SEL 9679  BARNJARN
MT TODD DISTRICT, NT

ANNUAL REPORT FOR EXPLORATION
YEAR THREE OF TENURE
27 NOVEMBER 1998 – 26 NOVEMBER 1999

OPEN FILE

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1. **INTRODUCTION**

Substitute Exploration Licence 9679 was granted to Territory Goldfields NL on 27th November 1996 for a term of four (4) years, then immediately transferred to Pegasus Gold Australia Pty Ltd (subject to Deed of Company Arrangement) under terms of the Wandic JV sale agreement. The licence now comprises 265 graticular blocks for a total area of 859 km².

This licence is a consolidation of titles SEL 9212, EL8867 and EL9107, held by Territory Goldfields following their purchase from Dominion Mining Ltd.

The Barnjarn Joint Venture agreement between Pegasus Gold Australia (PGA), Barnjarn Mining Company (BMC) and the Barnjarn Aboriginal Corporation was made on 25th November 1996 whereby PGA and BMC beneficially own SEL9679 in the proportions PGA 90% and BMC 10%.

Following the severe decrease in the gold price and faults in the project design criteria, the Mt Todd mine was put on care and maintenance status on 15th November 1997.

The Administrators of PGA undertook an extended sale process during 1998, with sale to the Yimuyn Manjerr Joint Venture (Multiplex Resources Pty Ltd 93%, General Gold Resources NL 2%, PGA 5%) finalized on the 18th March 1999. General Gold Operations Pty Ltd holds the exploration licence in trust for the JV and has management control.

This report summarizes exploration activities conducted within SEL9679 for the 12 months ending 26 November 1999.

2. **LOCATION AND ACCESS**

The Barnjarn area is located approximately 220km south east of Darwin, 50km east of Pine Creek and approximately 25km north west of Katherine. The tenement can be found on the Mt Evelyn and Katherine 1:250,000 geological sheets (SD53-5, SD53-9) and the Ranford Hill and Katherine 1:100,000 geological and topographical sheets (5370, 5369).

SEL9679 lies between 13°39'S and 14°15'S and 132°00'E and 132°22'E. It covers a total area of 265 graticular blocks (approximately 859km²) in two separate areas. Access can be gained via the Stuart Highway, Kakadu Highway, Edith Falls Road and 4-wheel drive tracks. See Figure 1 for tenement location.
3. REGIONAL GEOLOGY

SEL9679 Barnjam is located within the southeastern portion of the Early Proterozoic Pine Creek Geosyncline. Metasediments, granitoids, basic intrusives, acid and intermediate volcanic rocks occur within this geological province. See Figure 2 for the regional geological setting.

Within the Mt Todd area the oldest outcropping rocks are assigned to the Burrell Creek Formation. These rocks consist primarily of interbedded greywackes, siltstones and shales of turbidite affinity, which are interspersed with minor volcanics. The formation contains slump structures, flute casts, graded beds and occasional crossbeds.

Rocks of the Burrell Creek Formation have been folded about northerly trending F1 fold axes. The folds are open to closed style and generally have moderate to steep westerly dipping axial planes, with some sequences being overturned. A later north-south compression event resulted in east-west open style upright D2 folds.

The metasediments were folded and metamorphosed at \( \sim 1870 \text{ Ma} \) to lower to upper greenschist facies and, in places, to amphibolite facies. Largely undeformed late Early Proterozoic volcanics and sediments, and Middle Proterozoic, Palaeozoic, and Mesozoic strata rest on the geosynclinal sediments with marked unconformity. The geosynclinal sediments are intruded by pre-orogenic dolerite sills an syn-orogenic to post-orogenic granitoid plutons \((\sim 1840-1780 \text{ Ma})\) and dolerite lopoliths and dykes.

The geology of the tenement area comprises rocks of the following groups:

1. Katherine River Group – Kombolgie Formation
2. Cullen Granitoids
3. Edith River Group – Plum Tree Volcanics and Phillips Creek Sandstone
4. El Sherana Group – Tollis Formation
5. Finniss River Group – Burrell Creek Formation
6. South Alligator Group – Mt Bonnie Formation

The oldest rocks in the area belong to the Mt Bonnie Formation, which is the upper member of the South Alligator group. Shale, siltstone, greywacke, chert and minor tuff and dolomite represent the Mt Bonnie Formation. These rocks have been extensively hornfelsed close to granite contacts. Outcrop is restricted to low rubbly rises, strike ridges or incised creek beds and have been tight to isoclinally folded.

The Burrell Creek Formation conformably overlies or is faulted against the Mt Bonnie Formation. The Formation is dominated by greywacke and siltstone/shale and crops out extensively throughout the area on lightly timbered rubble strewn rises and low strike ridges. Within the hornfelsed auricole adjacent to the granites it forms prominent ridges and ranges up to 200m high. Most of the rocks within the unit are well cleaved and tightly folded about north to northwest fold axes.
Figure 2  Regional Geological Setting
The Tollis Formation is separated from the underlying Burrell Creek Formation by a structural and metamorphic discontinuity. The Tollis and Burrell Creek Formations are very similar with the boundary difficult to place.

The Edith River Group rocks form a small part of the licence area and unconformably overlie the Tollis Formation. The Phillips Creek sandstone comprises tuffaceous sandstone, conglomerate and minor siltstone while the younger Plum Tree Creek volcanics is made up by felsic to mafic volcanic rocks.

The Cullen batholith is a composite I-type batholith made up by 23 different plutons. Sixteen of the plutons coalesce or join at shallow depths while the others surround the main body and are probably interconnected at depths of less than 3 km. The granites intruded the early Proterozoic sediments importing differing levels of contact metamorphism. Rugged ridges of hornfels rise up to 200m above the level of the granitoids and topographically define their margins.

The Kombolgie Formation sandstone rests unconformably over the early Proterozoic sediments and the Cullen batholith and forms a discontinuous line of rocky hills and tablelands. Flat lying Mesozoic sediments and a thin layer of Cainozoic sand and laterite in many areas unconformably overlie the Kombolgie Formation.
4. **EXPLORATION HISTORY**

Literature review of the area reveals a rich history of mining beginning with the mining of gold at the Wandie Goldfield in 1895. Other metals mined in the area include copper, lead and tin.

During recent years numerous companies including Moline Management, Cyprus Gold Australia, Geopoko, Lachlan resources, Arimco, Billiton Australia, RGC Exploration, Newcrest Mining and Dominion Mining have carried out exploration in the tenement area.

Exploration by Dominion Mining Ltd under the Wandie JV consisted of broad spaced, systematic geochemical sampling guided in part by aeromagnetic data and partly from review of data held at the NT Department of Mines & Energy. This led to targeting of a number of priority areas centred on the historic Wandie goldfield and to areas surrounding and along strike of the Mt Todd gold mine. Exploration included gridding (652 km), lag/soil/rock chip sampling (179 rock, 377 soil, 4678 lag), bedrock vacuum drilling (887 holes for 3856m), vertical and angled RAB drilling (281 holes for 9897m), and stream sampling (26).

This work outlined a number of anomalous areas (within SEL9679) that are briefly described below:

- **Australus**: Soil anomaly (peak response 220ppb Au) located on the flank of the Mt Davis granite. RAB drilling returned intercepts of 40m @ 0.28 g/t Au.

- **Wandie/Saunders Rush/Brilliant**: Area (10km x 7.5km) containing a number of anomalies ranging in size from 800m to 3500m.

- **Everest**: Soil anomaly (peak response 1366 ppb Au), followup RAB drilling returned 10m @ 0.16 g/t Au.

- **Golden Slipper**: Lag anomaly of 59ppb Au

- **Triple Bull**: Several soil anomalies, up to 355 ppb Au, with rock chips to 2.49 g/t Au. RAB drilling returned a peak intercept of 10m @ 0.13 g/t Au.

Further anomalies were defined in several locations eg. Cullen, Mt Davis Mine, Mt Diamond, Emerald Creek, Driffield North and South, Black Mountain, with numerous ‘spot’ anomalies that were not investigated.
5. PREVIOUS EXPLORATION 1996-98

5.1 Data Compilation

Following the grant of SEL9769 an intensive review of all available public domain data for the tenement area was undertaken. Exploration data from previous company programs and government geological, geochemical and geophysical information were collated into a single database.

An assessment of the database generated geochemical and/or structural anomalies, which were prioritised according to geographic location and economic potential. See Figure 3 for anomaly location.

5.2 Rock Chip Sampling

Preliminary ground reconnaissance of the anomalies generated from the database was undertaken to assist in the prioritisation of targets. Rock chip sampling was completed at a number of these targets with anomalous values up to 12.3 g/t Au. Some anomalous results are listed below:

<table>
<thead>
<tr>
<th>Location</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Brilliant</td>
<td>12.3 g/t Au</td>
</tr>
<tr>
<td>Mt Davis</td>
<td>7.10 g/t Au</td>
</tr>
<tr>
<td>Ebony East</td>
<td>3.47 g/t Au</td>
</tr>
<tr>
<td>Hidden Valley</td>
<td>0.84 g/t Au</td>
</tr>
<tr>
<td>Whirlwind</td>
<td>0.76 g/t Au</td>
</tr>
</tbody>
</table>

After the initial regional soil sampling programs followup rock chip sampling was undertaken at several of the defined anomalies ie. RKD, Mountain View, Highway. Results from this sampling were highly encouraging with many assays returning values > 2 g/t Au. Anomalous values are listed below:

RKD: 24.3, 18.2, 14.5, 13.5, 7.32, 7.0, 4.98 g/t Au
Mountain View: 2.52, 0.82 g/t Au
Highway: 5.06 g/t Au

5.3 Soil Geochemistry

A number of regional soil sampling programs were undertaken to test the geochemical and/or structural anomalies generated in the initial review/assessment.

Numerous anomalous Au results were obtained with peak values at the different prospects listed below:

Cullen 220,170 ppb Au
Last Hope 950,485 ppb Au
RKD (Dead Car) 331,111 ppb Au
Mountain View 51 ppb Au
Highway 520,260 and 140 ppb Au
A10 105 ppb Au
S12 379,265 and 240 ppb Au
W11 229 ppb Au
W35 54 ppb Au

Extension and infill soil sampling was undertaken to further delineate several of the anomalies located during Year 1 of tenure. Maximum values for the infill/extension sampling at the different prospects are shown below:

S12 41 ppb Au
Dead Car 125 ppb Au
Mountain View 68 ppb Au
Wolfram 360 ppb Au
GT 535 ppb Au

5.4 Geological Reconnaissance

Ground reconnaissance and mapping to follow up the regional soil sampling was undertaken at the RKD, Cullen, Highway and Mountain View prospects.

The RKD (Dead Car) prospect is located approximately 6 km NNE of the Driffield Mining Centre and south of the Fergusson River crossing. Regional soil sampling over target areas generated by data compilation detected a 100m wide geochemical anomaly (ave. 221ppb Au). Initial rockchip sampling (5 samples) returned three +10g/t Au values from a small ridge south of the regional soil line. Followup rock chip sampling in the immediate area returned numerous +1 g/t Au assays. Geology is a predominantly fine grained, silicified shale-siltstone sequence with minor thin coarse units, similar to the Driffield North area. The mineralised zone (>200m) appears to dip steeply west and may represent a bedding parallel thrust within a axial planar zone. Regional mapping and photo interpretation has indicated a NNW trending fold structure with a series of crosscutting WNW regional scale structures. Base metal mineralisation has been detected at the intersection of these features in several localities.

Reconnaissance of the Mountain View prospect indicated a series of discordant quartz veins in a dominantly siltstone/greywacke sequence. The high grade rock chip values (2.52 g/t Au) were obtained from strongly ferruginised quartz veins.
At the Cullen prospect anomalous soil values appear related to N-NNW trending quartz vein stockwork within strongly hornfelsed metasediments.

The Highway prospect is located approximately 200m from the granite batholith within strongly deformed sediments. A major NW trending quartz vein with strike extent of at least 300m returned highly anomalous soil and rock chip values.

5.5 RAB Drilling

Three small RAB drilling programs have been undertaken to test the potential of the Everest, RKD and GT (Gold Trend) prospects.

RAB drilling at the Everest prospect (two traverses 400m apart, 25m drill spacing) was undertaken to further test the soil anomalies generated by Dominion Mining. Results from this program were poor with maximum intercepts of 3m @ 0.22 g/t Au from drillholes EVRB003 and EVRB025.

RAB drilling at the RKD prospect to test for the northern strike extent of the north trending shear structure beneath transported cover completed 57 holes for 1197m. Four drill traverses spaced up to 500m apart, on 50m centres, also returned poor results with a maximum intercept of 5m @ 0.48 g/t Au from DCRB006.

Drilling at the GT prospect was testing airborne magnetic targets beneath transported cover along trend from the Quigleys and Horseshoe resources. A total of 131 holes for 2750m were completed on five traverses with 50m drill spacing. No significant results were received.

5.6 RC Drilling

An initial RC drill program was completed at the RKD prospect to test the resource potential of the mineralised fault/shear structure.

A total of 38 RC drillholes (DCRC001-038) for 2595m were completed to test the strike and depth continuity of the structure.

Anomalous results for this program are tabled below;

<table>
<thead>
<tr>
<th>Hole No.</th>
<th>Location</th>
<th>Depth</th>
<th>Intercept (g/t Au)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCRC1</td>
<td>451181N 198479E</td>
<td>13-14m</td>
<td>1m@1.49</td>
</tr>
<tr>
<td>DCRC2</td>
<td>451141N 198482E</td>
<td>12-14m</td>
<td>2m@1.96</td>
</tr>
<tr>
<td>DCRC3</td>
<td>451116N 198482E</td>
<td>11-14m</td>
<td>3m@3.70</td>
</tr>
<tr>
<td>Station</td>
<td>Station Code</td>
<td>Latitude</td>
<td>Longitude</td>
</tr>
<tr>
<td>---------</td>
<td>--------------</td>
<td>----------</td>
<td>-----------</td>
</tr>
<tr>
<td>DCRC5</td>
<td>451187N 198501E</td>
<td>44-47m</td>
<td>1m@7.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>53-57m</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>inc 54-55m</td>
<td></td>
</tr>
<tr>
<td>DCRC6</td>
<td>451138N 198505E</td>
<td>27-29m</td>
<td>2m@1.24</td>
</tr>
<tr>
<td>DCRC7</td>
<td>451259N 198470E</td>
<td>8-10m</td>
<td>2m@1.49</td>
</tr>
<tr>
<td>DCRC8</td>
<td>451213N 198480E</td>
<td>10-12m</td>
<td>2m@14.3</td>
</tr>
<tr>
<td>DCRC9</td>
<td>451194N 198447E</td>
<td>48-52m</td>
<td>4m@2.65</td>
</tr>
<tr>
<td>DCRC10</td>
<td>451119N 198456E</td>
<td>34-37m</td>
<td>3m@1.41</td>
</tr>
<tr>
<td>DCRC14</td>
<td>451257N 198434E</td>
<td>51-53m</td>
<td>2m@13.77</td>
</tr>
<tr>
<td>DCRC17</td>
<td>451145N 198446E</td>
<td>49-51m</td>
<td>2m@2.92</td>
</tr>
<tr>
<td>DCRC20</td>
<td>451078N 198452E</td>
<td>40-43m</td>
<td>3m@1.81</td>
</tr>
<tr>
<td>DCRC24</td>
<td>451318N 198415E</td>
<td>53-55m</td>
<td>2m@6.18</td>
</tr>
</tbody>
</table>

### 5.7 Geophysics

A regional airborne geophysical survey over the northern portion of SEL9679 (north of Driffield) was completed for Pegasus by World Geoscience during September 1997. Specifications of the survey are detailed below:

- **Aircraft**: VH-ADH C206
- **Magnetometer**: Split beam cesium scintrex VIW2321-CS2  
  Resolution: 0.001 nano Tesla  
  Cycle Rate: 0.1 seconds  
  Sample Interval: 6.0 metres
- **Spectrometer**:  
  Packets Perm. 1000 256 Channel  
  Volume: 16.56 litres  
  Cycle rate: 1.0 seconds  
  Sample Interval: 60 metres
- **Data Acquisition**: Packets pads 1000 digital acquisition system  
  11 Channel RMS GR33A Chart recorder
- **Flight Line Spacing**: Traverse lines: 100 metres  
  Tie lines: 984 metres
- **Flight Line Direction**: Transverse lines: 270-090 degrees  
  Tie Lines: 000-180 degrees
- **Survey Height**: 60 metres – mean terrain clearance
- **Navigation**: GPS satellite positioning system

Digital images of this survey are enclosed in Appendix 5 of the 'SEL9679 Annual Report for Exploration 27 November 1997 – 26 November 1998'.

### 5.8 GIS and Remote Sensing Studies

Pegasus completed a thorough compilation of a GIS database through the acquisition of digital data from various government and private companies. This data included combined Landsat/SPOT imagery at
1:50,000 scale, digital aerial photography for the northern Barnjarn region (1:60,000 scale), 5m contours generated from this photography, 1:25,000 scale digital photography and 5m contours for the Driffield region, as well as the previously described airborne geophysics.

All this digital data was manipulated in ARCVIEW with all geochemical and drill data in GEMCOM Pcxplor and Micromine databases.

Continuation of the GIS compilation program in Year2 included generation of 5m contours for the various orthophotos, addition of 1997-98 Pegasus exploration data and the initial input of CAD geological mapping. Interpretation of the various datasets was initiated during the year.

Enclosed within Appendix 5 of ‘SEL9679 Annual Report for Exploration 27 November 1997 – 26 November 1998’are the digital airborne geophysical images, digital aerial photography images and specifications, and Landsat/Spot imagery generated for the Barnjarn licence.
6. **EXPLORATION 1998-99 (Year 3)**

6.1 **GIS and Remote Sensing**

Interpretation of the GIS database continued through the year with mapped geological data input, radiometric data evaluation and initiation of regolith data compilation.

6.2 **Rock Chip Geochemistry**

Reconnaissance rock chip sampling (BJR1000-61) of anomalies generated by GIS compilation was undertaken over the northern area of the title. Samples were taken from outcropping shear/breccia zones, massive and stockwork quartz veins, and zones of strong Fe alteration.

Rock chips were sent to Assaycorp in Pine Creek for Au, Cu, Pb, Zn and As analyses. Sample/analytical methods are detailed below:

- **Au**: detection limit 0.01 ppm, 50g fire assay
- **Cu**: detection limit 1 ppm, ICP techniques
- **Pb**: detection limit 5 ppm, ICP techniques
- **Zn**: detection limit 2 ppm, ICP techniques
- **As**: detection limit 10 ppm, ICP techniques

Rock chip sample locations are shown on Figures 4 & 5, with full assay results and sample descriptions in Appendix 1.

6.3 **Soil Geochemistry**

Extension and infill soil sampling was undertaken to further delineate four anomalies defined during previous exploration. Samples (495) were collected by a contract field crew with details listed below.

<table>
<thead>
<tr>
<th>Prospect</th>
<th>Sample No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emerald Creek</td>
<td>99BJ001-123</td>
</tr>
<tr>
<td>Triple Bull</td>
<td>99BJ124-268</td>
</tr>
<tr>
<td>Highway</td>
<td>99BJ269-386</td>
</tr>
<tr>
<td>RKD South</td>
<td>99BJ454-495</td>
</tr>
<tr>
<td></td>
<td>99BJ387-453</td>
</tr>
</tbody>
</table>

All samples were collected at 50m spacing along regional grid lines and sieved to ~40# size fraction in the field. Samples were dispatched to Assaycorp Pine Creek and analysed for Au (1 ppb DL), As (10 ppm DL), Cu (1 ppm DL), Pb (5 ppm DL) and Zn (2 ppm DL).

Maximum Au values for the infill/extension sampling at the different prospects are shown below:

- **Emerald Creek** 59.35 ppb Au
Triple Bull 58ppb Au
Highway 180,160ppb Au
RKD South 22 ppb Au

Soil sample location and Au assay results are shown on Figures 6-9 with full assay results listed in Appendix 1.

6.4 Geophysical Interpretation

Interpretation of the aeromagnetic and radiometric data over the northern area of the exploration licence was undertaken by Southern Geoscience Consultants (SGC).

SGC targeted six different mineralization types, based on known mineralization in the area, and generated 98 possible targets. Target types are detailed below:

- Discrete magnetic bodies
- NNE trending structural corridors
- N-S or NNW striking structures
- Tight fold structures with increased magnetite-pyrrhotite content
- Zones of magnetite destruction
- Concealed granite bodies at shallow depth

Correlation of the magnetic interpretation with the known mineralization in the area is disappointing due to their poor magnetic expression in relatively non-magnetic rocks. No potassium or uranium anomalies were identified.

The interpretation report is attached in Appendix 2 with digital copies of the 1:100,000 and 1:25,000 enhanced images.
CONCLUSIONS AND RECOMMENDATIONS

Exploration during year 3 of tenure has included further GIS database compilation and interpretation, rock chip sampling, gridding, geological reconnaissance and soil sampling.

Assessment of the database compilation and initial interpretation of the digital data generated at least 65 geochemical anomalies that require investigation. The 1996-97 regional soil sampling programmes had defined targets at the RKD, Mountain View, Wolfram and S12 prospects that underwent further geological reconnaissance and geochemical sampling.

At the RKD prospect drilling of the N trending structure has returned highly anomalous drill intercepts indicating the potential for a small resource. Further drilling to test for strike extensions and/or similar structures in this mineralised area is highly recommended.

RAB/RC drilling of the Highway, Mountain View, Wolfram, and S12 prospects is warranted after further geological mapping and surface geochemistry to assist in targeting. This should also involve testing below the transported Fergusson River floodplain between the RKD (Dead Car) and Mountain View prospects.

Initial assessment of the GT prospect has been mixed with poor results from the testing of covered airborne magnetic targets but anomalous geochemical values from the northern area require further investigation.

The structural targets (98) generated from the aeromagnetic interpretation will be married with the existing geochemical database to determine exploration priority. Continuation of the regional scale geochemical programs to test the potential of the +65 Barnjarn anomalies is required. This can lead to the development of satellite resources for the Yimuyn Manjerr mill or a stand-alone deposit.

The potential of the Wandie-Saunders Rush-Brilliant line of workings will be a priority for the forthcoming year as well as nearby Highway prospect.

REHABILITATION

No exploration activities that required rehabilitation were undertaken in this year of tenure. Previous RAB drill holes within SEL9769 were sealed immediately following the completion of the hole. No PVC collar pipe or plastic sample bags were used during RAB drilling.

Rehabilitation of the Dead Car Prospect drilling was undertaken in December 1997.
8. **EXPENDITURE**

Expenditure for year 3 of tenure is tabled below:

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salaries/Wages</td>
<td>$67,024</td>
</tr>
<tr>
<td>Vehicles &amp; Fuel</td>
<td>$ 1,889</td>
</tr>
<tr>
<td>Geophysics</td>
<td>$14,800</td>
</tr>
<tr>
<td>Contract Field Crew</td>
<td>$ 6,572</td>
</tr>
<tr>
<td>Consumables</td>
<td>$  568</td>
</tr>
<tr>
<td>Assays</td>
<td>$ 8,309</td>
</tr>
<tr>
<td>Tenement Consultant</td>
<td>$  250</td>
</tr>
<tr>
<td>Administration</td>
<td>$14,912</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$114,324</strong></td>
</tr>
</tbody>
</table>

9. **PROPOSED EXPLORATION AND BUDGET**

Exploration proposed for Year 4 of tenure includes regional soil sampling, rock chip sampling, RAB drilling and RC drilling on the various targets generated by the Years 1-3 program.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Quantity</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil sampling</td>
<td>(3000)</td>
<td>$60,000</td>
</tr>
<tr>
<td>Rock chip sampling</td>
<td>(100)</td>
<td>$ 2,000</td>
</tr>
<tr>
<td>RAB drilling</td>
<td>(5000)</td>
<td>$60,000</td>
</tr>
<tr>
<td>RC drilling</td>
<td>(2000)</td>
<td>$ 50,000</td>
</tr>
<tr>
<td>Earthworks &amp; Rehabilitation</td>
<td></td>
<td>$ 15,000</td>
</tr>
<tr>
<td>Geological Mapping</td>
<td></td>
<td>$  13,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$200,000</strong></td>
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</tbody>
</table>
SEL 9679 BARNJARN
MT TODD DISTRICT, NT

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APPENDIX 1

ROCK CHIP AND SOIL ASSAY RESULTS
<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Northing</th>
<th>Easting</th>
<th>(As) Assay Result</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BJR1000</td>
<td>8469140</td>
<td>185300</td>
<td>0.16</td>
<td>Qtz vein, ~150m x 1.5m, strike 175°, dip 70°W, in granite, recrystallised, minor sediment on contact</td>
</tr>
<tr>
<td>BJR1001</td>
<td>8470000</td>
<td>192400</td>
<td>0.06</td>
<td>Composite, boky qtz ± haem, Mn, mnr. shale ± thin shik</td>
</tr>
<tr>
<td>BJR1003</td>
<td>8469950</td>
<td>191100</td>
<td>&lt;0.01</td>
<td>Bx qtz vein, ± Pb, As staining, ± altered sediment</td>
</tr>
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SEL 9679 BARNJARN
MT TODD DISTRICT, NT

ANNUAL REPORT FOR EXPLORATION
YEAR THREE OF TENURE
27 NOVEMBER 1998 – 26 NOVEMBER 1999

APPENDIX 2

GEOPHYSICAL INTERPRETATION
GENERAL GOLD OPERATIONS PTY LTD

YIMUYN MANJERR PROJECT
AIRBORNE GEOPHYSICAL SURVEY
SHEETS 4 - 6

INTERPRETATION REPORT

W.S. PETERS
JANUARY 2000
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1. SUMMARY

Aeromagnetic and radiometric data over the northern part of the Yimuyn Manjerr project area have been processed and interpreted in order to select targets for gold and base metal mineralisation.

The magnetic relief is relatively low at about 300nT and there are large areas with very little magnetic character. Imaging and processing with RTP and FVD enhancements has significantly helped with the visualisation of the magnetic data.

The main rock types in the area are sediments and granites, most of which are virtually non-magnetic. The most significant magnetic stratigraphy is thought to be chlorite-magnetite ironstones within the Burrell Creek Fm. Magnetic patterns in this stratigraphy are complex and disrupted indicating extensive folding, faulting and intrusion.

There are three main fault sets striking NNE, NNW and N-S. The most prominent fault is a central major NNE corridor with dextral displacement striking through the entire area. The extrapolation of the Batman structural corridor from the south is only poorly defined.

There are a number of discernible fold structures in the magnetic sediments, particularly in the west of the area. Dips were difficult to interpret but tend to be mainly steep.

Radiometric data have allowed the classification of the area into zones of differing radioelement content, which could be used for lithology or regolith mapping. Various granite intrusives are well defined by the radiometric data and can be subdivided based on their radioelement content. No unknown radioactive granites were indicated. No discrete uranium or potassium anomalies of possible mineralisation interest and unrelated to rock type were indicated.

A system of target classification based on knowledge of the mineralising systems in the area was derived. A relatively poor correlation of known mineralisation with recognisable magnetic signatures, mainly due to the lack of any magnetic character in many areas, is disappointing. There were no discrete magnetic bodies similar in character to the Batman- Penguin pyrrhotite bodies to the south.

A total of 98 target zones of six different types were outlined. The more interesting of these targets were selected and discussed. Follow up and future exploration recommendations included integration with other geoscience data sets, possible airborne EM surveys, soil sampling and shallow drilling.
2. LIST OF FIGURES

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<th>FIG.</th>
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<td>TMI Gradient combination: Total Area</td>
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<td>Ternary Radiometric combination: Total Area</td>
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Figure 1
YIMUYN MANJERR PROJECT
AIRBORNE GEOPHYSICAL SURVEY
LOCATION PLAN
1:1 000 000
3. INTRODUCTION

Airborne magnetic and radiometric data have been flown in two phases by Pegasus Gold Australia (formerly Zapopan NL) over the Yimuyn Manjerr (Mt Todd) area, N.T. (Figure 1). The data from the southern first phase of surveying were previously processed and interpreted by the author (Peters, 1996). This interpretation describes the processing and interpretation of the data from the northern second phase of surveying at 1:25000 scale. The main aims are to outline the area in terms of lithology and structure, and to identify potential gold mineralisation targets.

This interpretation does not necessarily match the earlier interpretation at the common boundary. A reconciliation of the two interpretations can be done at a future stage if required.

4. GEOLOGY

The geological data used are as follows:

- Geology of the Edith River Region – Map: BMR/NTGS 1989 1:100000
- Ranford Hill – Map: BMR/NTGS 1986 1:100000
- Geology and Metallogeny of the Cullen Mineral Field – Map: BMR 1987 1:250 000

The area is within the southern portion of the Pine Creek Geosyncline and contains folded and metamorphosed greywacke, siltstone and minor Tuff of the Burrell Creek Fm. It is overlain in places by the Tollis Fm. Various granitoid rocks relating to the Proterozoic Cullen Batholith intrude these rocks. Contact metamorphism is common around these intrusives. The rocks are complexly folded, and strikes and dips are highly variable, but most stratigraphy strikes NW-SE. There is extensive faulting.

Mineralisation in the area is mainly hydrothermal veins & stockworks, stratabound VMS deposits, alluvial workings, and massive oxide deposits (Fe & Mn). It includes gold, copper, tin, tungsten, lead and silver. Most deposits are located on N-S to NNW striking faults and shears within older rocks. It is thought that most deposits are genetically related to the intrusive granitoids to some extent.

The gold mineralisation at Yimuyn Manjerr (Mt Todd) is hosted within pyrrhotite-rich sediments. The Batman and Penguin pyrrhotite bodies strike approximately north-south and are unconformable with the NW striking stratigraphy. The bodies are hosted within a NE striking structural corridor.
5. SURVEY DETAILS

Phase 1:
- Contractor: World Geoscience
- Date: June 1995
- Magnetometer: Scintrex Caesium Vapour
- Sample Interval: 6 metres
- Data Acquisition: Digital and analogue
- Flight Line Spacing: 100 metres and 50 metres
- Flight Line Direction: 090-270 degrees
- Survey Height: 60m
- Navigation: DGPS

Phase 2:
- Contractor: World Geoscience
- Date: August 1997
- Magnetometer: Scintrex Caesium Vapour
- Sample Interval: 6 metres
- Data Acquisition: Digital and analogue
- Flight Line Spacing: 100 metres
- Flight Line Direction: 090-270 degrees
- Survey Height: 60m
- Navigation: DGPS

6. DATA PROCESSING

The Phase 2 data were merged with the Phase 1 data. The combined data were image processed on the SGC imaging system with the following enhancements being recorded as an A3 image atlas:

INTENSITY (NL) - PSEUDOCOLOUR
INTENSITY (L) - PSEUDOCOLOUR
RTP INTENSITY (NL) - PSEUDOCOLOUR
RTP INTENSITY (L) - PSEUDOCOLOUR
INTENSITY (NL) - AGC - GREyscale
NORTH HORIZONTAL GRADIENT (NL) - GREyscale
NE HORIZONTAL GRADIENT (NL) - GREyscale
EAST HORIZONTAL GRADIENT (NL) - GREyscale
SE HORIZONTAL GRADIENT (NL) - GREyscale
HORIZONTAL GRADIENT COMBINATION (NL) (BLUE=NE,GREEN=E,RED=SE)

INTENSITY (NL) SHaded WITH 50% NORTH GRADIENT
INTENSITY (NL) SHaded WITH 50% NE GRADIENT
INTENSITY (NL) SHaded WITH 50% EAST GRADIENT
INTENSITY (NL) SHaded WITH 50% SE GRADIENT

RTP INTENSITY (NL) SHaded WITH 50% NORTH GRADIENT
RTP INTENSITY (NL) SHaded WITH 50% NE GRADIENT
RTP INTENSITY (NL) SHaded WITH 50% EAST GRADIENT
RTP INTENSITY (NL) SHaded WITH 50% SE GRADIENT
INTENSITY (L) SHADED WITH 50% NORTH AGC GRADIENT
INTENSITY (L) SHADED WITH 50% NE AGC GRADIENT
INTENSITY (L) SHADED WITH 50% EAST AGC GRADIENT
INTENSITY (L) SHADED WITH 50% SE AGC GRADIENT
INTENSITY (L) SHADED WITH 75% FVD AGC
INTENSITY (L) SHADED WITH 75% 2D AGC
RTP INTENSITY (L) SHADED WITH 50% NORTH AGC GRADIENT
RTP INTENSITY (L) SHADED WITH 50% NE AGC GRADIENT
RTP INTENSITY (L) SHADED WITH 50% EAST AGC GRADIENT
RTP INTENSITY (L) SHADED WITH 50% SE AGC GRADIENT

FIRST VERTICAL DERIVATIVE (NL) - GREYSCALE
SECOND VERTICAL DERIVATIVE (NL) - GREYSCALE
AGC ON 2VD (L) - GREYSCALE

1VD (NL) SHADED WITH 50% NORTH GRADIENT
1VD (NL) SHADED WITH 50% NE GRADIENT
1VD (NL) SHADED WITH 50% EAST GRADIENT
1VD (NL) SHADED WITH 50% SE GRADIENT

1VD (LIN) SHADED WITH 50% NORTH AGC GRADIENT
1VD (LIN) SHADED WITH 50% NE AGC GRADIENT
1VD (LIN) SHADED WITH 50% EAST AGC GRADIENT
1VD (LIN) SHADED WITH 50% SE AGC GRADIENT

RTP 1VD (NL) SHADED WITH 50% NORTH GRADIENT
RTP 1VD (NL) SHADED WITH 50% NE GRADIENT
RTP 1VD (NL) SHADED WITH 50% EAST GRADIENT
RTP 1VD (NL) SHADED WITH 50% SE GRADIENT

RTP 1VD (LIN) SHADED WITH 50% NORTH AGC GRADIENT
RTP 1VD (LIN) SHADED WITH 50% NE AGC GRADIENT
RTP 1VD (LIN) SHADED WITH 50% EAST AGC GRADIENT
RTP 1VD (LIN) SHADED WITH 50% SE AGC GRADIENT

ANALYTIC SIGNAL (L) - PSEUDOCOLOUR
ANALYTIC SIGNAL (NL) - PSEUDOCOLOUR

DIGITAL TERRAIN IMAGE (L) - PSEUDOCOLOUR

TOTAL COUNT (L) - PSEUDOCOLOUR
POTASSIUM (L) - PSEUDOCOLOUR
URANIUM (L) - PSEUDOCOLOUR
THORIUM (L) - PSEUDOCOLOUR
TERNARY RADIOMETRIC COMBINATION (BLUE=U,GREEN=TH,RED=K)
U/TH (L) - PSEUDOCOLOUR
K/TH (L) - PSEUDOCOLOUR

Abbreviations: Linear stretch - (L), Non-linear stretch - (NL), Automatic Gain Control - AGC, First vertical derivative - 1VD, 1.5 vertical derivative - 1.5VD, Second vertical derivative - 2VD, TC - Total Count, K - Potassium, U - Uranium, Th - Thorium, Reduced to Pole - RTP

From a study of the above enhancements the following maps were subsequently produced:

**1:100 000 Series:**
1. TMI contours on film (not included with report)
2. RTP TMI contours on film (not included with report)
3. RTP TMI (NL) colour with east shadow (not included with report)
4. TMI (L) colour with 2VD AGC shadow (not included with report)
5. RTP FVD (NL) colour with NE shadowing (not included with report)
6. TMI (NL) colour – NE shadow (Figure 3)
7. TMI (NL) RTP colour – NE shadow (Figure 4)
8. TMI (L) RTP colour – NE AGC shadow (Figure 5)
9. TMI FVD RTP (L) colour – NE AGC shadow (Figure 6)
10. TMI Gradient combination (Figure 7)
11. Ternary Radiometrics colour (Figure 8)

1:25000 Series (Sheets 4-6):
12. TMI contours on film (not included with report)
13. RTP TMI contours on film (not included with report)
14. TMI profiles on film (not included with report)
15. FVD profiles with and without AGC on film (not included with report)
16. TMI (NL) colour – NE shadow (not included with report)
17. RTP TMI (NL) colour – NE shadow (not included with report)
18. RTP FVD (NL) colour – NE shadow (not included with report)
19. RTP FVD (L) colour – NE AGC shadow (not included with report)
20. Ternary Radiometrics colour (not included with report)
21. RTP TMI (L) colour – NE AGC shadow (Figures 9-11)
7. INTERPRETATION

7.1 General Discussion:

This report only considers the interpretation of the northern three sheets (Sheets 4-6) at 1:25 000 scale. The magnetic response of the total survey area is shown in Figure 2. The magnetic interpretation is included as Figures 13-15. It is synthesis of data from the contours, profiles and images with input from the available geological information. Known mineralisation locations have been marked. A simple radiometric interpretation is also included as Figures 15-17. Recommended targets are shown in Figures 18-20.

7.2 Magnetic Interpretation:

A set of 1:25000 scale magnetic image maps is included as Figures 9-11 to allow correlation with the interpretation plans. The results of reduction to the pole (RTP) processing which places positive magnetic anomalies directly above the magnetic sources were assessed to be reasonably valid and as a result, RTP image plans were the basis for most of the interpretation. First vertical derivative (FVD) processing sharpens and separates magnetic features and was used to interpret fine detail.

The background magnetic intensity is about 47400nT. The magnetic relief averages little more than 300nT with most magnetic units in the area having magnetic responses of between 50nT and 100nT.

The magnetic response consists of extensive weakly to non-magnetic areas, folded magnetic stratigraphic units and some isolated smaller magnetic bodies. There is only minor magnetic response from ‘surficial’ sources such as magnetic debris in existing or paleodrainages.

There are a few magnetic responses probably due to man-made features in the vicinity of some old workings.

Classification of rock types by their magnetic response was attempted based on the geological information provided. This proved very limited because most rock types in the area are virtually non-magnetic sediments and granites. As a result much of the classification described below is based simply on magnetic intensity and character. The use of the terms, highly, moderately and weakly magnetic is relative to the area.

*Moderately magnetic rock unit* - probably sediments:
Most of these features are stratigraphic units as indicated by their linear and folded nature. They are within the Burrell Creek Fm and the most likely explanation is ‘banded green chlorite-magnetite ironstone’.

*Weakly magnetic rock unit:*
These are weakly magnetic features that are probably mostly magnetic sediments but could be weak magnetite alteration zones, magnetic phases in granites, minor hornfels adjacent to granites or magnetic material in drainages or laterite.
Non-magnetic rocks - mainly sediments:
These are the bulk of the central part of the survey area where there is no discernible magnetic response. These rocks are sediments of the Burrell Creek Fm.

Weakly to non-magnetic granitoid rocks – Wandie Type:
These are weakly to non-magnetic areas mapped or interpreted as granite. They are quite highly radioactive in all radioelements.

Weakly to non-magnetic granitoid Rocks – McCarthy's Type:
These are weakly to non-magnetic areas mapped or interpreted as granite. They are quite highly radioactive in all radioelements but less so in uranium than the previous type.

Weakly to non-magnetic granitoid rocks – sub-surface?
These are weakly to non-magnetic areas interpreted as granite. There is no radiometric response and little indication of granite on the geological maps. These are interpreted to be sub-surface at reasonably shallow depth.

Hornfels margins - magnetic:
These are weakly to moderately magnetic areas at granite margins. They are assumed to be hornfelsed sediments, although they may in some cases be magnetic stratigraphy interrupted and folded by the granite intrusion.

Isolated magnetic bodies:
These are relatively isolated magnetic features that look to be unconformable with stratigraphy. They may be pyrrhotite or magnetite concentrations formed by chemical and/or thermal reactions associated with hydrothermal fluids and intrusives.

As many magnetic units as possible were delineated using the profiles, contours, and imaging. Using this interpreted stratigraphy, faults, folds and general structure have been interpreted. This is usually only possible in the areas containing the magnetic chlorite-magnetite unit stratigraphy.

The area is reasonable well exposed and the radiometric data clearly show most of the mapped granite intrusives, whereas these are often very ill defined in the magnetic data. The granites have been differentiated to some extent based on their radiometric character. There are no significant indications in the radiometric data of any unmapped granites. Several zones where magnetic stratigraphy seems to be intruded by non-magnetic rocks have been interpreted as shallow sub-surface granite (G1-G3), although there are alternative explanations.

There are no magnetic dykes visible in the data.

Dips have been interpreted in a few places and are mainly steep. Some fold structures are indicated, again mainly within the chlorite-magnetite stratigraphy.

Numerous faults have been interpreted to explain the complex, disrupted magnetic patterns. These faults strike in several different directions and have varying displacements. It is probable that the fault displacement is vertical/normal as much as lateral because of the doming effects of granites. There are three main fault directions: NNE, NNW and N-S. Some of the more notable faults are commented on below.
The NNE trend is the same as the corridor containing the Mt Todd gold deposits. The most striking NNE striking fault system is the zone comprising faults F1-F5. This corridor which is up to 1500m wide has dextral displacement much of which looks to be ductile in nature. The second most prominent NNE fault zone is F6-F8 in the west of the area adjacent to the granite, which offsets the magnetic stratigraphy in a more brittle fashion. The possible continuation of the Mt Todd structure corridor from the south is not distinct but may be indicated by fault F9.

Prominent NNW striking fault systems is F10-F11 in the west of the area and F12, F13 & F14 (Coronet Fault) in the north. Fault F15 is also a prominent magnetic break in the stratigraphy in the north. In the south of the area, faults F16-F23 strike along the margins of a major granitoid intrusive and offset the magnetic stratigraphy around its margin. At least one of these faults (F16) correlates well with known mineralisation (Cu).

The most well defined N-S faults are F24-F26 in the north of the area striking into a granitoid intrusive. Numerous others are interpreted throughout the area but they are usually less certain.

There are several well-defined fold structures but it is difficult to determine whether they are anticlinal or synclinal. The best defined are adjacent to the western granitoid.

7.3 Radiometric Interpretation:

As an aid to interpreting different rock types, the radiometric data were used to classify the area into zones of different radiometric character (Figures 15-17). This is a relatively qualitative interpretation based on the following classifications:

- Type A: Very high K, U, Th: Wandie-type granite intrusives: biotite leucogranites
- Type B: High K, U, moderate Th: Wandie-type granite intrusives: biotite leucogranites
- Type C: High K, Th, low U: McCarthys-type granite intrusives: leucogranites
- Type D: Low K, U, moderate Th: McCarthys-type granite intrusives: leucogranites -- areas of residual cover?
- Type E: Very low K, U, Th: Burrell Creek Fm sediments or derived soils. Often alluvial drainage systems.
- Type F: Moderate K, U, low Th: Burrell Creek Fm sediments or derived soils.
- Type G: Low K, U, Th: Burrell Creek Fm sediments or derived soils.
- Type H: Low K, Th, moderate U: Alluvium with slight uranium concentration.

These data may also be used for regolith interpretation.

Trends in the radiometric data that appear to be related to bedrock stratigraphy were annotated on the interpretation plans.

No significant uranium anomalies were seen in the imaged data. No unusual potassium anomalous zones unrelated to granitoids and that may indicate hydrothermal alterations were seen.

7.4 Targets:

Six different target types were decided upon after considering the known mineralisation in the area. The emphasis is on gold-copper mineralisation.
- **Type TM**: Unusual discrete magnetic bodies, which may be pyrrhotite-magnetite accumulations of the Batman/Penguin type.
- **Type TC**: NNE striking structural corridors such as that containing the N-S striking Batman/Penguin gold – pyrrhotite deposits (in dilational gashes?).
- **Type TF**: N-S or NNW striking structures – these contain most of the known mineralisation occurrences in the area.
- **Type TT**: Tight fold structures with increased magnetite-pyrrhotite content. Mineralisation tends to be concentrated in zones of tight folding and deformation.
- **Type TD**: Zones of magnetite destruction. Hydrothermal alteration associated with mineralisation may have destroyed the magnetite.
- **Type TG**: Concealed granite bodies at shallow depth. The roof zones of such granites are favourable mineralising environments.

Other target types such as uranium and potassium anomalies were considered but could not be identified.

The correlation of the magnetic interpretation with the known mineralisation in the area is relatively disappointing. Many of the deposits have no discernible magnetic expression as they exist in non-magnetic rocks. It should be appreciated that no targets could be interpreted in these relatively extensive, magnetically featureless areas and the resulting interpreted targets are therefore biased towards areas of magnetic stratigraphy.

There are 98 targets in total consisting of 21 TM, 3 TC, 40 TF, 20 TT, 9 TD and 5 TG targets. It is difficult to prioritise the targets but some of the better looking targets are mentioned briefly below.

There are no magnetic anomalies similar in character to Batman/Penguin but there are a number of reasonably interesting isolated anomalies. Targets TM1, TM5, TM7, TM12, TM14, TM17, TM20 and TM21 are of the most interest initially. Targets TM4 and TM16 may be due to man-made sources.

The most prominent NNE structural corridor is TC3 which is however, very large in area and apparently lacking any known mineralisation. TC2 is also well defined but also lacking in known mineralisation. TC4 is an obvious target area because of its probable correlation with the Yimuyn Manjerr deposits.

The TF features could be expected to be the most favorable for mineralisation but are unfortunately less well defined because they are often near-parallel to the stratigraphy. The most interesting zones initially are TF3, TF11, TF12, TF15, TF19, TF25, TF29, TF31, TF32 and TF40.

The TT targets are loosely based on tight fold structures but are extended to include zones of anomalously high magnetic response within a magnetic feature. The more interesting targets of this type are TT4, TT5, TT6 and TT18.

Zones of magnetite destruction are of course difficult to distinguish from windows or intrusions of non-magnetic rocks. The better looking, reasonably confined targets of this type are TD1, TD2 and TD5.
The concealed granite targets are very speculative considering the outcrop of sediments over most of them, however, they are worth looking at. The better initial targets are TG2, TG3 and TG5.
8. CONCLUSIONS AND RECOMMENDATIONS

The aeromagnetic and radiometric data have allowed interpretation of the area in terms of magnetic lithology and structure, however, the extensive areas with no magnetic relief are a limiting factor.

The data are of high resolution and good quality and there is little merit in considering more detailed magnetic surveying.

The total magnetic relief is about 300nT, but magnetic relief is very low over much of the area.

Processing with RTP and FVD enhancements has significantly improved the visualisation of the magnetic data.

The magnetic patterns are complex and disrupted indicating extensive folding, faulting and intrusion.

The main rock types are various sediments and granites, most of which are virtually non-magnetic. The main magnetic stratigraphy is thought to be chlorite-magnetite ironstones within the Burrell Creek Fm.

The three main fault sets strike NNE, NNW and N-S. The most prominent of these is the central major NNE corridor with dextral displacement striking through the entire area. The Batman structural corridor is only poorly defined.

The most discernible fold structures are in the magnetic sediments in the west of the area.

Dips are difficult to interpret but tend to be mainly steep.

The radiometric data allow a classification of the area into zones of differing radioelement content, which can be used for lithology or regolith mapping. The various granites are well defined by the radiometric data and can be subdivided based on their radioelement content. No unknown radioactive granites are indicated.

The system of target classification is based on knowledge of the mineralising systems in the area. The relatively poor correlation of the known deposits with recognisable magnetic signatures is disappointing. This is mainly due to the lack of any magnetic response in many of these areas.

A total of 98 target zones of six different types are outlined composed of:

- Unusual discrete magnetic bodies – 21
- NNE striking fault systems - 3
- N-S & NNW striking structures – 40
- Fold noses and increased magnetite – 20
- Magnetite destruction – 9
- Sub-surface granitoids – 5
There are no discrete magnetic bodies similar in character to the Yimuyn Manjerr pyrrhotite bodies with the possible exception of M15 (Black Hill), however, there are several bodies of more than average interest.

The main NNE striking fault corridor target of the Batman / Penguin type is TC3 striking through the centre of the area.

The numerous NNW and N-S striking structures are thought to parallel the main mineralisation direction and several of the more prominent of these are recommended targets.

Areas of increased and decreased magnetite content, are inferred to be related to alteration with possible associated mineralisation.

Several possible sub-surface granites are indicated and the roofs and margins of these are favourable target zones for several different mineralisation types.

There are no discrete uranium or potassium anomalies indicated that would be targets of interest.

Existing additional geophysical data other than aeromagnetics should be reviewed and incorporated. Gravity data should help with understanding the structure of the area, in particular with locating sub-surface granites. An airborne electromagnetic (AEM) survey may have significant application in mapping conductive, non-magnetic marker horizons and delineating shallow massive sulphide deposits.

There are numerous and extensive selected target areas and some rationalisation and assigning of priorities will be required. The final selected target areas should be geologically assessed and soil sampled if appropriate. RAB drilling may be required on some targets to get valid geochemical samples. If any particular area becomes a significant prospect, then more detailed interpretation and computer modelling could be done on the magnetic and any other available geophysical data.
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IMAGE PROCESSING OF AIRBORNE GEOPHYSICAL DATA
SOUTHERN GEOSCIENCE CONSULTANTS

W.S. Peters

INTRODUCTION:
These notes were put together initially for the use of clients of SGC. They are, however, sufficiently generalised to be of use to explorationists using other imaging services.

Image Processing generally consists of taking a set of 'located X,Y,Z' data, converting it to pixel format (gridding), carrying out computations to enhance the data and then presenting it in some form of 'hard copy'. The company uses a wide variety of software, some commercial and much written in-house, which is all PC based.

THE RAW DATA:
Airborne geophysical data are generally measurements of one or several of the following:
- Total magnetic field
- Total count radiation (TC)
- Potassium radiation (K)
- Uranium radiation (U)
- Thorium radiation (Th)
- Electromagnetic parameters (QUESTEM, GEOTEM)
- Elevation (DTM)

These measurements are usually gathered from a height above ground level of about 50m using a line spacing of say 200m and sampling along line about every 5m. These data are all recorded digitally together with real time positional information from differentially corrected GPS.

LOCATED DATA:
The raw data and the positional information are processed and merged. The geophysical data are corrected for PARALLAX and HEADING which are due to recording system lag and aircraft magnetic effects respectively. Radiometric data are calibrated and STRIPPED to convert the readings into pure element responses. The theoretical earth's (IGRF) magnetic field may be removed from the magnetic data. The resulting data, now deemed to be free of errors, corrected, calibrated and accurately located are written out as the LOCATED DATA TAPE (LDT). This is usually in the form of one line ASCII records containing various fields such as:
• Flight line
• Fiducial
• Northing
• Easting
• Raw magnetic value
• Corrected magnetic value
• Total count
• Potassium
• Uranium
• Thorium
• Elevation

A typical 10000 line km survey would thus have about 2 million records and create an LDT file of 200 Mb.

GRIDDING:
This is the first step whereby the X,Y,Z data are interpolated onto a regular square mesh using an appropriate pixel size. If the data are in a poorly processed state they may require 'leveling'. Often the contractor will supply the client with both X,Y,Z data and gridded data as Located Data Tapes and Gridded Data Tapes respectively.

The LDT file is subset on the computer to extract:
• Line Number
• Easting
• Northing
• Value (eg Magnetic reading)

This data is essentially in the form of an approximate 200m (line spacing) by 5m (sample interval) grid. The gridding process uses this data to estimate the data value on a regular square grid or mesh. The spacing of this mesh is usually set at about 1/3 to 1/4 of the line spacing (eg 50m x 50m for 200m line spacing).

Gridding is achieved by using one of several means including:
• Bicubic splines
• Akima
• Minimum curvature
• Inverse Distance
The gridded data are then recorded as the GRIDDED DATA TAPE (GDT). This file normally contains a header describing:

- Origin of the grid (E, N)
- Rotation angle of the grid
- Mesh size
- Number of lines (rows)
- Number of pixels (columns)
- Data type

The actual readings follow the header and are often in BINARY format to save space. They can be 1 byte, 2 byte or more commonly 4 byte integers. For the theoretical 10000 km survey on a 50m x 50m mesh this would be 800 000 grid points or 3.2 Mb in 4 byte format.

**STATISTICS AND HISTOGRAMS:**

The gridded data file is scanned by a program to determine the MINIMUM, MAXIMUM and MEAN of the data. Using these numbers another program produces a HISTOGRAM of the data showing its distribution. A CUMULATIVE FREQUENCY table is also generated.

**SCALING:**

In order to produce an image of raw data it is necessary to convert the data from 4 byte numbers to 1 byte numbers (0 to 255). This is because most imaging systems have a display and processing capability of 256 levels of grey or colour.

LINEAR scaling is done by setting the 1% value of the data (from the cumulative frequency plot) to 0 and the 99% value to 255 and proportionally scaling the data in between. The data below 1% and above 99% is clipped and set to 0 and 255 values respectively. Linear scaling can also be done using the minimum and maximum values rather than 1% and 99% but this usually gives an image with little information other than the very high and very low anomalies.

NON-LINEAR scaling usually uses the cumulative frequency histogram to scale the data so that the data range containing the bulk of the data is expanded over a wide 1 byte range and the upper and lower (less common) values are compressed into a smaller 1 byte range. This is also known as HISTOGRAM EQUALISATION and has the effect of extracting more detail in lower amplitude background areas. The resulting 1 byte files are SINGLE CHANNEL (BAND) files that can be displayed.

**PSEUDOCOLOURING:**

A displayed single channel image is in GREyscale initially. By using a LOOKUP TABLE (LUT) it can be coloured according to any colour scheme stored as a LUT file on the computer. A LUT is simply a list of 255 rows of 4 columns containing:

- Greyscale
- Blue
- Green
• Red

The grey scale value is read and the blue, green and red colour guns are set to the corresponding values in the table to create the desired colour. The most commonly used LUT is the rainbow spectrum with purple/blue values being low and red/white values being high.

MULTI-CHANNEL IMAGES:

Imaging systems can usually display the three primary colours, blue, green and red (BGR) as separate channels. This means that say uranium could be displayed in blue, thorium in green and potassium in red. This gives a multicoloured image with the different colour hues representing element ratios and the colour intensities the concentrations. This can be extended to displaying various combinations of magnetic, radiometric and other data types.

ENHancements (FILTERING):

The raw gridded data is processed in many different ways to produce a wide variety of enhancements, each of which is stored as new grid files. These enhancements commonly include:

• Four greyscale directional gradients (horizontal derivatives)
• First and second vertical derivatives
• Automatic Gain enhancements on the above
• Pseudocoloured magnetic intensity - linear and non-linear scaling
• Coloured magnetic intensity shadowed with any of the first three enhancements
• Combinations of gradients

Radiometric and elevation data if available can be treated in the same manner.

The 1 byte image files or the 4 byte grid files can be mathematically processed to produce ENHANCED or FILTERED files. In geophysical work it is preferable to process the 4 byte files to maintain precision. This of course means that the resulting intermediate files go through the STATISTICS, HISTOGRAM and SCALING steps. Filtering is done in either the SPATIAL or FREQUENCY domains:-

SPATIAL DOMAIN FILTERING:

Spatial filtering generally involves the convolution (multiplication) of the data grid (an R x C array where R = number of rows and C = number of columns) by a filter array (operator) (usually 3 x 3). A simple horizontal gradient filter would look like:

```
1 1 1
-1 0 1
1 1 1
```

This would create an image with an apparent illumination from the west. More complicated algorithms can be used to produce filter arrays that will simulate illumination from any elevation and azimuth. Other filters can be designed and applied to generate vertical derivatives, edge enhancements, etc.
FREQUENCY DOMAIN FILTERING:
This is usually done by SGC on 2 byte grid files using two dimensional fourier transform software. It allows the computation of first and second derivatives, reduction to the pole, upward and downward continuation and spectral filtering (commonly referred to as depth slicing by some contractors).

- The first vertical derivative is theoretically the rate of change of the magnetic field with increasing height. In practice it has two desirable effects. Firstly it tends to sharpen and separate magnetic anomalies. Secondly it makes the mean background level of the data equal to zero.
- The second vertical derivative is the rate of change of the rate of change of the magnetic field with increasing height. It sharpens and separates anomalies even further and is also symmetric about zero. SGC tends to use spatial filtering to obtain this parameter.
- Reduction to the pole is the correcting of the magnetic field for the inclination of the earth's magnetising field in the survey area. It theoretically removes dipolar lows and places the positive highs directly over the magnetic bodies. In practice it can result in artefacts, particularly if remanence is present.
- Upward or downward continuation is the calculation of what the magnetic field would look like if measured at a height different to that actually used. Upward continuation is relatively straightforward and results in a smoother data set with less detail. Downward continuation is more complicated and initially sharpens up anomalies. It can, however, rapidly break down and give numerous artefacts.
- Spectral filtering is the practice of separating out the data into different spectral populations. This can be done by calculating the spectral profile of the data, measuring the various breaks in the profile, and then calculating the specific populations. These populations are clustered around different wavelengths of anomalies and are related to depth. If say three populations of spectral wavelengths can be separated, they can be crudely equated to three depth slices.

AUTOMATIC GAIN CONTROL:
Automatic gain control (AGC) is a process whereby anomalies or features in an image are all reduced to similar amplitudes. This is very useful for extracting fine detail from images that are otherwise dominated by one or two high amplitude features. There are several steps to the procedure which is done in the space domain.

Firstly a WINDOW size is selected appropriate to the data (it is often 11 to 19 cells (pixels) across). This square window is moved over the gridded data one pixel at a time. All of the pixel values within the window are squared, added together and then averaged. The square root of this average gives the mean absolute amplitude of the data within the window. The inverse of this value becomes the amplification factor which is multiplied by the central pixel in the window to give a new pixel value in the output file. The effect is to amplify pixels in low relief areas and depress pixels in high relief areas.
One common artefact of AGC is the creation of an artificially quiet area adjacent to formerly high amplitude features. This boundary of this zone can look like a contact. The width of the zone is related to the window size.

**SHADOWED IMAGES:**
A common operation is to 'shadow' a pseudocoloured ELEVATION channel with a shading channel. Typically this is the pseudocoloured magnetic intensity shadowed or illuminated with a horizontal gradient or illumination (eg North gradient). This creates the 'sun angle illuminated' coloured images that are in common use.

The operation is very simple. The elevation data channel (typically magnetic intensity) is firstly pseudocoloured but then the resulting three colour (blue, red, green) pixel values are combined with the shading band value one at a time. The simplest operation is to add 50% of the colour pixel value to 50% of the shading pixel value to give the output pixel value. These percentages can be varied depending on whether the shadowing or the colouring should be dominant. The output is a three band (BGR) file.

Many combinations are possible. The elevation data can be magnetic intensity (linear or non-linear scaling), digital terrain, total count, etc. The shadowing channel can be a magnetic gradient, a vertical derivative, with AGC or without, etc.

The method can also be applied to existing three band images such as a K, U, Th combination. In this case shadowing with say a magnetic derivative or gradient can be useful in relating the magnetics to the radiometrics. The colour information of the multispectral data is retained.

Another technique is to shadow magnetic data with a Landsat Band or scanned aerial photography to give positional information in the image. Alternatively three Landsat bands can be shadowed with a magnetic gradient or derivative to give a colour Landsat image with magnetic trends.

**REAL TIME IMAGING:**
The RTICAD software used by SGC allows the various enhancements to be viewed and manipulated interactively using a 'sun illumination' that can be moved in real time - this is very useful during interactive interpretation.

**IMAGE SLIDES:**
SGC routinely record all enhancements in full resolution as fully annotated 35mm slides taken directly of the screen. These suffer from some minor distortion and are not ideal to make later maps from but have the advantage of being low cost and offering the client every enhancement available for his data. It is useful to project these slides onto a wall or through a projection table during interpretation.

**PHOTOGRAPHIC HARD COPY:**
This involves the production of an undistorted transparency (usually 10 x 8) using a bureau to convert the digital data directly to an image. Several enhancements can be combined on one
transparency to save costs if resolution is not compromised. The resulting transparency is used to produce large accurately scale photographic prints using commercial laboratories. SGC can annotate these images with AMG grid lines, scale bar and title block but the numbering of the grid lines has to be done manually later.

**A0 INK JET PRINTS:**
This is now the most commonly used method of making large prints. The quality is slightly lower than photographic prints but costs are lower, particularly for large maps. This output is from RTICAD at SGC and allows full annotation, contour overlays, vector overlays and many other features. Multiple copies are considerably cheaper than photographic prints.

**ELECTROSTATIC PRINTS:**
SGC uses this method through BHP Engineering to produce very large maps at moderate cost. It is the only method that allows stable images on double clear film. Reasonable annotation, AMG grid lines, numbering, etc are provided. The quality is slightly lower than the Ink Jet plots.