Geophysical characterisation of the Trident gold deposit, Western Australia

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SUMMARY

The Trident gold deposit is contained in the Plutonic Well Greenstone Belt, about 900 km northeast of Perth, Western Australia. The deposit is hosted in a highly sheared ultramfic unit overthrusted by granite.

This project examined the physical properties of the important rock units to determine whether they contrast sufficiently to allow mapping of mineralisation, geology and structure. It investigated the possible occurrence at Trident of the most important mineralised lithological unit in the district, the ‘mine mafic’. The project also investigated the nature of the thrusted contact between granites and greenstones, one of the most important structures in the district.

Drill core samples representing the major lithologies at Trident underwent a range of petrophysical testing. Gravity profiles were collected over the deposit and these were analysed along with high resolution airborne magnetic and radiometric data. The magnetic and radiometric data were assessed qualitatively with comparisons to maps of geology, regolith and known mineralisation. Gravity and magnetic data were computer modelled using drilling information and petrophysical data.

The host ultramafic unit was readily mapped and modelled to depth using magnetic data. Mineralisation itself was expressed as a relative low within the magnetic ultramafic unit. The down dip extension of the mineralised ultramafic presents a good drill target. The gravity profiles are not long enough to allow accurate interpretation, but modeling shows that it is unlikely that the mine mafic is present at Trident. Radiometric data mapped broad geology and regolith trends but did not show an anomaly related to mineralisation. The results from IP and resistivity tests on core samples indicated that these techniques were not well suited for targeting this style of mineralisation.

Key words: Trident, petrophysics, magnetic, radiometric, gravity.

INTRODUCTION

The Trident gold deposit is located 180 km northeast of Meekatharra and 900 km northeast of Perth, Western Australia (Figure 1). Within 20 km of Trident are the worked out Keilor 1 and 2, Salmon and Triple P gold deposits and the still producing Plutonic gold mine. Since 1990, over 2 5000 000 oz of gold have been produced from these deposits. The Trident deposit was discovered in 1996 by Resolute Mining Limited. The deposit had no surface geochemical expression and was drilled because of its along strike location from known mineralisation. An attempt to mine the deposit in 1998 failed due to engineering complications and it remains unexploited. Barrick Gold of Australia now controls the deposit.

The reason for research into the Trident deposit is because little is known about the geophysical character of the deposit. This project therefore aims at characterising the geophysical response of the Trident deposit and provide exploration guides for the area.

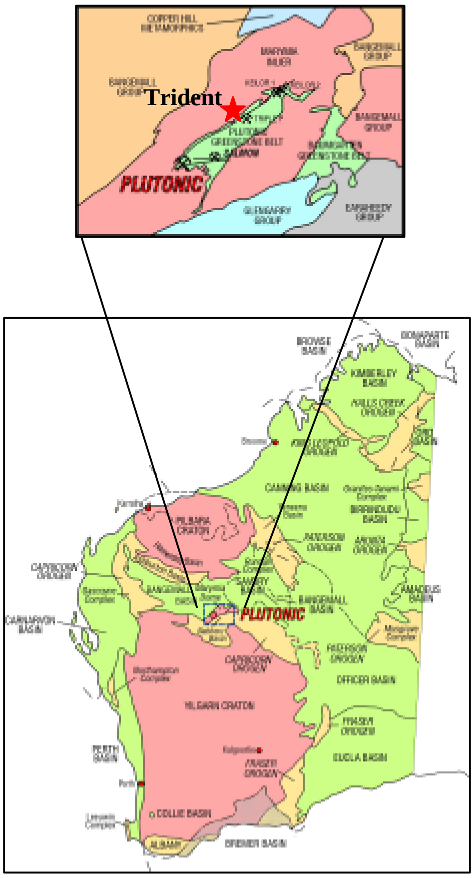

Figure 1. The Trident gold deposit is located on the central north flank of the Plutonic Well Greenstone Belt in central Western Australia.

Gold deposits pose a particular problem to the exploration geophysicist. While gold itself is very dense (19.4 g/cm^3) and conductive (5 x 10^{-7} S/m) it makes up such a low proportion of ore material (as little as 1 ppm in some cases) that it does not significantly alter the overall petrophysical characteristic of that rock. This makes the direct detection of gold mineralisation by geophysics impossible. The only exception to this is the use of electromagnetic detectors for near surface gold nuggets. Instead, the geophysicist must look for associations between gold and other minerals that do alter the petrophysical characteristics of the rock or find areas that are structurally favourable for gold mineralisation.

The aims of the project were addressed by utilising previously acquired datasets including airborne magnetic and radiometric data along with geological mapping and core logging. Added to this were petrophysical data collected on drill core samples taken from the Trident deposit and gravity surveying over the deposit. These data were analysed through computer image processing and modelling. Detailed analysis of these results was made to provide solutions to the major aims of the project.

GEOLOGY

The Plutonic Well Greenstone Belt (PWGB) is a northeast trending inlier within the Marymia Dome (Figure 1). The PWGB is 50 km long and 12 km wide. The belt consists of metamorphosed ultramafic, mafic and felsic volcanics, sediments with cross cutting Proterozoic dykes in complex structural contact with the surrounding granite. Banded iron formation units occur in the northeastern section of the belt. Metamorphism is generally upper greenschist but may be locally lower amphibolite facies (Vickery et al, 1998).

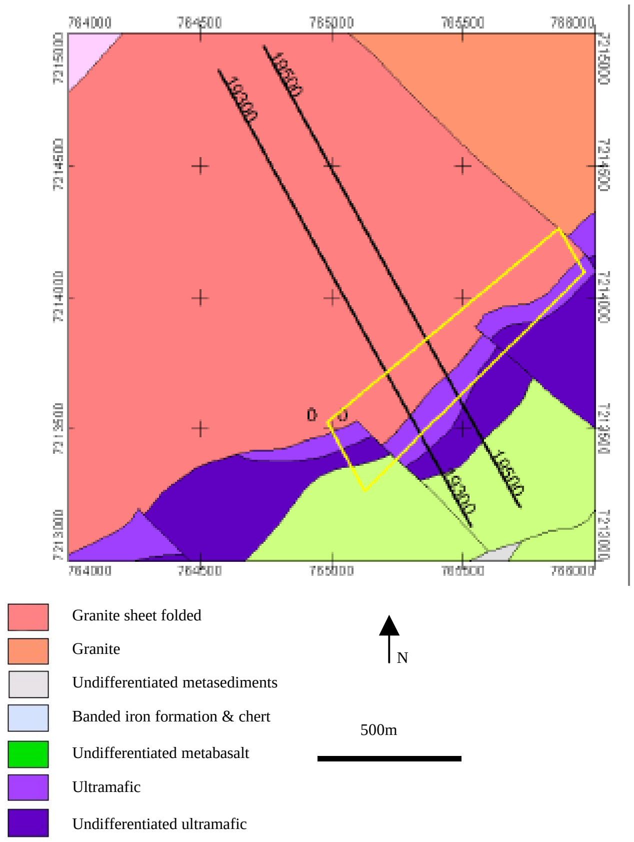

Figure 3. Geology map of the Trident deposit. The known extent of gold mineralisation is shown outlined by the yellow polygon and modelled sections are shown in black.

Gold mineralisation occurs along the length of the greenstone belt in a variety of settings and is typically, but not exclusively, hosted in mafic units (Lally *et al*, 1999). The largest producing mine in the PWGB is the Plutonic gold mine. This deposit is hosted in a mafic unit called the 'mine mafic' and is adjacent to an ultramafic unit. This stratigraphy is important because the Trident gold deposit is hosted in an ultramafic unit and may be the stratigraphic equivalent to the Plutonic gold mine ultramafic. If this is the case then there is a good chance that the mine mafic occurs at the Trident deposit and offers a prime exploration target.

The Trident gold deposit is located on the central north flank of the Plutonic Well Greenstone Belt (Figures 1 & 2). The deposit has a measured resource of 2,568,000 tonnes at 3.8 g/t. Mineralisation is hosted in an ultramafic unit in the greenstones. This unit is bounded to the southeast by a mafic unit and to the northwest by overthrusted granite containing fault rafts of mafic material. The greenstone sequence strikes northeast-southwest and dips at about 30^o to the northwest (Hellewell and Leonard, 1998).

High gold grades are intimately associated with pyrrhotite, bismuth and bismuth telluride assemblage (Hellewell and Leonard, 1998). It strikes to NE over a length of 1100 m and dips to the NW with the geology at around 30^o (Figure 3.4). At its shallowest the deposit is 50 m below the surface and has been drilled out to a depth of 250 m. Mineralisation is open at depth with only broad drilling defining the down dip extension of the deposit.

DATA ACQUISITION

Petrophysical analysis was conducted on 20 diamond drill core samples taken from the study area. Samples were analysed at Curtin University of Technology by the author and by Don Emerson of Systems Exploration. Additionally, magnetic susceptibility measurements were taken on core samples at 1 metre intervals for one hole (PMDD001). The results are summarised in Table 1.

Lithology		Magnetic Susceptibility (x10^{-3}SI)	Density (g/cc)	Resistivity (ohm.m)	IP Effect (mrad)
Granite		0.16	2.80	10232	31
Mafic Volcanic		0.73	3.05	3023	52
Ultramafic Volcanic	Chlorite Tremolite Schist	22.2	2.92	6125	20
	Serpentinte/ Komatiite	22.1	2.92	4106	17
	Mineralised	9.9	2.94	1318	8

Table 1. Summary of the petrophysical properties of the important lithologies of Trident gold deposit.

Kevron Geophysics completed a detailed airborne magnetic and radiometric survey over the Plutonic Well Greenstone Belt from September to November 1998. The survey parameters are summarised below.

Line spacing:	25 m
Line direction:	0-180^o
Tie line spacing:	250 m
Tie line direction:	90-270^o
Survey height:	25 m

Magnetometer:	Geometrics G822A Caesium Vapour
Sample rate:	0.1 Hz (6 m)
Gamma Ray Spectrometer:	Geometrics GR-820D, 256 channels
Crystal Volume:	33.6 litres
Crystal Type:	NaI (T1)
Sample rate:	0.5 Hz (approximately 30 m)

Two gravity traverses were surveyed over the Trident deposit using a 50 m station spacing (Figure 3). A 2 minute read time was used for base station readings taken at the beginning and end of the survey and a 40 second read time was used for station readings. Each station was surveyed for location and height using Trimble GPS equipment.

RESULTS

The petrophysical properties in Table 1 show there is sufficient physical contrast to enable the delineation of lithologies using geophysics. This is borne out in the airborne magnetic data. Figure 3 shows the analytic signal of the magnetic data.

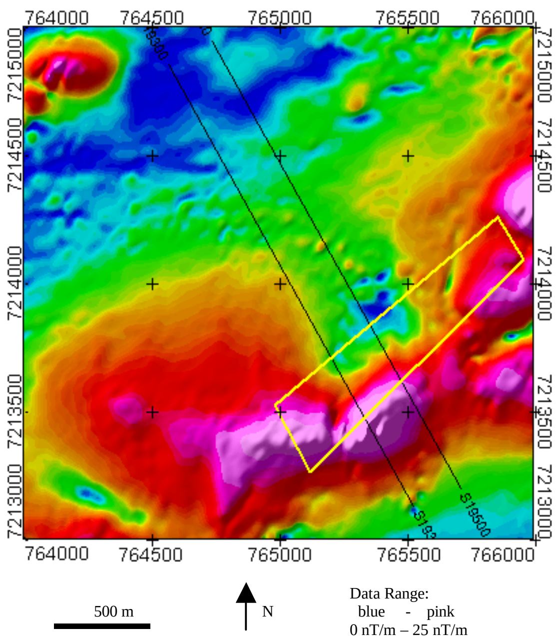

Figure 3. Pseudocolour image shaded from the northwest of analytic signal of Total Magnetic Intensity over the Trident deposit. The known extent of gold mineralisation is shown outlined by the yellow polygon and modelled sections are shown in black. Note the low over the northern flank of the deposit that is interpreted to be due to magnetite destruction in the ultramafic unit by mineralising fluids.

High analytic signal values in Figure 3 correspond to the magnetic ultramafic unit while the footwall mafic and hanging wall granite have a much lower values. The exception to this is a high anomaly in the northwest of image which is interpreted to be a previously unmapped raft of ultramafic rock. Perhaps the most significant feature is an analytic signal low that straddles the northwest flank of known mineralisation. It occurs in a fault block formed by two transform faults and drilling shows that the ultramafic unit continues to dip moderately under the granite veneer in this fault block. This leads to the conclusion that the ultramafic does occur below this low feature but has a reduced magnetic susceptibility. Furthermore, if the low is caused by the destruction of magnetite by mineralising fluids then the as yet untested down dip extension of the Trident deposit is a prime exploration target.

Total count radiometric data is shown in Figure 4. The radiometric data was successful in mapping the major geological structures and regolith features over the broader study area. The granites in the northwest part of the area had a higher total count than greenstones in the southeast. This is due to greater relative concentration in radioactive elements in the granite. Variations are also present in the data that are due to regolith features. Drainage and areas of transported cover mostly show a much lower total count than fresh rock or in situ weathering products.

The Trident area itself has a high total count feature spatially coincident with mineralisation. It was initially thought that the total count high could be a feature related to increased alteration around the deposit and thus a key characteristic used for building an exploration model. However, analysis of mapped regolith showed there is clear correlation between the total count high and ferruginous saprolite. This ferruginous saprolite is an in situ quartzo-feldspathic product of weathering granite. Around this feature are transported sediments and products of ultramafic weathering with relatively low total counts. The north of this area has a very high total count and this is related again the granite saprolite.

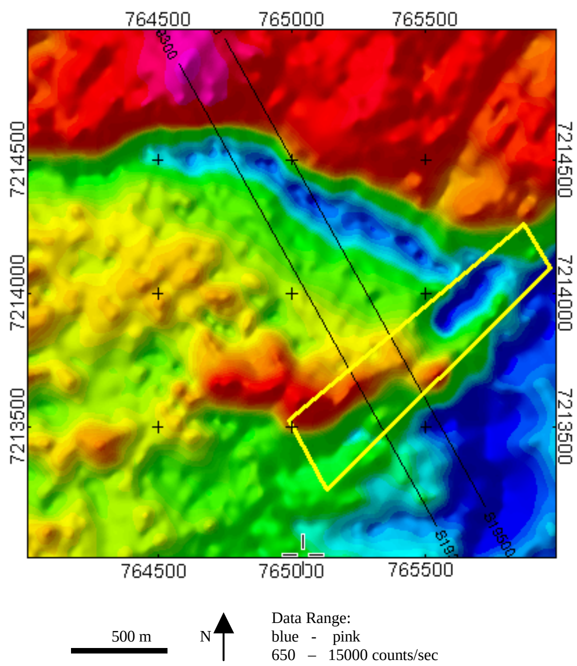

Figure 4. Pseudocolour image shaded from the northwest of total count radiometric data over the Trident deposit. The known extent of gold mineralisation is shown outlined by the yellow polygon and modelled sections are shown in black. The high values in the north of the image are due to granite saprolite and the isolated high over the southern part of the Trident deposit is quartzo-feldspathic saprolite also derived from granite.

It was noted during the study that a large total count high occurs about 3 km southwest of Trident. This anomaly cannot be explained by previously mapped geology or regolith.

outside the scope of this study it does represent an area of interest for follow up work.

The two gravity traverses over the Trident deposit were primarily aimed at defining the dip of the greenstone under the overthrusted granite and to determine the presence or otherwise of the mine mafic. While the results from the gravity survey area are mixed it does appear that the Trident deposit itself does not produce a measurable gravity anomaly. This fits with the petrophysical analysis that shows there is no discernible density contrast between mineralised and barren ultramafic.

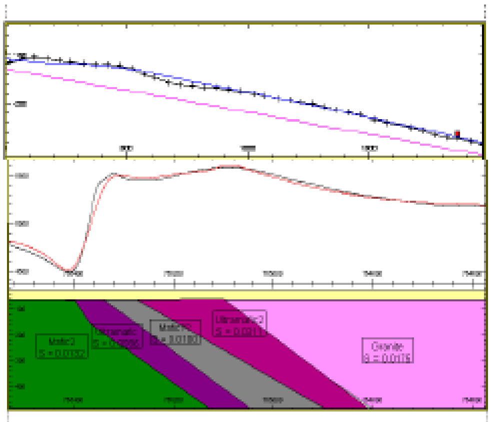

Figure 5. Gravity (top) and magnetic (center) responses over the Trident deposit (line 19300E). The profiles shown are Bouguer gravity field data (black), model data (blue) and regional (pink). The regional response dominates the profile and it is difficult to delineate local features. The magnetic profile shows field data (black) and model data (blue). The model fits well with petrophysical and drilling data.

Identification of the mine mafic at Trident and mapping the granite greenstone contact are more ambiguous. The gravity modeling used a linear regional gradient that closely followed the measured profiles. This removed much of the variation in the profile and therefore left little information on the geology and structure of the target. The residual anomaly profiles can certainly be mapped with a number of realistic forward models (Figure 5). It does appear unlikely that a significant mafic unit sits on top of the ultramafic. This is because this unit has the highest density in the package and would produce a recognisable anomaly which is not seen in the field data.

The length of the gravity profiles is a concern when making interpretations. The large gradient that dominates the profile is not fully delineated. The profiles need to be longer to be sure that it is a regional feature. If the gradient flattens or dips the other way to the north or south of Trident then the regional gradient used in the modeling makes the results invalid. The only way to be certain that the true nature of the regional gradient in the area is to extend the gravity survey lines to the north and south of the existing survey.

Although the gravity modeling does not provide conclusive evidence, gravity profiling is capable of mapping the granite-greenstone contact. There is a sufficient density contrast in the order of 0.2 g/cm^3 to show that a gravity response over the contact is measurable. Furthermore, gravity surveying has been successfully in the southwestern part of the PWGB to map the granite-greenstone contact.

CONCLUSIONS

The Trident deposit host ultramafic unit was readily mapped and modelled to depth using magnetic data. Mineralisation itself was expressed as a relative low within the magnetic ultramafic unit. The down dip extension of the mineralised ultramafic presents a good drill target. The gravity profiles are not long enough to allow accurate interpretation, but modelling shows that it is unlikely that the mine mafic is present at Trident. Radiometric data mapped broad geology and regolith trends but did not show an anomaly related to mineralisation. The results from IP and resistivity tests on core samples indicated that these techniques were not well suited for targeting this style of mineralisation.

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