Mapping undercover domal structure using audio-magnetotellurics in Zambia.

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SUMMARY

The increasing depth of investigation for sediment hosted copper mineralisation in the Central African Copperbelt requires the use of adequate geophysical methods such as natural source audio magnetotellurics (NSAMT) as opposed to conventional electrical geophysics techniques (resistivity/IP and time domain electromagnetics) which have limited depth of investigation. A NSAMT survey was carried out at the Solwezi East project near the Kansanshi copper mine in north-western Zambia in order to map a possible undercover domal structure which is thought to control mineralisation at the mine. A total of 50 line kilometres of NSAMT successfully identified a confined domal structure 1.2 km long and 700m wide buried at about 700m below surface. The mapped dome awaits a drill test to confirm the presence of economic mineralisation. NSAMT is proven to be successful for mapping buried domes at considerable depth.

Key words: natural source audio magnetotellurics (NSAMT), Kansanshi, dome, structure

INTRODUCTION

The Central African Copperbelt (CACB) is the world's largest sedimentary copper province and holds the world's largest cobalt reserves (Hitzman et al., 2012) . First Quantum Minerals (FQM) holds 80% of Kansanshi Cu-Au mine, a sedimen-t hosted deposit located in Solwezi, north-western Zambia, approximately 400 kilometres north of the capital city Lusaka (**Error! Reference source not found.**). The geology of Kansanshi consists of recumbently folded schist, marble, carbonaceous shale, diamictite, sandstone and dolomite. The main orebody is hosted in reduced packages (reduced carbonaceous shales, diamictite) and late cross cutting quartz carbonate veins. Similarly to most deposits in the CACB, the Kansanshi orebody was found by conventional exploration methods such as surface geochemical sampling and geological logging. In 2011, FQM ran a benchmark survey which accurately mapped the folded carbonaceous phyllite associated with mineralisation. (***Figure 2*** & **Error! Reference source not found.**).

Various petrophysics measurements on core and particularly the wireline logging at Kansanshi helped to characterise conductive carbonaceous phyllite. ***Figure 4*** shows inductive conductivity results along two boreholes where the highest conductors are associated with carbonaceous phyllite (CBPH).

Following the above success, a natural source audiomagnetotellurics survey was planned south of the mine to identify similar domal structures.

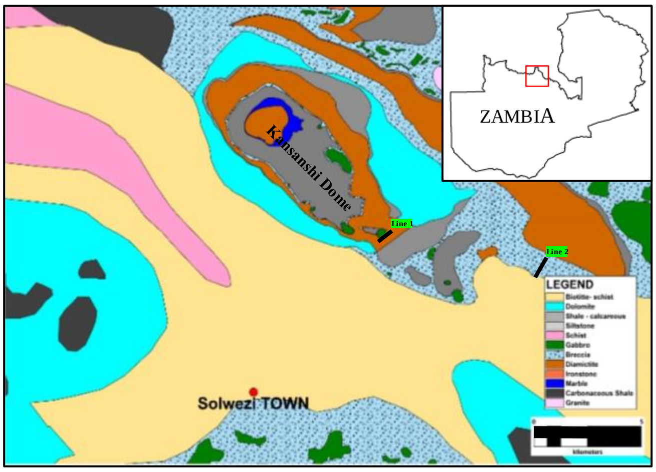

Figure 1: Location of Kansanshi Cu-Au mine overlaid on regional geology map

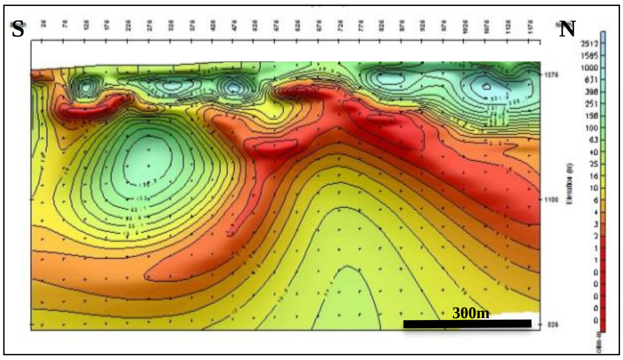

Figure 2:Folded carbonaceous shale mapped over the South East dome deposit (Line 1).

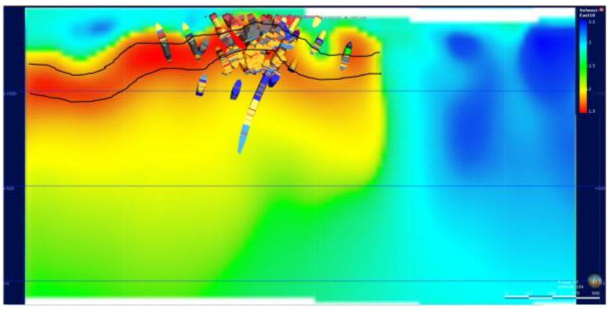

Figure 3:1D inverted resistivity for the same section as Figure 2 over SE Dome deposit. The conductive horizon

represents carbonaceous phyllite intersected in the drilling in grey colour (Line 1).

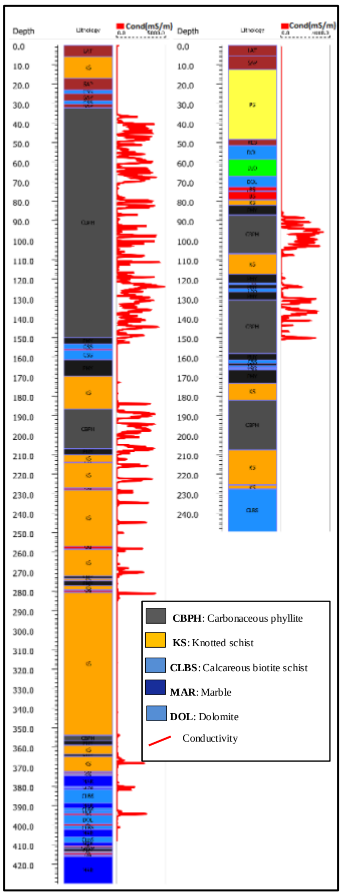

Figure 4: Wireline logging inductive conductivity profile showing the conductive carbonaceous phyllite responsible for the NSAMT response

METHOD AND RESULTS

The magnetotellurics method is a natural source electromagnetic method used to determine the resistivity distribution of the subsurface by measuring the electric and magnetic fields in two mutually perpendicular directions on the surface (Vozoff, 1990).
Typically, the electric field is measured along the strike direction and across it at 90-degree separation. The horizontal electric field $(E_x \; and \; E_y)$ is measured with grounded electrodes. The horizontal magnetic field $(H_x \; and \; H_y)$ is simultaneously measured using magnetic coils (or fluxgate magnetometers)(Vozoff, 1990) . And Hz, when is it measured and not measured?

The magnetotelluric field splits into two independent modes: (1) the transverse magnetic mode (TM mode) where the magnetic field is transverse to vertical direction, and (2) the transverse electric mode (TE mode) where the electric field is transverse to vertical direction (Mark N. Berdichevsky, 2008).

The data was acquired using the Zonge GDP32 multi-receiver instrument by GSS Zambia with 50 m electric dipoles and magnetic coils placed every 100 m. Processing is done using proprietary Zonge SCS2D MT/IP inversion software. The data is inverted for frequencies ranging from 16 to 10000 Hz. This allows fast processing time and visualisation of results. When required, the full frequency spectrum of the NSAMT survey is inverted for deeper targets.
The 2D TM and TE mode inversions used 1D inversion results as starting background resistivity models. The initial 1D inversion uses a constant resistivity background.
The survey mapped a few sections of folded, highly conductive carbonaceous phyllite forming a series of synforms and antiforms. The top of the antiform is estimated to be 700 m below surface. Above the carbonaceous phyllite is a series of relatively resistive carbonates, sandstones and biotite hornblende schists (**Error! Reference source not found.**).
The TM mode (Figure 5) and TE mode (

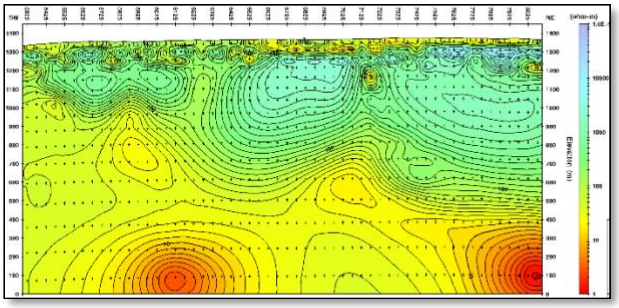

Figure *6*: **TE mode 2D resistivity inversion along the same profile as in Figure 5. Note that the folded phyllite is unclear on this section (Line 2).**

) have a different response to the carbonaceous phyllite. This is indicative of the electric field being stronger across the survey line direction. Does this make sense geologically and why?

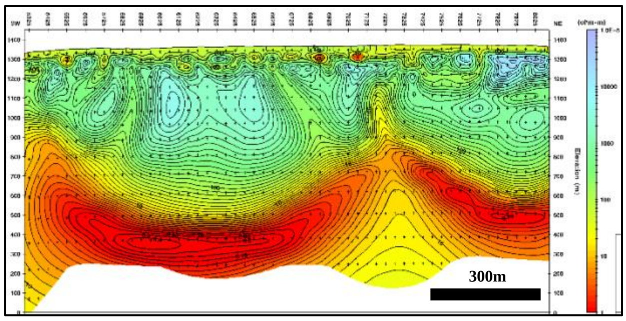

Figure 5: TM mode 2D resistivity inversion showing folded carbonaceous shale mapped along NE-SW oriented (line 2)

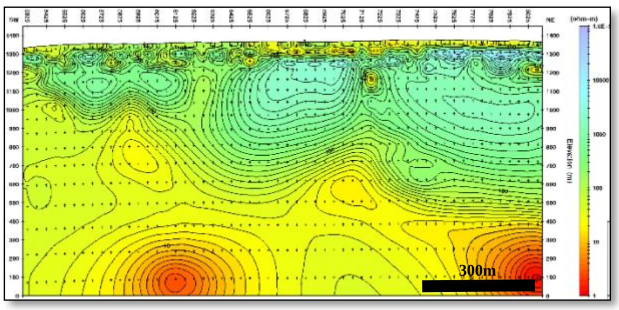

Figure 6: TE mode 2D resistivity inversion along the same profile as in Figure 5. Note that the folded phyllite is unclear on this section (Line 2).

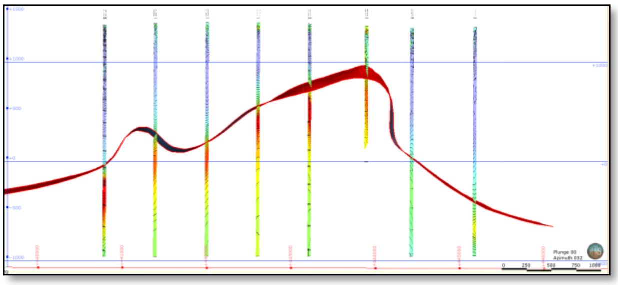

Figure 7: Cross section domal structure derived from TM mode resistivity at Solwezi East. The surface represents top of the conductor highlighted by the bars (conductivity sections).

CONCLUSIONS

A NSAMT survey over the Solwezi East project was able to map a buried domal structure 700m deep, which is clearly out of reach for conventional active time or frequency domain electromagnetics. Drill testing will prove the presence of the dome and possible mineralisation. Magnetotellurics is a key tool for sediment-hosted copper mineralisation, especially now that most of outcropping deposits have been found.

ACKNOWLEDGMENTS

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