zones.

5.8.2 Recommendations

- A close spaced alphameter survey should be carried out on the old grid, especially in the area of costeans 1 and 5 to check out the broad radiometric anomaly there and geochemical samples should be collected from the bottom of the holes for analyses.

- Costeans 1 and 5 should be extended to further check out this broad radiometric anomaly.

5.9 ROCKHOLE REVERSE FAULT EXTENSION

5.9.1 Summary and Recommendations

The major reverse fault zone between Lower and Middle Proterozoic strata that is mineralised at the Rockhole Mine is host to several small uranium prospects along its length such as Teague's, Airstrip, and the anomaly NW of Teague's. Consideration should be given to testing this fault zone along much of its strike length by radon sampling to try and detect areas of concealed uranium mineralisation. The very steep topography and thin and highly variable soil cover over much of this area will present perhaps insurmountable problems to interpreting the results of this type of survey in such difficult terrain, but the attempt should be made. The use of alphameters rather than Track Etch cups is recommended as this will allow closer spacing of sample sites and allow quick follow up and re-sampling of anomalous zones.

5.10 ANOMALY 105/110

5.10.1 Summary and Recommendations

Very little is known about this area located 67 km NW of El Sherana in an area believed to be underlain by Koolpin Formation and/or Kapalga Formation rocks.
Old UUNL reports locate it on photo 5183 of run 41 and describe the area as follows:

"...a north-south trending ridge of blocky scree continues to the north as a low ridge of laterite. The scree is composed of cherty and quartzitic rocks, all highly weathered with ferruginous material in cavities. Box work-like structures are frequently present but are thought to be due to surface redistribution of silica and are not gossan.

RADIOMETRY

An area of 120,000 square feet is enclosed by the 30 uR/hr contour. Values drop away from this to as low as 5-8 uR/hr on alluvium or siliceous scree".

The highest assays reported, 0.10 lb/t U₃O₈, are in laterite but it is thought that a brief program of surface mapping, radiometrics, and possibly geochemical sampling is in order to determine if the area warrants further work.
6. **NOTES ON THE ALLIGATOR RIVERS URANIUM FIELDS**

6.1 **EAST ALLIGATOR RIVER FIELD**

The East Alligator River Uranium Field is known to contain at least 4 very large and quite similar uranium orebodies. Published ore reserves at individual mines range from the Massive Jabiluka 2 orebody with 207,000 t of contained uranium at an ore grade of 0.397% U₃O₈ and 8100 kg of contained gold at 15.3 gm/t Au, to the smaller but richer Nabarlek deposit with 9098 t contained uranium with an ore grade of 1.84% U₃O₈.

The host to all the East Alligator deposits is the Lower Proterozoic Cahill Formation lying a short distance below the Lower/Middle Proterozoic unconformity. The Cahill Formation is composed of quartz-muscovite-chlorite schists in the mine areas with graphite schists and chlorite schists being developed locally as well as local chert and dolomite.

The uranium ore zones consist of disseminated and massive uraninite below the weathered zone and are roughly stratiform on a large scale but on a smaller scale can frequently be seen to transgress the different schistose units, especially at Jabiluka 2 where brecciation appears to be more of a controlling factor than lithology. Several of these orebodies are associated with zones of major structural disturbance such as reverse faulting and/or brecciation, some of which may be the result of solution effects or volume reduction in carbonate units. Ore grade mineralisation extends to at least 300 m below the unconformity at Jabiluka 2 (i.e. some 500 m below the present day land surface) and probably considerably deeper. The deposits discovered to date are all located in close proximity to Archean - Late Lower Proterozoic granitic complexes.

6.2 **SOUTH ALLIGATOR RIVER FIELD**

The South Alligator River uranium deposits discovered to date are several orders of magnitude smaller than the East Alligator deposits but their mode of occurrence does have several similarities.

The largest of these mines was the El Sherana and El Sherana West operation (Appendix 1) that produced 360 t of contained U₃O₈ at an average ore grade of approximately 0.65% U₃O₈. In addition gold was also recovered from some of these mines, notably Palette, Coronation Hill and El Sherana. The orebodies are found mostly in the Lower Proterozoic Koolpin Formation which is currently believed to lie at a higher stratigraphic level than the Cahill Formation of the East Alligator River Field. Ore tends to be concentrated in rich pods up to a few metres in length along or near faulted contacts in the Koolpin Formation or between the Koolpin Formation and Middle Proterozoic strata although in some deposits a considerable proportion of the ore was extracted from fractures in the overlying Middle Proterozoic sandstone, immediately above the unconformity.

The Koolpin Formation consists of shales and siltstones interbedded with chert horizons and nodules. These shales and siltstones have been found to be strongly graphitic in the mine workings and large dolomite lenses in the Koolpin Formation are known to exist near some of the mines and prospects.
Total production of uranium from the 13 small deposits is believed to be approximately 874 tonnes U₃O₈ from 1954-1964.

6.3 SUMMARY

The following features in the South Alligator River region are similar to those found in the East Alligator River region and may be important for the formation of large U₃O₈ deposits.

(a) MAJORFAULTING - Major faults between Lower and Middle Proterozoic strata with associated brecciation are present in most of the prospect areas discussed in this report. This brecciation as well as that resulting from karst formation and/or volume reduction in carbonates may have provided the necessary plumbing system for ore fluids.

(b) MAJOR UNCONFORMITY - The Lower/Middle Proterozoic unconformity represents a huge time break and known ore bodies in both regions lie not far below it. The unconformity may be important as an ore fluid channelway after Middle Proterozoic sedimentation or as a period of exposure to the atmosphere for the Lower Proterozoic units allowing them to be prepared structurally for ore concentration.

(c) FAVOURABLE HOST - Some horizons of the Koolpin Formation are rich in graphite which is considered to play an important role in uranium concentration in the East Alligator River deposits. Magnesium metasomatism may not be as extensive in the South Alligator River region although dolomitisation and chloritisation have occurred in some areas. The grade of metamorphism is also less in the South Alligator River region but the importance of this for ore formation is uncertain.

(d) URANIUM SOURCE - The uranium content in the Edith River Volcanics is considered by Ayres, D.E., et al to be higher than average for this kind of rock. It is conceivable that uranium could be leached from these rocks and travel along a suitable pathway (the unconformity surface?) to be deposited in a favourable host that has been structurally prepared.
APPENDIX I

DESCRIPTIONS OF TWO SOUTH ALLIGATOR RIVER VALLEY MINE AREAS

1. EL SHERANA AND EL SHERANA WEST

1.1 ILLUSTRATIONS:

PLATE 16 GEOLOGICAL PLAN 1:480
PLATE 17 GEOLOGICAL CROSS SECTIONS 1:480
PLATE 18 LONGITUDINAL SECTION AND COMPOSITE LEVEL PLAN 1:1200

1.2 INTRODUCTION

The El Sherana and El Sherana West mines were the two largest \( U \text{O}_2 \) producers in the SARV having a combined production of 362 t of contained \( U \text{O}_2 \). The El Sherana Mine commenced production in 1956 as the result of the discovery of a rich pitchblende vein on the surface which was followed by underground workings and then an open cut. The El Sherana West Mine commenced production in 1961 as the result of follow up work on a second order SP anomaly discovered by the BMR. Production was from an open cut as well as underground working but both mines had ceased production by 1964.

1.3 GEOLOGY

The Lower Proterozoic succession (Plates 16, 17) consists of shale/siltstone with interbedded chert horizons and nodules (Fig. 3, Photos 3,4) as well as beds of shale/siltstone of the Koolpin Formation. At depth the shales and siltstones are often carbonaceous and pyritic. Dips are generally very steep to vertical although tight folds are known from underground workings.

The Middle Proterozoic succession overlies this with pronounced angular unconformity having a flat lying poorly sorted quartz sandstone of the Edith River Volcanics at its base. This variably hematitic unit is followed by a coarse volcanic agglomerate and then a pinkish/purple ignimbrite that shows a variable amount of small angular quartz grains, probably of a pyroclastic nature.

A discontinuous band of grey siliceous breccia to the SW of the open cuts contains very angular quartz and chert fragments a few centimetres in size in a granular siliceous matrix. Long thin quartz fragments similar to those observed at Sleisbeck and the Scinto Plateau suggest that these rocks may have a similar origin (section 5.4.5.2 (c)).

1.4 MINERALISATION

Uranium ore occurs both as pitchblende and as secondary uranium minerals; the pitchblende frequently being found in large, often concretionary masses, some of which are museum specimens weighing over 700 kg, as well as smaller veins and disseminations along fractures.
Much of the ore at El Sherana was extracted from fractures and veins in the Middle Proterozoic sandstones (and possibly volcanics?) a few metres above the Lower/Middle Proterozoic unconformity. At El Sherana West it was often localised along or near contacts between the Lower Proterozoic units and some writers believe that contacts <50 feet apart have some significance although the evidence for this seems somewhat doubtful.

Along with Palette and Coronation Hill, the El Sherana Mines were the major gold producers in the SARV and although analyses of up to 180 dwt/ton are reported in some drill holes a grade of 2-4 dwt/ton in ore zones was probably the average.

2. ROCKHOLE MINE

2.1 ILLUSTRATIONS: PLATE 19 GEOLOGICAL PLAN 1:480
PLATE 20 GEOLOGICAL CROSS SECTION 1:480
PLATE 21 LONGITUDINAL SECTION AND COMPOSITE LEVEL PLAN 1:960

2.2 INTRODUCTION

The Rockhole Mine area includes the Teague's, Sterrit's and O'Dwyer's prospects and is the northernmost of the mines operated in the SARV, being located 6 km NW of El Sherana. The Rockhole Mine was the third largest in the SARV, after El Sherana and El Sherana West, and was discovered by Uranium Development and Prospecting N.L. (UDP) who sold its interest to South Alligator Uranium N.L. which was later taken over by UUNL. The mine was developed by South Alligator Uranium N.L. and operated from 1955-1962 separately from the other deposits in the SARV. It had its own solvent extraction plant on site, believed to be the smallest solvent extraction plant in the world, having a 15 tons per day capacity, designed for an ore feed of 20 lb/ton (0.89% U₃O₈). This high grade required very selective mining but a total of 148 tons of contained uranium were produced entirely by underground workings nevertheless.

2.3 GEOLOGY

The Rockhole Mine is located along a major reverse fault zone between Lower and Middle Proterozoic rocks. As at El Sherana, the Lower Proterozoic succession contains shale/siltstone with variable amounts of interbedded chert horizons and nodules. The shale/siltstone beds are carbonaceous and often pyritic at depth.

The relatively flat lying Middle Proterozoic units rest with strong angular unconformity on the high paleo relief Lower Proterozoic surface as shown in Figure 3, Photo 1, taken above O'Dwyer's No.3 Adit. The grey pebbly sandstone and conglomerate above this unconformity belong to the Middle Proterozoic Edith River Volcanics as do the rhyolites and ignimbrites that overlie it. In some areas a purple amygdaloidal flow with pale green sericitic amygdules is present apparently interbedded at the base of the acid volcanics. An unconformity is also believed to exist between the ignimbrite and the overlying quartz sandstones of the Kombolgie Formation.
2.4 MINERALISATION

The reverse fault zone at Rockhole Mine consists of several parallel faults that follow bedding planes in the steeply dipping Koolpin Formation quite closely. Displacement along individual fault planes probably varied from a few to 50 metres, and the ore was localised in small pods along the faults ranging from a few centimetres to 2 metres in width. Ore occurs in patches along these faults, especially where a thin carbonaceous shale horizon is found along a major fault, but also along contacts between sections of Koolpin Formation with differing amounts of chert interbeds. Additional ore occurs in joints and shears in the sandstone at the footwall of the reverse fault but is rarely found in the volcanics in a similar location.

The ore consists of massive pitchblende stringers or pods as well as sooty pitchblende on fractures and joints. Gold is present, but in much smaller quantities than at El Sherana and has some associated galena but was not recovered, and much pyrite and margasite are found in some ore. Siderite is occasionally found on fractures and joints in the wall rock and in the ore. The ore was produced from small stopes generally less than 3m wide developed intermittently for 650 m along strike.
APPENDIX II

SELECTED BIBLIOGRAPHY


NORANDA AUSTRALIA LTD. : Various Reports to the South Alligator Joint Venture as listed in Appendix V.

SHEPHERD, J. 1962 : "Uranium in Northern Australia with Special Reference to the Ore Bodies of the South Alligator River Area, Northern Territory" Univ. of Queensland PhD Thesis.


WALPOLE, B.P., et al, 1968 : "Geology of the Katherine-Darwin Region, Northern Territory" BMR Bull. 82.

APPENDIX III

SUMMARISED CONTENTS OF NORANDA AUSTRALIA REPORTS ON SOUTH ALLIGATOR JOINT VENTURE

No.157  "Review of Exploration on Prospecting Authorities 2212 and 2225 N.T., Sept. 1971"
        by Battey, Foy, Rodwell, Thomas

        SOUTH ALLIGATOR R. AREA  P/A  2225
        - El Sherana and El Sherana W.
        - Rockhole
        - Palette
        - Saddle Ridge
        - Coronation Hill
        - Scinto V, VI
        - Koolpin Creek
        - Skull
        - Sleisbeck
        - Various S.A. Valley Prospects

        PANDANUS CREEK AREA - P/A  2212
        - Eva Mine
        - Cobar II & Old Parr Prospect
        - El Hussen
        - NE West Moreland Area
        - Fish R. (Melanie)
        - Milestone
        - Chapman's
        - Various Other Anomalies
        - Crystal Hill
        - Norris's Copper Prospect

No.161  Summary of Geochemical and Geophysical work to date
        by J.A. Climie
        Radiometric Anomalies
        - 2,3,4,20,11,9,8,18,12,22,23,15,16
        Base Metal Prospect

No.171  "Report on an Airborne Magnetometer Survey over Part of Prospecting Authority 2212, Pandanus Creek N.T., May 1972"
        by N. Rodwell
No. 172

"Report on Airborne Magnetometer Survey over Part of Prospecting Authority 2225, S. Alligator R. Area, N.T., May 1972"
by N. Rodwell

No. 184

"Report on Prospecting - E.L. 120, N.T., 1972"
by Curry, Lee, Rodwell, Tucker, Wyntje
- Airborne Radiometric Anomalies:
  - S5C, 5P, 5Q, 5G, 5N, 5233, 5D, 5A, 5a, 5B, 5K, 5145
  - 5E, 5F, 5H, 5I, 5J, 5L, 5M 5R, 5S, 5T, 5U, 5V,
    - 5067, 5068, 5074, 5076, 5084 Combined
    - 5112, 5127, 5141, 5147, 5158, 5173, 5176, 5181
    - 5182, 5192, 5193, 5230, 5236, 5238, 5268, 5271.

No. 185

"Report on Prospecting - EL 119, N.T., 1972"
by Petch, Tucker, Wyntje, Rodwell
- Kombolgie reconnaissance or Window II
- Airborne Radiometric Anomalies
  - 3A, 3B, 3C, 3D, 3E, 3G, 3H, 3I, 3K, 3L, 3M
  - 3N, 30, 3F, 3T
  - 302, 308, 312, 313, 3U and V, 3J and Q

No. 186

"Report on Prospecting - EL 123, N.T., 1972"
by Foy, Wyntje, Tucker, Curry, Lee, Rodwell
- Anomaly 2J
- Sandstone Anomaly
- Window I
- Window II
- Airborne Radiometric Anomalies
  - 2A, 2B, 2C, 2D, 2E, 2F, 2G, 2H, 2I, 2K, 2L,
  - 210, 213, 214, 215, 236, 242a
  - 4-001, 4-012, 4-047, 4-049, 4-050, 4-051, 4-052,
    - 4-054, 4-056, 4-064, 4-074, 4-075, 4-077, 4-081

No. 187

"Report on Prospecting, EL 121, N.T., 1972" (Pandanu Creek Region)
by Petch, Tucker
- Red Rock
- Crippled Horse

No. 188

"Report on Prospecting, EL 122, N.T., 1972" (Pandanu Creek Region)
by Petch, Tucker
- Anomaly 30
- Radiometric Anomalies
  - 2A, 2B, 6A, 6B

No. 189

"Report on Prospecting, E.L. 124 N.T., 1972" (Pandan Creek Region)
by G. Petch
- Radiometric Anomalies
  - 4A, 7A, 7B, 7D

No. 190

"Report on Prospecting, E.L. 125, N.T., 1972" (Panda Creek Region)
by G. Petch
- Localities 1-16 inc.

No. 191

"Report on Prospecting, E.L. 158, N.T., 1972" (Nourlangie Area)
- Radiometric Anomalies 8, 9, 16 (Watershed)
Base Metal Zones 1 - 6 inc.
No. 199
Interpretation of Aeromagnetic and Radiometric Data
EL's 280, 281, 282, 158, N.T. July 1973
(Nourlangie Area)
by M.L. Faluey
- Aeromagnetic Anomalies
- A-G Inc.
- Radiometric Anomalies
- Zone A Association
- Mt. Brockman Association

No. 200
Interpretation of Regional Aeromagnetic Data
EL's 119, 120, 123, N.T. August, 1973
by M.L. Faluey

No. 216 (VI)
(Drawer NS-13)
EL 119, N.T.
by Foy, Migzitis, Wyntje, Pietsch, Tucker
- Upper Turnoff Creek
- Jim Jim Catchment Reconnaissance
- Katherine R. Reconnaissance
- Airborne Radiometric Anomalies
  - 3-171, R-18, R-19, R-20

No. 216 (V2)
EL 119, N.T.
Report on 1973 Investigations on that Portion
Surrendered in Dec. 1973
by Miezitis, Lee, Rodwell, Wyntje, Climie, Pietsch, Tucker
- Kombolgie Reconnaissance
- Airborne Radiometric Anomalies
  - 1972:
    - 3B, 3C, 3D, 3E, 3H, 3I, 3L, 3M, 312, 313
  - 1973:
    - 315, 3-111, 3-132, 3-135, 3-138, 3-138, 3-141,
    - 3-143, 3-145, 3-169, 3-172, 3-173, 3-175,
    - 3-176, 3-226, R-23, R-24

No. 217 (VI)
EL 123 N.T.
by Foy, Migzitis, Wyntje, Pietsch, Tucker
- Anomaly 2J
- Window I
- Window II
- Radon Survey
- Kurrundie Creek Reconnaissance

No. 217 (V2)
EL 123 NT
Report on 1973 Investigations on that Portion
Surrendered in Dec. 1973
by Foy, Migzitis, Wyntje, Pietsch, Tucker
- Kombolgie Reconnaissance
- Radon Survey
- Kurrundie Creek Reconnaissance
- Airborne Radiometric Anomalies
  - C-45, BMR 1972, C-32, C-36, C-39, C-42 (1973)
  - 2B, 2C, 2F, 2G, 2H, 2K, 242A, 4-052, 4-053,
  - 4-064, 4-075, 4-081 (1972)
No. 218 (VI)
EL 120 N.T.
by Miezitis, Wyntje, Dunlop, Pietsch, Tucker
- Anomalies 5P, 5C
- Anomalies 1A, 5-025, 5-057, 5-062, 5-065, 5-077,
  5-083, 5-086, 5-092, 5-073, 5-087, 5-144,
  5-245, 5-256

No. 218 (V2)
EL 120 N.T.
Report on 1973 Investigations on that Portion
Surrendered in Dec. 1973
by Miezitis, Tucker, Pietsch, Wyntje
- Airborne Anomalies
  5-032, 5-125, 121 (1973)
  5H, 5I, 5-147, 5-158, 5-271 (1972)

No. 219
EL 124, N.T. Report on 1973 Investigations
(Pandanus Creek Region)
by G. Pietsch
- Anomaly 7D

No. 220 (VI)
EL 158 N.T.
Report on 1973 Investigations on that Portion
under Application for Renewal in May 1974
(Nourlangie Area)
by Foy, Climie, Dunlop, Tucker
- Stream Sediment Anomalies
  73-1, 73-2, 73-6, 73-7
- Radiometric Anomalies
  73-8, 73-10, 73-11
- Copper Anomaly Zone 1

No. 220 (V2)
EL 158, N.T.
Report on 1971-73 Investigations on that Portion
to be Surrendered in May 1974
(Nourlangie Area)
by Foy, Climie, Dunlop, Tucker
- Airborne Radiometric Anomalies
  73-9, 73-12
- 1973 Stream Sediment Anomalies
  73-3, 73-4, 73-5
- 1972 Radiometric Anomalies
  8, 9
- 1972 Base Metal Mineralisation
  Zone 2, Zone 4, Zone 5
- Previous Work
  Anomaly 2,3,4,15

Misc.
A Reappraisal of the Coronation Hill Prospect N.T.
June, 1974
by Foy, Wyntje

No. 231
EL 119, N.T., Report on 1974 Investigations
by Foy, Miezitis, Pietsch, DeRoss
- Sleisbeck
- Anomalies 3-110, 3-117, 3-123
- Coronation Hill
No. 232
EL 120, N.T.; Report on 1974 Investigations by Foy, Miezitis, Pietsch, DeRoss
- Barramundie Creek Reconnaissance
- Anomalies 5A, 5C, 5G, 104, 110
- Base Metal Anomaly
- Anomaly 77
- BMR Anomaly
- Goodparla, Coirwong Creek Radon Survey

No. 233
EL 123 N.T.; Report on 1974 Investigations by Foy, Miezitis, Pietsch, DeRoss
- Barramundie Creek Reconnaissance
- Window I
- Window II
- Anomaly 2J
- Gerowie Creek Radon Anomaly
- South Alligator Valley Auger Drilling

No. 243
EL 119, N.T.; Report on 1975 Investigations by Pederssen, Duncan
- Sleisbeck
- Anomaly 3-171

No. 244
EL 120, N.T.; Report on 1975 Investigations by Pedersen, Wright, Pietsch
- Regional Radon, Uranium and Base Metal Surveys
- Anomaly I, II, 77, 77 South, 5D

No. 245
EL 123 N.T.; Report on 1975 Investigations by Pedersen, Pietsch
- Window II
- Window I
- Barramundie Creek
- Anomaly 2J

No. 259
EL 119, N.T.; Report on 1976 Investigations by Pietsch, Wright, Chapple
- Sleisbeck
- Anomaly 3-171
- N.W. Margin of Malone Creek Granite
- Coronation Hill
- Reconnaissance Investigations
  A - Dinner Creek to Coronation Hill
  B - Coronation Hill to Saddle Ridge

No. 260
EL 120, N.T.; Report on 1976 Investigations by J. Wright
- Anomaly 9000E, 4000N
- Anomaly 8500E, 5500N
- Anomaly 77 South
- Track Etch Anomalies I, II
- Basal Koolpin Traverses

No. 261
EL 123 N.T.; Report on 1976 Investigations by J. Wright
- Dinner Creek to Coronation Hill
- Coronation Hill to Saddle Ridge
| No. 265 | Scinto Plateau and Coronation Hill, N.T. Report on 1977 Investigations by J. Wright |
Petrological Examination of 33 Samples
From the South Alligator River Region
Northern Territory

Report No.: 79/117

21st December, 1979

For: Utah Development Company

G. G. LONDER
Consulting Petrologist
SUMMARY AND COMMENTS

Petrographic descriptions of 33 rock samples from the South Alligator River region in the Northern Territory are presented in this report, and a summary of the main petrographic features is provided below.

B5: Dolomite; possible biogenic (stromatolitic) origin; carbonate identity confirmed by XRD.

B11: Altered basalt; porphyritic; greenschist secondary minerals, mainly epidote.

B17: Shale; indurated, micaceous.

B65: Indurated shale; more distinctly micaceous than B17; possible vitric tuff origin.

B72: Altered, tuffaceous quartz wacke; strong sericitic alteration; reworked rhyolitic pyroclastic.

B78: Altered dolerite; sericitic alteration; supergene hematite.

B80: Meta-chert; granular quartz with subordinate lepidoblastic mica component.

B81: Oxidised banded iron formation; could also be described as hematitic quartz-chlorite schist.

B82: Oxidised tuff; strong weathering obscures original lithology but acid tuff likely.

B86: Sheared quartz vein; fluid inclusions numerous; minor sericite; trace of former pyrite.

B90: Altered, tuffaceous quartz wacke; similar to B72; probably a reworked, rhyolitic tuff; significant apatite component.

B98: Sericitised vitric tuff; affinities with B65.

B112: Sericitised crystal-lithic tuff or wacke; very similar to B90; distinct bedding could be a true pyroclastic or rework from tuff.

B133: Sericitised tuffaceous wacke; very similar to B72; all or mostly reworked from rhyolitic tuff.

B142A: Sandstone; poorly sorted but quite well rounded quartz grain predominate; authigenic overgrowths; abundant fine, pale brown mica in matrix; 3-4% secondary apatite.

B154: Sandstone; similar to B142A but with much rarer apatite; 15-20% matrix mica.
B157: Tuffaceous sandstone; similar to previous two samples, but with mainly clay rather than mica cement; 2% secondary (matrix) apatite; numerous volcano-lithic sandy grains.

B176: Altered vitric tuff; similar to B98; sericitic alteration, with hematite.

B196: Sandstone; similar to B142A etc., but has a substantial phosphate component (~15%), grading from colophane through dahllite to apatite.

B200: Phosphatic sandstone (wacke); similar to B196 but coarser and richer in phosphate (~20%); phosphate not well crystallised, mainly confined to cement.

B213: Sandstone; notably finer than B200 and no recognisable phosphate.

B234: Hematitic, altered tuff; strongly altered and weathered; quartz-sercite-clay-hematite mineralogy; tuffaceous interpretation tentative.

B245: Sandstone; similar to earlier sandstone samples but not phosphatic.

B249: Rhyolite; distinctive, acid volcanic texture; altered and weathered.

B257: Sandstone; mainly argillic cement; reworked rhyolitic volcanic, minor phosphate.

B279: Oxidised basalt; similar to B78, but finer; mineralogy now largely clay and hematite, but primary texture well preserved

B280: Sandy siltstone; well bedded; diagenetic mica.

B301: Oxidised fine tuff; quartz-rich; tentative identification.

B304: Silicified rhyolite; dominantly quartz; minor limonite after pyrite.

B305: Ferruginous silicified rhyolite; similar to previous sample but very hematitic.

B306: Dolomite; fairly uniform, similar to B5 but with no recognisable biogenic structures.

B307: Siliceous dolomite; similar to B306 but richer in quartz; both dolomite and quartz are fluid-rich.

B316: Sericitised quartz arenite; fairly well sorted but poorly rounded quartz grains; no definitely tuffaceous components.

Specific Comments

1. Samples B5, 306, 307 are similar and consist of uniform carbonate that does not effervesce in dilute HCl. X-ray
diffraction analysis of B5 confirmed dolomite as the sole or dominant carbonate phase.

2, 3. No graphite was recognised in B80, B2 (B4 not submitted), and metamorphic grade is low.

4. Samples B17, 65, 82, 98, 176, 234 have a possible to probable tuffaceous origin; samples B72, 90, 112, 133, 142A, 154, 157, 196, 200, 213, 245, 257, 301, 304, 305 have a probable or definite tuffaceous component (rhyolitic).

5. a), b), c), d) - see petrographic table.

e) B234 and B249 are rhyolitic volcanic rocks; B279 is a basaltic volcanic and B280 consists of sandy siltstone.

f) B304 and B305 are silicified acid volcanics, whereas B86 consists of sheared vein quartz.

g) B5, 306, 307 are similar, but 5 has possible biogenic structures and 307 is quite siliceous.

6. Phosphate present in B90, B142A, B154, B157, and especially in B196 and B200. Chlorite present in B81 and as a minor component in a few other cases.
<table>
<thead>
<tr>
<th>SAMPLE NO.</th>
<th>SAMPLE SITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>B5</td>
<td>NW of Coronation Hill</td>
</tr>
<tr>
<td>B11</td>
<td>Koolpin Creek Mine</td>
</tr>
<tr>
<td>B17</td>
<td>El Sherana Mine Area</td>
</tr>
<tr>
<td>B65</td>
<td>Rockhole Mine - O'Dwyers No. 3 Adit</td>
</tr>
<tr>
<td>B72</td>
<td>Rockhole Mine - Sterritt's No. 1 Shaft</td>
</tr>
<tr>
<td>B78</td>
<td>Rockhole Mine - Sterritt's Area</td>
</tr>
<tr>
<td>B80</td>
<td>Sleisbeck - Exposure 5 (Eastern Hill)</td>
</tr>
<tr>
<td>B81</td>
<td>Sleisbeck - Input Anomaly SB4</td>
</tr>
<tr>
<td>B84</td>
<td>Exposure 3 (Western Hill)</td>
</tr>
<tr>
<td>B90</td>
<td>Palette Mine - Adit 4 Area</td>
</tr>
<tr>
<td>B93</td>
<td>Rockhole Mine - Sterritt's Area</td>
</tr>
<tr>
<td>B112</td>
<td>Palette Mine - Adit 5 Area</td>
</tr>
<tr>
<td>B133</td>
<td>Teague's Prospect - No. 2 Shaft Dump</td>
</tr>
<tr>
<td>B142A</td>
<td>Palette Mine - No. 5 Adit Area</td>
</tr>
<tr>
<td>B154</td>
<td>Palette Mine - No. 1 Adit Area</td>
</tr>
<tr>
<td>B157</td>
<td>&quot; &quot; &quot; &quot;</td>
</tr>
<tr>
<td>B176</td>
<td>Pul Pul Hill Area - Meta Shale Anomaly</td>
</tr>
<tr>
<td>B196</td>
<td>Skull II Prospect</td>
</tr>
<tr>
<td>B200</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>B213</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>B234</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>B245</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>B249</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>B257</td>
<td>&quot; &quot;</td>
</tr>
<tr>
<td>B279</td>
<td>Saddle Ridge Area - NW of Open Cut</td>
</tr>
<tr>
<td>B280</td>
<td>&quot; &quot; &quot; &quot; &quot; &quot;</td>
</tr>
<tr>
<td>B301</td>
<td>Saddle Ridge Area - SE of Open Cut</td>
</tr>
<tr>
<td>B304</td>
<td>&quot; &quot; &quot; &quot; &quot; &quot;</td>
</tr>
<tr>
<td>B305</td>
<td>&quot; &quot; &quot; &quot; &quot; &quot;</td>
</tr>
<tr>
<td>B306</td>
<td>Saddle Ridge South Prospect Mullock Dump</td>
</tr>
<tr>
<td>B307</td>
<td>&quot; &quot; &quot; &quot; &quot; &quot;</td>
</tr>
<tr>
<td>B316</td>
<td>Saddle Ridge Area - SE of Open Cut</td>
</tr>
</tbody>
</table>
SAMPLE SITE LOCATIONS (contd.)

A. ROCKHOLE MINE AREA
   B85
   B72
   B78
   B98
   B133

B. EL SHERANA MINE AREA
   B17

C. Koolpin Creek Mine
   B11

D. PALETTE MINE AREA
   B30
   B112
   B142A
   B154
   B157

E. SKULL II AREA
   B195
   B200
   B213
   B234
   B245
   B249
   B257

F. SADDLE RIDGE AREA
   B273
   B280
   B301
   B304
   B305
   B315

G. SADDLE RIDGE SOUTH AREA
   B306
   B307

H. PUL PUL HILL REGION
   B5
   B176

I. SLEISBECK AREA
   B80
   B81
   B82
   B86
PETROGRAPHIC DESCRIPTIONS

Sample No.   B5

Rock Type   Dolomite

Hand Specimen  A fine grained, carbonate rock, with distinct banding. Colour ranges from pink to grey, both within bands and across bands. Quartz occurs in layers that are essentially concordant and are etched in relief on the weathered surface. There is no effervescence in dilute HCl.

Thin Section  The rock consists very largely of a fine grained, uniform mosaic of carbonate. Maximum grain size is about 0.2 mm but most of the carbonate is much finer than that and some of it is essentially cryptocrystalline. To some extent, grain size varies systematically in layers, but in many parts of the section there are coarser grained patches of the carbonate enclosed in the finer host. Grain size variations, mainly responsible for the banding visible in hand specimen but the carbonate does have somewhat variable cloudiness which contributes to the banded appearance. Although some layers are quite flat most have a curved or colloform nature that may be an indication of origin as stromatolite. Such an origin may explain the vertical pink structures cutting across the grey banding visible in hand specimen. A few thin grains of clearer carbonate cut across the section and some of these incorporate quartz. Elsewhere there are aroid bodies comprising somewhat clearer, relatively coarse grained (0.2 mm) carbonate with subordinate quartz. These also may be biogenic structures. Quartz is best developed in a prominent layer, most of which is fine grained (less than 0.05 mm), but the core zone of this layer contains notably coarser grained (0.5 mm), somewhat deformed quartz, that appears secondary. Apart from this, quartz occurs sporadically throughout the section as small patches, single grains and discontinuous veinlets. The section contains a trace of semi-opaque matter and some of the quartz veins are dusted by limonite.

Origin of this rock as carbonate sediment is clearly defined and it seems likely that there is a substantial biogenic component. The siliceous layer may have originally been a cherty band which has suffered some disruption and mobilisation. Lack of effervescence in cold, dilute HCl indicates that calcite is lacking or at most a very minor component of the carbonate. The relatively uniform appearance of the carbonate mosaic in thin section suggests that only one carbonate species is present and this was confirmed by x-ray diffraction, which identified dolomite as the only carbonate phase present. Dolomitisation thus seems to have been very uniform and pervasive throughout the rock, with perhaps a small amount of remobilisation.
into the clearer carbonate grains. The original rock was probably a stromatolitic limestone.

**Sample No.** B11

**Rock Type** Altered basalt

**Hand Specimen** A dark green, fine to medium grained rock of massive, uniform character.

**Thin Section** Strong alteration has affected this rock, substantially modifying the primary mineralogy and at the same time obscuring its original nature. Nevertheless, primary porphyritic texture is preserved and the rather numerous phenocrysts (30%) are enclosed in a relatively coarse grained, intergranular matrix. Phenocrysts are generally between 0.5 and 2 mm in size and in the matrix enclosing them grain size is of the order of 0.1 mm. Phenocrysts appear to have consisted originally of plagioclase, olivine and augite, but only the pyroxene phase remains partly intact. All the augite crystals show at least some alteration, whereas olivine and plagioclase have been completely replaced and are recognisable now only by their characteristic outlines.

The most abundant alteration product in this sample is epidote, which occurs as brown, prismatic crystals forming a dense network in the matrix. Epidote also partly replaces some of the phenocrysts. The epidote mineral (which may actually be clinozoisite), is very weakly birefringent but shows anomalous brown and blue interference colours. The phenocrysts appear to have been replaced principally by mixtures of serpentine and chlorite, with some probable talc in many cases, especially former olivine crystals. Carbonate is present in a few cases, and is best developed as patchy replacement of augite. Interstitial quartz is common in the matrix and is probably of secondary origin, produced as a by-product of the other alteration processes. A small amount of yellow, more birefringent epidote is present and primary opaque matter has been converted to semi-opaque leucoxene.

Although the alteration processes have obscured the original nature of this rock it is clear that the sample is of basic primary composition and the presence of porphyritic texture, with augite, olivine and probably plagioclase phenocrysts, favours basaltic volcanic rather than doleritic intrusive origin for the rock. Alteration is strong and the secondary minerals
developed represent greenschist metamorphism.

Sample No.  B17

Rock Type  Shale

Hand Specimen  A very fine grained, uniform, brownish-grey rock, with distinct cleavage. There is some suggestion of a micaceous sheen on the cleavage surfaces, but this is not strongly developed.

Thin Section  The rock has a very uniform, extremely fine grained texture and is made up dominantly of strongly foliated tiny flakes of clay or mica. Strong foliation of these flakes is emphasised by optical continuity, with most flakes reaching maximum or minimum birefringence at the same position. Individual flakes are of the order of 0.01 mm in length, although in many cases discrete crystals can not be readily distinguished. Birefringence is high enough to indicate that the rock contains relatively well crystallised phyllosilicate, probably illite rather than a kaolin type clay, and some of the flakes are probably true muscovite. Development of the clay/mica is very massive and uniform throughout the section and there is no evidence of grain size or compositional layering. A light brown pleochroism is distinctly developed in the clay/mica material. The other components of this rock are very much subordinate, but small lenticular or elongate grains of quartz are quite common and are invariably oriented parallel to the cleavage. Opaque or semi-opaque matter is also conspicuous and generally occurs in lenticular or stringer-like bodies that are strictly concordant with the cleavage. Tiny specks (0.01 mm) of hematite are uniformly and pervasively dusted throughout the clay/mica and this material no doubt contributes much to the colour of hand specimen. There is a slight tendency for the hematite dust to be concentrated in linear masses but this does not really amount to compositional banding.

This is a very fine grained, clastic, sedimentary rock, which may be described as shale. The strong foliation developed may represent primary bedding but the relatively high birefringence of the material in the rock may indicate significant induration and the foliation could then be an imposed incipient metamorphic feature. The rock is thus tending towards phyllite in identity but the grain size and development of mica do not seem to be sufficient for the rock to qualify as phyllite.
Sample No. B65

Rock Type Indurated shale

Hand Specimen A very fine grained rock of khaki colour. There is some suggestion of cleavage, but it is not as well developed as in the previous sample. A number of irregular quartz veins cut the rock and there is some limonite staining on fractures.

Thin Section In broad terms, this rock is very similar to the previous sample. However, it seems to be slightly coarser grained, with more strongly birefringent (micaceous) material and less well developed foliation of the individual grains. Substantial preferred orientation does occur, as indicated by optical continuity of much of the material in the rock, but it is certainly less marked than in the previous sample. At the same time, much more of the material in this case has strong birefringence and is certainly micaceous rather than argillic in nature. Quartz is the most abundant of the minor constituents and is best developed in veins and irregular patches especially in one part of the sample. Some of these veins appear to have formed as healing of incipient brecciation. The quartz is generally fine grained, probably recrystallised, but in some veins it is relatively coarse, with fairly strong strain extinction. Quartz is also widely developed as small, lenticular bodies and stringers which are very numerous scattered throughout the fine mica mosaic. These quartz bodies are strongly parallel and range up to about 1 mm in length. They are fairly uniformly developed throughout the section and some have a suggestion of spicule or cuspatc shape. In a few cases the lenticular or linear bodies of finely granular quartz grade into discontinuous, concordant veinlets. Fine, hematitic opaque matter occurs as clusters in some parts of the section but it is not generally abundant and the pervasive hematite dusting present in the previous sample is lacking in this case. Small elongate or prismatic crystals of opaque or semi-opaque matter are conspicuous in some parts of the section but are generally very sparse elsewhere.

The simplest interpretation of this rock would identify it as a fine, clastic sediment (shale), which has undergone some induration, causing crystallisation of primary argillic matter to fine white mica. However, the thin lenses and stringers of very finely granular quartz are a rather unusual feature, especially for a shale, and they bear some resemblance to compacted vitriclastic texture. In other words, it is possible that these thin quartz bodies are flattened glass shards of volcanic origin and the rock could
be a vitric tuff which has undergone very low grade metamorphism. Distinction between these possibilities cannot be made on the basis of this sample by itself and it is probably best to describe the rock as indurated shale. However, the possibility of the pyroclastic origin should be noted. The same interpretation could possibly be made with regard to the previous sample (B17), but in that case the texture is not as distinctive.

**Sample No.** B72

**Rock Type** Altered tuffaceous quartz wacke

**Hand Specimen** A green, uniform rock, with discrete sandy crystals scattered through a finer matrix.

**Thin Section** Quartz and sericite are the dominant constituents of this rock, which has an unsorted clastic texture. Quartz grains range from 0.05 - 1.5 mm in size, with no layering or sorting within the area represented by the thin section. Most grains are angular or sub-angular in shape, and many of the smaller ones are strictly sliver-like. Many of the quartz grains show embayments like those developed in volcanic quartz and a few show partly developed crystal faces. Deformation of quartz veins is expressed by undulose extinction, but its intensity varies from virtually nil to extreme in different grains. Furthermore, some quartz grains consist of granular quartz aggregate. In total, quartz grains make up about 30% of the rock. Most of the remainder is dominantly sericitic in nature, but there are distinct recognisable grains of muscovite, zircon, tourmaline and altered biotite. In addition, there are numerous grains which consist of sericite but are clearly altered pseudomorphs of an early phase, probably feldspar. Some of the sericitised grains may be lithic fragments and elsewhere there are grains of very finely crystalline quartz, which probably are silicified volcanic groundmass material. Some of the finely crystalline siliceous fragments appear to enclose sericitised phenocrysts. Several of the lithic fragments display "snowflake" texture, which is fairly typical of devitrified rhyolitic volcanic rocks. There is a slight tendency for detrital mica flakes to be aligned, and some of the more elongate quartz grains are oriented parallel to this direction, which presumably represents bedding but this feature is not at all well developed. In addition to the rather common zircon and tourmaline, accessory opaque matter is quite conspicuous and apatite occurs sporadically, some of it as inclusions in quartz grains. The altered biotite flakes are recognisable as masses of
secondary muscovite dusted by semi-opaque matter. Enclosing all of the larger, recognisable detrital components there is a massive mosaic of fine sericite, possibly intergrown in part with cryptocrystalline silica. No diagnostic primary textures are recognisable in this sericitic material.

This rock clearly has a poorly sorted, clastic origin, and the association of more and less deformed quartz crystals indicates a mixed provenance for the detritus. It seems very likely that the less deformed, embayed crystals of quartz are of rhyolitic volcanic origin and many of the smaller, very angular quartz grains are probably of similar origin. The strongly deformed quartz grains as well as those with recrystallised nature appear to be of separate origin but their provenance is uncertain. Other probable volcanic components include lithic fragments and possible altered feldspar crystals. Non-volcanic components are probably represented by tourmaline, muscovite and a number of the quartz grains and lithic grains. The rock thus appears to have a mixed provenance, partly volcanic and partly non-volcanic. The volcanic component probably predominates but in view of the presence of tourmaline, muscovite and similar grains, it is perhaps more appropriate to describe the rock as tuffaceous quartz wacke, rather than crystal tuff. Alteration is principally sericitic and is probably the result of low grade metamorphism.

Sample No. B78
Rock Type Altered dolerite
Hand Specimen A strongly oxidised, purplish-brown rock of fine to medium grain size. A very prominent, complex vein cuts across the sample.
Thin Section Although strong alteration has affected this rock the primary igneous texture is quite well preserved. The rock is weakly porphyritic with sparse phenocrysts of altered feldspar scattered through a uniform, medium grained matrix. Plagioclase was the dominant primary constituent and substantial feldspar remains unaltered. The phenocrysts range up to about 3 mm in length and appear to have consisted of plagioclase but they are now completely altered in the matrix, feldspar forms lath-shaped grains which average about 0.5 mm in length. Alteration of these crystals varies from slight to complete and sericite is the principal product of alteration. Mafic material was also quite abundant in the rock prior to alteration but no primary mafic material remains
as such. Olivine seems to have been the principal if not the only mafic component and generally forms relatively small grains (of the order of 0.2 mm) that are crowded together between the feldspar laths. This essentially forms an intergranular texture. A few of the mafic grains could be described as micro-phenocrysts, forming prismatic crystals up to 1 mm in length. Alteration of olivine has produced a mixture of phyllosilicate phases, ranging from colourless to light green and with moderate to high birefringence. The phases present as alteration of olivine seem to be principally chlorite, serpentine and talc. The green, birefringent alteration products resemble what is sometimes described as "bowlingite". Secondary hematite is also very well developed in this rock, occurring to a large degree along fractures in the olivine and around the grain margins. Some hematite also occurs dusted within feldspar or concentrated in the interstitial sites between feldspar grains and there are many elongate masses of hematite which are probably oxidised, primary Fe/Ti oxide grains. Pervasive, yellow limonitic staining affects much of the rock but is very patchy and irregular in its development.

The prominent vein developed in the hand specimen is 5 or 6 mm wide and consists principally of finely granular quartz or chalcedony. It has a distinctly banded nature, with the bands running parallel to the main walls. In addition to the siliceous components the vein contains much hematite, tending to be concentrated in bands or layers but also in aggregates of grains of the order of 0.1 - 0.2 mm in size. Some of these hematitic grains have a suggestion of cubic outline and could be derived from sulphide but diagnostic textures are not preserved. A conspicuous, brown ferruginous band occurs within this vein. Its constitution is uncertain but in part of its length the iron staining is lacking and the vein is made up by prehnite. The other important component of this vein is green, pleochroic micaceous material, much of it with quite high birefringence. The presence of these high interference colours indicate that the phase is not simply chlorite and much of it in fact resembles the bowlingite described in olivine pseudomorphs.

Good preservation of primary texture of this rock indicates fairly clearly that it has a basic igneous origin. It is very weakly porphyritic and the medium grain size of most of the sample favours dolerite rather than basalt identity. The rock is thus described as altered dolerite with strong development of hematite, which is presumably of supergene origin. Significance of the vein is uncertain but it appears to relate to the development of sericite and other alteration products in the main part of the rock. Although described as dolerite, this sample is a relatively fine
grained variety and it could occur as an unusually well crystallised volcanic rather than intrusive rock.

Sample No. B80

Rock Type Meta-chert

Hand Specimen A fine grained, very siliceous rock, which is mostly grey in colour but contains some creamy mottling. Colour banding is developed but is not particularly distinct.

Thin Section Quartz is by far the dominant constituent of the rock, forming a tightly interlocking granular mosaic whose grain size varies between 0.03 and 0.2 mm. Variation in grain size is fairly systematic and defines the relict primary layering. This is somewhat disrupted by both concordant and discordant quartz veins. Some recrystallisation of quartz has possibly taken place, especially where grain size varies along the length of the layer, but discrete grain size variation between layers implies that the rock has not undergone major metamorphic recrystallisation. Nevertheless, the term meta-chert has been applied because, in addition to quartz, the rock contains numerous tiny flakes of mica, which while not a major component overall, are quite conspicuous. They show strong parallel orientation and are dusted through the quartz mosaic, defining a typical lepidoblastic foliation. Some of the micaceous flakes are distinctly birefringent and probably consist of muscovite (sericite), while others appear to have low birefringence and are probably chlorite. Most of the micaceous flakes are less than 0.05 mm in length and some are extremely tiny. They are very numerous in the quartz mosaic generally and also occur in the veins, although in the latter case they are quite sparse. Nevertheless, within the veins the tiny micaceous flakes show the same orientation as the flakes elsewhere in the rock. This indicates pre-metamorphic age for the quartz veins. The other main feature of this rock is a relative abundance of hematite or similar ferruginous matter. This material is variably developed throughout the rock and is quite concentrated in some parts. Most is extremely fine grained and some of it occurs in narrow, highly contorted veinlets. Elsewhere the hematite tends to be strung out parallel to the foliation defined by mica flakes. A small proportion of the hematite occurs in cubic pseudomorphs that are probably after sulphide. These range up to 0.2 mm in size but constitute only a very small proportion of the rock overall. Occasional, obscure secondary titaniferous grains are also present.
This is a very siliceous rock whose grain size and texture indicates cherty origin. Preservation of banding and the development of foliated mica flakes suggest that the rock is a true chert and is not the product of supergene silicification of carbonate. All of the very fine grained opaque matter appears to be hematite rather than graphite.

Sample No.      B81
Rock Type       Oxidised banded iron formation (hematitic quartz-chlorite schist)
Hand Specimen   A dark red-brown, very hematitic rock with distinct colour banding. It appears to be quite siliceous but some parts of the sample are quite soft. Grain size is uniform and rather fine.

Thin Section    Strong development of supergene hematite obscures the primary nature of this rock, but it clearly consists dominantly of quartz and degraded chlorite. Quartz forms a rather uniform granular mosaic, with grain size around 0.05 mm. Some layers consist very dominantly of quartz and may be described as cherty bands. Other layers consist of a mixture of quartz and chlorite and in a few cases chlorite greatly predominates. The chlorite commonly forms flakes with well defined lepidoblastic foliation, but in some layers it is essentially massive. All of the chlorite has a rather bleached, degraded nature and supergene hematite is best developed in the most chlorite-rich layers. Some of the chloritic layers are very strongly altered to hematite and are essentially opaque. In other cases hematite is lightly to heavily dusted through the layers and its presence is clearly responsible for the colour banding visible in hand specimen. In addition to the dusty, pervasive hematite staining the rock contains numerous small cubic grains, most of which now consist of hematite, but the presence of weak relict magnetism in the rock indicates that some and probably all of these cubic grains originated as magnetite. In a few places, the section contains pods of granular quartz which enclose a dense network of prismatic pseudomorphs. These pseudomorphs now consist of hematite but their form indicates replacement of an earlier prismatic phase, possibly amphibole.

Precise origin of this rock is uncertain but it does appear that the primary constituents were mainly quartz and chlorite, although magnetite was also quite abundant. The chlorite is now largely degraded and strong development of secondary hematite in this rock suggests that the primary chlorite was rather iron-rich. Thus although the rock could be described as oxidised...
quartz-chlorite schist, it is possible that the original rock was a banded iron formation in which primary cherty quartz was interlayered and mixed with iron chlorite (chamosite) and oxide iron in the form of magnetite. The prismatic hematite pseudomorphs may be after the iron amphibole grunerite.

Sample No. B82

Rock Type Oxidised tuff

Hand Specimen A light brown, very weathered, argillic rock, with some suggestion of foliated structure.

Thin Section Strong weathering has obscured much of the primary nature of this rock. However, some relict original texture remains and appears to be of pyroclastic type. Quartz grains up to 0.5 mm in size are scattered through the rock and many have angular shapes that suggest origin as crystal clasts. There are also numerous pseudomorphed bodies that appear to have been feldspar and mica crystals, as well as numerous very hematitic masses that could be lithic fragments. These are enclosed in a matrix which now consists very dominantly of clay or colourless chlorite, with very low birefringence, together with small irregular grains of quartz. Light hematite staining is developed pervasively throughout this part of the rock but the most intense hematite is concentrated in the possible lithic fragments referred to. Primary bedding is possibly represented by a very distinct preferred orientation for these hematitic bodies and some of the probable quartz crystal clasts are also oriented parallel to this direction. Opaque or semi-opaque matter, of leucoxene type, is also widely distributed through the section. This material is distinguished by white colour in reflected light. In several places there are pseudomorphs composed of red goethite that appear to be after sulphide. No graphite can be recognised, especially in such a strongly oxidised rock, and although metamorphic grade is likely to be low the strongly oxidised nature of the sample in its present form prohibits definite assessment of this aspect. The rock is interpreted as oxidised tuff, probably of fairly acid composition, but the presence of strong weathering makes more detailed description unwarranted in this case.

Sample No. B86

Rock Type Sheared quartz vein
Hand Specimen A very leucocratic, siliceous rock, mainly white in colour but with pink zones and prominent healed fractures, some of which are stained by hematite.

Thin Section Most of the section is made up by a large mass of optically continuous quartz, which is intensely deformed with extreme undulose extinction. In some parts of the section the optically continuous quartz gives way to fine grained recrystallised silica which encloses 'islands' of highly strained quartz like that elsewhere in the section. Some of the fine grained quartz is notably prismatic rather than granular. Veins or seams of recrystallisation cut through the large, optically continuous quartz masses. In the recrystallised areas quartz is accompanied by significant but variable sericite, which occurs in both dusted and locally more or less massive form. Hematite staining tends to be associated with the sericite. The primary, optically continuous quartz has a cloudy appearance due to the presence of very numerous fluid inclusions. In contrast, veins and zones of recrystallised quartz are rather clearer. The former presence of sulphide is indicated by occasional pseudomorphs with cubic outline, as well as a few similar voids.

The very coarse, optically continuous nature of the major part of this sample, as well as its fluid-rich nature, indicates origin as vein quartz. That quartz has been sheared, fractured and partly brecciated, with healing by secondary or recrystallised quartz, together with sericite. The hematite staining may be simply an exotic, supergene feature.
Sample No. B90

Rock Type Altered, tuffaceous quartz wacke

Hand Specimen A light khaki-coloured rock, partly of sandy grain size. There are no veins or obvious bedding structures and the rock is quite uniform.

Thin Section Substantial similarity exists between this sample and the earlier one, B72. It is a poorly sorted, arenaceous rock that appears to be of mixed provenance. Detrital grains range between 0.1 and 2 mm in size. Both quartz and probable volcano-lithic fragments are well developed as clastic grains and are about equally abundant. Minor clastic components include muscovite, altered biotite, zircon and possible shaly fragments. Feldspar grains are not recognisable, either in fresh or altered form. Most quartz grains show at least moderate strain extinction and some are intensely deformed or recrystallised. Quartz grains are generally sub-angular shape and some contain embayments typical of resorption texture. In certain cases, the embayments are filled with cryptofelsic material. The volcano-lithic fragments consist generally of very fine grained siliceous mosaic or cryptofelsite, moderately to heavily dusted by sericite. These fragments are believed to be of rhyolitic volcanic groundmass origin, an interpretation supported by the presence of the same kind of material within embayments in some quartz crystals. Furthermore, these volcano-lithic fragments characteristically contain unusually abundant small crystals of apatite; this is a feature quite commonly encountered in acid volcanic rocks. A few of the lithic fragments contain quartz phenocrysts but porphyritic texture is not well developed, nor are there grains showing snowflake texture. Muscovite occurs sporadically as a primary detrital component and biotite is quite common, though generally in rather degraded form. Zircon is a conspicuous accessory phase in this rock but unlike sample B72 tourmaline is lacking. Secondary rutile occurs in clusters of small granules and this is another feature which indicates a volcanic component in the rock. The matrix enclosing the clastic grains consists principally of fine grained sericite, with pale greenish colour. A certain amount of fine silicate is mixed with the sericite, but in many cases it is difficult to distinguish small sericitised lithic fragments from the matrix.

The presence of a tuffaceous component in this rock is indicated by the numerous grains of what are believed to be volcano-lithic material, as well as the quartz crystals that show typical resorption embayments
filled by cryptofelsite. At the same time, the association of moderately deformed quartz grains with intensely deformed or recrystallised material suggests a mixed source and the flakes of muscovite and perhaps biotite may also be indicative of a non-volcanic provenance. Significantly, however, there is no tourmaline in this sample. A substantial tuffaceous component is believed to be present in this rock, which may be essentially crystal-lithic tuff of rhyolitic composition. However, there are certain features which suggest some non-volcanic material and the rock may be re-worked tuff rather than a direct pyroclastic deposit. Strong alteration is principally sericitic in nature and probably reflects low grade metamorphism. The sample certainly resembles B72 but is notably coarser grained and richer in the arenaceous component, particularly in the lithic fragment component. Another difference is the common occurrence of fine granules of apatite within the volcano-lithic fragments and although these crystals are a small proportion of the rock overall, they are nevertheless unusually abundant. Because of the apparent mixed provenance, the rock is described as altered, tuffaceous quartz wacke, but it could also reasonably be described as altered crystal-lithic tuff.

Sample No. B98

Rock Type Sericitised vitric tuff

Hand Specimen A dark green, fine grained, rather argillic rock, with uniform non-banded character. There is a vague suggestion of foliation but cleavage is not well developed.

Thin Section Affinities of this rock lie with the earlier sample B65. As in that case, it consists dominantly of very fine grained, essentially crypto-crystalline mica. This mica has quite strong birefringence and is of greenish colour. Most of it is in optical continuity and foliation is especially defined by the presence of numerous, slightly darker, lenticular bodies, with strong parallel orientation. These range up to about 2 mm in length and some of them are more angular rather than lenticular shaped. Although greenish sericite is by far the dominant constituent of the rock quartz occurs sporadically as small elongate or sub-rounded to sub-angular grains, some of them distinctly slivery-shaped. A small amount of quartz occurs as finely granular lenses or streaks. rather like those that are so well developed in B65. Other component
of the rock are few, but there are occasional small opaque grains and some exotic, supergene limonite staining occurs, mainly near a well defined fracture. Discrete clastic flakes of mica occur very sparsely in the section, and include both muscovite and degraded biotite.

Mineralogically, this rock is quite simple, consisting as it does very largely of cryptocrystalline mica. This mica is the product of low grade metamorphism and although formation of the mica has somewhat obscured the origin of the rock, sufficient of the primary texture remains to make it fairly certain that the sample originated as a glassy pyroclastic rock. The darker lenticular bodies are interpreted as flattened pumiceous fragments and the finely granular quartz may be after compacted glass shards. Angular grains and slivers of quartz elsewhere represent a subordinate crystal clastic component. The rock may therefore be described as sericitised vitric tuff.

Sample No. B112

Rock Type Sericitised crystal-lithic tuff or wacke

Hand Specimen A medium to fairly coarse grained, arenaceous rock, generally of purplish-brown colour, but with a creamy-coloured band. This lighter band interferes with the other rock and may represent primary bedding, but this is difficult to ascertain in the small hand sample. The rock is otherwise quite massive and uniform.

Thin Section Origin and history of this rock are very similar to those of sample B90. The rock consists principally of quartz crystal clasts and altered lithic fragments enclosed in a fine grained, mainly sericitic matrix. Most quartz grains are essentially angular or irregular in shape, but volcanic origin is indicated in many cases by well defined resorption embayments or crystal faces. Grain size of the quartz clasts ranges up to about 2 mm and sorting is perhaps a little better than in earlier samples of this lithology. Strain extinction is generally well developed in the quartz grains and some are substantially or totally recrystallised. Lithic fragments are more strongly altered than in B90 and in many cases they merge with the matrix around their margins. Strong sericitisation has affected all of the lithic fragments but in a few places there are patches of cryptofelsic material remaining. Volcanic origin of these fragments is further indicated by the presence of resorption-rounded phenocrysts of quartz within some of these fragments. The lithic clasts show a similar size range to that of quartz and both the major components
are somewhat sorted into layers with the lighter coloured part of the hand specimen more or less corresponding to bands of slightly finer grained material. Very many of the lithic fragments are dusted by fine hematite granules, whose presence is largely responsible for the colour of the hand specimen. The lighter coloured zone essentially lacks this finely granular hematite. Biotite is a common minor component of the rock but is invariably degraded to secondary muscovite and dusty semi-opaque matter. Zircon is also a common accessory phase but no tourmaline is recognisable. Clusters of secondary rutile or leucoxene grains, like those in B90 are quite common. A small amount of hematite occurs as narrow veins or fracture coatings.

Substantially volcanic origin for this rock is clearly defined and there is no definite non-volcanic component. The rock has distinct bedding which is defined partly by grain size variation but also by preferred orientation of the clastic mica flakes. The tiny granules of apatite which are a conspicuous feature of B90 occur only rarely in this case. The sample may be described as crystal-lithic tuff or wacke, but it seems very likely in this case that most if not all of the clastic material is of volcanic origin. Composition is certainly rhyolitic and the rock has undergone strong sericitic alteration, which is presumably the result of low grade metamorphism. However, no metamorphic foliation is developed in the secondary sericite.

Sample No.  B133

Rock Type  Sericitised tuffaceous wacke

Hand Specimen  A light khaki-coloured rock of fine to medium grain size. It is quite uniform, with no obvious bedding or other structures.

Thin Section  Although this rock has undoubted affinities with the previous sample it is particularly similar to the earlier rock B72. The similarity with that sample is marked especially by the presence of detrital tourmaline in this case. Average grain size is somewhat finer than in B72 and certainly much finer than in the previous sample. Quartz grains are in the range 0.05 to 1 mm in size, while lithic fragments tend to be somewhat larger and range up to 3 mm. Quartz is very common but not a dominant constituent in this rock and it occurs as angular unsorted grains, some of which show distinctive resorption textures. Strain extinction is generally only moderate in the quartz grains and there are relatively few grains of granular, recrystallised aggregate
No feldspar is recognisable as such but there are many completely sericitised grains which could be altered feldspar or altered lithic fragments. Several lithic fragments consist of cryptofelsite and some exhibit the snowflake texture also seen in B72. Mica is a common minor detrital component and is represented by both muscovite and degraded biotite. Other accessory detrital minerals include zircon, rutile and rather conspicuous tourmaline. The matrix enclosing all of these components consists principally of pale greenish sericite. There appears to be also a component of cryptocrystalline silica and there may also be chlorite but these phases are not clearly distinguishable. No primary structures are preserved in the matrix, nor is there any detectable grain size or compositional layering in the rock. However, bedding is vaguely suggested by some preferred orientation of elongate clasts, particularly the larger lithic clasts.

This rock is clearly another example of sericitised rhyolitic tuff, similar to sample 72, 90 and 112. The presence of accessory tourmaline and detrital muscovite flakes in this rock suggest a non-volcanic component and the rock may thus have hybrid origin, as was proposed for B72. For this reason the rock is described as sericitised tuffaceous wacke, but there is little doubt that most of it is made up of acid pyroclastic debris, including crystal, lithic and vitric components.

**Sample No.**
B142A

**Rock Type**
Sandstone

**Hand Specimen**
A medium to fairly coarse grained, distinctly sandy rock, with light pinkish-brown colour. There is a suggestion of colour banding which may represent bedding but this is not particularly marked.

**Thin Section**
Very well defined, clastic arenaceous texture is visible in this rock. Quartz is the dominant detrital constituent and forms fairly well rounded but not very well sorted grains in the range 0.2 - 2.5 mm. Most of the detrital quartz grains have authigenic overgrowths of optically continuous quartz, but the original detrital grains are clearly defined by the presence of dusty inclusions around clastic grain margins. The quartz grains are not very tightly packed and show much the same range of size throughout the section, except for what appears to be a band of finer material a few millimetres wide; this presumably represents primary bedding. Strain extinction is widely develop
in the quartz grains but overall varies from slight to extreme and there are quite a number of recrystallised granular aggregate grains. Such variation in the degree of undulose extinction in the quartz grains indicates that the strain this expresses is an inherited feature derived from the parental rock. Overall detrital quartz makes up 60-70% of the rock.

Other detrital components are very conspicuous but quite minor compared with quartz. These phases include muscovite, zircon, tourmaline and apatite. The muscovite flakes range up to about 1.5 mm in length and tend to be wrapped around adjoining quartz grains as a result of compaction. The detrital heavy mineral grains (tourmaline, zircon, apatite) tend to be very well rounded and range up to about 0.5 mm in size. Lithic fragments also constitute a minor detrital component and most seem to consist of finely granular siliceous material, possibly of volcanic origin. Some fragments consist of foliated sericite and are possibly shaly origin.

Much of the cement in this rock consists of optically continuous, authigenic overgrowth on the detrital grains, or comprises finely granular silica in a variety of other forms. However, the rock is particularly noteworthy for a relative abundance of fine, very pale brown mica. This occurs as non-foliated massive aggregates, filling spaces between detrital grains, either alone or intergrown with extremely fine grained silica. It is highly birefringent, and thus distinctly micaceous, and invariably incorporates fine flakes of bladed hematite. Identity and origin of this mica are rather uncertain it appears to have grown at the expense of pre-existing, cementing component, perhaps clay, and could be the product of diagenesis or hydrothermal alteration. Another unusual feature of this rock is the relative abundance of secondary apatite, which occurs as aggregates of finely granular material or as larger massive patches that are strictly confined to the interstices between detrital grains and in places this form of apatite acts as a cement. Detrital apatite grains are commonly overgrown by the secondary form, which is distinguished by a brown cloudiness and a common association of hematite. However, some of the secondary, interstitial apatite is quite clear. The secondary apatite is also very commonly associated with or intergrown with the pale brown mica. Origin of the phosphate could be hydrothermal or the mineral may reflect a primary phosphatic chemical component in the original sediment. This form of apatite can be distinctly radioactive in a uranium-bearing environment. The pale brown mica makes up 10-15% of this rock and the secondary apatite constitutes another 3 or 4%. 

Good preservation of primary texture clearly indicates a sandy sedimentary origin for this rock. An acid igneous or sandy sedimentary provenance is indicated and significant deformation had affected the source rocks. Substantial post-depositional mineralogical change has occurred in this rock, affecting mainly the cement component and has led to the widespread development of pale brown mica and apatite, both with common associated hematite.

Sample No. B154

Rock Type Sandstone

Hand Specimen A pale pink, medium to fairly coarse grained, distinctly sandy rock, with a vague suggestion of colour banding.

Thin Section In most respects this rock is very similar to the previous sample, but an important difference is the much rarer occurrence of secondary apatite in this case. Primary texture is well preserved and comprises poorly sorted sandy rock with sub-angular to rounded grains ranging between 0.2 and 3 mm in size. Quartz greatly predominates in the detrital component and occurs as grains which show slight to extreme undulose extinction, or in many cases comprise recrystallised granular aggregate. Authigenic overgrowths of optically continuous quartz are well developed. Although no grain size or compositional layering is recognisable, bedding is vaguely indicated by preferred orientation of many of the more elongate detrital grains. A narrow shear or zone of brecciation cuts across this direction. Lithic fragments, mostly comprising siliceous aggregate, are a fairly common minor detrital component and these grains may be of volcanic origin. Muscovite is also rather common and occurs as narrow flakes that tend to be wrapped around the adjoining quartz grains.

A number of rounded completely sericitised grains are recognisable and these may be detrital lithic material (shaly). Tourmaline is the main detrital heavy mineral component and commonly occurs as composite grains, intergrown with quartz. Zircon is quite common and many zircon grains occur as inclusions in detrital quartz grains. Both this sample and the previous one contain fairly common, irregular patches of secondary titaniferous matter. Unlike the previous sample, detrital apatite seems to be lacking in this case. Pale brown, very birefringent mica is well developed in this sample, where it constitutes 15-20%. A significant difference from the previous sample is the rare occurrence only of secondary apatite, which was noticed in only one or two places as clusters of small, poorly crystallised grains.
Although this is clearly a clastic rock and may be described as sandstone, it is noteworthy that many of the quartz grains have shapes that suggest resorption prior to deposition as quartz sand. This may be an indication that the detritus in the rock is largely derived from an acid volcanic terrain and indeed, there are certain features in common between this sample or the previous one and the sericitised tuffaceous wacke samples described earlier (i.e., B72, B90, B112). The pale brown mica developed in this rock is somewhat finer grained than that in B142A and the virtual absence of secondary apatite in this sample may be quite significant.

Sample No. B157

Rock Type Tuffaceous sandstone

Hand Specimen A pale pinkish-brown, fairly coarse grained, sandy rock, with conspicuous patches of hematite.

Thin Section In broad lithologic terms this rock is quite similar to both of the previous samples, but it is distinguished by only a very minor occurrence of the pale brown mica present in those samples. In addition, lithic fragments are a conspicuous detrital component and the rock contains numeorous patches of secondary apatite, like those in B142A. Quartz is the major detrital component, occurring as angular to rounded grains, generally with authigenic overgrowth. Sorting is rather poor and quartz grains range up to about 2.5 mm in size. Lithic fragments constitute an important part of this rock and are commonly somewhat larger than quartz grains, ranging up to 5 or 6 mm in length. Most of the lithic fragments appear to be of acid volcanic origin, and many of them contain well defined quartz phenocrysts in a finely granular or cryptofelsic matrix. A few lithic grains consist of finely granular silica and may be of cherty origin. Deformation of quartz grains is generally rather strong and recrystallised granular aggregates are numerous. Many of the detrital quartz grains exhibit clearly defined resorption embayments, like those also preserved in the phenocrysts within lithic fragments. Muscovite, tourmaline and zircon occur as detrital heavy mineral grains, but no detrital apatite was notice.

A small amount of pale brown mica does occur in the matrix of this rock but generally the cement consists either of authigenic silica or of weakly birefringent clay, presumably of kaolin type. Fibrous sericite does occur in a few places and it is probable that the clay matrix in this rock
corresponds to the mica matrix of the previous sample and represents the unaltered precursor. The other noteworthy feature of this rock is the common occurrence of secondary apatite, which occurs as clusters or aggregates of small, light brown grains confined to the matrix. It is very similar to the apatite in B142A but is a little less abundant; constituting perhaps 2% of the rock.

A substantial tuffaceous component of this rock is clearly indicated by the volcanic textures preserved in the lithic fragments, as well as the volcanic character of many of the individual quartz grains. Nevertheless, the rock is not strictly a crystal-lithic tuff because many of the grains of both quartz and lithic material are quite well rounded and have clearly been subject to transport and abrasion. The rock may therefore be described as tuffaceous sandstone whose provenance is largely acid volcanic type, but which may also include other source rocks, reflected by tourmaline and muscovite. A similar origin is very likely for samples B142A and B154, but the much stronger development of secondary mica in those samples tends to obscure the volcanic lithic component, much of which presumably has been replaced by that mica. Close affinity can thus be drawn between this group of three samples and at the same time, there is likely relationship between this group and the earlier samples described as tuffaceous wacke. The main difference is that those earlier samples contained much more angular detritus and probably included directly pyroclastic material, whereas these samples are clearly reworked. Another difference is that the secondary mica present in the tuffaceous wacke samples is more typically sericitic than is the pale brown secondary mica in these tuffaceous sandstone samples.

Sample No. B176
Rock Type Altered vitric tuff
Hand Specimen A generally fine grained, dark brownish-green rock, with a rather massive character, although somewhat foliated possible fragments are visible on the cut surface.

Thin Section Substantial similarity exists between this sample and the earlier one B98. It consists dominantly of very fine grained, somewhat foliated sericite, which forms a dense massive aggregate. Scattered through this massive sericite are a number of angular or lenticular bodies which consist of
cryptocrystalline quartz and mica with some brownish staining. These correspond to the fragments visible in hand specimen and probably represent former pumiceous fragments. The massive sericite has moderate birefringence and a somewhat brownish colour. This contrasts with the sericite that is developed in some fractures or veins, which is much more birefringent but also essentially colourless. Small, angular quartz grains are sparsely scattered through the massive sericite and are similar to those present in B98. Foliation is generally much weaker than in that earlier sample, probably indicating a lower degree of compaction in this case. Fracturing, however, is prominent and the fractures have been healed by quartz or sericite or a combination of the two. Some fractures also contain limonite. Specularitic hematite is quite well developed as a pervasive dissemination throughout the massive sericite. Tiny prisms of apatite occur as a primary accessory phase and there is a trace of accessory tourmaline. Precise origin of this rock has been obscured by strong sericitic alteration, which has destroyed most of the primary structures. Nevertheless, by comparison with earlier samples, it seems likely that the rock originated as a glassy pyroclastic and may thus be described as altered vitric tuff.

Sample No. B196
Rock Type Sandstone
Hand Specimen A brownish, medium grained, sandy rock, with no obvious bedding or other structures.

Thin Section Affinities of this rock clearly lie with sandstones described earlier, such as sample B142A. It is distinguished from those earlier rocks, however, by what appears to be a substantial phosphate component. Quartz is the dominant detrital component and lithic fragments are relatively few. Sorting is poor, with grains ranging up to about 4 mm in size. Grain shape ranges from angular to rounded and most quartz grains exhibit authigenic overgrowth. Strain extinction in quartz varies from slight to strong and recrystallised granular aggregates are present. There is no grain size or compositional layering but bedding is somewhat defined by preferred orientation of elongate grains. Lithic fragments are not as abundant as in B157 but there are quite a number of detrital grains that consist either of cherty material or of fragments of acid volcanic rock. Muscovite is a minor detrital component and tourmaline is particularly conspicuous, occurring as well rounded grains up to 1 mm in diameter. Zircon is also a common accessory phase but rarely exceeds
0.2 mm in size.

The matrix of this rock is rather variable in nature. In part, it consists of authigenic quartz or finely granular, diagenetic silica. Elsewhere it consists of colourless to very pale brown mica, not unlike that described in earlier samples. The major feature of interest in the matrix of this rock is the presence of what appears to be phosphate material in several forms. Most of it is somewhat brownish in colour but it ranges from discrete prismatic crystals of apatite to rather amorphous or fibrous, isotropic or very weakly birefringent material. These various forms are commonly intergrown and generally are confined to the matrix between the detrital grains, but there are a few rounded pellets of similar material. Precise nature of this brown fibrous material is uncertain, but it is quite likely that the rock contains a gradation from amorphous collophane, through dahlrite to apatite. Chemical testing would easily confirm the apparent abundance of phosphate material in this rock, but from microscopic evidence, it appears that phosphate makes up something of the order of 15% of the rock. Another distinctive feature of the matrix in this rock is the common occurrence of hematite staining, which in many places makes the matrix more or less opaque.

Some of the detrital material in this rock is certainly of acid volcanic origin and much of the dominating quartz grain component may also be of similar origin. However, the rock is clearly a clastic, arenaceous sediment, with many well rounded, obviously abraded grains. The rock is certainly similar to sandstones described earlier in the suite, but it is distinguished by what appears to be a substantial and important phosphate component. This phosphate probably has a chemical sediment origin and there is a suggestion of some reworking of phosphate, represented by rounded pellets of brown phosphatic material.

Sample No.   
B200

Rock Type   
Phosphatic sandstone (wacke)

Hand Specimen  
A rather light coloured, coarse grained sandy rock. There is a suggestion of graded bedding in the hand specimen, which is also cut by a distinct vein. Sandy quartz grains are etched in relief on the weathered surface.
Thin Section This is another example of poorly sorted quartz arenite having close affinity with the previous sample and thus with several of the sandy rocks before that. The most distinctive feature of this sample, however, is strong development of brownish phosphatic material, which is a major cementing component and makes up about 20% of the rock. Quartz is the dominant detrital constituent and occurs as rather deformed grains, many of which are recrystallise Sorting is very poor and the total range of grain size is substantially greater than in the earlier samples, ranging up to about 5 mm. Grains vary from rounded to angular in shape and although authigenic overgrowths are commonly developed, they are not as well marked as in some of the earlier samples. Lithic fragments of acid volcanic or cherty origin are quite common, but detrital muscovite is rather rare. Rounded grains of tourmaline are the main accessory phase, but there are traces of rutile and zircon. Some tourmaline grains appear to have been fractured and fragmented. Indeed, at several places in the section the rock shows evidence of post-depositional deformation.

The most distinctive and important feature of this rock is the strong development of phosphate as a cement. Very little of the phosphate could be correctly described as apatite, and most is brownish with weak or very weak birefringence. Radiating or fibrous crusty structures are common and in some cases there are columnar aggregates which retain ghosted primary cracks. There is little doubt that the phosphate in this rock originated as amorphous collophane and has undergone partial crystallisation to what is probably dahllite and may perhaps locally be described as incipient apatite. The phosphate does seem to be very largely restricted to the matrix but there are a few veins of phosphatic material that cut across detrital grains. Other cementing materials do occur and seem to consist principally of authigenic silica and fine mica. The rock is a quartz arenite which can be described as sandstone or perhaps wacke and is characterised by an important phosphatic component. The phosphate appears to be a primary chemical sedimentary component, deposited originally in amorphous form and having undergone partial crystallisation.

Sample No. B213
Rock Type Sandstone
Hand Specimen A light pinkish-brown, fairly fine grained, sandy rock with a vague suggestion of colour banding.
Thin Section  

Bulk composition of this rock is very similar to that of several of the earlier samples, as it is essentially quartz arenite. It differs from the previous sample (B200) by being notably finer grained. Maximum detrital grain size is about 1 mm and there is a vague suggestion of grain size layering parallel to the bedding direction defined by preferred orientation of elongate grains. Quartz is the dominant detrital component and occurs in sub-angular to rounded grains with distinct authigenic overgrowths. Strain extinction is generally well developed in the quartz grains. Lithic fragments are rather few, but tourmaline is once again a very conspicuous accessory component and there are fairly common flakes of detrital muscovite. Zircon and rutile also occur as accessory phases. Weakly birefringent clay is the principal cementing material and appears to be of kaolin type. Some fine grained silica also acts as a cement and there is weak to moderate development of secondary mica. No secondary apatite or other phosphate material is recognisable in this sample but there is some patchy hematite staining in the matrix. The rock may be described simply as sandstone in which the detritus consists mostly of quartz whose provenance is mostly of acid volcanic type. Clay cement is well developed, to the apparent exclusion of phosphate, and there has been some development of secondary mica at the expense of clay. The rock has obvious affinities with several of the earlier samples but is a finer grained, non-phosphatic variety.

Sample No.  

B234

Rock Type  

Hematitic, altered tuff

Hand Specimen  

A dark red-brown, massive, very weathered rock, obviously rich in hematite and clay.

Thin Section  

Primary nature of this rock has been obscured by strong alteration as well as subsequent strong weathering. However, it is clear that the primary texture was very different from that of the previous few samples and the rock has a somewhat fragmental appearance. Quartz, sericite, clay and hematite are now the principal constituents, but only the quartz is likely to be of primary origin and even some of the quartz is possibly secondary. Some quartz grains resemble phenocrysts or partly resorbed crystal clasts and these range up to about 0.6 mm in size. They are enclosed in a hematite-dusted matrix, rich in highly birefringent sericite and weakly birefringent clay. Hematite
is also very well developed as pseudomorphs of earlier prismatic or rhombic crystals, perhaps of mafic type such as hornblende. Small irregular patches or grains of quartz are commonly intimately intergrown with these phyllosilicate secondary minerals and this quartz is possibly of secondary origin. In a few places there are suggestions of radiating structure and some of the sericite masses seem to be pseudomorphs of an earlier crystal or lithic fragment. The rock is thus thought to be a pyroclastic volcanic of acid composition and was probably of direct pyroclastic deposition, rather than formed by reworking of volcanic rocks. However, this is a rather tentative identification, in view of the very strong alteration and weathering. Nevertheless the rock is clearly different from the sandstones described previously and tuffaceous origin seems the most likely explanation for the relict textures preserved.

Sample No. B245

Rock Type Sandstone

Hand Specimen A rather coarse grained, arenaceous rock of fairly dark colour, with prominent yellowish cementing material. Hematite occurs on fractures and there are patches in the matrix.

Thin Section Coarse clastic texture is well developed in this rock, which shows close similarity with several of the earlier samples described as sandstone. Grain size averages about 1 - 2 mm and quartz is the dominant detrital component. Strain extinction in the quartz varies from slight to extreme and many of the detrital grains consist of recrystallised granular aggregate. In addition to quartz, the rock contains a number of lithic fragments of acid volcanic origin and many of the quartz grains themselves have typically volcanic, resorbed outlines, or else show crystal faces. Authigenic overgrowths are well developed on the quartz and the outlines of the original crystals are clearly indicated by the mantling of dusty inclusions. Zones of shearing or fine scale brecciation occur within the section. Accessory tourmaline and zircon occur rather sparsely and detrital muscovite seems to be lacking.

Fine grained, highly birefringent mica is the most abundant cementing material in this rock and corresponds to the yellowish cement visible in hand specimen. Under the microscope this mica is distinctly brown and somewhat pleochroic and may be described as a form of biotite. It fills interstices between detrital grains and commonly penetrates along grain boundaries in aggrega
Fine grained authigenic silica locally forms a cement in the rock and hematitic staining of biotite occurs in places, ranging from light dusting to intense staining, which makes the matrix more or less opaque. No phosphate is recognisable in this sample. However, there is some development of authigenic tourmaline which occurs as dense clusters of small prisms filling interstices between quartz grains and commonly penetrating inwards from the margins of those grains adjoining the clusters. The rock may be described as sandstone having broad affinities with several of the earlier samples but lacking phosphate and having more distinctly biotitic, micaceous cement.

**Sample No.**

B249

**Rock Type**

Rhyolite

**Hand Specimen**

A dark red-brown, rather fine grained rock, of massive, uniform character.

**Thin Section**

Although rather strongly oxidised this rock retains well defined primary igneous textures that indicate origin as a rhyolitic volcanic rock. The texture is very weakly porphyritic, with a few phenocrysts which are now completely altered but appear to have consisted of feldspar. Occasional patches of quartz may represent micro-phenocrysts. Apart from these features the rock consists of a uniform mosaic of quartz and secondary minerals, with grain size of the order of 0.1 - 0.2 mm. The quartz forms an interlocking mosaic with elongate needle-like crystals cutting through it. This is a typical acid volcanic texture, with the elongate needles representing primary tridymite which crystallised in a glassy matrix. Devitrification of that glassy matrix has brought about development of the quartz mosaic, which may be described as a variety of 'snowflake' texture. Feldspar was undoubtedly a major component of the rock at one stage but it appears now to have been altered to a mixture of sericite and clay, although the latter may be largely of supergene origin. Other supergene affects are clearly represented by the wide spread development of hematite staining, which is particularly strong along fractures and in the envelopes of quartz veins.

Precise original composition of this rock has been obscured by the alteration and weathering but the texture is typical of acid volcanic rocks and the original composition is probably rhyolitic to dacitic. Phenocrysts are rather few and the original rock was probably very glassy in nature. The
sample seems to have suffered strong sericitic alteration, including some development of sericite in the veins as well as the formation of secondary quartz in the veins and perhaps elsewhere. Subsequent strong oxidation has converted some of the sericite to clay and caused substantial ferruginous staining. Some textural similarity exists between this sample and sample B234, although that rock is of more fragmental nature. Nevertheless, both are believed to have acid volcanic composition and the earlier sample is possibly a pyroclastic equivalent of this rock whose uniform texture suggests origin as a rhyolitic lava flow.

Sample No. B257

Rock Type Sandstone

Hand Specimen A rather light coloured, fairly coarse, sandy rock, with a white argillic cement and quartz grains that are etched in relief on the weathered surface.

Thin Section This is another example of quartz arenite with relatively coarse, not very well sorted grain size, ranging up to about 3 mm. The quartz grains range from angular to rounded in shape and optically continuous, authigenic overgrowths are very well developed. Many of the quartz grains show evidence of volcanic origin, in the form of resorption embayments or crystal phases. Strain extinction in quartz grains ranges to slight to extreme and recrystallised granular aggregate grains are quite common. Other lithic grains are of rhyolitic volcanic type and include finely felsic aggregate, as well as porphyritic or micro-fragmental types. Most of the volcano-lithic fragments show a brownish cloudiness. Tourmaline is a very conspicuous accessory component, occurring in very well rounded grains that range up to 1.5 mm in size. In some places tourmaline grains appear to have been shattered into fragmental clusters. Zircon and rutile also occur as accessory phases and some of the zircon grains are enclosed in detrital quartz crystals. One or two instances of tourmaline crystals occurring as inclusions in quartz are also present in the section. Detrital muscovite seems to be lacking in this sample.

Weakly birefringent clay is the principal cementing material in this rock, although authigenic silica is also quite common. Distinctly birefringent mica does occur, partly as massive cement and partly as fibrous dusting within patches of clay. The rock also contains occasional patche
of brown, poorly crystallised, phosphatic matter. The rock consists of quartz sandstone in which the greater part of the detritus appears to have been derived from acid volcanic source rocks. The cement is dominantly argillic but some micaceous alteration of that clay has taken place and there is a very small phosphate component.

Sample No.  B279
Rock Type  Oxidised basalt
Hand Specimen  A dark red-brown, fine to medium grained rock, of massive uniform character.

Thin Section  This rock is radically different from most of those before it but is quite similar to one of the earlier samples, namely B78. It is strongly altered and thoroughly oxidised, with copious development of supergene hematite. Nevertheless, primary igneous texture is very well preserved and it is clear the rock originated as a basic volcanic. There is a weakly porphyritic texture, with scattered altered phenocrysts enclosed in a relatively coarse grained, intergranular groundmass. Plagioclase was clearly the dominant constituent in the original rock but no feldspar remains as such. Most of the phenocrysts have distinct, euhedral or subhedral lath-shapes that indicate plagioclase original identity. One or two of the pseudomorphed phenocrysts appear to be after olivine. The total amount of phenocrysts in the sample is quite small, not more than 5%. The largest of the phenocrysts is about 3 mm in length. This compares with the groundmass where original plagioclase laths were of the order of 0.2 - 0.8 mm in length. These laths have a decussate, slightly oriented form and the interstices between the former plagioclase laths are filled with secondary minerals that are derived from primary mafic or Fe/Ti oxide components.

Intense alteration has affected the rock and it now consists very largely of clay and hematite. These phases are very likely to be substantially of supergene origin, but it is also likely that the rock was already strongly altered before supergene oxidation. This is because fine, birefringent mica (sericite) is quite common, especially in the pseudomorphed phenocrysts and also in the matrix feldspar. Original identity of the intergranular mafic component is uncertain but some of the pseudomorphed grains have shapes that suggest olivine and others have cubic outlines that suggest former
magnetite. For the most part, however, the interstices between the altered plagioclase laths are intensely hematitic. Hematitic staining is especially strong adjacent to fractures and the rock also contains a few thin discontinuous veins of isotropic material whose identity is uncertain but whose pale brownish colour suggests the possibility of colophane.

Excellent preservation of primary texture, in spite of intense alteration, clearly indicates basic igneous origin for this rock. The grain size of the matrix is relatively coarse for a volcanic rock but at the same time would be relatively fine for a dolerite. Thus, although the rock shows some similarity with sample B78, it is described as basalt and the field relations will presumably indicate whether it is intrusive or extrusive. It is a weakly porphyritic basaltic rock which was probably very rich in olivine as well as plagioclase before strong alteration and intense weathering.

Sample No. B280
Rock Type Sandy silstone
Hand Specimen A purplish-brown, rather fine grained rock with distinct layering.

Thin Section Bedding is very clearly defined in this sample, not only by variation in composition and grain size, but also by strong preferred orientation of elongate detrital grains. Variations in grain size and composition are responsible for the layering that is visible in hand specimen and although the bulk of the sample may be described as sandy silstone, some of the layers are notably finer and could be described simply as siltstone or even as shale. The principal detrital components still recognisable as such in the more sandy layers are quartz and mica. The quartz grains are generally angular and some are distinctly sliver-shaped. They range up to about 0.1 mm in size. Mica flakes are very numerous and although most of those now recognisable as mica consist of muscovite the rock also contains many elongate bodies of hematite which are commonly associated with muscovite and possibly represent thoroughly oxidised biotite. The detrital mica flakes show strong preferred orientation and many of the more elongate sandy quartz grains are also oriented parallel to this direction. This clearly represents bedding and is parallel to the compositional and grain size layering. Detrital zircon and tourmaline are quite common and there may be some strictly clastic opaque matter.
Apart from these grains however, the rock consists of a very fine grained, rather obscure mixture of secondary phyllosilicates. This material was probably deposited originally as clay but diagenesis has converted it to sericite and perhaps other forms of clay; no chlorite is recognisable in the rock. Much of the clay and some of the sericite has a distinct brownish cloudiness. In the finer grained layers the proportion of the quartz diminishes to virtually zero in the shale layers and the abundance of sericite increases. Fine hematite is dusted throughout the rock but is particularly concentrated in the shaly layers and is responsible for their darker appearance in hand specimen.

Much of the material in this rock is below the formal lower limit for sand (0.05 mm) and it seems best to describe the rock as siltstone. However, grains in the range 0.05 - 0.1 mm are very numerous and so it must be described as sandy siltstone. Source rocks for the sandy silt sediment are likely to have been fine grained, low grade metamorphic rocks or perhaps other sediments or acid igneous rock. There is no direct evidence of pyroclastic or other volcanic components in this rock.

**Sample No.** B301

**Rock Type** Oxidised fine tuff

**Hand Specimen** A light purple, rather fine grained rock with prominent, cross-cutting white veins.

**Thin Section** No bedding or diagnostic primary structure is preserved in this rock and there is rather strong pervasive staining by dusty hematite as a result of supergene oxidation. Quartz and clay seem to be the dominant constituents, although distinctly birefringent fine mica is also quite abundant. Quartz grains rarely exceed 0.1 mm in size and many are very much smaller. The finer quartz seems to form a tightly interlocking mosaic, whereas the larger grains appear to be scattered clastic grains. The common occurrence of clay and fine sericite within this siliceous mosaic suggests that it is a relict of a primary rock rather than the product of supergene silification. This suggests that the rock originated as a glassy volcanic and subsequently undergone devitrification, which produced a fine felsic mosaic. Later alteration converted the feldspar components of that mosaic to sericite and clay and after that strong oxidation produced the abundant hematite.
The veins which are so prominent in the hand specimen are also very distinct in the thin section but consist of two types of material. Some of the veins are made up of finely granular to prismatic, clearly secondary quartz. Other veins consist of very finely granular to cryptocrystalline siliceous mosaic which is somewhat dusted by mica but does not contain the abundant hematite present in the remainder of the rock. It is also notably finer grained than the mosaic in the adjoining rock. This material seems to be devitrified volcanic glass, although its precise origin is rather obscure. The volcanic interpretation is supported by the presence of what appears to be small crystal clasts or phenocrysts of quartz, although these have recrystallised into granular aggregates. The other important feature of these zones is the presence of hemitic pseudomorphs and voids with cubic outlines and these are likely to be after pyrite in the original rock.

This rock contains few really diagnostic structures and the mineralogy apart from quartz is largely of supergene origin. However, most of the features are consistent with oxidised fine tuffaceous origin and rhyolitic composition, although in view of the altered state of the rock, this is only a tentative identification.

Sample No. B304
Rock Type Silicified rhyolite
Hand Specimen A white to creamy, very siliceous and clearly fragmental rock, with relatively high porosity and some ferruginous staining.
Thin Section Primary texture and mineralogy of this rock have been substantially modified as a result of intense silicification. Nevertheless, there are a few features preserved which indicate origin as an acid volcanic rock, although it is not clear whether the original lithology was of pyroclastic or lava flow origin. The rock now consists almost entirely of quartz which occurs in a variety of forms, including cryptocrystalline mosaic, microcrystalline mosaic, relatively coarse, granular aggregate and veins of prismatic or fibrous chalcedonic silica. It is likely that the very fine grained siliceous mosaic is more or less a relict of the original devitrification of a glassy rhyolitic rock. This interpretation is supported by the presence of occasional grains of quartz that are clearly phenocrysts or quartz crystal clasts. There is also a vague suggestion of banding within this fine grained mosaic. Elsewhere the quartz is clearly of secondary origin, whether it be in veins or in massive
replacement patches. Some of the more chalcedonic silica in the rock has brownish colour and light brown staining occurs in patches throughout the sample. Fine grained or bladed crystals of hematite occur in a number of places and tend to be concentrated in patches or clusters. Other structures recognisable in several places include colloform banding within some of the quartz veins and the occasional pseudomorph after pyrite. The latter characteristically have cubic outlines and limonitic margins but are filled by quartz. Substantial void space occurs within the rock and many of the larger voids are surrounded by relatively coarse grained quartz. Some voids are partly infilled by brown clay.

The rather fragmental nature of the hand specimen is not so apparent in thin section and is probably partly a reflection of the variation in grain size within the sample. Nevertheless, it does seem likely that the rock has suffered brecciation at some stage and has subsequently been thoroughly healed by intense silicification. The sample is interpreted as silicified rhyolite which originally contained at least some pyrite mineralisation. Origin or nature of the silicification is uncertain.

Sample No.  B305
Rock Type    Ferruginous silicified rhyolite
Hand Specimen A dark red-brown, silicious rock, with a somewhat fragmental structure. Some of the fragments resemble segments of quartz veins and are white rather than red coloured.

Thin Section  In terms of primary lithology and subsequent history this rock is probably rather similar to the previous sample. However, it is distinguished by strong hematitic staining which affects much of the rock but leaves many small clear areas. Quartz greatly predominates as the major constituent and occurs in a great variety of forms. Much of the quartz is in granular aggregates or fine mosaics which range from cryptocrystalline to relatively coarse grained. Quartz also occasionally forms probable relict phenocrysts or crystal clasts and there are many angular bodies of massive silicification. Some of the silicified bodies also contain dusty sericite. The matrix enclosing obvious fragments or segments of veins and patches of massi silicification is rather obscure in view of the intense hematitic staining.
However, it does appear to be largely siliceous and probably originated as volcanic glass. It is very difficult to determine if the fragmental nature of this rock is a primary structure resulting from pyroclastic deposition or a secondary feature resulting from intense silicification. The pyroclastic interpretation is favoured, but in view of the intense silicification and ferruginous staining of the rock, this identification must remain tentative. A few of the fragments in this sample contain small cubic pseudomorphs that are probably after pyrite.

**Sample No.**
B306

**Rock Type**
Dolomite

**Hand Specimen**
A fairly dark grey, fine grained carbonate rock. There is no significant effervescence in dilute HCl.

**Thin Section**
Carbonate is by far the dominant constituent of this rock and forms a massive granular mosaic with somewhat variable but generally fine grain size. Some parts of the carbonate mosaic could be described as cryptocrystalline, whereas elsewhere individual crystals are clearly recognisable and range up to about 0.1 mm in size. No layering or other primary structures are apparent and the coarser grained carbonate mosaic occurs as irregular patches and inter-connected networks within the finer mosaic. Colour of the carbonate is fairly uniform and generally very pale neutral in nature, but the finer grained carbonate tends to be a little darker. There are no clear veins of carbonate in this rock. Many veins and healed fractures do in fact occur but are filled with granular quartz rather than carbonate. Quartz also occurs sparsely as small granular patches within the carbonate mosaic.

This is a carbonate rock which is probably very similar to the first sample (B5). In view of the lack of effervescence in dilute HCl and by analogy with sample B5, which was x-rayed, the carbonate in this rock is believed to be all dolomite. Origin and history of the rock are likely to be similar to those of B5 but in this case there are no layers or possible biogenic characteristics. Relatively strong fracturing or incipient brecciation has occurred and has subsequently been healed by finely granular quartz. A few of the quartz veins contained minor clear carbonate and limonitic staining occurs within some veins. The rock may be described as dolomite but there is
no clear evidence of whether it is of chemical precipitation or biogenic origin.

**Sample No.** B307

**Rock Type** Siliceous dolomite

**Hand Specimen** A fine grained carbonate rock with mottled grey and pink colour, together with irregular patches of dark grey quartz. There is no effervescence in dilute HCl.

**Thin Section** This rock has obvious affinity with the previous sample and also with B5. It is, however, rather more recrystallised than those samples and contains a significant component of quartz. Much of the rock consists of fine grained carbonate in a tightly interlocking mosaic with grain size of the order of 0.05 mm. In some places this mosaic is slightly finer or coarser grained but there is no recognisable layering or biogenic structure. Cutting through the finer mosaic are numerous broad areas of much coarser grained, recrystallised carbonate. Some of these form discrete veins, whereas others simply link up into very irregular masses. Grain size within these masses ranges from 0.2 - 1 mm and much of the carbonate occurs in spary crystal form. Both the fine mosaic and the coarser, recrystallised carbonate generally show a neutral-coloured cloudiness, which seems to be due in large part to an abundance of fluid inclusions. There are, however, a few irregular veinlets and masses of clear carbonate, free of fluid inclusions, cutting through the cloudy material. This could be a different carbonate but in many cases single crystals are partly cloudy and partly clear.

The other main component of the rock is quartz, which occurs largely in broad irregular masses of obviously secondary material. These occur principally within the areas of recrystallised carbonate and the quartz tends to be developed into prismatic forms. Quartz grain size ranges up to about 2 mm but is rather variable and many of the large siliceous masses have coarse grain size for the most part but are surrounded by a rim of fine grained quartz adjacent to the carbonate. The coarse grained quartz is relatively cloudy and again this is due to an abundance of fluid inclusions. A small amount of quartz occurs as isolated grains or small aggregates enclosed in the fine grained carbonate mosaic. Some quartz also occurs in narrow veins, either by itself
or together with clear carbonate. The only other phase of note is limonite, which occurs sparsely along some of the fractures and veins in the rock.

Optical properties of the carbonate and lack of effervescence in the hand specimen favour dolomite composition for this rock and this is especially so by comparison with sample B5, which was x-rayed and found to consist of dolomite. This sample has clearly undergone substantial recrystallisation of carbonate, together with introduction or remobilisation of a siliceous component. The sample gives no indication of whether it is of biogenic or chemical precipitation origin.

Sample No. B316
Rock Type Sericitised quartz arenite
Hand Specimen A fine to medium grained, sandy rock, which is essentially light coloured but contains significant limonite staining.

Thin Section The rock has a rather loosely packed, clastic arenaceous texture with fairly well sorted detrital grains averaging about 0.5 mm in size. Rounding of grains is rather poor and most can be described as angular or sub-angular in shape. Quartz is the dominant clastic constituent and makes up about 50% of the rock. These grains show moderate to strong strain extinction and some comprise recrystallised granular aggregate. Some of the quartz is concentrated into broad, discontinuous veins which may in fact be large lithic fragments. Zircon occurs sporadically as a detrital accessory phase but no tourmaline is recognisable. There is also a trace of detrital muscovite. Another component appears to have occurred as a detrital phase originally but has been strongly oxidised, stained by limonite and largely leached.

Sericite is the other main component of this rock and occurs in great abundance as an interstitial matrix between the quartz grains, as well as penetrating along grain boundaries. It also occurs in relatively large masses (up to 2 mm across) that are probably replacements of another detrital component. Some of these broad sericitic masses enclose angular quartz crystals that are smaller than elsewhere in the rock and these bodies may be largely sericitised lithic fragments. Most of the sericite is highly birefringent and clearly micaceous but it varies from cryptocrystalline to discrete small crystals of light mica. The rock contains quite a number of voids and many of
these are lined by limonite. Some of them could be after sulphide but diagnostic shapes are not really preserved and the limonite may be simply exotic. Some limonite also occurs along fractures and as patchy staining within sericitic masses.

Strong sericitic alteration has affected this rock and as a result the precise nature of the original detrital components has been obscured. Some of the sericite may be after feldspar and elsewhere there are masses of sericite that appear to be after lithic fragments. In the latter case the presence of angular quartz grains different from those elsewhere in the rock is a noteworthy feature and these lithic fragments may have comprised rhyolitic tuffaceous rock. The sample shows some similarity with the sericitised wackes and sandstones described earlier, but it is somewhat better sorted than those samples while at the same time the quartz grains are not as well rounded as in those rocks and there are no authigenic overgrowths of silica. Another important difference is that nearly all of those earlier rocks contained tourmaline as an accessory phase, while this sample lacks tourmaline. This rock does appear to have a clastic origin but whether this is simply a sedimentary rock or whether it has a pyroclastic component can not be determined with certainty. Texture and mineralogy are consistent with a pyroclastic origin or component but there are no diagnostically tuffaceous characteristics. The rock is therefore described simply as sericitised quartz arenite, with some similarity to the earlier sandy rocks but with also a number of distinctive differences.
INTERPRETATION REPORT

AIRBORNE ELECTROMAGNETIC SURVEY

BARRINGER "INPUT" SYSTEM

OF THE

SLEISBECK AREA

NORTHERN TERRITORY

FOR

UTAH DEVELOPMENT COMPANY

(83-296)

SYDNEY, AUSTRALIA

JUNE, 1979

T. WHITING
GEOPHYSICIST
CONTENTS

I. INTRODUCTION
   1-2

II. PERSONNEL
   3

III. DATA PRESENTATION
    4-6

IV. GEOLOGICAL ENVIRONMENT
    7-8

V. INPUT INTERPRETATION
    9-18

VI. CONCLUSIONS AND RECOMMENDATIONS
    19-20

ACCOMPANYING THIS REPORT:-

APPENDIX A: INPUT Equipment and Procedures

APPENDIX B: INPUT Interpretation

APPENDIX C: Instrument Specifications

EM Plan Map
   Plate 11

Residual Magnetic Intensity Map
   Plate 12

Structural Interpretation Map.
I. **INTRODUCTION**

On the 16th May, 1979, Geoterrex Pty. Limited flew a combined electromagnetic and magnetic survey over the Sleisbeck Area of the Northern Territory for the Utah Development Company. The operational base was Darwin.

The area covered 8 square kilometres, a total of 137 line kilometres being surveyed. Line spacing was 600 metres and flight heading was north-south.

The project was conducted with a Super Canso PBY-5A under registration VH-EXG which is operated by Executive Air Services for Geoterrex Pty. Limited. It was equipped with a Barringer Mark V INPUT EM System, a Geometrics G803 magnetometer, Visicorder 1912, a Sperry Stars RT-220 radio altimeter, a 50 Hz powerline monitor and a Hulcher 35mm continuous strip tracking camera. Navigation was by visual means utilizing airphoto mosaics. The aircraft was operated at a mean terrain clearance of 120 meters.

The major aims of the survey were as follows:

(1) To delineate pyritic carbonaceous shales and ferruginous chert rocks of the Koolpin Formation often found to be associated with uranium mineralization.
(2) To structurally interpret Total Magnetic Field data with the aim of locating fault and other related deformational structures which possibly control emplacement of uranium mineralization.

The geophysical pattern associated with the known Sleisbeck deposit together with the knowledge of structural and lithological mineral references, allows similar zones within the area to be localized and discussed with regard to their potential as specific follow-up targets.

The survey was conducted under the supervision of G. Butt in consultation with C. Gregory representing Utah Development Company.
II. PERSONNEL

The following Geoterrex personnel took part in the field phase of the survey:

Pilot                                      C. Moody
Co-Pilot                                   D. Stott
Electronics Technician                    H. Gyllero
Chief Technician                          L. Williams
Aircraft Engineer                         W. Mitchell
Data Compiler                             R. Hanly
Data Compiler                             B. LePine
Geophysicist                              T. Whiting
Geophysicist                              G. Butt
Chief Geophysicist                        W. Tschaikowsky

The magnetic data was compiled in Sydney by J.C. & R.A. Templin Pty. Ltd.
III. **DATA PRESENTATION**

One air photo mosaic at a scale of approximately 1:16,000 provides the base for the EM Plan Map of the area. This map is presented as a clear overlay and includes sufficient planimetry to allow correlation to other data maps of the area.

The **EM Plan Map** shows all anomalies considered to be caused by bedrock conductors. It portrays the key characteristics of the INPUT anomalies using our conventional symbolism.

This symbolism which is explained in the map legend, includes the following:-

- anomaly peak position
- anomaly half-peak width
- number of channels affected
- amplitude of the first and sixth channels, in units of 1/10th inch chart deflection.
- terrain clearance of the aircraft in metres
- amplitude of any apparent associated magnetic anomaly in nanoteslas.
- any associated response on the 50 Hz monitor.

A lag of 4.0 seconds is used to plot the INPUT anomalies.

All amplitudes and half-peak widths are measured from true zero level.
When the profiles indicate a possibly significant correlation between an INPUT and a magnetic anomaly the amplitude of the magnetic response is shown on the EM Plan Map. (Plate II)

If the EM anomaly is located on the flank or edge of a magnetic feature, the magnetic amplitude is affixed with an arrow pointing in the direction of the offset of the magnetic anomaly relative to the conductor.

During the course of data evaluation, groups of anomalies are outlined to show our interpretation of the extent of the geologically conductive zones. If any doubt exists, the outlines are dashed. Conductors of interest are numbered to facilitate reference to the report.

The original INPUT records containing the geophysical information are presented in one envelope. The various traces are identified on Line 201N.

The negative 35mm tracking film is delivered in one roll and labelled according to flight number.

The point picking airphoto along with the tracking film must be consulted for accurate location of any ground follow-up investigation.
One can refer to the flight log, or to the information which is noted on each of the records in order to relate the film to the geophysical records and map.

On the Isomagnetic Contour Map the total field magnetic data is presented in conventional form by isomagnetic contours. Contour interval is 1 nanoteslas wherever gradient permits and values are taken from an arbitrary datum.

Instrument sensitivities and settings are tabled in Appendix "C" attached to this report.
IV. GEOLOGICAL ENVIRONMENT

The survey area forms part of the South Alligator Uranium Field, a north-west trending belt 24 kilometres long and 3 kilometres wide located about 220 kilometres south-east of Darwin. Here, Lower Proterozoic sediments are exposed unconformably beneath a thick sequence of mainly flat-lying Carpentarian sequences.

Uranium mineralization of the South Alligator field occurs in a variety of rock types (predominantly Lower Proterozoic), mainly within the Koolpin Formation but also within the Edith River Volcanics, the Kombolgie Formation, and probably the Masson Formation. Minor mineralization has also been found in the recently redefined Stag Creek Volcanics.

The Koolpin Formation consists of pyritic carbonaceous siltstone which has beds rich in chert bands, lenses, and nodules which are silicified carbonate, and banded iron formation. Sleisbeck is a small uranium occurrence located at the extreme south-eastern edge of the South Alligator Uranium Field, and is thought to lie in the Koolpin Formation.
It was anticipated that the INPUT AEM system (with Total Magnetic Field data) would be useful in delineating graphitic shales, banded iron formations and faults possibly associated with uranium mineralization.

Mineralization is located mainly in faults, shears or fractures close to and on the contact (faulted in places) between the Lower Proterozoic and Carpentarian rocks. Pitchblende in the Koolpin Formation occurs mainly as veins, but in places is disseminated in pyritic, carbonaceous shale and ferruginous chert - banded shale, and commonly along the boundaries between these rock types, indicating the presence of iron and carbon may be responsible for its precipitation.
V. INPUT INTERPRETATION

Commonly used interpretation techniques rely mainly on qualitative review of data and refer to anomaly shape, symmetry, strike extent and variability within conductive zones. The apparent conductivity, as determined by the rate of decay of the INPUT response (see Figures 1 to 4) is an important criterion in the analysis of conductors.

One of the most important problems is the differentiation between non-economic surface conductors and bedrock conductors. Our initial interpretation was therefore directed towards separating likely bedrock responses from those due to cultural or surficial sources.

The criteria conventionally considered as favourable indicators of a bedrock conductor are:

1. Intermediate to high conductivity. Channels five and six generally affected.

2. Good anomaly shape. Narrow relatively symmetrical anomalies, with well defined peaks.

3. No serious displacement of anomaly peak position with line direction on successive flight lines.

4. Small to intermediate amplitude.

5. Associated geophysical parameters, like magnetic responses with similar strike.
(6) A degree of continuity. Maintenance of any, or all, of these characteristics is strong evidence in favour of a bedrock conductor.

In addition, the geologic environment and the relationship of anomalies to known mineralization should be examined. Only bedrock conductors are discussed in this report. Bedrock zones were selected after general consideration of amplitudes and decay rates. Decay curve shape is affected by conductance, depth, dip and conductor size and shape.

The decay characteristics obtained from sheet-like (bedrock conductors) and horizontal strip (conductive overburden) conductors may be recognised as linear and concave curves respectively. Anomalies exhibiting a fast linear decay usually coincided with river deposits, implying a surficial origin and were therefore removed from further consideration.

**Interpretation Procedure**

The main purpose of the interpretation of INPUT data is to determine the probable source of anomalies detected during the survey and to suggest recommendations for a further exploration program.

Through the use of an appropriate interpretation procedure based on relevant geophysical and geological data, INPUT responses most likely to be arising from conductive graphitic shales may be effectively located.
As previously stated, economic uranium occurrences within the South Alligator River region are associated with deformational structures such as faults and shears. Their concurrence with graphitic conductors of the Koolpin Formation will therefore outline potentially mineralized zones. As a result the main purpose of the magnetic interpretation was to delineate magnetic features within the Koolpin Formation and establish their relationship to INPUT anomalies arising from bedrock sources.

This procedure will not lead to the localization of specific drilling targets but rather to areas which could contain uranium mineralization. More specific definition within these areas is possible on the basis of enhanced conductivity; however, zones selected in this way are of interest only if the greatest concentrations of graphite are directly associated with mineralization.

Discussion of Results

Major Magnetic Features

Prior to embarking on any magnetic interpretation it is important to establish the geological character and tectonic style of the area under consideration. Preliminary interpretation was therefore undertaken in two stages:-

1. Magnetic profiles and contour maps were analysed to yield a number of geometrical shapes which distinguish areas of different magnetic character.
(2) These geometrical shapes were then translated into geological terms.

A cursory investigation of Plate 12 (Structural Interpretation of Residual Magnetic Intensity) reveals the Sleisbeck area as one possessing areas of contrasting magnetic character.

The south-eastern corner of the survey area is composed of complex magnetic contours, in which an internal structure is hard to recognise. Often characteristic of extensive flat-lying magnetic horizons, this pattern may be directly correlated with the Birdie Creek Volcanic member.

In contrast with this zone is an adjacent area of low magnetic relief. Corresponding to outcropping Kombolgie Formation, this area is moderately faulted, and bounded to the north by the Carpentarian – Lower Proterozoic unconformity.

Central sections of the survey area are dominated by a moderate regional gradient decreasing to the north. East-west magnetic trends of low amplitude located near the unconformity surface are superimposed on this regional and may possibly be attributed to banded ferruginous cherts or magnetite-bearing shales of the Koolpin Formation.

Also interrupting the north-south magnetic regional is a broad area of intense magnetic activity which embodies the northern third of the region flown. Unlike the first zone discussed, individual curvilinear trends of extensive strike length may be traced possibly outlining "dyke-like" bodies.
Reference to geological survey maps indicates only rocks of the Koolpin Formation outcrop at this location, raising doubts about the source of this magnetic zone. Magnetic dolerites of the Zamu Complex which intrude Lower Proterozoic sequences in the form of extensive sills, outcrop to the north of this zone and underlie Koolpin sediments.

**Input Zones**

In this section bedrock conductors which comply with criteria usually associated with mineralization (outlined in earlier Sections) have been described. Zone, line and fiducial numbers together with first to sixth channel amplitudes are included in order to facilitate reference to the original records and plan maps.

The order of zone numbers bears no relation to the relative importance of the conductors.

Anomalies in the northern section of the survey area which are outlined but not numbered are interpreted as surficial and are not discussed.

Linear east-west conductors are initially obvious features of the EM Plan Map. Our zone boundaries interrupt these conductors and are placed on the basis of consistency of INPUT decay shape and decay rate of individual responses. (Figures 1 to 4).

Overall correlation of INPUT zones and trends of total magnetic intensity at first appears to be good. This is true in the south, where magnetic horizons are conformable but not directly coincident with INPUT zones.
The distinctive style of magnetic anomalies in the north indicates they are not due to sources within the Koolpin Formation. They may be associated with rocks of the Zamu Complex which are deeper than the penetration of the INPUT system. The INPUT zones here are interpreted to be due to conductors within the shallower Koolpin, possibly graphitic shales.

**Zone SB - 1A**

<table>
<thead>
<tr>
<th>Line</th>
<th>Fid</th>
<th>46/5.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>201N</td>
<td>122.33</td>
<td></td>
</tr>
<tr>
<td>202S</td>
<td>133.78</td>
<td>32/1.7</td>
</tr>
<tr>
<td>203N</td>
<td>140.45</td>
<td>52/0.9</td>
</tr>
<tr>
<td>204S</td>
<td>152.45</td>
<td></td>
</tr>
</tbody>
</table>

Located at the south-eastern edge of the area, this zone appears to lie within the Koolpin Formation adjacent to the unconformable contact with overlying Carpentarian sandstones.

The six channel anomalies of lines 201N and 202S are well developed with excellent shape, width and decay rate. They must be considered a high priority target due to the possible association of uranium mineralization with graphite and because of the close proximity of faulting.

The decay rate increases whilst amplitude progressively decreases to the west, reflecting diminishing conductance and possibly increasing conductor depth.
This horizon abruptly disappears on Lines 205N and 206S at a faulted contact. Absence of conductors in the fault zone may not preclude the occurrence of uranium mineralization. Conformable magnetic horizons in this zone indicate quite complex faulting recognised by complete changes in strike direction and decreasing magnetic intensity across fault lines.

This zone is interpreted as having the same conductive source as Zones SB - 1B, Sb - 1BB and SB - 1C which appear to be located at the same stratigraphic level.

**Zone SB - 1B**

<table>
<thead>
<tr>
<th>Line</th>
<th>Fid</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>207N</td>
<td>174.80</td>
<td>45/0.7</td>
</tr>
<tr>
<td>208S</td>
<td>184.85</td>
<td>42/1.7</td>
</tr>
</tbody>
</table>

Anomalies constituting this zone exhibit good shape and width and may be correlated with the Sleisbeck deposit.

Their decay rates are clearly faster compared to responses along strike, possibly indicating a reduction in the amount or distribution of carbonaceous material.

Faulting near this zone may have been a controlling influence in the emplacement of uranium mineralization.

**Zone SB - 1BB**

<table>
<thead>
<tr>
<th>Line</th>
<th>Fid</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>209.1N</td>
<td>208.50</td>
<td>39/2.2</td>
</tr>
<tr>
<td>209.0N</td>
<td>190.45</td>
<td>42/2.6</td>
</tr>
</tbody>
</table>

Selection of this zone was based upon noticeably enhanced conductivity within Zone SB -1B.
If faulting within these two zones is linked with uranium mineralization of the Sleisbeck deposit and conductivity is a parameter indicative of uranium occurrence through the presence of graphite, then this zone must be considered as a prime follow-up target.

<table>
<thead>
<tr>
<th>Zone SB - 1C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
</tr>
<tr>
<td>212N</td>
</tr>
<tr>
<td>to</td>
</tr>
<tr>
<td>217S</td>
</tr>
<tr>
<td>Fid 225.12</td>
</tr>
<tr>
<td>31/1.0</td>
</tr>
<tr>
<td>Fid 275.02</td>
</tr>
<tr>
<td>10/0.2</td>
</tr>
</tbody>
</table>

Narrow symmetrical six channel anomalies with high conductivity characterise this zone. Responses of lines 212N to 214N are considered the most important. Successively decreasing amplitude of INPUT and magnetic anomalies may be indicative of increasing depth to the west, although aircraft altitude is higher on the three most westerly lines, no doubt due to the difficult terrain.

<table>
<thead>
<tr>
<th>Zones SB - 2, SB - 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lines</td>
</tr>
<tr>
<td>217S</td>
</tr>
<tr>
<td>215.0S</td>
</tr>
<tr>
<td>214N</td>
</tr>
<tr>
<td>213S</td>
</tr>
<tr>
<td>Fid 274.66</td>
</tr>
<tr>
<td>28/-</td>
</tr>
<tr>
<td>Fid 252.80</td>
</tr>
<tr>
<td>15/-</td>
</tr>
<tr>
<td>Fid 241.97</td>
</tr>
<tr>
<td>16/0.2</td>
</tr>
<tr>
<td>Fid 235.82</td>
</tr>
<tr>
<td>12/0.2</td>
</tr>
</tbody>
</table>

| Line 208S            |
| Fid 184.28           |
| 72/0.5               |

Initial analysis of the distribution of these zones with respect to zones SB - 1C and SB - 1B, coupled with associated magnetic trends of this area, outlines a structure suggestive of a synclinal fold. Alternatively, these similarities may imply separate parallel sources of the same composition. However,
a closer scrutiny of the data indicates that similar variation of conductivity along strike occurs within zones parallel to each other, implying that these zones have the same source.

The existence of such a structure would mean that Zone SB-3 would represent a mirror image of the Sleisbeck deposit, making it an important prospect. These two responses on Line 208S exhibit extremely similar decay characteristics, although their rates of decay are at variance.

Greatest conductivity within Zone SB-2 occurs on Lines 213S and 214N, as in Zone SB - 1C.

Decreasing response amplitudes to the west would imply any structure is plunging in that direction. This may explain the absence of any parallel magnetic horizon in the western portion of the area.

Zone SB - 4

<table>
<thead>
<tr>
<th>Lines</th>
<th>Fid</th>
<th>58/3.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>201N</td>
<td>125.40</td>
<td></td>
</tr>
<tr>
<td>to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>217S</td>
<td>273.09</td>
<td>41/ -</td>
</tr>
</tbody>
</table>

Zone SB - 4 seems to be a linear narrow source, considering the well aligned peaks and overall sharp anomaly character. Conductivity is intermediate in the west, increasing abruptly east of Line 209.0N.

Generally these six channel anomalies have good symmetrical shapes indicative of bedrock sources.
With regard to faulting, areas of interest are located on Lines 203N and 213S and on Line 214N where a major shear zone is apparent.

<table>
<thead>
<tr>
<th>Zone SB - 4A</th>
<th>Lines</th>
<th>Fid</th>
<th>22/0.5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>204S</td>
<td>148.53</td>
<td></td>
</tr>
<tr>
<td></td>
<td>205N</td>
<td>161.57</td>
<td>40/1.1</td>
</tr>
<tr>
<td></td>
<td>206S</td>
<td>165.47</td>
<td>49/3.0</td>
</tr>
<tr>
<td></td>
<td>207N</td>
<td>178.40</td>
<td>30/1.4</td>
</tr>
</tbody>
</table>

In what appears to be a branch of Zone SB - 4, conductivity is lower and more typical of the western section of that zone. To the east the zone is truncated by faulting.

<table>
<thead>
<tr>
<th>Zone SB - 5</th>
<th>Line</th>
<th>Fid</th>
<th>42/1.1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>206S</td>
<td>164.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>207N</td>
<td>179.53</td>
<td>64/2.1</td>
</tr>
<tr>
<td></td>
<td>209.1N</td>
<td>213.20</td>
<td>53/1.1</td>
</tr>
</tbody>
</table>

INPUT anomalies of Zone SB - 5 occur in a long conductive trend which is interpreted to have a surficial source (See Figure 4). Conductivity is low here as it is in the rest of the trend, but added sharpness and persistence of responses implies an enhanced conductivity typical of a bedrock source.
VI. CONCLUSIONS AND RECOMMENDATIONS

1. The INPUT survey has successfully delineated several anomalous conductive zones which have a high probability of being caused by graphitic sources.

2. Contrasts indicated by the magnetic contour map can be related to lithological variations expected in the area. From trends and depths thus indicated an approximate structural picture is developed especially in the region of the Sleisbeck mine. Combining this data with the conductivity map several locations of possible interest are defined. However, it should be clearly noted that the assumption is not made that uranium mineralization always relates directly to graphite occurrence or content. The survey has been flown on the basis that this is one possibility.

3. The following locations are suggested for ground follow-up and consist of INPUT anomalies displaying enhanced conductivity in structurally favourable areas:

Zone SB - 1A   Line 201N   Fid 122.33
               Line 202S   Fid 133.78

Zone SB - 1BB  Line 209.1N  Fid 208.50
               Line 209.0N  Fid 190.45
<table>
<thead>
<tr>
<th>Zone</th>
<th>Line</th>
<th>Fid</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB - 1C</td>
<td>212N</td>
<td>225.12</td>
</tr>
<tr>
<td></td>
<td>214N</td>
<td>241.58</td>
</tr>
<tr>
<td>SB - 3</td>
<td>208S</td>
<td>184.28</td>
</tr>
<tr>
<td>SB - 4</td>
<td>203N</td>
<td>143.65</td>
</tr>
<tr>
<td></td>
<td>213S</td>
<td>233.55</td>
</tr>
<tr>
<td></td>
<td>214N</td>
<td>244.05</td>
</tr>
<tr>
<td></td>
<td>209.0N</td>
<td>193.51</td>
</tr>
</tbody>
</table>

Respectfully submitted,

T.H. WHITING
Geophysicist.
APPENDIX A

INPUT EQUIPMENT AND PROCEDURES

I. BARRINGER INPUT SYSTEM

a) General:

The INPUT (INduced PULSE Transient) method is based upon the study of the decay of secondary electromagnetic fields created in the ground by short pulses generated from an aircraft. The time-varying characteristics of the decay curve are analyzed and interpreted in terms of information concerning the conductivity characteristics of the terrain.

The principle of separation in time between the production of the primary field and the detection of the measured secondary signal gives rise to an excellent signal-to-noise ratio and an increased depth of penetration compared to conventional continuous wave electromagnetic systems. It also makes the INPUT system relatively independent of air turbulence.

At a normal survey altitude of 400 feet (120 metres) above terrain, the typical effective depth penetration is estimated at about 400 feet (120 metres) below surface, depending on the conductivity contrast between the conductive body and surrounding rocks, the size and attitude of the conductor and the presence or lack of conductive overburden. In optimum conditions a penetration of 600 feet (185 metres) subsurface can be achieved.
One of the major advantages of the INPUT method lies in good differentiation between flat-flying surface conductors and bedrock conductors so that the latter can be detected even under a relatively thick overburden such as glacial or pedological formations (laterite, weathered zone, etc.).

However, the application of the airborne INPUT electromagnetic method is limited to the solution of problems that are characterized by a reasonable resistivity contrast. The method is not considered to be applicable to the direct search for disseminated mineralization, except where this resistivity contrast exists.

b) Equipment:

The INPUT system has been developed by Barringer Research Limited of Toronto, Canada.

The transmitted primary field is discontinuous in nature (Fig. 1A) with each pulse lasting one millisecond; the pulse repetition rate is 288 per second. The electromagnetic pulses are created by means of powerful electrical pulses fed into a 3-turn shielded transmitting loop surrounding the survey aircraft and fixed to the nose and tail of the fuselage and to the wing tips.
The secondary field reception is made by means of a receiving coil wound on a ferrite rod and mounted in a "bird" towed behind the aeroplane on a 500 foot (150 metre) co-axial cable. The axis of the pick-up coil is horizontal and parallel to the flight direction. Gaps of two and a half milliseconds between successive primary pulses (Fig. 1B) are used for detecting the INPUT voltage, which is a transient voltage (Fig. 1C) corresponding in time to the decay of the eddy currents in the ground.

The analysis of the signal is made in the INPUT receiver by sampling the decay curve at several points or gates, the centre and width of which have a fixed relationship with respect to time zero ($t_0$) corresponding to the termination of the pulses. There are six sampling gates, the centres of which are commonly at a mean delay of 300, 500, 700, 1100, 1500 and 1900 microseconds after time zero (Fig 1D).

The signals received at each sampling gate are processed in a multi-channel receiver to give six analogue voltages recorded as six continuous analogue traces (Fig. 2) on a Honeywell Visicorder direct-reading optical galvanometer recorder. Each trace represents the coherent integration of the transient sample, the time constant of integration being about three seconds on the Mark V unit.
This integration delay plus the separation between the receiving bird and tracking camera installed in the aircraft introduces a delay which has to be taken into consideration and corrected prior to correlating the electromagnetic data with the other simultaneously recorded data.

Other recorded data are:
- Fiducial marks
- Altimeter trace
- Earth's total magnetic field
- Hz monitor
- Radiometric levels (optional)

An eddy current is induced in the airframe by the primary field. To compensate for this effect a special device is used which feeds into each channel of the INPUT receiver a signal equal in amplitude and waveform but opposite in polarity to the signal induced by the airframe eddy current. The compensation signal is derived from the voltage induced in the receiving coil by the primary field. It is constantly proportional to the inverse cube of the distance between the bird and the aircraft. Thus, swinging of the bird and changes of coupling are automatically corrected. The compensation adjustment is a simple procedure carried out during flight at a terrain clearance of 2,000 feet (600 metres) to eliminate the interference of ground conductors.
II. MAGNETOMETER

The magnetometer is a Geometrics G-803 nuclear precession unit (with high performance option) especially adapted to operate in conjunction with the INPUT equipment. Readings are taken every 1.0 second with a sensitivity of plus or minus 2 gammas and recorded at a full scale of 5 inches for 200 gammas. The coarse trace is recorded at a full scale of 5 inches for 2,000 gammas. The sensing head is mounted at the end of a 3-metre stinger, on the tail of the PBY aircraft. The magnetometer record is also shown in Figure 2.

III. OTHER EQUIPMENT

The tracking camera is a 35 mm Geocam continuous strip camera equipped with a wide-angle lens. The 35 mm film is synchronized with the geophysical record by means of fiducial marks printed every 20 seconds; the counter of the intervalometer being driven by the clock of the magnetometer.

A Sperry RA-220 Altimeter is used, and its output is recorded on the chart.

In most cases a Hz monitor is employed to assist in the detection of power lines.

Optional equipment can include a Doppler navigation system, frame camera (in addition to the strip camera), spectrometer and a digital recorder.
INPUT SIGNAL

A - TRANSMITTED PRIMARY FIELD

B - PRIMARY FIELD DETECTED IN THE BIRD (after compensation)

C - PRIMARY AND SECONDARY FIELD

D - SAMPLING OF INPUT SIGNAL

FIGURE 1.
TYPICAL INPUT RECORDING

FIGURE 2.
IV. PROCEDURES

a) Field Operations:

The flight line spacing is normally in the range of 1/8 mile to 1/4 mile. During survey flights, the altitude of the aircraft is maintained at approximately 400 feet (120 metres) above the ground with the bird flying about 200 feet (60 metres) below the aircraft.

The heading of the aircraft is such that two adjacent lines are normally flown in opposite directions. Visual navigation is based on airphoto mosaics or in some cases on topographic maps of suitable scale.

Just after take-off, the calibration of the altimeter is checked by flying straight and level over the runway at a barometric altitude AGL of 400 feet (120 metres). The compensation adjustment is checked during ferry from the base to the survey area.

b) Compilation:

At the end of each flight, all records and films are developed, edited and all synchronized fiducial marks are checked. Then, the actual flight path recovery is made by picking visible marks common to both 35 mm film and photo mosaics.
Identified points with their fiducial number are plotted on the mosaic. Then, the electromagnetic anomalies are transferred from the records onto the mosaic overlay by interpolation according to their own fiducial number.

The position of the INPUT anomalies must be corrected to take into account the separation between the bird and the aircraft as well as the delay introduced in the integration circuitry. This offset, or lag, is plotted towards the smaller fiducial numbers (to the left on the record).

The INPUT anomalies are represented on a map by means of symbols that condense the most significant characteristics: the location of the centre and half-peak width of the electromagnetic anomaly; the number of INPUT channels affected by a noticeable deflection; the peak amplitudes of the first and fourth channels. Shown also are the altitudes at which the anomalies were recorded, the amplitude of any magnetic features which coincide with INPUT anomalies and any associated response on the Hz monitor.

The only subjective elements introduced by this processing are in the decision as to whether a deflection corresponds to a genuine anomaly or to a noise source (electrostatic atmospheric discharge, compensation noise, etc.) and in the correlation of the anomalies from line to line to delineate a conductive zone.
APPENDIX B
INPUT INTERPRETATION

I. INTRODUCTION

Although the approach to interpretation varies from one survey to another depending upon local conditions, the following generalizations may provide the reader with some helpful background information.

The main purpose of the interpretation is to determine the probable origin of the conductors detected during the survey and to suggest recommendations for a further exploration programme by taking into account a limited amount of available geophysical data. This is possible through an objective analysis of all characteristics of the different types of conductors and correlating magnetics, if any. Then, the maps of electromagnetic results are compared to the available geological maps. A certitude is seldom reached, but a high probability is obtained in the appreciation of the conductive causes in most cases. One of the most important problems is usually the differentiation between non-economic surface conductors and bedrock conductors.

II. TYPES OF CONDUCTORS

a) Bedrock Conductors:

The different types of bedrock conductors that are normally encountered are the following:
1. Graphites (including a large variety of carbonaceous rocks) occur in the sedimentary formations of the Precambrian as well as in volcanic tuffs, often concentrated in shear zones. They correspond generally to long, multiple conductors lying in parallel bands. They are not magnetic unless associated with pyrrhotite or magnetite. Their conductivity is variable but generally high.

2. Massive sulphides. Syngenetic sulphides often correspond to long multiple conductors and their conductivity, which varies considerably, may be very high, as for graphites. Pyrrhotite, often associated with other sulphides may be the cause of coincident magnetic anomalies. Generally, sulphides are not as frequently encountered as is graphite.

Isolated orebodies of massive sulphides give rise to short conductors of high conductivity. They present quite often a direct magnetic anomaly and are easily recognized. However, some sulphide orebodies are not magnetic, some are not very conductive (discontinuous mineralization), and they can be located among formational conductors so that one must not be too dogmatic in the selection of the prospects.

3. Magnetite and some serpentinized ultra-basic rocks are conductive and very magnetic.
4. Manganese oxides may give a weak electromagnetic response.

b) Surface Conductors:

1. Clayey alluvium or residual soils, some swamps and brackish groundwater are usually poorly conductive to medium conductive.

2. In unglaciated areas lateritic formations, residual soils and the weathered layer of the bedrock often cause surface anomalous zones, the conductivity of which is generally low to medium but can occasionally be high. Their presence is often related to the lithology of the underlying bedrock.

c) Man-made Conductors (Cultural):

1. Power Lines. These frequently, but not always produce a conductive type response on the INPUT record. In the case of direct radiation of their field, the anomaly shows phase changes with the different channels which are recognized easily. In the case of a grounded wire, or steel pylon, the anomaly may look very much like a bedrock conductor.

2. Grounded fences or pipelines. These will invariably produce responses much like a bedrock conductor. Whenever they cannot be identified positively a ground check is recommended.
3. **General Culture.** Metal barns or houses, tailings ponds, dumps, etc., may produce **INPUT** anomalies. However, their instances are rare and can generally be verified by identification on the path recovery film.

III. **ANALYSIS OF THE CONDUCTORS**

The apparent conductivity alone is not generally a decisive criterion in the diagnosis, and other factors are also very important:
- the pattern of conductors
- the shape and size
- the associated geophysical parameter (aeromagnetics)
- the position with respect to the direction of structures
- the geological environment
- the local variations of characteristics within conductive zones.

The first objective of the interpretation, then, is to classify each zone under one of three categories, according to its most likely origin. The categories are cultural, surficial, and bedrock. A second objective is to give each zone a rating as either good, fair or poor, according to its potential as a sulphide prospect if it were considered as a bedrock conductor.
The characteristics of each of the three major classifications are discussed below in subsections a, b and c.

For any particular anomaly or zone the criteria used to analyze it are applied as rigorously and consistently as possible in order to establish the correct classification. In the vast majority of zones finally selected, the evidence is never totally conclusive. Consequently, the ultimate class selection is the one which appears to be the most probable, bearing in mind that every zone which is discussed in detail has some chance of being a bedrock conductor.

The experience of handling a large amount of INPUT data and observing the ground followup results over a large portion of this data has confirmed the validity of our interpretational criteria.

a) Cultural Conductors

The vast majority of cultural anomalies occur along roads and are accompanied by a 50 Hz response. Power lines are clearly the most common source. Although some power lines are recognised immediately on the records by virtue of phase reversals or an abnormal rate of decay, most yield INPUT anomalies of a normal "high conductivity" character which would be mistaken for bedrock responses. There are also many power lines which cause no INPUT response whatsoever.
Fences, pipelines, communication lines, railways and other man-made conductors can give rise to INPUT responses, the strength of which will obviously depend on the grounding of these objects.

Our analysis of suspected cultural anomalies is helped a great deal by the 50 Hz monitor. It is important to note, however, that the 50 Hz response must be sharply peaked in order to be a reliable indicator and it is equally noteworthy that the 50 Hz response along a power line will occasionally vanish on one or more lines.

The exact location of an INPUT anomaly with respect to the associated 50 Hz response is important. In cases where a definite cultural conductor is known, the lag between the monitor and INPUT responses is consistent from line to line. Any departure of the lag interval from the "normal" would raise suspicion of an additional conductor being present.

The direction of the power line must also be considered, as the inductive response diminishes, sometimes markedly, with reduced coupling when the power line makes a shallow angle with the flight line. In other cases, the shallow angle results in a broadening of the anomaly shape and of the 50 Hz response.
Geological conductors often carry 50 Hz response in the vicinity of power lines but these usually have the appearance of broad swells on the monitor record rather than sharp peaks.

Invariably, there are a few borderline cases which are uncertain; hence the "Hz?" nomenclature appears occasionally on the maps.

It is also necessary to utilize the tracking film. The exact positions of all anomalies, with the exception of the obvious broad surficial features, are checked on the film and possible cultural sources, or the lack thereof, are noted on the work sheets. In this way, cultural features are located which may not be apparent on the planimetric maps, as are small offsets from cultural features which can be very significant in the interpretation of the data.

Another facet of this analysis is the line-to-line comparison of anomaly character along suspected man-made conductors. In general, cultural anomalies should be very narrow, sometimes exhibiting small negatives on their leading edge, and the lag for plotting is often slightly greater than for geological conductors. The INPUT amplitude, the rate of decay, and the anomaly width should not vary a great deal along any one man-made conductor, except for the variation in amplitude related to terrain clearance variation. A marked departure from the average response character along any given feature gives rise to the possibility of a second conductor.
Any monotonous string of narrow anomalies along a road with a sharp 50 Hz response can be discarded immediately. Even the more localized narrow anomalies can usually be eliminated if a potential cultural source is evident on the tracking film and there is a sharp 50 Hz response. A response over a farm or a farm laneway can be eliminated with confidence if the source of power to the farm is obvious. Similarly, an apparently isolated response along a road can often be discarded by checking for feeble, unplot ted anomalies on adjacent lines or for 50 Hz responses with no INPUT anomalies.

Anomalies identified as cultural with a very high degree of reliability (designated by "C") can be ignored in the followup programme. In those cases where any reasonable element of doubt remains as to the type of source and/or where the anomalies have sufficiently favourable character to be considered sulphide prospects, a "C?" is shown and the conductive zone is outlined and a ground check is usually recommended.

In most cases a visual examination of the site will suffice as it is only necessary to verify the presence of a man-made conductor. In a few instances we know already that one cultural conductor is present and the object of the ground check is to determine if there is a second cultural source, a variation in the construction of the single source, a change in the grounding conditions, or perhaps a bedrock source. This type of check is obviously more difficult to accomplish.
b) Surficial Conductors

This term is used for geological conductors in the overburden, either glacial or residual; and in the weathered layer of the bedrock. Most surficial conductors are probably caused by clay minerals. In some environments, salty deposits give rise to highly conductive surficial features.

Other possible electrolytic conductors are residual soils, swamps, brackish groundwater and lake or river-bottom deposits.

Fortunately, most conductive surficial features have low, or at best, intermediate conductivity so they are not easily mistaken for highly conducting bedrock features. Many of them are very broad features and their anomaly shapes are typical of broad horizontal sheets.

When the conductivity is higher, it is usually still possible to identify a flat-lying surficial conductor, thanks to a typical asymmetry in the INPUT responses observed on both edges of the conductor (edge effect) when flying adjacent lines in opposite directions (Figure 1). Flying from A to B, the coupling between the transmitting coil and the flat-lying conductor AB is maximum when the coil is over the leading edge A and minimum when the coil is over the edge B. The INPUT response appears stronger over Point A than over Point B. The phenomenon is reversed when
flying from B to A. The actual limits of the conductive zone correspond, in fact, to the envelope of the leading edges of staggered anomalies. In practice there are many variations on this basic pattern caused by variations in width, thickness and conductivity.

Other surficial conductors may be recognized by analyzing the radio-altimeter trace, e.g. conductive deposits in the valleys or increased thickness of the weathered zone on top of the hills. Also, a comparison to the altimeter profile is essential when flying over a surface layer of apparently high conductivity where a sudden dip of short duration (or small hill) can cause an apparent anomaly which is quite sharp.

However, the existence of surficial conductors related to bedrock lithology does introduce ambiguities into the interpretation. There are instances where we cannot distinguish between weakly conductive serpentine or poorly developed graphite within the bedrock and weakly conducting soils or weathered layer above the bedrock. This does not generally detract from the prime purpose of the survey which is the location of highly conducting massive sulphides, but it does complicate the overall analysis of the data.

If the anomaly shapes show a dependence on line direction, a surficial source is probable; if they show multiple peaking and a lack of dependence on line direction a bedrock source is probable; but in the weaker anomalies the shape is often insufficiently clear for a reliable interpretation.
Formational surficial conductors seem to be most commonly related to rocks of intermediate to basic composition, as they tend to follow magnetic highs. (This is also true of most of the formational bedrock conductors.) However, there are also examples of formational surficial conductors in acidic environments.

Surficial conductors are not always portrayed completely on the EM Map because weaker INPUT responses are not usually plotted. Sometimes, the distribution of this type of conductor is indicated by the stronger sections which are plotted and by the conductor outline which delineates the entire zone.

Any outlined conductive zones which are not assigned an identification number can be taken as interpreted surficial features. Similarly, any isolated anomalies which bear no zone number and no "C" designation are interpreted as surficial.

c) Bedrock Conductors

This category is comprised of those anomalies which do not fit the criteria laid down for classifications a and b. It is difficult to assign a specific set of values which signify bedrock conductivity because any individual zone or anomaly might exhibit some, but not all, of these values and still be a bedrock conductor.
The criteria considered as favourable pointers to a bedrock conductor are:

1. Intermediate to high conductivity. Channels five and six are generally affected. Where the conductivity drops (i.e. first to fourth channel ratios greater than 15) it is difficult to distinguish narrow surficial conductors from bedrock ones.

2. Good anomaly shape. Narrow, relatively symmetrical, anomalies with well defined peaks are preferred to wider anomalies with rounded peaks. The leading flank should show a gradual increasing response with no abrupt change in slope or tendency to go negative.

3. No serious displacement of anomaly peak position with line direction, i.e. edge effect. Some displacement can be expected from a wide bedrock source or banded bedrock source which is not resolved into more than a single peak. However, major displacements in peak position appears to be associated with surficial conductors only.

4. Small to intermediate amplitude. Large amplitudes do occur but, generally, the amplitude of the response is smaller than for thick, extensive surficial conductors. The amplitude varies according to the depth of the source.
5. A degree of continuity. Maintenance of any, or all, of characteristics 1, 2, 3 and 4 is strong evidence in favour of a bedrock conductor.

6. Associated magnetic response with similar strike. A related magnetic response is usually interpreted as signifying a lithologic unit carrying the magnetic and conductive material.

However, as discussed in subsection b, some basic rocks which weather to produce a conductive upper layer will possess this magnetic association. In the absence of characteristics 1, 2, 3 or 4, the related magnetic response does not help to distinguish between surficial conductivity related to a bedrock feature and genuine bedrock conductivity.

Interference, then, with a conductive overburden can make the identification of a bedrock conductor somewhat difficult but a careful and consistent comparison of residual responses to the above criteria results in a high level of success.

Residual anomalies, basically, are those which, in comparison to other deflections, appear to be located "on" rather than "part of" the already deflected traces.
Most obvious bedrock conductors occur in long, relatively monotonous, sometimes multiple zones following formational strike. Graphitic material is usually the most probable source. Massive syngenetic sulphides running for many miles are known in nature but, in general, they are not common.

Other sources of bedrock conductivity are massive magnetite and serpentine. We rely heavily on the amplitude and dimensions of the associated magnetic activity plus the geological setting of the conductor to distinguish these cases.

The criteria used for selection of a bedrock conductor which is considered to have a good chance of being due to a massive sulphide are:

- high conductivity,
- good anomaly shape,
- small to intermediate amplitude,
- isolation,
- short strike length,
- preferable with a localized, small amplitude magnetic anomaly of the same width.

If the magnetic anomaly has similar lateral dimensions, has an amplitude of the order of 20 to 400 gammas, and correlates directly with the EM response, there is a strong possibility of pyrrhotite being present.
We must consider, however, the possibility of localized occurrences of massive sulphides within or near formational conductors. The selection of targets from within these extensive belts is a difficult problem. They are singled out primarily on the basis of a marked local increase in conductivity and/or amplitude or some evidence for a relatively localized occurrence. Variations within the conductive formations themselves can account for these characteristics so the reliability of this type of selection is considered to be low.

Localized magnetic correlations within long formational conductors can be taken as evidence of pyrrhotite. In some environments, however, this criterion is very difficult to apply due to the prevalent association of conductors to magnetically active rock types. The compilation of the magnetic data into isomagnetic contour maps assists this type of selection.
APPENDIX C
INSTRUMENT SPECIFICATIONS

INPUT RECEIVER

Gate Settings.

<table>
<thead>
<tr>
<th>Channel</th>
<th>Centre (USEc)</th>
<th>Width (USEc)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>500 after pulse</td>
<td>200</td>
</tr>
<tr>
<td>2</td>
<td>700</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>900</td>
<td>400</td>
</tr>
<tr>
<td>4</td>
<td>1200</td>
<td>400</td>
</tr>
<tr>
<td>5</td>
<td>1600</td>
<td>600</td>
</tr>
<tr>
<td>6</td>
<td>2100</td>
<td>600</td>
</tr>
</tbody>
</table>

Calibration 2mV at receiver = 3.0 in chart deflection.

Primary signal strength 1300 mV at receiver.
i.e.; 0.1 in = 51 ppm of primary field.

MAGNETOMETER

Sensitivity: +/- 1 nT.
FSD: 5 inches : 100 nT/1000 nT.
Sample Time: 1 second.
field increases downwards.

ALTIMETER

Scale 1" = 100"
400' (120m) level is approximately 7" from top of analogue chart.
Altitude increases downwards.

INTERVALOMETER

1 Fiducial = 20 magnetometer samples.
= 20 seconds.