ELECTROMAGNETIC SURVEYS OF THE REGOLITH PROFILE OVER THE KALKAROO MINERAL PROSPECT, CURNAMONA PROVINCE, SOUTH AUSTRALIA

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INTRODUCTION

The electromagnetic (EM) method of geophysical exploration utilizes broad range of instrumentation systems. The main physical property derived by this technique is electrical conductivity (σ), which is an indication of how easily electric current can pass through a material (this property is also represented by its reciprocal, electrical resistivity (ρ)). Conductivity within the subsurface is a complex function of several variables, which includes the conductivity of the material or rocks (depending on their chemical/ mineralogical composition), porosity, conductivity of pore fluids, degree of saturation. EM techniques can be classified as (i) transient or time domain (TEM) systems, where the measurements are made as a function of time, and (ii) frequency domain (FEM) systems which use one or more frequencies. The conductivity of the ground is measured by inducing an electrical field through the use of time-varying electrical currents in transmitter coils located at or above the surface of the ground. These time-varying currents create magnetic fields that propagate in to the earth and cause secondary electrical currents, which can be measured using receiver coils either while the primary field is transmitting (in FEM) or after the primary field has been switched off (in TEM). Shallow depth-resistivity soundings are mainly done using TEM, while mapping of lateral conductivity contrasts are predominantly done using FEM.

In this paper we discuss the results of TEM surveys designed to image the shallow subsurface conductivity distribution over the Kalkaroo mineral prospect in the Curnamona Province, South Australia. The information derived from the survey is being used in the CRC LEME Curnaminex Project to assist with developing effective mineral exploration strategies in this area of very thick cover.

EXPERIMENT

During the phase-I of the survey TEM data was collected along three pre-defined lines cutting across the zone of mineralisation. Geochemical and hydrogeochemical sampling was also conducted along these lines (Fabris et al, 2006). Each TEM line was approximately 750m long and oriented approximately NW-SE. During phase-II of the survey we selected two more lines parallel to that of phase-I and one tie-line cutting across most of the lines of phase I and II. Figure 1 shows the location of the survey region and the TEM survey profiles.

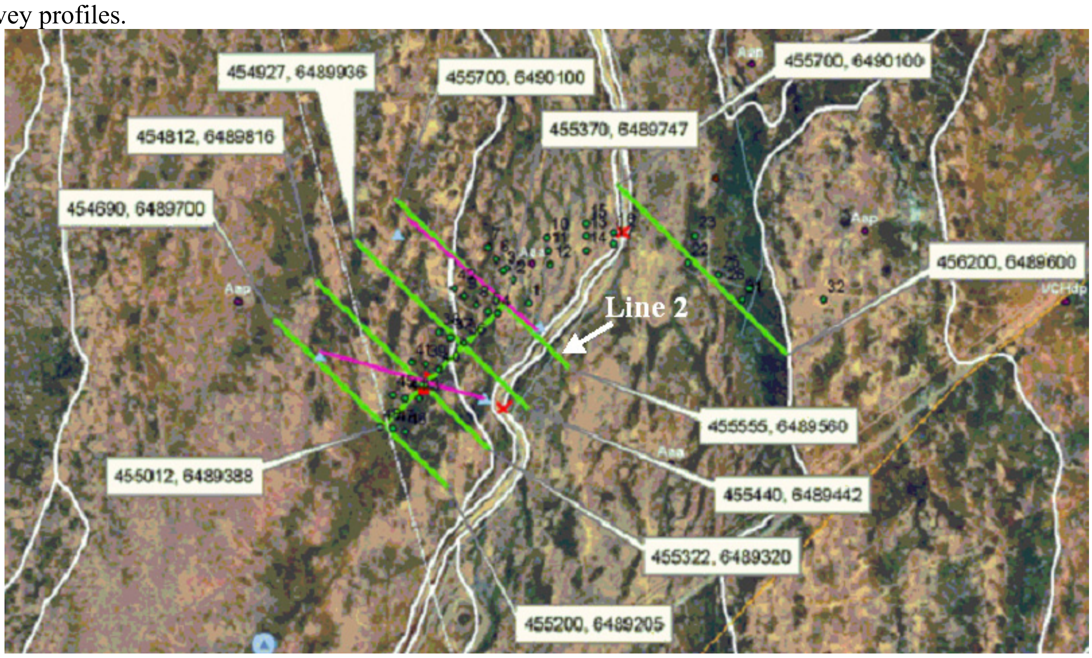

Figure 1, Location map of the Kalkaroo mineral prospect. The TEM survey lines are shown in green and the geochemical sampling lines are shown in purple. Drill holes in the area are also indicated.

We used a fast turn-off TEM system called NanoTEM, developed by Zonge Engineering and Research Organisation with a 20m X 20m transmitter (Tx) loop and 5m X 5m receiver (Rx) loop configuration. Figure 2 shows a cartoon of the NanoTEM system in the field. Data were collected with a station spacing of 20m. At each station we collected at least three sets of readings and averaged them to minimize the signal-to-noise ratio. The middle line (see Line No.2 on Figure 1) was repeated with different Tx-Rx configurations to see what depth resolution could be obtained and thus constrain the resistivity distribution of shallow (up to a depth of 60-70m) subsurface structures. We experimented with two different configurations, one with smaller loop size (Tx=10X10m; Rx=2X2m) and the other with a larger loop size (Tx=40X40m; Rx=10X10m).

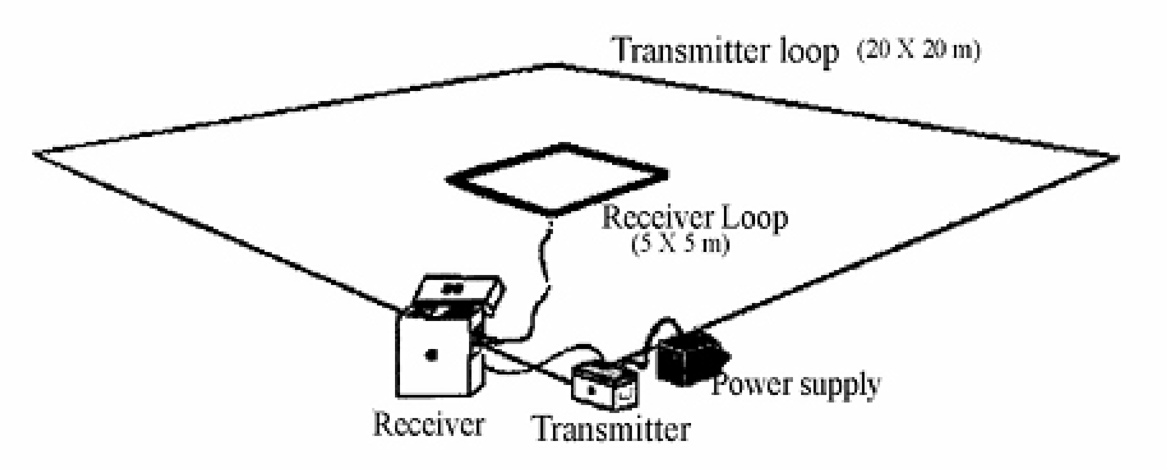

Figure 2, A cartoon of fast turn-off NanoTEM transmitter-receiver system and the Tx-Rx loop configuration (*after Joseph et al, 2005*).

RESULTS

The data were processed and the depth-resistivity profile for each station was computed using a smooth-model inversion technique called STEMINV (MacInnes, 2005). Figure 3 shows the measured transient electromagnetic response and the 1-D depth-resistivity profile obtained for one station after applying the smooth inversion technique. It is apparent that the resistivity values in the near surface region are about 10 ohm.m., that they gradually decrease to about 1-2 ohm.m at a depth of 20-25m and then increase again with depth. The 1-D responses from all the stations on a particular survey line can be stitched or joined together to form a pseudo 2-D model. Figure 4 shows such a 2-D depth-resistivity profile corresponding to the Line No.2. This image clearly shows the presence of a very low resistive or conducting layer at a depth of 15m with a thickness about 20-25m. Resistivity values corresponding to this layer indicate the presence of a highly conductive clay layer or the presence of ground water. The eastern most line showed a distinctly different feature close to SE end of the line, which may indicate the presence of a shallow subsurface fault zone. Orthophoto (Figure 1) and aeromagnetic data indeed support the existence of such a shallow tectonic feature.

During the Phase-I survey, one of the exploration companies (Havilah Resources NL) was carrying out drilling about a kilometre away from the location of the TEM survey profiles. This drilling gave us insight into the nature of the regolith materials with depth (Figure 5). Quaternary sediments appear in the top 20-30m. These sediments are underlain by a 10-15 m thick clay layer, which has been identified as the Namba Formation. Below this clay layer is poorly sorted sediment, interpreted as Eyre Formation overlying saprolitic materials of similar nature. These observations clearly support the depth-resistivity distribution obtained from the TEM survey. Using all of the available TEM data an attempt was made to create a three-dimensional depth-resistivity model for the survey area (Figure 6). This 3-D model clearly shows the changes in thickness of various subsurface layers within the survey region.

CONCLUSIONS

The TEM survey conducted at Kalkaroo has highlighted the high conductivity of cover sediments in the region. General differentiation of cover sediments was achieved, including thickness variations, dips and the possible presence of a fault zone. This information will be used to assist with interpreting the phyto, hydro and geo-chemical results obtained from this region.

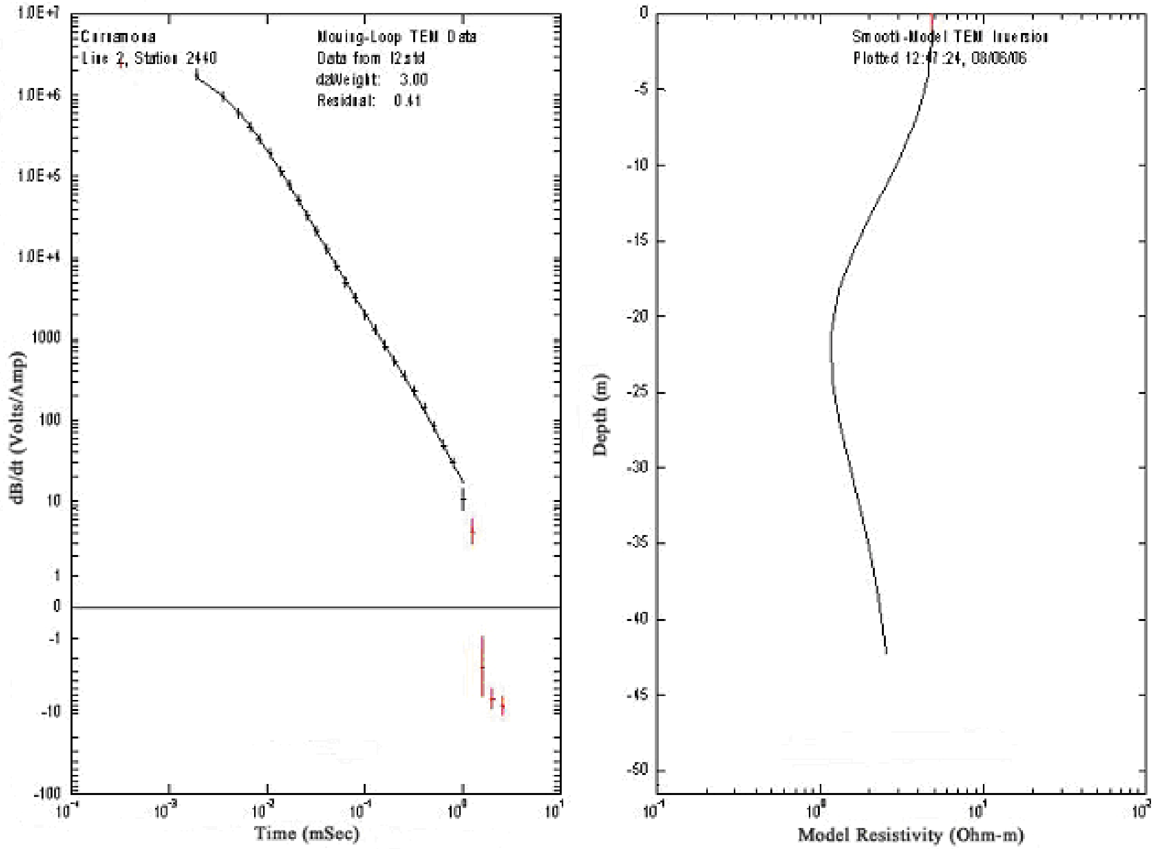

Figure 3, Transient electromagnetic response obtained from one of the stations in the Kalkaroo survey. (a) decay curve of the secondary magnetic field and (b) 1-D depth-resistivity profile obtained after applying smooth inversion technique.

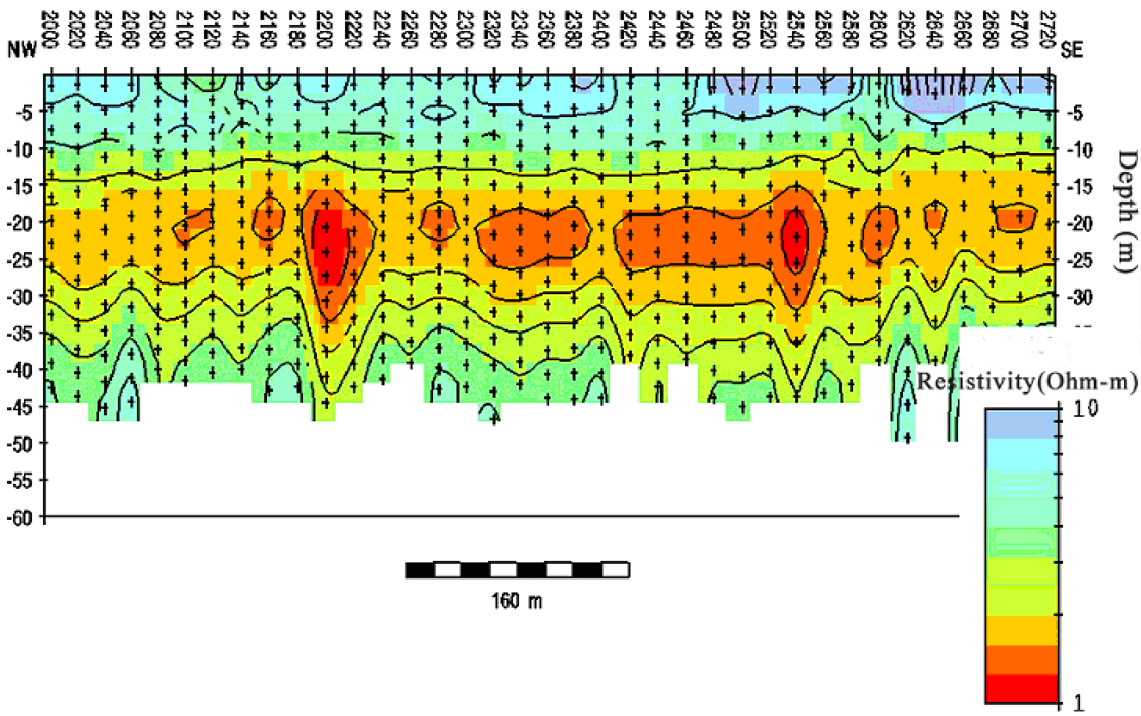

Figure 4, Two-dimensional depth-resistivity profile corresponding to survey line No.2 at Kalkaroo. A very low resistive (highly conductive) zone is clearly seen between 15 and 30m.

Figure 5, Images of the fresh drill cuttings recovered by Havilah Resources NL

REFERENCES

FABRIS, A.J., KEELING, J.L, FIDLER, R.W., 2006, A comparison of geochemical exploration techniques: Curnamona Province, CRC-LEME Regolith Symposium-2006 Abstract Volume.

JOSEPH, E. J., KIM, S., HATCH, M., HEINSON, G., AND DROWN, C., 2005, Transient Electromagnetic Studies near the Baggy Green Gold Prospect, South Australia, Extended abstract, CRC-LEME Regolith Symposia-2005, p152-155

MACINNESS, S., 2005, STEMINV: Smooth-Model TEM inversion, Zonge Engineering and Research Organization Inc., AZ

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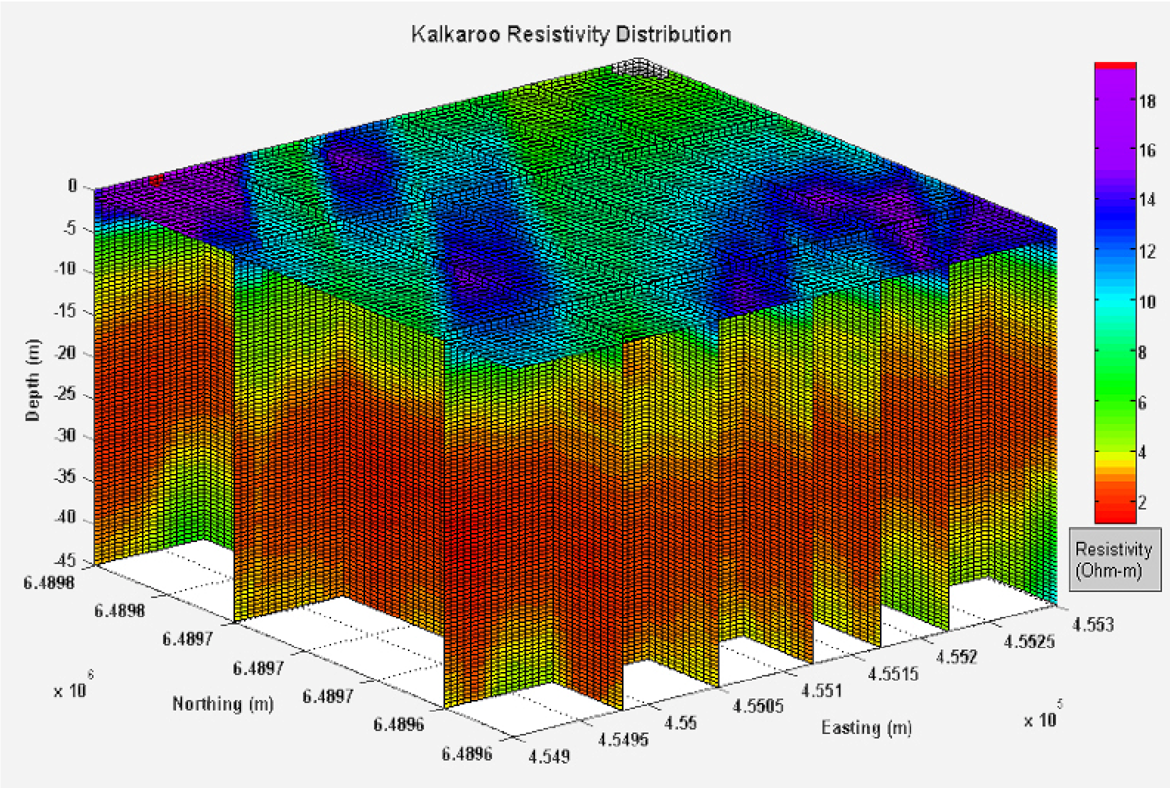

Figure 6, A 3-D resistivity distribution corresponding to a part of the survey area. The red coloured region highlights the variable depth and thickness of the highly conductive Namba Formation.