First 3D modelling of the sub-surface of east-central Namibia using combining geophysics with distal geological data

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BIOGRAPHY

Chloé Burney completed her university studies in 2010 receiving a Master's degree from the Institute of Earth Physics in Paris (geology studies with a major in geophysics). She is employed by Intrepid Geophysics in various roles including geophysical processing, 3D geology modelling and software training.

SUMMARY

The Damara Belt Inland Branch, located in north-east Namibia, is obscured by variable thicknesses of Tertiary cover comprised of Kalahari Formation and Namib Group (70-0 Ma). Currently none of the geological maps available describe the geology beneath cover in this area.

The challenge of this project is to create a 3D geology model of the Damara Belt Inland Branch using knowledge gained from geophysics (magnetics and EM), and from the structural geology trends of the Damara Belt where it is exposed to the south-west.

Key words: 3D Geological Model, Damara Belt, Geophysics, Magnetic.

INTRODUCTION

The Geophysics Division has embarked on its country-wide interpretation of world-class airborne magnetic and radiometric geophysical data in 2012. This integrated interpretation of geophysical data sets started with the successful Karas Interpretation project, whereby the geophysical data of the Karas Region was prepared, analysed and interpreted by Geological Survey of Namibia (GSN) geophysicists and geologists over a period of 18 months in co-operation with the Council for Geoscience, Pretoria, South Africa.

The experience and interpretation techniques gained during the Karas Interpretation identified that additional specialized software and computer-based 3D modelling and rendering should be applied. The application of these new techniques required specialist training on data selection and preparation, 3D modelling, interpretation, map production and reporting.

To this end, it was decided to invest in 3D modelling using the GeoModeller software package exclusively developed by Intrepid Geophysics. This step was taken to:

- Derive maximum benefit from the vast digital geoscientific data sets housed at the GSN;
- Develop 3D models of the sub-surface Namibian geology;
- Build significant human resource capacity within the GSN across various disciplines.

Following an intensive training program on GeoModeller conducted at the GSN, the Geophysics Division and Intrepid Geophysics embarked on an ambitious project to develop the first ever 3D model of the sub-surface of eastern Namibia using the full suite of geophysical and vector based geological data available at the GSN.

The area chosen for this project is not well mapped and a good choice for 3D modelling as this is where the strength of geophysical data sets and the power of 3D software can be fully utilized. A long-standing and friendly partnership between the GSN and Intrepid Geophysics, that is more than a decade old, has assisted greatly in the ease of an integrated interpretation of this project area. For this reason, it was decided that Intrepid Geophysics will take the lead in the development of the first 3D model.

This approach is part of a long term commitment on the part of the GSN to expand its competency and expertise base as well as investing greatly in human resource capacity building over the next 5 years.

Geological Context

Deposition of the Damara Sequence spanned the Neoproterozoic between at least 770 and 600 Ma (Miller 1983; Gray et al 2008; Roper et al, 2006.). The Damara Orogen is a Pan-African collisional orogen which developed between the Congo and Kalahari Cratons during the Gondwana amalgamation approximately 580-550 Ma (Figure 1). Now well exposed, the Damara Belt corresponds with the site of closure of the Mozambique and Khomas oceans.

Sediments of the Kalahari Group cover eastern and northern Namibia. They occupy sub-basins of the greater Kalahari, Owambo, Omaheke and Aranos Basins and comprise marine, fluviatile and aeolian deposits.

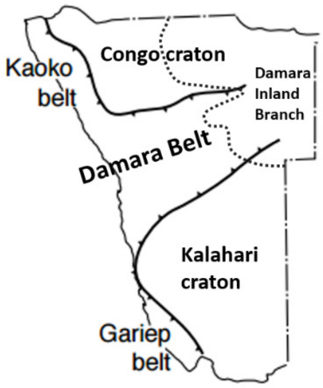

Figure 1. Schematic tectonic map of Namibia showing the Damara Belt and Inland Branch.

METHOD AND RESULTS

Model Construction

The project area corresponds to the zone between longitude 17˚5E to 21˚E and latitude 20˚S to 22˚S (Figure 2). Geological maps, the digital terrain model, and processed geophysical data from this zone were used to constrain an implicit 3D model of formation boundaries and structural geology for the Inland Damara Belt area and overlying Tertiary cover. GeoModeller software was used because it has the advantage of an integrated workspace for all available data, and creates geolocated models. The Projection System of the model and it's constraining data is WGS84/SUTM33S.

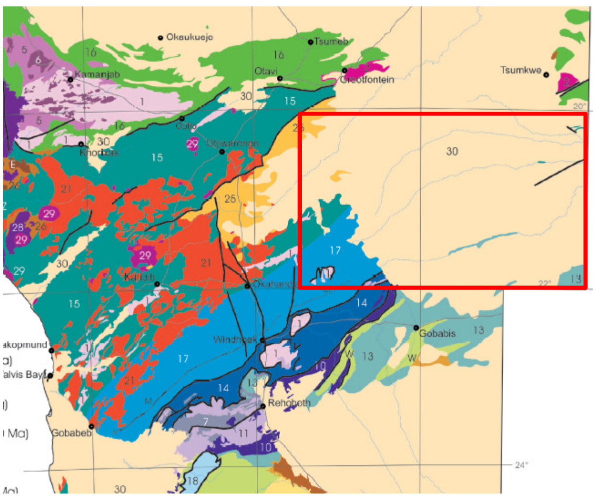

Figure 2. Simplified geological map of Namibia (modified after Mendelsohn et al., 2002) with the modelled area shown in Red.

The stratigraphic pile for the project was created combining knowledge from two geological maps and simplifying in order to create a realistic but simplified geological pile (Figure 3). Formations which are well revealed by the geophysics data were also given priority.

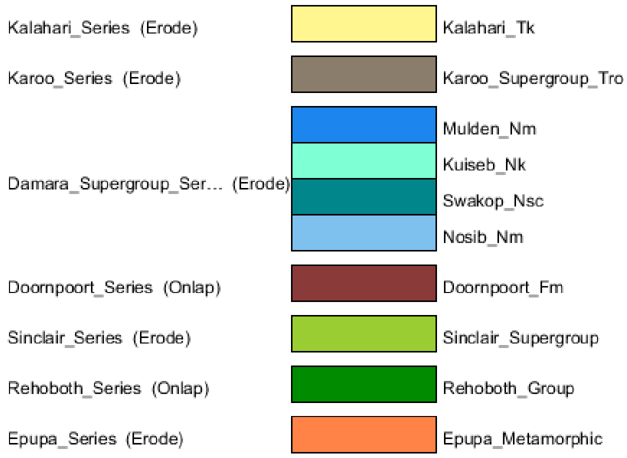

Figure 3. Stratigraphic pile of the geological model.

Geophysical Data Interpretation

Processed airborne geophysical data available from the Geological Survey of Namibia and used for the modelling are:

- Omaheke magnetic TMI
- Omaheke magnetic Reduced to Pole (RTP)
- Omaheke magnetic Analytic signal
- Omaheke magnetic Tilt Angle
- Omaheke magnetic VRTP drape 1Vd (first vertical derivative of the RTP)

The draped vertical derivative from the RTP were created to domain the magnetic signal and facilitate compartmentalization of the large-scale geological features. This enabled contouring of the structural features of the Damara Belt below the Tertiary cover.

By using variable transparency in each layered data set, the RTP could be juxaposed on the geological maps in workspace. This allowed extrapolation of the trend of the Damara thrust belt and incorporated sequences from the south-west to the north-east. In this manner, continuity of the Damara Belt under the Tertiary Cover was clearly evident (Figure 4).

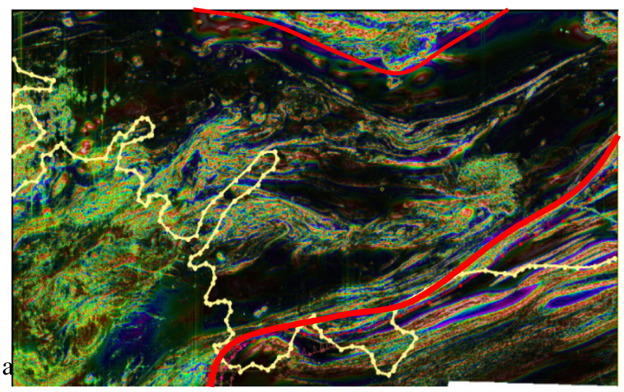

Figure 4. Magnetics (a grid of the VRTP namib_vrtp_ta_drape_asa.ers) is superimposed with the geology map. Yellow outline: limit of the Kalahari cover. Top red: magnetic limit of the Congo craton, Lower red: magnetic limit of the Kalahari craton.

Results: Preliminary Model

A preliminary 3D model of the Damara Belt Inland Branch has been achieved using knowledge gained from magnetic survey data expressing signal from geological sources under the Kalahari cover (Figure 5).

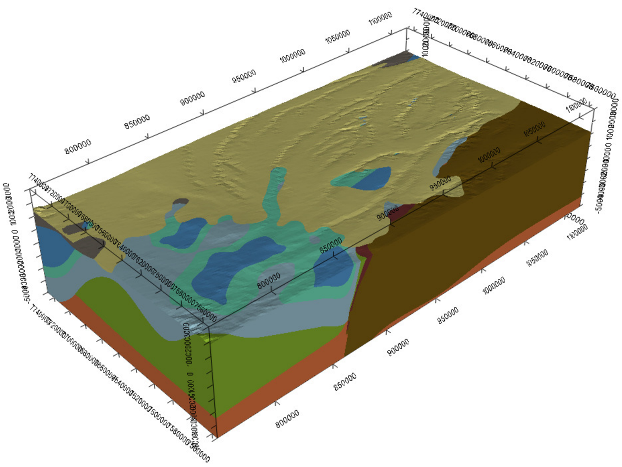

Figure 5. Preliminary 3D geological model.

Discussion

The magnetics provide good quality imagining for the fold and thrust sequences above magnetic basement (within the Karoo), albeit qualitative in the sense of indicative depths-to-sources, and dip angles. Some structures and major folds can also be identified within the Proterozoic basement, although again qualitatively.

CONCLUSIONS

A preliminary 3D geology model of the Damara Belt Inland Branch has been successfully created using geological knowledge gained from airborne magnetic data.

Further work

Next, depth converted EM sections (CDI images) will be incorporated into the model, and used to better constrain the cover thicknesses. (Revision of the model with new data can easily be accommodated.)

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