BIF Hill Geophysical Interpretation

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Summary

- A ground gravity and aeromagnetic data interpretation was conducted over the gravity anomaly at BIF Hill.

- The gravity modelling suggests that two bodies at depths of 110m and 200m (similar to other Tennant Creek Ironstone bodies) are the source of the two detected anomalies. The largest anomaly (line 392920) occurs directly south of the smaller anomaly (line 392800). The sources appear to be vertical.

- A single magnetic ‘bulls eye’ anomaly is slightly offset from the southern gravity anomaly by 50 m to the NNW. When looking at the aeromagnetics on a regional scale the anomaly appears to be structurally controlled by a fault.

- Four angled drill holes are recommended to test the source of the two anomalies, which are of similar magnitude to the gravity response over other mineralised Tennant Creek Ironstone deposits in the area. This will enable quantitative interpretation of the gravity, magnetic and stratigraphic data.

Introduction

BIF Hill is located on EL24471 on the Bonney Well 250K mapsheet which was granted in August 2005. It is located approximately 40 kilometres south of Tennant Creek in the central part of the Northern Territory, and was secured to explore for prospective gold and copper mineralisation associated with ironstones similar to that found in the Tennant Creek goldfield. Access to, and within, the area is by the sealed Stuart Highway south from Tennant Creek, and then by unssealed station tracks leading west from the Stuart Highway. The Alice Springs to Darwin Railway also crosses the area. The area is located on the western margin of the Tennant Creek Inlier in an area of poor outcrop. The tenement forms part of the Rover joint venture between TNG Ltd and Western Desert Resources Ltd (WDR) in which WDR is the operator. Refer Figure 1.
Vertical tabular bodies of varying width, depth, depth extent and density have been modelled to create a calculated gravity field that replicates the observed data. The density range present in the modelled bodies assumed to be tenant creek ironstone is 3-4g/cc with the sedimentary/surrounding bodies at densities of 2.13-2.98g/cc. The gravity data was compared to aeromagnetic images of the area.

Data
The data used for interpretation are Normandy’s 1997 aeromagnetic data collected and processed by World Geosciences Corporation and GPS location data and gravity from a ground based survey carried out by Daishsat Surveys for WDR in 2011. See Figure 2 for data location.
Figure 2b: Location of the 1997 Billiat aeromagnetic survey over the BIF Hill area.
Geology
The area is located on the western margin of the Tennant Creek Inlier (Donnellan et al 1999). The central part of the Inlier is comprised of the Tennant Creek Province of Palaeoproterozoic age. Due to a thick cover of younger sediments over most of the tenement area, the local geology is interpreted from rare outcrop, limited drill testing and geophysical surveys (airborne magnetic).

The Tennant Creek Goldfield is characterised by gold, bismuth and copper deposits within shear or fracture zones hosted by quartz - magnetite - hematite 'ironstones' of low temperature hydrothermal origin. Below the base of oxidation the magnetite-rich ironstones generate discrete dipolar "bullseye" anomalies which have been the main exploration focus since the early 1950's.

Further to the north of EL 24471 the Tennant Creek Block is an elevated area of Early Proterozoic basement surrounded by Cambro-Ordovician to Devonian sediments. It is estimated that Warramunga Group Sediments extensively intruded by porphyry dykes underlie about 70% of the licence area. The remainder is underlain by large granite. In the western and southern parts of the tenement Warramunga Group rocks with intrusive porphyries are overlain by Palaeozoic Wiso Basin sandstones. The thickness of Wiso Basin sandstone cover increases to about 60 metres on the western margin of EL24471. However, surface exposure of the inferred underlying geology is rare to generally absent being almost entirely concealed below Cenozoic, alluvium, colluvium and aeolian cover. Normandy concluded, to the south of 7774000 N a significant thickness >50 metres of Wiso Basin Cambrian sediments overlie Proterozoic basement.

TNG has targeted the Bonney Well map sheet (namely EL 24471) because;

- The Warramunga Group Sequence is identical to Tennant Creek exposures except greywackes are less common.
- The presence of quartz - feldspar porphyry dykes and sills comagmatic with those in the Tennant Creek area.
- Porphyry/Warramunga Group contacts are usually shear zones which are orientated east-west to northwest-southeast and sometimes exhibit Tennant Creek-style hydrothermal alteration.
- Field mapping by Davidson (1983) within the area of EL 24471 showed outcrop is reasonable wherever minor relief occurs and 'really good' on the minor scarps which occasionally edge broader plateaus of intensely lateritised Hatches Creek Group quartzites.

Davidson commented that up to 1500 metres of vertical sequence is exposed comprising felsic volcanics, pyroclastics, tuffaceous limestones, ferruginous cherts, volcanic sandstones, siltstones and banded iron formations. The above sequence is tightly folded about 8 moderately plunging southwest axes. A second folding episode is apparent within the overlying Hatches Creek Group sandstones plunging shallowly to the southeast.
The occurrence of mineralised, stratiform, banded iron formation (BIF) intersected in drillcore at Explorer 142 and Rover 1 some 20km northwest of BIF Hill prospect located in the southwest quadrant of EL24471 further enhances the area’s prospectivity.

Fox, 1993 commented the area exhibits similar oxidation depths to Tennant Creek and will therefore show similar ore elemental leaching characteristics. He concluded 'there is excellent potential for discovery of a Rover 1 gold-bismuth-copper deposit within the northern Bonney Well map sheet area "Mainly because there is sufficient evidence to show that the banded iron-rich rocks within the area of EL24471 owe much if not all of their petrogenesis to the sustained high volume passing of hydrothermal fluids." See Figure 3 for 250k mapsheets.
Figure 3 - Local Geology (NTGS 250k geological sheets). The purple square denotes BIF Hill area
PREVIOUS EXPLORATION

BIF Hill has been known in previous exploration (from 1971-75 by Australian Development Ltd (ADL)) as GW502 and GW504. GW502 and GW504 were adjacent comprising one prospect located by ground reconnaissance traverses. A permanent baseline was surveyed and the area gridded (61 m x 91.4m).

Ground magnetometry over the above grid defined GW502 as a discrete 600 gamma anomaly however the GMAG data is "noisy" due to the presence of near surface banded iron and jaspilite beds. The interpreted source of the above anomaly is postulated to be a wide, tabular body of low magnetic susceptibility.

Geological mapping at 1:2400 scale was completed over the GW502 anomaly/BIF Hill prospect (Figure 4) defining a series of banded iron and jaspilite beds forming a tightly folded, northeast-trending (through the interpreted source of the anomaly) synclinal structure. The banded iron beds comprise alternating red jasper bands i.e. iron-rich microcrystalline silica and grey to black martite-rich bands. Cropping out on the southwest flank of BIF Hill is a sequence of lateritised volcanics comprising porphyritic crystal tuffs of rhyolitic composition which appear to be faulted against the banded iron beds. The above faulted contact is coincident with a major geochemical anomaly (size of the anomaly is not noted in past reports) deemed to constitute a prospective drill target at depth which was subsequently tested by DDH 426, collared in April 1973 and drilled to 112.76m. The faulted contact was intersected at 64.6 metres after the drill hole passed through a sequence of steeply north dipping banded iron beds interbedded with sand, silt and mudstones.
Figure 4 – Historical Mapping: Shell 1984 BIF Hill Geology and Drill hole locations (in red box)
Below the unmineralised fault porphyritic crystal tuffs with disseminated magnetite were intersected thus explaining the small magnetic peak contour closure. The vertical, surface hammer drill hole 95 was designed to test the geochemical anomaly located within the axial plane region of the synclinally-folded banded iron sequence. Excess water at 73.15m prevented the hole from reaching its planned depth of 91.4m intersecting banded iron beds, oxidised shales and siltstones. Anomalous gold values were recorded from 9.1m - 15.2m averaging 0.31 grams/tonne, gold and also from 61m - 64m and 70m - 73m where both intervals averaged 0.46 grams/tonne gold. DDH 428, To 128 metres was collared about 90 metres north of DDH 426 and drilled on the same azimuth to test the above synclinal axial plane area at depth intersecting interbedded banded irons, jaspers, mud, silt and sandstones. Interestingly the precollar from 3m to 18m downhole depth averaged 1.03 grams/tonne, gold (including a 3 metre interval averaging 2.02 grams/tonne, gold). A 1.2 metre core interval from 64.6m to 65.8m averaged 2.7 grams/tonne gold. Senior ADL Geologist G Granger (1973) concluded:

- In both section and plan anomalous gold values are restricted to certain beds indicating the primary source of gold is syngenetic deposition of transported gold mineralisation from "within the original sediments."
- The major surface sampling geochemical anomaly is aligned along the main synclinal axis
- "mineralisation is due to primary deposition of detrital and chemically precipitated minerals with the sediments."

In May 2000, Normandy relocated 2 ADL and 1 Shell drill holes in the BIF Hill area:

<table>
<thead>
<tr>
<th>Drill hole</th>
<th>Easting (AMG53 AGD66)</th>
<th>Northing (AMG53 AGD66)</th>
<th>Easting (MGA zone 53 GDA94)</th>
<th>Northing (MGA zone 53 GDA94)</th>
<th>Dip</th>
<th>Azimuth</th>
</tr>
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<td>392784</td>
<td>7775559</td>
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</tbody>
</table>

Although basemetal values are uniformly low, gold values in surface BIFs and hematised vitric crystal tuff show a high background of 0.1 - 0.2 grams/tonne gold. Note: of the 32 rock chip samples assayed from BIF Hill every sample has an elevated gold value, ranging from 50 to 250 ppb.

The BIF Hill prospect comprising a 50m sequence of BIFs and sediments fold thickened in a southwest plunging syncline was also examined for its low grade gold potential in view of sporadic elevated values intersected by previous ADL drilling where certain BIF and magnetite-bearing horizons are preferentially enriched up to 1.5 grams/tonne gold.
MAGNETIC INTERPRETATION

Equipment
The Billiat aeromagnetic survey instrument used was a Scintrex VIW2321/CS2 Split Beam Cesium Vapour sensor (sensor height of approximately 40m above ground level) and pre-amp with a Picodas magnetometer. The magnetometer has a resolution of 0.001nT.

Acquisition Parameters
The magnetometer sample interval was 0.1 seconds (approx 6.0 m). The survey was flown on NS lines with a 75m separation and a 40m terrain clearance. The survey co-ordinates are based on the AMG Grid Zone 53, AGD84. Please note that the data shown in this document has been converted to GDA94 MGA53.

Data Processing/Gridding
The data was supplied as grids in ERMapper format, and as vector data in ASEG-GDF format. The vector data (Total Magnetic Intensity – TMI) was input to Model Vision 9.0 as lines. Channels of digital elevation model (DEM) were produced from the 2010 Daishsat gravity survey data and sensor height above ground level (Sensor_Z) was also created. The survey was cut to the modelling area and gridded. The data was then sampled along the gravity lines to produce the profiles in the cross sections.

Final Magnetic Data (Interpretation)
The grid used in interpretation was a TMI grid as shown in Figure 5. Bif Hill has one, asymmetric bullseye anomaly, a NNE trending feature, 50m NNW from the peak of the southern gravity anomaly. The maximum amplitude is around 346.4 nT, above the background magnetic signature of the surrounding sedimentary basin. The northern gravity anomaly sits on the edge of the magnetic anomaly gradient. The ADL and Shell holes were plotted on the image and were found to have missed the peak of the magnetic anomaly by almost 170m. They were all drilled too shallowly to have hit the source even if they were drilled at the peak. On a more regional scale it appears the magnetic anomaly presses up against a structure to the south, possibly a fault (Figure 6).
WDR BIF Hill Prospect - 1997 Billiat aeromagnetic survey

Figure 5: BIF Hill aero magnetics. The image on the left is the magnetic grid overlaid with magnetic contour lines. The image to the right is the magnetic grid overlaid with magnetic contour lines (black) and gravity survey contour lines (light blue). The green drillholes on the left are the historic drill holes (x3), the blue drillholes on the right are the proposed drillholes (x4)
Figure 6 - Regional Magnetics (1997 Billiat Aeromagnetic survey). The broken black line indicates the potential fault.
GRAVITY INTERPRETATION

Equipment
The gravity survey was conducted by Daishsat and used a Scintrex CG-5 Gravity metre and Leica system 1230GG geodetic grade GPS receivers collecting GPS and GLONASS (Global Navigation Satellite System) positional information.

Acquisition Parameters
The gravity observations were made simultaneously with GPS observation (two at each station) in the BIF Hill area. The observations consisted of a 20-sec or greater stacking time. The data was acquired on a grid of nine N-S lines spaced 120m apart with observations at 120 metre intervals on all lines.

Data Processing/Gridding
Data was downloaded and corrected for diurnal variations based on base station data. Tidal, free air, Bouguer and other standard corrections were applied to the gravity data. The data was supplied by the contractor as grids in ERMapper format, and as point data. The data was formatted for input to Model Vision 9.0 as lines. Grids created in ModelVision 9.0 have a minimum cell size of 30m which is 1/4 of the line spacing.

Note that if certain gravity corrections are not properly applied or the assumption of density is incorrect this will create final data with an artefact reflecting topographic variation. Note that there was no downhole logging in any of the three holes in the area. As such, the density for the Bouguer correction (of which several standard corrections were made) has been analysed using Nettleton’s method. While Nettleton’s method proved inconclusive, the drilling data provided an average density of the host unit of around 2.8g/cc hence the 2.67g/cc Bouguer anomaly values were used.

Final Gravity data
The BIF Hill Bouguer gravity consists of 2 NNE trending maxima approximately 370m apart (Figure 7). The anomaly is largely unrelated to the topography in this area indicating correct processing of the gravity data. The southernmost anomaly is the greater of the two and when plotting the Normandy holes it was found that this anomaly was missed by almost 175m. The strong southern gravity maxima is possibly due to the anomalies relationship to the interpreted structure, considered to be a fault as seen in the magnetics.

The maximum amplitude of the southern anomaly is 0.7 mgal and the amplitude for the northern anomaly is 0.5 mgal relative to background gravity values.
Figure 7: BIF Hill gravity grid. The image on the left is the gravity grid overlaid with gravity contour lines. The image to the right is the gravity grid overlaid with gravity contour lines (black) and magnetic contour lines (Purple). The red drillholes on the left are the historic drill holes (x3), the blue drillholes on the right are the proposed drillholes (x4).
Modelling
Initial gravity modelling was based on body specifications given by specialist Bill Laing for a typical Tennant Creek orebody. A typical Tennant Creek orebody is represented by a vertical, rectangular pipe with the following specifications: dimensions = 100m x 100m x 500m, density = 4.36 (60% magnetite/hematite at 5.0g/cc + 40% altered shales at 3.4g/cc), background metasediment density = 2.8 g/cc and average depth to the top of the body is 200m. The anomalies were modelled using vertical non-overlapping bodies and were labelled A-H (From S to N) for each line. The bodies were each vertical, oriented with their strike NS, with a depth extent of 500m. The background host rock density was set at 2.8g/cc. Based on this an inversion was run allowing the density and thickness (NS) to vary to achieve a best fit to observed data solution. The solution was then assessed for geological feasibility. Bodies were then altered and added to satisfy observed data with a focus on potential geological density sources and a further inversion run allowing the parameters of density, thickness (SW-NE), E-W position, and depth to vary. Bodies were once again manually altered for geological feasibility and fit. Densities were chosen based loosely on the physical properties given by Bill Laing.

Figure 8a shows the plan view of the bodies used to model the ground gravity data lines. Figure 8b shows a 3D perspective of the model. Figures from 8c-8k show the overall results of the modelling in individual cross-sections. The plan view, 3D perspective and cross sections show the modelled bodies with colouring based on density values (note that all ‘D=’ values are in g/cc).
WDR BIF Hill Prospect - 2011 Ground Gravity Modelling Session Results

Figure 8a: Shows the overall results of modelling with the Bouguer gravity anomaly basemap below the modelled gravity bodies on the left and the TMI magnetic anomaly base map below the modelled gravity bodies on the right. The bodies are coloured according to their density. Please see cross sections for values. Black circles indicate the two target bodies. All co-ordinates are in GDA94 MGA zone 53. The above is a plan view of the bodies.
**WDR: BIF Hill Prospect - 2011 Ground Gravity Modelling Session Results**

Figure 8b: Shows overall results of modelling with the model 3D prospective. The bodies are coloured according to density (red = 4g/cc). The two targets are circled. The insert shows the Gravity survey lines shown over the model.
Cross Section Line 392320

Figure 8c - Gravity modelling cross section, note bodies are coloured according to density
Cross Section Line 392440

Figure 8d - Gravity modelling cross section, note bodies are coloured according to density
Cross Section Line 392560

Figure 8e - Gravity modelling cross section, note bodies are coloured according to density.
Cross Section Line 392680

Figure 8f - Gravity modelling cross section, note bodies are coloured according to density
Cross Section Line 392800

Figure 8g - Gravity modelling cross section, note bodies are coloured according to density
Cross Section Line 392920

Figure 8h - Gravity modelling cross section, note bodies are coloured according to density
Cross Section Line 393040

Figure 8i - Gravity modelling cross section, note bodies are coloured according to density
Cross Section Line 393160

Figure 8j - Gravity modelling cross section, note bodies are coloured according to density
Cross Section Line 393280

Figure 8k - Gravity modelling cross section, note bodies are coloured according to density
The modelling fitted the shape of the observed data profiles using a number of source bodies. While the modelling has aimed to take all source bodies into account it must be noted that the resultant models exhibit a bulk property and that in physical reality may be a composition of smaller layers with varying physical properties.

The bodies have been restricted to a maximum depth extent of 500m however this clearly will vary over the anomaly in actuality. Both gravity anomalies are modelled by bodies with a density of 4 g/cc with the southernmost body (Line 392920E) at a depth of 110m and the northernmost body (Line 392800E) at a depth of 200m. In most cases you can see that the magnetic peak for each line is generally coincident with or slightly to the north of the gravity peak for each line.

**Further Work and Recommendations: Proposed Drillholes**

The proposed program is to drill two pairs of scissor holes into the anomalies on line 392920 (As opposed to one pair on 392920 and one on 392800 – so as to obtain a NS cross section of the anomalies). DH001 and DH002 will drill to a depth of 340m and an angle of 60 degrees (one to the north, one to the south) to test the southernmost anomaly. DH003 and DH004 will drill to a depth of 420m and an angle of 60 degrees (one to the north, one to the south) to test the southernmost anomaly. The drill hole collars can be seen in the line 392920 cross section. The drill hole coordinates are in GDA94 MGA zone53:

<table>
<thead>
<tr>
<th>Drill hole</th>
<th>EAST_MGA</th>
<th>NORTH_MGA</th>
<th>RL</th>
<th>Dip</th>
<th>Azimuth</th>
<th>Depth</th>
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<td>327</td>
<td>60</td>
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</tr>
</tbody>
</table>

*Table 1. Coordinates of proposed drillholes.*

Down hole geophysical logging of the drill hole will be undertaken. Information from gamma, density and conductivity logging may assist recognition of any alteration or mineralising processes. It is envisaged that Borehole Wireline would be contracted to perform the logging.

**References**


*Emily Craven*