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The use of VTEM data in geological mapping and mineral exploration in north-eastern Namibia.

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ABSTRACT

In June 2008 a 3310 line-km airborne geophysical survey was flown in north-eastern Namibia for the Geological Survey of Namibia. Time domain electromagnetic data (dB/dt and B-field) as well as magnetic data were acquired with the VTEM system. The survey area is covered with sand and no other detailed information on the sub-surface geology is available. The objectives of the survey were to delineate sub-surface geological units and trends, and to identify possible exploration targets. The TDEM data were processed to obtain three-dimensional conductivity-depth information, decay constant maps and discrete anomaly picks from both the B-field and dB/dt data sets. Together with the magnetic total field data and its derived products (analytical signal, vertical and horizontal derivatives), these were used to delineate geological structures and classify geological units based on their regional setting and physical properties. In addition, targets with exploration potential were identified. The data and some interpretation results are presented in this paper, illustrating the value added to regional mapping and greenfields exploration with airborne TDEM surveys.

Key words: TDEM, Namibia, Damara Metamorphic Belt, VTEM

INTRODUCTION

The Geological Survey of Namibia (GSN) plays an active role in stimulating investment in Namibia's mining sector in order to contribute to the economic development of the country. As part of this initiative the GSN contracted Geotech Airborne Limited to execute a 3310 line-km airborne geophysical survey over a project area in north-eastern Namibia, including data acquisition, processing and interpretation. The survey area is situated on the Damara Metapmorphic Belt. It is in a similar geological environment as Tsumeb mine and it is possible that the same type of mineralization can occur in the project area.

The Damara Belt, as illustrated by the Tsumeb deposit, contains a great diversity of ore minerals of lead, copper, zinc, silver, arsenic, antimony, cadmium, cobalt, germanium, gallium, gold, iron, mercury, molybdenum, nickel, tin and tungsten. The Tsumeb mine was once the foremost producer of lead in Africa and, over its life, has produced in excess of 2 million tonnes of lead, some 500,000 tonnes of zinc, and over 1 million tonnes of copper (The Mineral Gallery, 2009).

The objectives of this survey were to delineate sub-surface geological units and trends, and to identify possible exploration targets.

TECTONIC SETTING

As stated the survey area is located in the Damara Metamorphic Belt. Its tectonic history starts during the breakup of Rhodinia, approximately 700 million years ago, when various rifts developed. One of these rifts formed between the Congo- and Kaapvaal Cratons as illustrated in Fig. 1b. The rifts were filled with shallow seas and sediments accumulated, broken by volcanic activity. With the assembly of Pangaea, approximately 500 million years ago, these rifts began to close. The sedimentary rocks in the Khomas sea (Fig. 1a) were compressed and folded. Magmas intruded into these folded sediments. This buckled and metamorphosed assemblage of rocks is known as the Damara Belt (McCarthy and Rubidge, 2005) and provides a geological environment suitable for the formation of massive sulphides and other types of especially lead and zinc ore deposits. The survey area is sand-covered with no drilling, geochemical or other geological information available at the time of the survey.

DATA ACQUISITION

dB/dt and B-field time domain electromagnetic data, as well as magnetic and positional data were acquired with the helicopter-borne VTEM system. The system and survey acquisition parameters are summarized in Table 1 and the system configuration shown in Fig.2.

Table 1: VTEM North-eastern Namibia survey and system parameters.

Base Frequency	25 Hz
Waveform	Polygonal
Current	207 A
Peak dipole moment	440 000 NIA
Tx loop diameter (area)	26 m (540 m^2)
Tx Turns	4
Nominal Tx/Rx height	40 m
Rx Time gates	27 (0.083 – 7.5 ms)
Tx turn-off time	1.1 ms
Tx Pulse On Time	7.36 ms
Magnetometer height	66 m
Nominal survey speed (station spacing)	80 km/h (2.2 m)
Flight line spacing	400 m

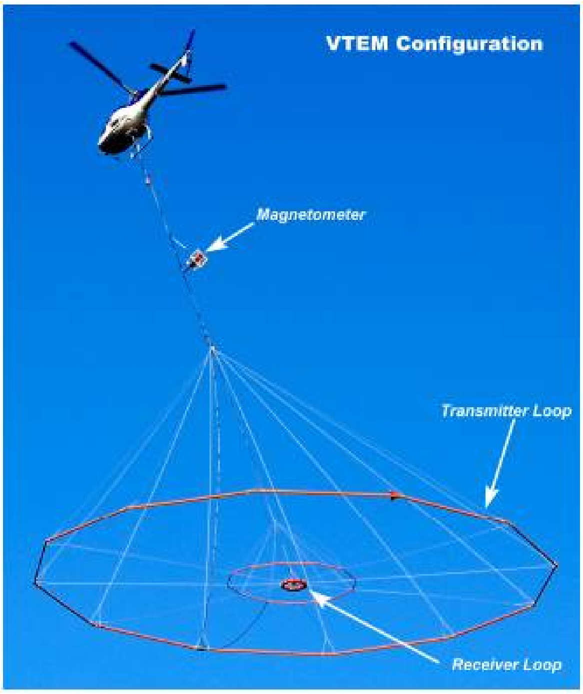

Figure 2. VTEM system configuration.

PROCESSING AND INTERPRETATION

The TDEM data were processed with EMFlow (Encom Technology Pty. Ltd., North Sydney, NSW, AU) to obtain conductivity-depth information in three dimensions. These are presented as conductivity-depth images (CDI's), contour maps of conductivity at constant depths below surface, voxels and conductivity iso-surfaces (Fig. 3). An additional tool for mapping conductors is decay constant contour maps. These are generated based on the late time exponential decay behaviour of confined conductors. Apart from these semi-automated analyses, visual inspection of profiles and conductor analysis for distinct anomalies were also performed.

Together with the magnetic total field data and its derived products (analytical signal, vertical and horizontal derivatives), the described EM products were used to delineate geological structures and classify geological units based on their regional setting and physical properties.

Delineation of dykes, faults and lineaments

Dykes are readily identified as prominent highs on the analytical signature of the total field magnetic data. This is illustrated by the heavy green lines in Figure 4.

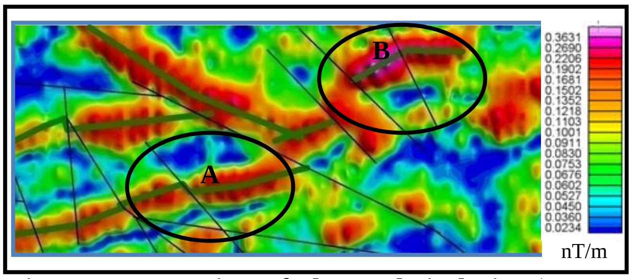

Figure 4: A section of the analytical signa illustrating features which are used to identify dykes and faults.

Lineaments and faults were recognized by a number of features not only on the analytical signal map, but also on the other derivatives of the magnetic data. Two examples are:

i. A displacement in a prominent linear feature such as **A** in Fig. 4.
ii. A sharp change in amplitude as illustrated in **B** in Fig. 4.

Geological zoning

The survey area was divided in zones based on the contrasts in textures and amplitudes observed on the total field magnetic map, the analytical signal map, the conductivity-depth sections derived with EMflow from the B-field and dB/dt data and the various decay constant maps. The regional geology, combined with the expected physical properties, was used to tie the most probable lithologies to each zone. It should be noted that this type of map projects three-dimensional geology on a two-dimensional plane and should not be treated as a geological map.

Fig. 5 illustrates the first vertical derivative grid of the magnetic total field data, Fig.6 shows depths to magnetic sources and Fig.7 shows stacked conductivity contour maps derived from the dB/dt data. Superimposed on Fig.'s 5&6 are three black dashed lines indicating the major structural directions that are evident on the magnetic data and a white dashed line that indicates a structural direction visible only on the electromagnetic data.

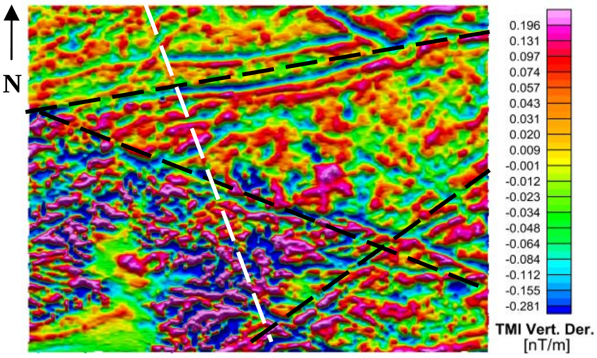

Figure 5: Total Magnetic Field Vertical Derivative.

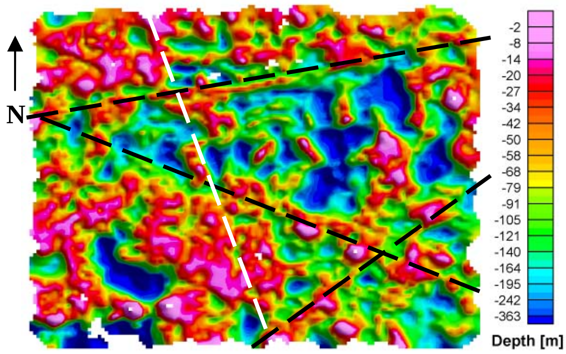

Figure 6: Contour map of depths to magnetic sources, generated with USGS Euler deconvolution (Phillips, 2007).

The NW–SE trending line falls on a fault and associated dyke that roughly splits the survey area into a northern and southern half. The basement depth is shallower on the southern side; visible on both the conductivity-depth and Euler-depth solutions. In addition the EM data indicate a conductive layer (interpreted as amphibolite and/or schist) in the north that is dipping to the east and elevated on the western side of the white line. There are also a number of deep (250m – 350m) basement conductors visible in the south-western corner of the survey area that are associated with large structural features and form promising exploration targets.

CONCLUSIONS

An airborne geophysical survey was done in north-eastern Namibia to map a sand-covered area in the Damara Metamorphic Belt. A combination of TDEM and magnetic data were acquired and processed to yield sub-surface information to depths of roughly 450m. This allowed the development of a first phase structural and lithological model of the project area.

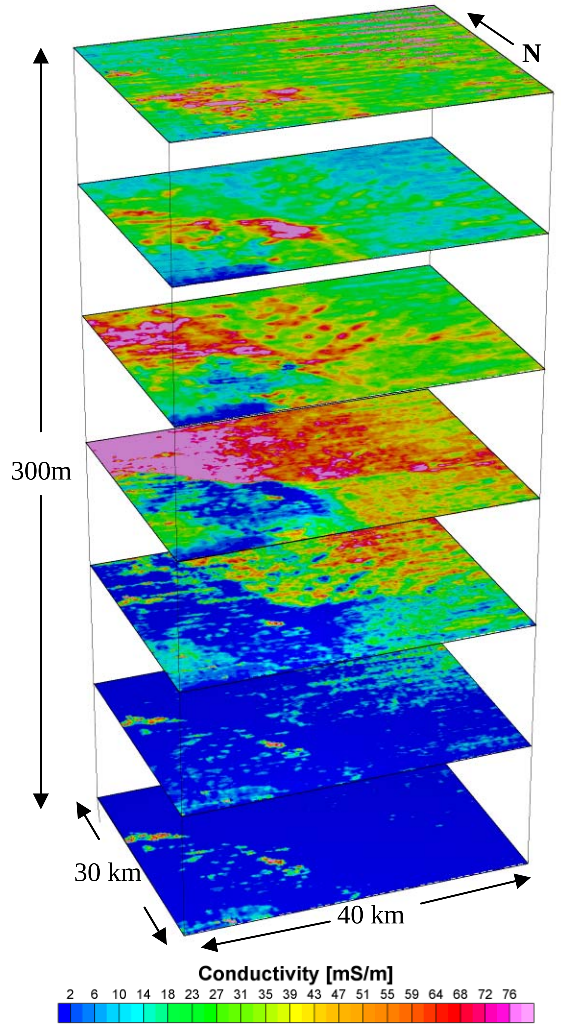

Figure 7: Stacked conductivity contour maps at 50m depth intervals, from 50m to 350m below surface. Conductivity-depth information was obtained from dB/dt VTEM data.

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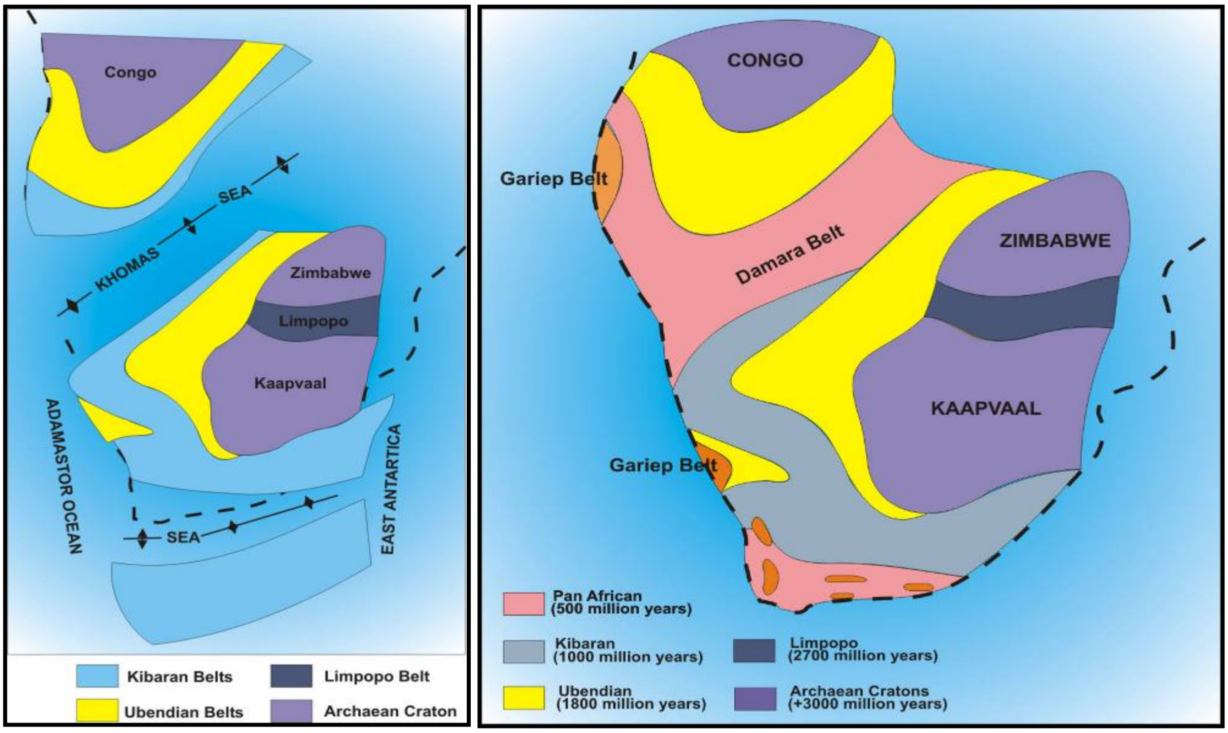

(a) **(b)**

Figure 1. A simplified illustration of the forming of the Damara Metamorphic Belt (after McCarthy and Rubidge, 2005)

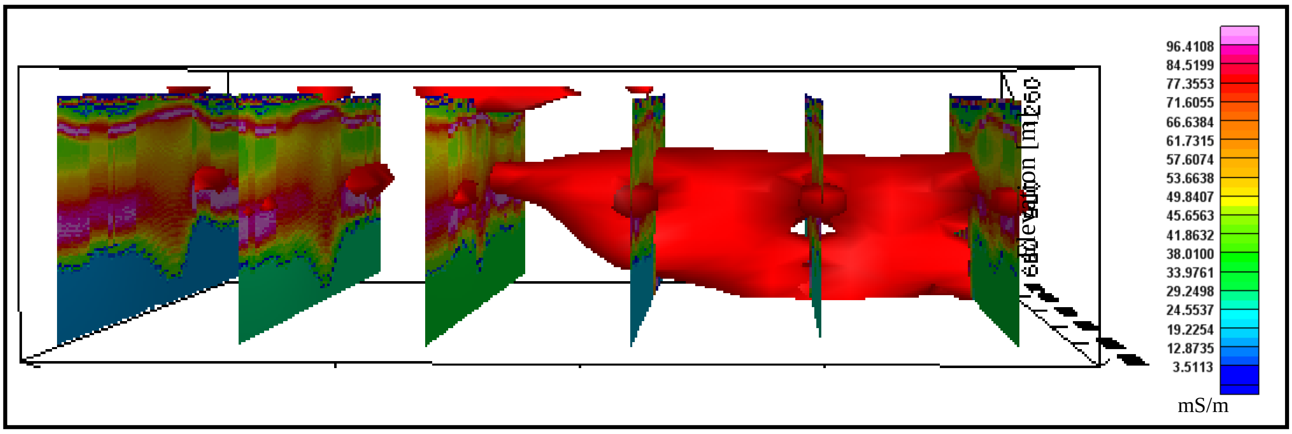

Figure 3. Stacked CDI and conductivity iso-surface (80mS/m) presentation of B-field data.