TRANSIENT ELECTROMAGNETIC STUDIES NEAR BAGGY GREEN GOLD PROSPECT, SOUTH AUSTRALIA

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INTRODUCTION

The Baggy Green prospect is located about 20 km north-east of Wudinna on the northern Eyre Peninsula, South Australia. The extensive cover of Quaternary deposits largely limits the understanding of subsurface geology of this region. Drilling carried out by Adelaide Resources Ltd. has reported promising gold intersections from this area. Earlier studies (Drown 2003) indicated that this gold prospect is situated quite close to the boundary of highly metamorphosed Archean Sleaford Complex (towards the east) and intrusive of 1690-1680 Ma Tunkillia Suite (towards the west). The high-resolution aeromagnetic data obtained recently by Adelaide Resources Ltd. (*pers. comm.*) reveals that the Tunkillia Suite consists of NNE-SSW trending high magnetic anomalies compare to that of Sleaford Complex and thus demarcate the boundary between them. The above interesting observations have attracted detailed geological, geochemical and geophysical studies of this mineral prospective region. Figure 1 shows the geology of the survey area. We conducted a preliminary ground based geophysical survey in this area during April 2005. In this paper we report the results obtained from the above survey.

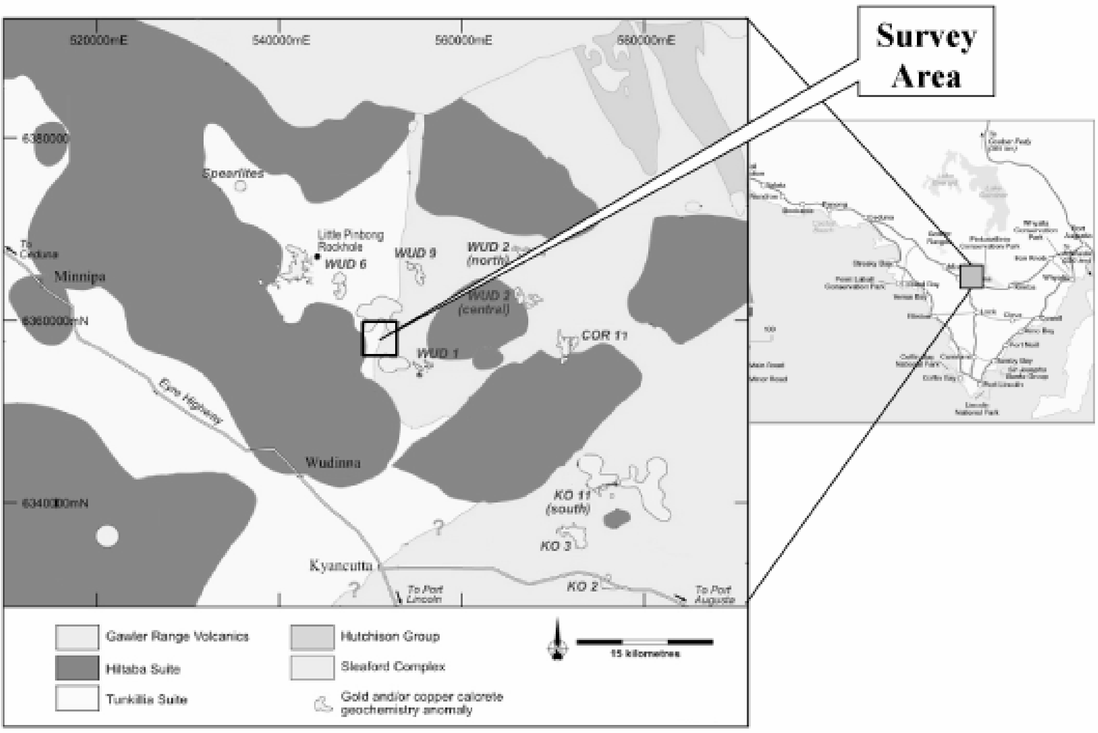

Figure 1: Geological Map of the survey area based on magnetic data, drill hole data and few outcrops. Baggy Green is indicated as WUD 6. The closest one to the survey area is *Wud'nitbenice* prospect. Modified from Drown (2003).

SURVEY METHOD

Electromagnetic (EM) techniques have been proved to be efficient in delineating the subsurface structures in terms of varying patterns of electrical resistivity. In this study we opted for the transient electromagnetic (TEM) method to delineate shallow subsurface (< 100 m) depth-resistivity structure. In the TEM method, the Earth's responses to a primary electromagnetic field are measured. The primary field is generated by flowing electric current through a transmitter coil (loop of insulated wire) on the Earth's surface. When the applied current is changed rapidly, the EM field becomes time-varying, which in turn produces the time varying primary magnetic field (H_p). This primary field induces subsurface eddy currents depending on the

In: Roach I.C. ed. 2005. *Regolith 2005 – Ten Years of CRC LEME*. CRC LEME, pp. 152-155.

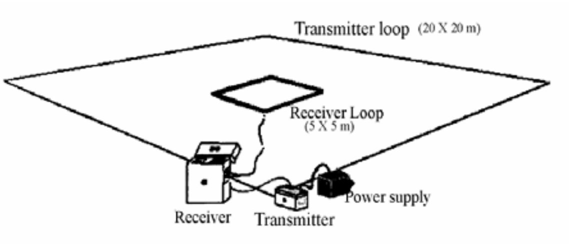

Figure 2: A cartoon of NanoTEM system in the field.

electrically conductivity structure, which in turn produces a secondary magnetic field (H_s). This decaying secondary field is measured using a receiver coil. We used a fast turn-off NanoTEM transmitter system and GDP16 receiver system from Zonge Engineering and Research Organisation with a transmitter (Tx) loop (20 x 20 m) and receiver (Rx) loop (5 x 5 m) configuration. Figure 2 shows a cartoon of the NanoTEM system in the field. Data were collected from 84 stations with spacings of 20 m. At each station we collected at least three sets of readings and averaged them to minimize the signal-to-noise ratio. Later the same survey line was repeated with a different Tx-Rx configuration (Tx = 40 x 40 m; Rx = 10 x 10 m) to obtain deeper responses. Due to some logistic reasons, we could not complete the second profile, but managed to get enough data to compare with first set of data. Figure 3 shows the TEM survey line superposed on Total field Magnetic Intensity (TMI) image produced from aeromagnetic data.

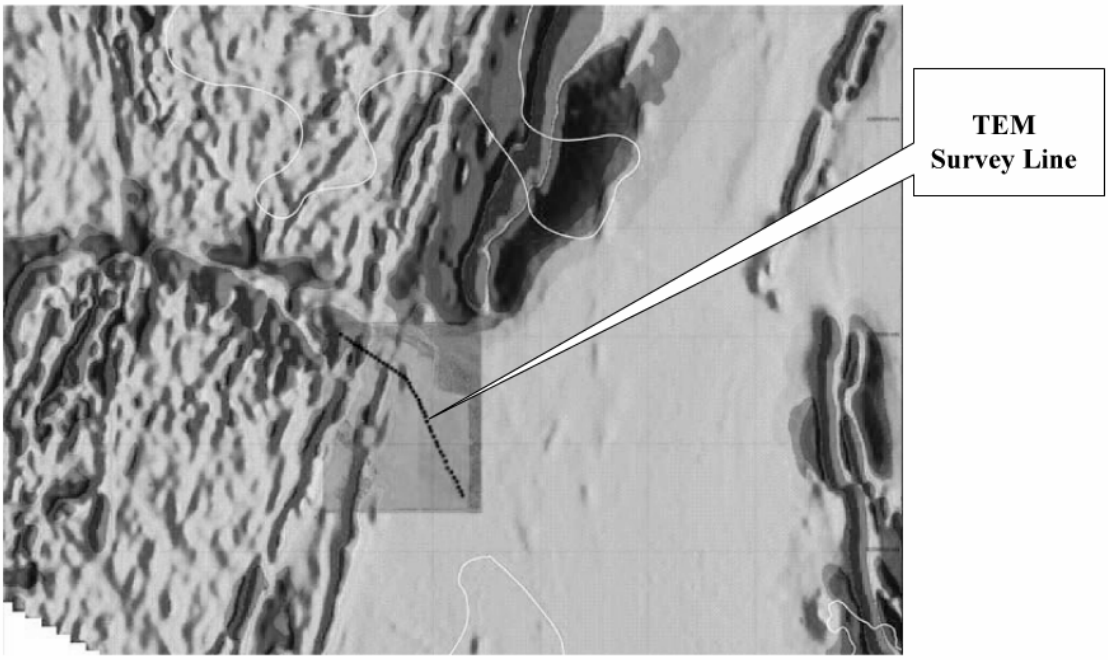

Figure 3: The TEM survey line (black dotted line) superposed on a Total field Magnetic Intensity (TMI) image produced from aeromagnetic data from Adelaide Resources Ltd.

RESULTS

During the data inversion, secondary EM field responses with an error greater than 5% were disregarded and the depth-resistivity profile for each station was obtained. Figure 4 shows such responses from a few selected stations along the survey line. All TEM stations except 1180 and 1280 show three-layer structures. Station 1180 shows a two-layer structure and station 1280 shows almost a single layer. Towards the right-hand side of the survey line (see Figure 4), the subsurface responses change back to a 3-layer situation. The depth-resistivity responses from all the stations were then used to create the best fitting 2-dimensional model. For this purpose we used the STEMINV software package (MacInnes & Raymond 2001), which is a smooth-model inversion technique. Figure 5 shows the 2-D depth-resistivity model corresponding to smaller loop (Tx =20 x 20 m; Rx = 5 x 5 m) configuration. The left-hand side (NW) of this 2-D model indicates that there is a layer of 5-6 m thickness with a resistivity of 10-20 ohm-m followed by less

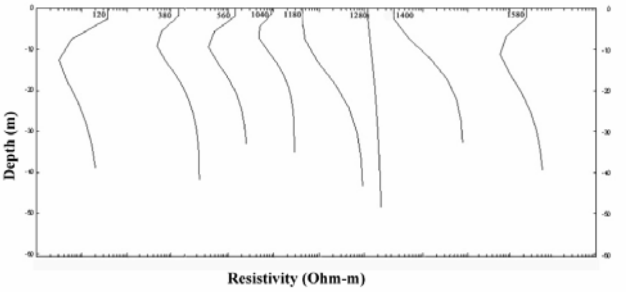

Figure 4: Dept-Resistivity model responses from selected TEM stations. X-axis represents the resistivity in Ohm-m and Y-axis the depth in meters.

resistive layer (< 10 ohm-m) with a thickness of 5-10 m. This layer is underlain by a more resistive layer (15-30 ohm-m) with a thickness of about 25-40 m. The lowest layer has intermittent patches of high resistivity (100-500 ohm-m). Towards the right-hand side (SE) of the 2-D model there is a very highly resistive (100-2000 ohm-m) feature, which lies closer to the surface. There are also two large lobes of very high resistivity. Towards the end of the profile there is a 3-layer structure (resistive-less resistive-highly resistive), similar to the beginning of the survey line. As mentioned previously, we repeated the survey line with a larger Tx-Rx configuration, which provided deeper responses. Figure 6 shows the 2-D depth-resistivity model from the repeat survey. The large gap in the centre of the model is due to the lack of data for logistical reasons. There is a consistency between the depth-resistivity responses between the two profiles except that the second profile (Figure 6) has less resolution for the upper part of the model comparing to that on first profile (Figure 5). The two large high-resistivity lobes on the right-hand side of the survey line are clearly reproduced. This provided more confidence on our results.

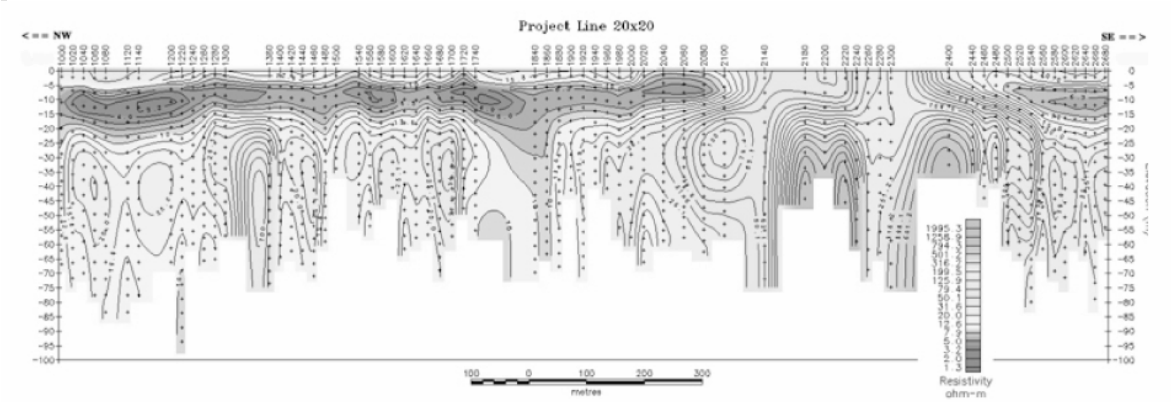

Figure 5: 2-D Depth Resistivity profile obtained from the TEM response using Tx (20 x 20 m)-Rx (5 x 5 m) configuration. Resistivity scale indicates that there is a wide range of resistivity (i.e. from 1.5 Ohm-m to 1995 Ohm-m).

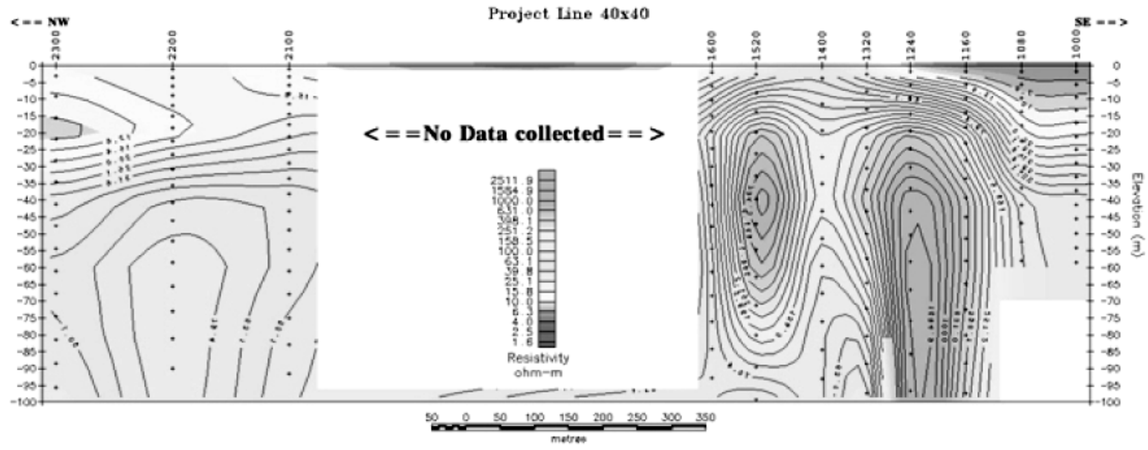

Figure 6: 2-D Depth Resistivity profile obtained from the TEM response using Tx (40 x 40 m)-Rx (10 x 10 m) configuration. Resistivity scale indicates that there is a wide range of resistivity (i.e. from 1.5 Ohm-m to 2510 Ohm-m).

DISCUSSION

The depth-resistivity models obtained from this preliminary survey shows a three-layer model in the left-hand side of the survey line, two or an almost single layer structure towards the right-hand side and a three layer structure again at the far right. The resistivity values and surface expressions of the upper most layer indicates that it corresponds to the thin (ca. 5 m) aeolian deposit followed by a Saprolitic Clay Layer. The clay layer can hold water in it and thus makes it very less resistive. The thickness of this conductive clay layer may not be as thick as defined on the 2-D model. This is because we have adopted a smooth inversion technique, which could merge the responses and thus the thin conductive layer between two resistive layers looks thicker than it really may be. The lowest layer seen on the 2-D model seems to be saprock. We made an attempt to verify these findings with drill hole data available from Adelaide Resources Ltd. (*pers. comm.*). These data indicated the presence of uppermost aeolian sands followed by a thin weathered clayey layer, which is underlain by thicker saprock. The intermittent lobes with more resistivity could be related to mafic intrusions within the Tunkillia Suite. To verify this, we selected the aeromagnetic data corresponding to the TEM survey profile and compared it with resistivity model obtained, which is shown in Figure 7, which shows highly magnetic anomalies in the left-hand side and nearly even intensities toward the right-hand side of the profile. The resistive lobes on the left-hand side of the 2-D resistivity model coincide with the magnetic highs associated with the TMI profile, which may indicate the presence of mafic intrusions.There are other possibilities such as the presence of gneissic layers on a grand scale or even variable destruction of accessory Magnetite, etc. Towards the right-hand side of the profile the nearly flat TMI response corresponds to the very high resistivity structure in the Tem data. Generally the resistivity range of mafic intrusions like basalt, gabbro and felsic intrusions like granite have a similar range of electrical resistivity (100-10^6 Ohm-m). However, their magnetic intensities are entirely different, with mafic rocks having very high magnetic intensity. So the resistive lobes seen on the right hand side of the TEM profile could be a felsic intrusion. Another important point to be noticed is that the above mentioned high resistive felsic intrusion is situated almost at the boundary between the Sleaford Complex and the younger Tunkillia suite. So the above mentioned resistive unit could be a very silicious rock of tectonic origin (e.g. Mylonite) at this boundary.

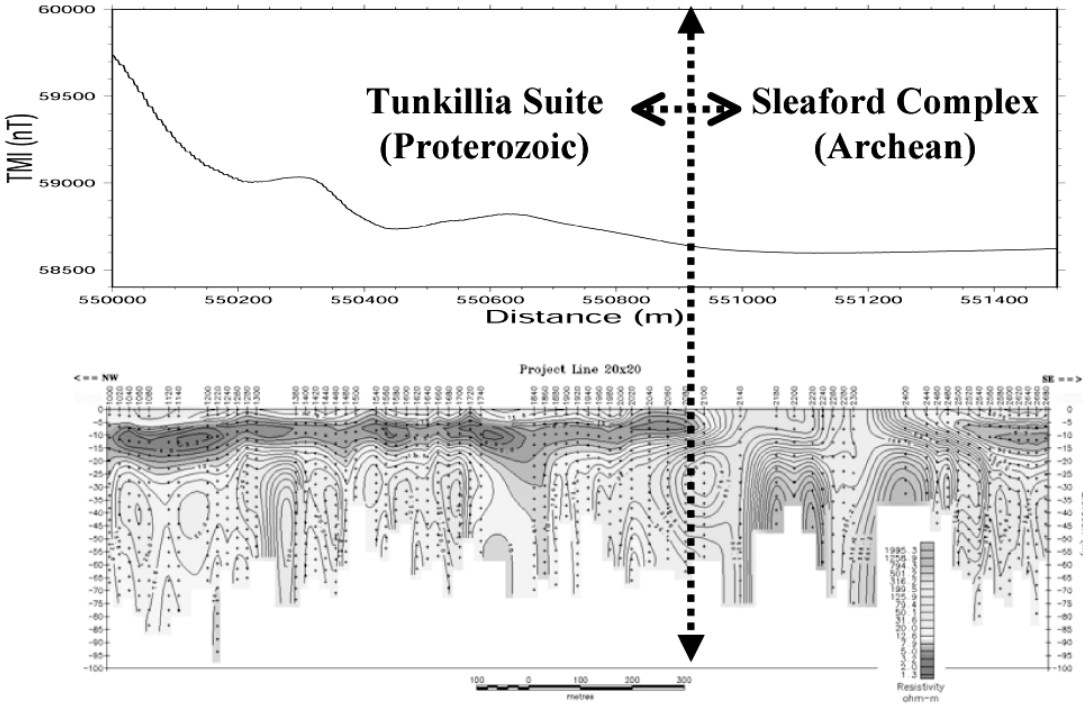

Figure 7: Comparison of the 2-D Depth resistivity profile and the TMI values obtained from the aeromagnetic data along the survey profile. Demarcation between Tunkillia Suite and Sleaford Complex is quite clear on both the data.

CONCLUSIONS

Results obtained from the preliminary TEM survey conducted near Baggy Green Mineral prospect identified various geological structures in the shallow subsurface. There is a general trend of three different geological/lithological units, namely the aeolian sands on the top followed by Saprolitic Clay, which is underlain by saprock at 25-40 m. Towards the Sleaford Complex, the situation is different. A felsic/silicious but highly resistive body has been located very close to the boundary between the Sleaford Gneissic Complex and Tunkilia Suite. This finding may have some implications on the mineral prospects of the Baggy Green area. The results are from a preliminary survey with just one TEM profile, so the need remains to conduct a detailed geophysical survey to fully delineate this double-lobed highly resistive structure.

REFERENCES

DROWN C. 2003. The Barns Gold Project – discovery in an emerging district. *MESA Journal* **28**, 4-9.

MACINNESS S. & RAYMOND M. 2001. *STEMINV Documentation – Smooth-Model TEM inversion, version 3.00*. Zonge Engineering and Research Organisation Inc.

Acknowledgements: Our sincere thanks to CRC LEME for funding for the project “the Electrical and EM regolith studies”. Andreas Schmidt Mumm and Steve Hill are thanked for their support at the field survey.