geophysical solutions

Report

to

KUTh Energy Ltd

on

Qualitative Interpretation of Central Midlands Aeromagnetics and Gravity

Geoforce ref: WE1197KE_1.0_Qual_Mag+Grav

Author: Kate Godber **Reviewer:** James Reid

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1/288 Victoria Road Malaga WA 6090 Australia
Ph 61 8 9209 3070
Fax 61 8 9209 3071
ABN: 89102 329 484
www.geoforce.com.au

Summary

In September 2009 Geoforce Pty Ltd (Geoforce) was commissioned by KUTh Energy Ltd to do a simple structural interpretation of aeromagnetic and gravity data over the central Midlands area. The primary aim of this work was to identify deep seated regional structures, with a subsidiary aim of identifying possible dolerite feeder pipes.

The interpretation was based on the 1999 AGSO Midlands survey aeromagnetic data, the 2008 KUTh Central Midlands survey aeromagnetic data, and located residual gravity data provided by Mineral Resources Tasmania.

The resultant interpretation is divided into three separate layers based on strength and persistence of the interpreted structures. Essentially these divisions reflect the relative crustal penetration of the structures.

1. Weak lineaments: Subtle high frequency magnetic fabrics which have limited strike extent, disappear with low pass filtering and/or upward continuation to >1000m i.e. surface or shallow structures such as small brittle faults and edges of various dolerite sills. Often also apparent in the digital elevation model.
2. Lineaments: Clear, extensive and persistent features in the magnetics (and sometimes gravity) which generally do *not* lessen drastically with filtering and/or upward continuation.
3. Deep crustal lineaments: Very strong, extensive and persistent features that are apparent in the regional gravity, 4000m upward continued magnetics, and possibly also regional digital elevation model.

The structure is dominated by a large, arcuate fracture zone extending from the northwest to the eastern portion of the survey area. This fracture zone is very clear in both the gravity, magnetics and digital elevation model, and may form the southern extension to the Highway Fault. The other major fault sets trend northwest, east-northeast, and north-south.

The magnetic response proved unreliable for discriminating location of feeder zones because of the competing influences of dolerite remanence and susceptibility variations. Despite this, the major broad positive magnetic and gravity anomalies have been flagged as possible dolerite feeder pipes, simply because feeders pose a significant risk to drilling success. To mitigate this risk, we strongly suggest infill gravity, MT and AMT with modelling to delineate the dense and resistive dolerite cores over any selected drill site.

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1 Introduction

In September 2009 Geoforce Pty Ltd (Geoforce) was commissioned by KUTh Energy Ltd to interpret regional potential field data over the central Midlands area (Figure 1.1). The aeromagnetic data are on east-west lines with 200m inter-line spacing, and the regional gravity data on 600m to 7km station spacing.

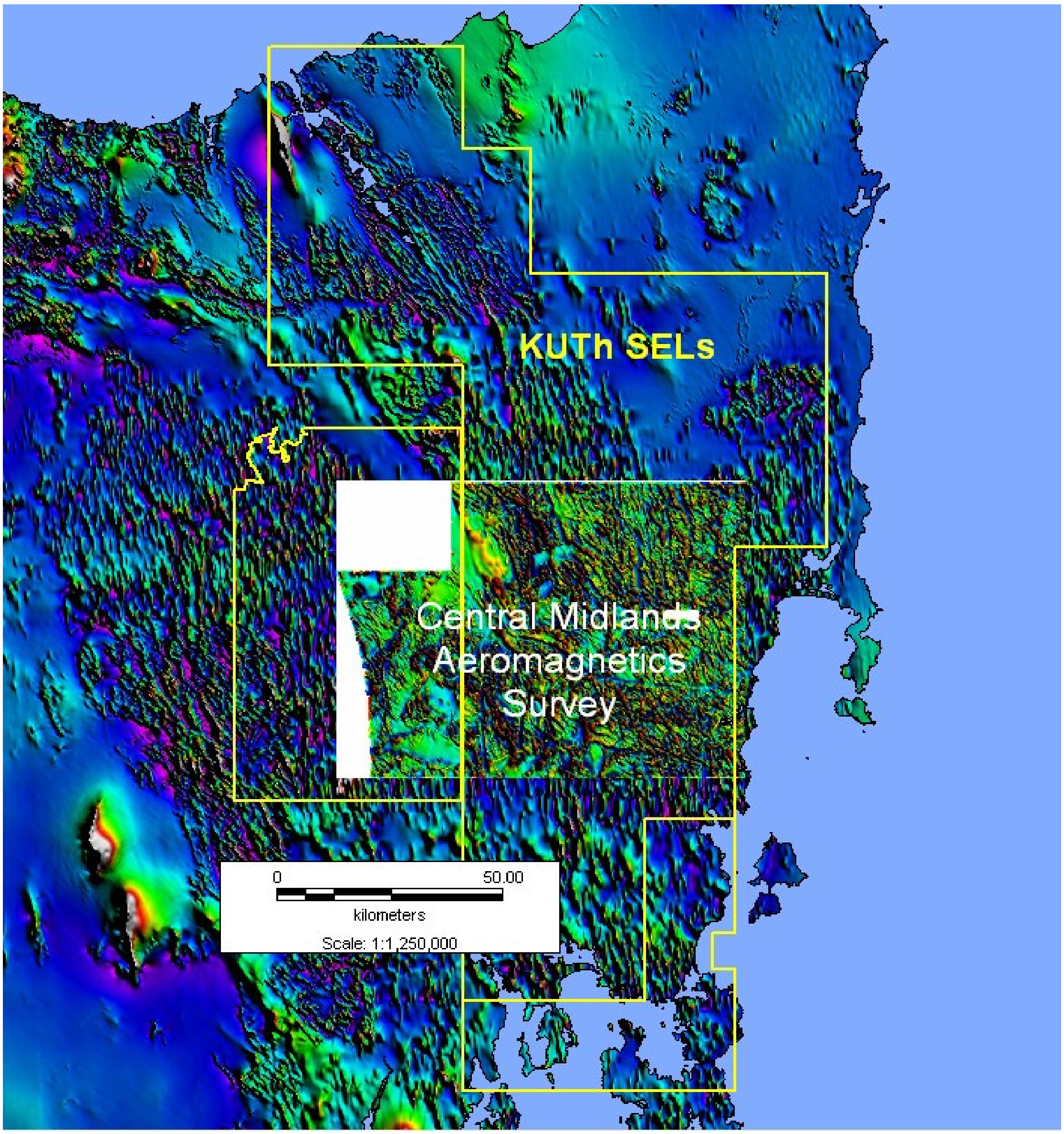

Figure 1 – Central Midlands aeromagnetic data (labelled) overlain on the regional magnetic field.

2 Geology

The basement under the central Midlands is composed of the Ordovician-Devonian Mathinna Beds (sandstone, slate, shale, and quartzite) intruded by Devonian granitoid plutons. The Mathinna Beds are unconformably overlain by the Parmeener Super-Group comprising marine limestone, coal seams, lacustrine sandstones and shales. Much of the Parmeener Super-Group is hidden by a very extensive, thick, faulted sheet of dolerite, which originally intruded the Parmeener Super-Group as a series of massive sills during the Jurassic Period. Jurassic and Tertiary tensional faulting has produced faulted basins in which the Parmeener and Mathinna are exposed through the dolerite.

Magnetics

The Mathinna, Parmeener and basement granitoids within the area of interest are effectively non-magnetic. Therefore, the magnetic response reflects only the structural and compositional variation of the magnetic Jurassic dolerite. The magnetic properties of this rock are extremely variable. Magnetic susceptibility is generally moderate to low, and ranges between 5 to 30 x 10^{-3} SI. The remanent intensity, however, is comparable to the induced field and ranges between 0.08 to 0.6 Am^{-1} (Leaman and Richardson, 1980). The combination and induced and remanent magnetisation causes significant total field anomalies from ±500 nT to ±10 000 nT at surface (Leaman, 2002). The total field anomalies caused by massive dolerite are very distinctive, with high amplitude, high frequency spikes superimposed on the broad positive magnetic response due to the bulk induced magnetisation of the dolerite sill. Dolerite talus is characterised by a low amplitude, high frequency response. Permian and Triassic sediment outcrops are characterised by very low amplitude, featureless response.

Gravity

Gravity is a more reliable tool for delineating basement structures and locating dolerite feeder pipes. This is because the gravity response is by nature a combination of the response from all sources, and does not just reflect dolerite distribution or effective susceptibility. Since the Permian, Triassic or dolerite contrasts yield residual attractions of -8.4, -13.4 and +6.7 $\mu m/s^2$ per 100m respectively (Leaman, 1980), qualitative thickness estimates may be based on the sign and value of the residual Bouguer anomaly. The dolerite density of ~2.83 t/m^3 will cause a weak positive residual Bouguer anomaly if a sufficiently thick accumulation exists (e.g. feeder swarms). However, large negative residual values may imply thick sedimentary sections regardless of dolerite thickness. This is all complicated by the regional large negative values caused by basal granite plutons.

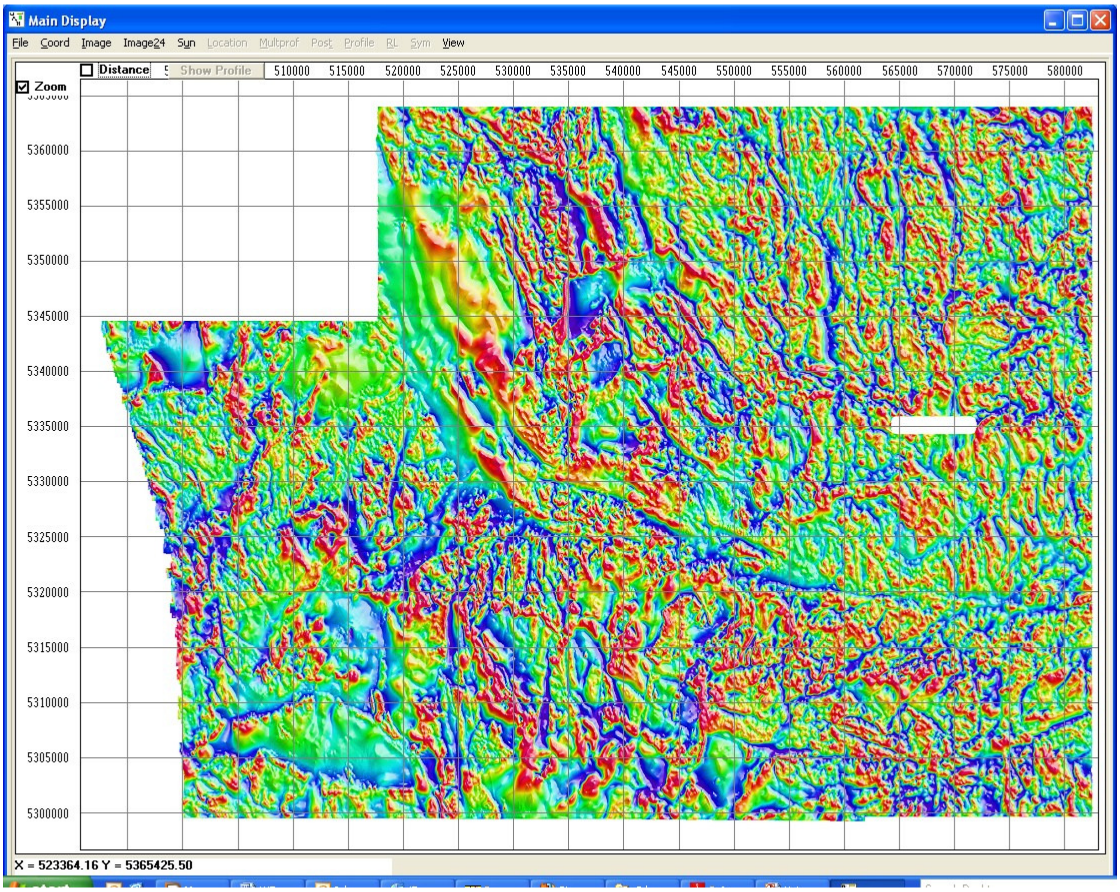

Figure 2 – Combined KUTh and AGSO reduced to pole TMI.

3 Method

Magnetics data and image processing

All magnetic data were reduced to magnetic pole using the ERMapper RTP function. The RTP data were then filtered and imaged with a combination of gradient filters, colour drapes, derivatives and upward continuation. Listed below is a description of the filters used to image the data:

- Northeast and northwest sun angle colour drape - *highlights magnetic texture perpendicular to sun angle*
- First vertical derivative – *highlights gradients allowing better edge detection of near-surface features*
- Second vertical derivative – *emphasizes the sharp peaks and troughs of magnetic response facilitating more accurate trend interpretation.*
- Hanning filter – *highlights near surface gradients allowing better edge detection of near-surface features*
- Upward continuation to 500m, 1000m, 2000, and 4000m – *effectively shows the magnetic field as it would appear if measured at higher flight heights. This filters out the contribution from high frequency (small) sources and emphasizes regional sources.*
- Residual (RTP minus upward continuation to 1000m) – *effectively removes the signal component from deep seated sources, thereby emphasizing moderately shallower sources.*

Gravity data and image processing

The regional gravity data were regridded and presented as pseudocolour and pseudocolour plus northeast sun angle images. All lineament analysis was done using these presentations.

The resultant interpretation was divided into three separate layers based on strength and persistence of the interpreted trends. Essentially these divisions reflect the relative crustal penetration of the structures.

1. Weak lineaments: Subtle high frequency magnetic fabrics which have limited strike extent, disappear with low pass filtering and/or upward continuation to >1000m i.e. surface or shallow structures such as small brittle faults and edges of various dolerite sills. Often apparent also in the digital elevation model.
2. Lineaments: Clear, extensive and persistent features in the magnetics (and sometime gravity) which generally do *not* lessen drastically with filtering and/or upward continuation
3. Deep crustal lineaments: Very strong, extensive and persistent features that are apparent in the regional gravity, 4000m upward continued magnetics, and possibly also regional digital elevation model.

4 Interpretation

The overall magnetic fabric is dominated by a large, arcuate fracture zone extending from the northwest to the eastern side of the survey area. This fracture zone is very clear in the gravity, magnetics and digital elevation model, and may form the southern extension to the Highway Fault. The other major fault sets trend northwest, east-northeast, and north-south. Several of these large structures coincide nicely with deep conductive zones on the KUTh MT lines and clear offsets in the DTM. This indicates very recent activation on these structures (presumed faults), combined with significant crustal penetration.

The majority of small scale features trend north to northwest, and are offset by larger northeast trending structures. There is also a clear north-south trending fabric in the dolerite on the eastern side of the survey area. There is significant fracturing throughout the dolerite.

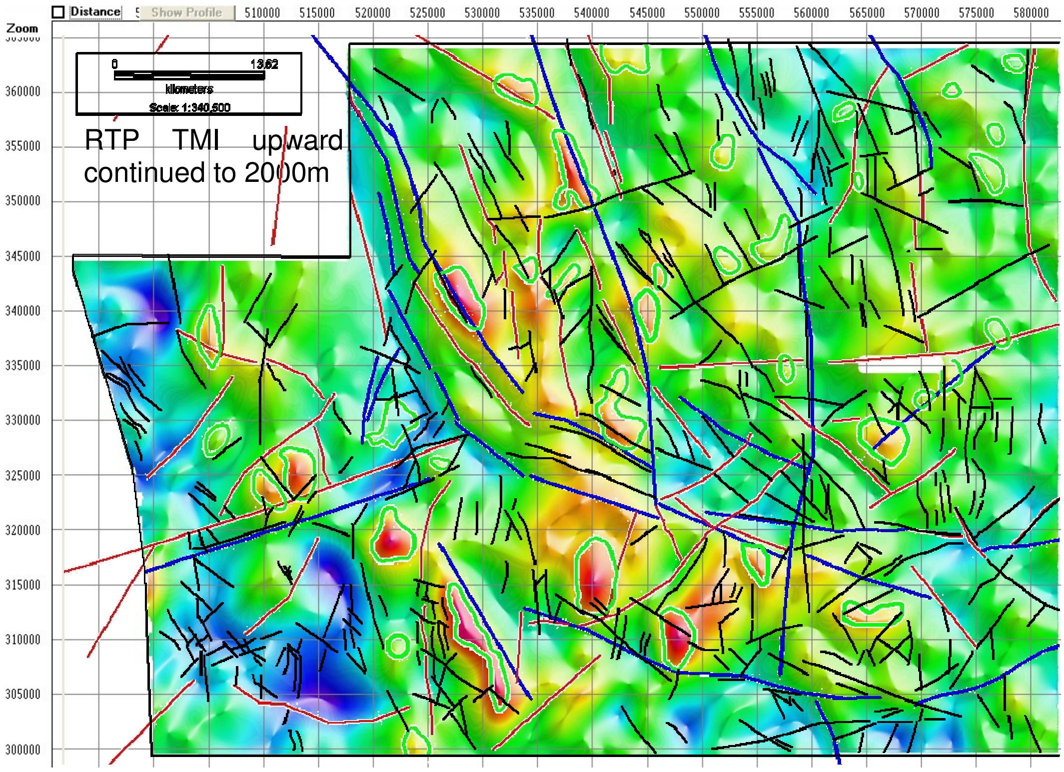

Figure 3 - Reduced to pole magnetic field upward continued to 2000m with interpreted magnetic trends and zones of high magnetic intensity outlined in green. Blue = strong structures, red = moderate, black = weak

Dolerite feeders pose a significant risk to any deep drilling project in this area. Leaman and Richardson (1980) suggested that up to 15% of the basement may be composed of dolerite feeders. Magnetics was postulated as a tool to locate the dolerite feeder pipes. Unfortunately, the magnetic response is unreliable for discriminating location of feeder zones because of the complicated interactions of dolerite remanence and susceptibility. In many areas, remanence is actually a larger component than induced magnetisation. Consequently the total field is often not directly related to source thickness. Nevertheless, several broad large amplitude response persist even with upward continuation to >4km. These are outlined as areas of possibly thicker dolerite, despite the uncertain provenance. To mitigate the risk of drilling into a dolerite feeder, we strongly suggest infill gravity, magnetotellurics and audio-magnetotellurics with modelling to delineate the dense and resistive dolerite cores over any selected drill site.

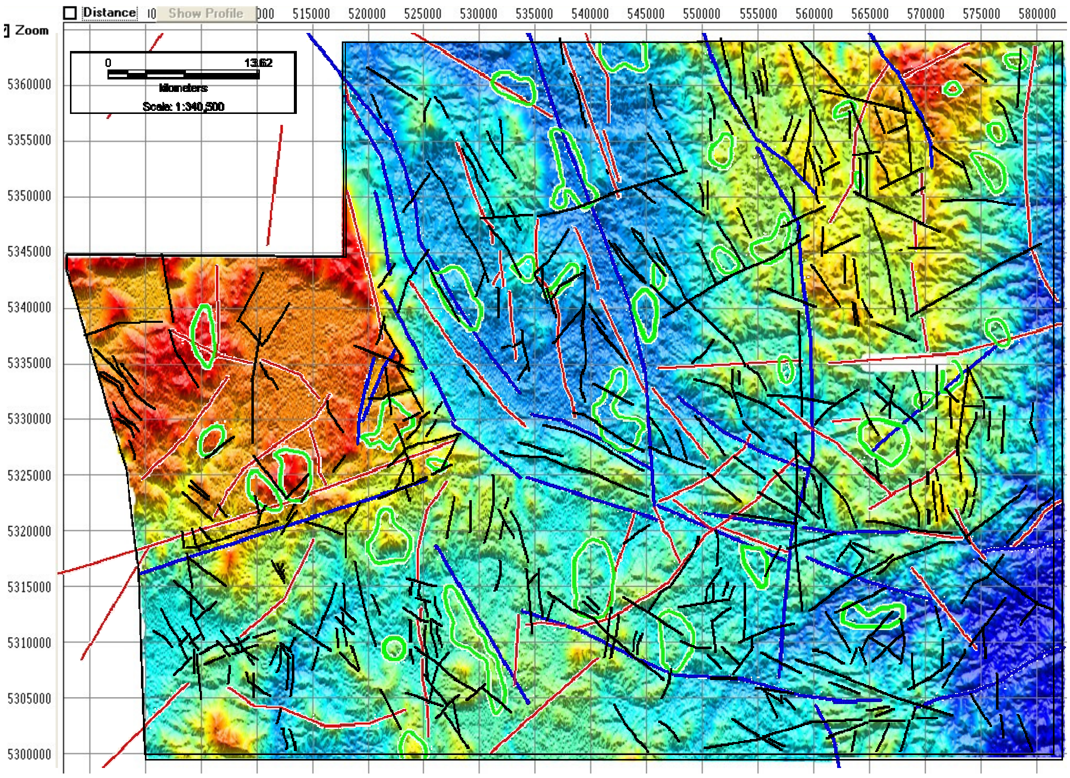

Figure 4 – Digital terrain model showing recent activation of some of the structures visible in the TMI and gravity grids.

5 Conclusions

Tenement-scale qualitative interpretation of regional potential fields data was incorporated into the exploration program for the central Midlands. The resultant structural maps help confirm the nature and trend of deep structural features visible in the regional magneto-telluric (MT) and seismic data. This information is vital for planning the next stage of exploration, and nearly impossible to get through surface geological methods alone.

6 Recommendations

To date, KUTh exploration has been largely tenement scale. This means that the detail required for prospect scale exploration is lacking. For example, structures that are insignificant on a regional scale can suddenly become very important when drilling commences. This includes features such as brittle faults and dolerite feeders. Given that KUTh is now at the point of selecting drilling targets such as the Lemont high heat flow area, geophysics provides vital risk mitigation before expensive drilling. This should include, but not be limited to:

1. ***To locate best developed conductivity anomaly off-line from existing anomalies:*** 2 orthogonal 15km long MT + AMT(?) lines (30 stations total) directly over the target prospect .
2. ***To maximise drill stability and penetration rate by avoiding surface faults, dolerite feeders and estimating dolerite thickness:*** Gravity and

magnetic modelling of 2 to 4 sections (each 3-8km long) directly over the target prospect. Depending on the prospect, this may require infill gravity surveying to 500m or 1km stations.

3. ***To monitor local ground stability and locate active fault systems:*** Passive seismic monitoring network.

7 References

Leaman, D., 2002, *The effective magnetisation of the Jurassic Dolerites of Tasmania*, Exploration Geophysics, **33**, 166-171

Leaman, D. and Richardson, R.G., 1980. *Magnetic Surveys of the Fingal Tier Region,* UR1980_46, report to Mineral Resources Tasmania.

Disclaimer

The interpretations contained in this report are based on the training and experience of the author and information passed on during the course of the investigation. As with all geophysical data, multiple interpretations are possible. The client is advised to consider information from all available sources prior to making a decision on how to proceed.

Kate Godber

Geophysicist