Unearthing the Xade Complex, Botswana

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SUMMARY

The Xade Complex, situated in central Botswana, is completely buried under younger cover. It was identified during the first regional aeromagnetic survey of the country in 1976. This paper presents the results of an exploration venture which has been in progress since 2005.

The Complex, as previously published, is evidenced by coincident magnetic and gravity anomalies, occurring on the margins of the Kaapvaal and Zimbabwe Cratons. It is shown here that the Complex comprises two lobes - a southern lobe (SL), and an hitherto unidentified northern lobe (NL). Forward modelling of both data sets over the SL indicates it to be a lopolithic feature. The NL is deeply buried in the northwest beneath the Neoproterozoic Passarge Basin, but its southern and eastern margins partially suboutcrop beneath Karoo sediments. Inversion depths range from 250 to 900 m beneath Kalahari and Karoo sediments, and well in excess of this beneath the Passarge Basin.

One recent and two historic boreholes in the SL reveal a sequence of basaltic lavas with subordinate gabbro. A further single historic and two recent boreholes drilled into the NL margins reveal a package of heterogeneous gabbronorites. An U-Pb zircon age of 1109.0±1.3 Ma has been published for a gabbro unit, which is coeval with the Umkondo Igneous Province.

The combined extent of both lobes of the Xade Complex is approximately one-third the size of the Bushveld Complex, making it a very large differentiated magmatic system, with Ni, Cu and PGE potential.

Key words: Xade, mafic, complex, Botswana

INTRODUCTION

The Xade Complex occurs in the Central Kalahari semi-desert of Botswana. It was initially identified in 1976 during the first regional aeromagnetic survey of the country (Reeves, 1978). Cover sequences comprise 200-900 m of Karoo Supergroup sediments and basalts, and overlying Kalahari Group sediments. Two boreholes were drilled as part of the follow-up Kalahari Drilling Project (Meixner and Peart, 1984), the one intersecting gabbronorite at 815 m and the other a weathered basalt at 419 m, passing into dolerite. The gabbronorite has yielded an U-Pb zircon age of 1109.0±1.3 Ma (Hanson *et al*., 2004), which is coeval with the Umkondo Igneous Province. The Anglo American Corporation (Ambot) subsequently held exploration licenses over the Complex as part of their Kalahari Gold Project (Ambot 1995, 1998). A borehole, drilled on a seismic line traversing the southern portion of the Complex, intersected amygdaloidal lava at 621 m, passing into dolerite and shales they assigned to the Waterberg Group. More recently, Manica Minerals Ltd has held licenses over the Complex, having drilled a further three boreholes in partnership with Mvelaphanda Resources Ltd. Manica is currently advancing exploration of the Complex in a Joint Venture with Australian company Impact Minerals Limited.

This paper presents an integrated interpretation of published documentation and advanced exploration conducted on the Complex to date. The following datasets were utilised:

- the medium resolution aeromagnetic data, acquired under contract to the Botswana Department of Geological Survey (DGS), at a 200 m line spacing;
- the latest ground gravity data provided by the DGS;
- a single reflection seismic line acquired by the Anglo American Corporation (Ambot, hardcopy);
- Time Domain Electromagnetic soundings plus detailed gravity surveys, conducted along a number of profiles selected as sites for initial drilling;
- the abovementioned three historical boreholes, and a further three drilled as part of the initial phase of the current program.

The interpretation includes:

- the compilation of a detailed sub-surface geological map of the Complex, showing both structure and lithological zonation, using the aeromagnetic data and filter products thereof;
- determination of depths to the top of the complex from the aeromagnetic data, using 2D Euler deconvolution;
- forward modelling of the aeromagnetic and gravity data along the ground profiles;
- a more regional aspect, placing the Xade Complex within a cratonic setting.

INTERPRETATION METHODS AND RESULTS

The DGS Total Magnetic Intensity aeromagnetic data, with a 50 m grid interval, were Reduced-to-the-Pole (RTP). Filter products thereof that were used in the interpretation included *inter alia,* the First Vertical Derivative, Analytical Signal, Tilt Derivative and the Total Horizontal Derivative, the latter

being used as an aid to contact mapping. An image of the RTP data is shown in Figure 2. A Gaussian Residual image of the DGS Bouguer gravity data is shown in Figure 3. The Euler deconvolution software for (2D) profile analysis, of Professional Geophysical Software (Cooper, pers. comm.), was used to determine depths. A total of 65 grid profiles were extracted across the magnetic anomalies of the Complex, at right angles to strike. The DGS gravity data, although too coarse for detailed mapping, served a valuable purpose for confirming the extent of the Complex, and for the modelling which incorporated ground gravity profiles.

What is generally viewed as being the Xade Complex, as also reported on in the given references, is the high amplitude kidney-shaped zoned main magnetic anomaly with two semi-linear anomalies extending to the northwest and northeast in a Y formation (Figures 1,2,3). The present geophysical mapping interprets the zoned kidney-shaped anomaly as being a **Southern Lobe** (SL) of a larger Xade Complex (Figure 1). The semi-linear anomalies forming the upper limbs of the Y formation to the north are interpreted to be the sub-Karoo margins of a **Northern Lobe** (NL). However, the major extent of the NL occurs beneath a thick pile of sediments within the Neoproterozoic Passarge Basin, as evidenced by deep magnetic and gravity anomalies to the northwest (Figures 1,2,3). The SL lobe is clearly zoned magnetically. Forward modelling, of both magnetic and gravity data along a section across the SL, indicates that it is a lopolithic feature with a depth extent of approximately 4 km (Figures 1,4). The modelling suggests a possible central feeder at depth. Forward modelling across the southeast margin of the NL confirms westerly dips, consistent with a deepening to the northwest.

The Euler deconvolution depth analysis revealed a cover thickness, including both Kalahari and Karoo strata, varying over the SL from 300 to 900 m, and from 250 to 800 m over the southeastern margin of the NL. Depths of the NL beneath the Passarge Basin have not been determined but are expected to be well in excess of 2 km based on results published for the Nosib Basin to the west.

The three boreholes drilled into the Southern Lobe to date indicate that it comprises a sequence of basaltic lavas, with subordinate gabbro (Figures 1,2,3,4). Borehole CKP6A, drilled during the Kalahari Drilling Program (KDP), intersected weathered basalt at 419 m, and terminated in dolerite at 443 m. Borehole XD09-01, drilled during the current program, intersected highly magnetic heterogeneous basaltic lavas with subordinate gabbro from 435 to 968 m. Drill core dips support the modelled lopolithic form. Borehole XH1 drilled by Ambot (1995, 1998) intersected amygdaloidal lavas at 621 m.

The three boreholes drilled into the Northern Lobe margins to date (Figures 1,2,3,4), i.e. KDP borehole CKP6, and boreholes XD09-02 & 03 (current program), indicate that the NL comprises, in part, an extremely heterogeneous sequence of gabbronorite. Monzodiorite was also intersected.

Subsequent to the commencement of our exploration program and the interpretation presented here, Pouliquen and Key (2007) independently published a modelling interpretation of the Xade Complex. This was based on an inversion of the DGS gravity data along the Ambot seismic line (Figure 1), through borehole XH1. Their model and derived depths are consistent with our modelling, although less constrained than that shown in Figure 4 due to their primary use of the gravity data, and the potential density variability.

The SL is situated on the Kaapvaal Craton, at its northern margin, whereas the NL straddles the Kaapvaal margin, extending over the Damara-Ghanzi-Chobe Belt, and eastward across the Zimbabwe Craton margin. A feeder dyke system has been identified. The combined extent of both lobes of the Xade Complex is approximately one-third the size of the Bushveld Complex, making it the largest Midproterozoic differentiated magmatic system in southern Africa.

CONCLUSIONS

Historical work on the Xade Complex has been limited, with only 3 boreholes having been drilled. This ongoing study has shown, for the first time, that the Complex comprises two lobes of potentially different magmatic character. Magnetic lithologies and structure associated with the Complex have been mapped in as much detail as current airborne and ground data will allow, giving focus to future exploration.

The cratonic setting of the Xade Complex, its Midproterozoic age, and its total extent of approximately one-third the size of the Bushveld Complex, hallmark it as a very large differentiated magmatic system, with potential for Ni, Cu and PGE mineralization.

ACKNOWLEDGMENTS

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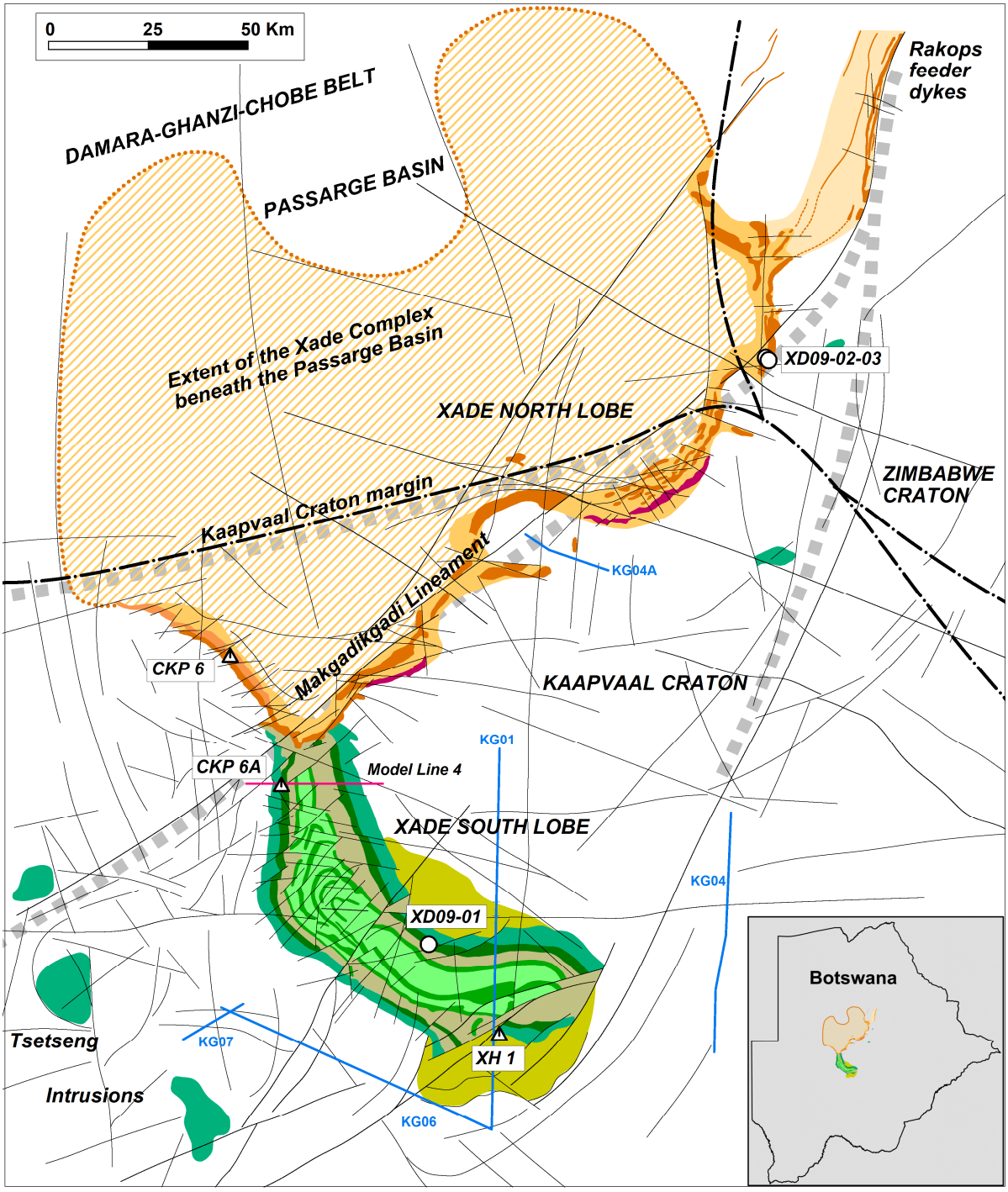
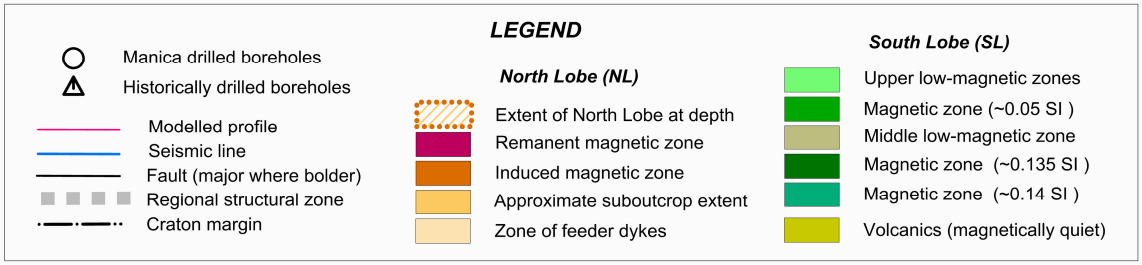


Figure 1. Sub-surface map of the Xade Complex interpreted from the aeromagnetic, ground gravity, and drilling data. The Southern and Northern Lobes are coloured in shades of green and brown respectively. The location of the Complex within Botswana is given to scale in the insert. The Legend is given below.



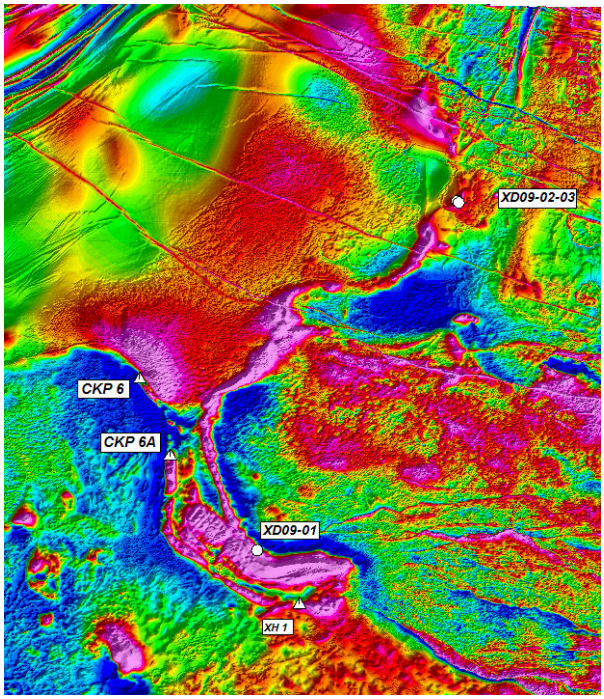


Figure 2. Reduced-to-the-Pole aeromagnetic image (compiled from DGS 200 m line spaced data).

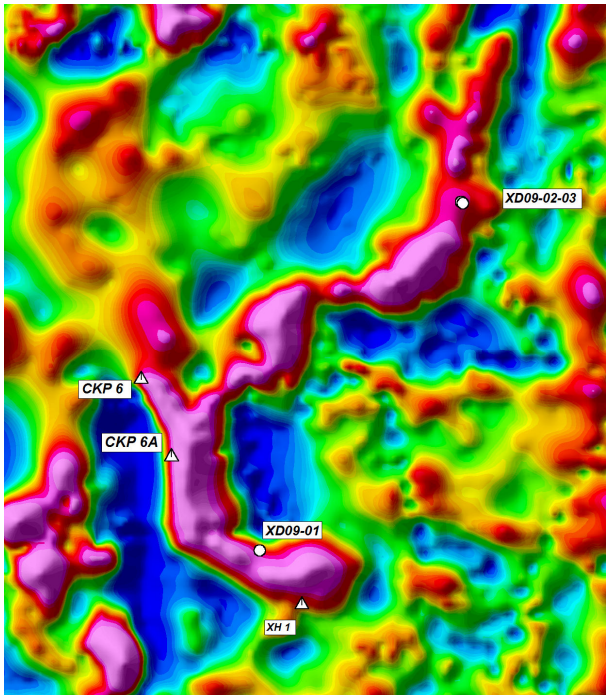


Figure 3. Residual Bouguer Gravity image (DGS ground data).

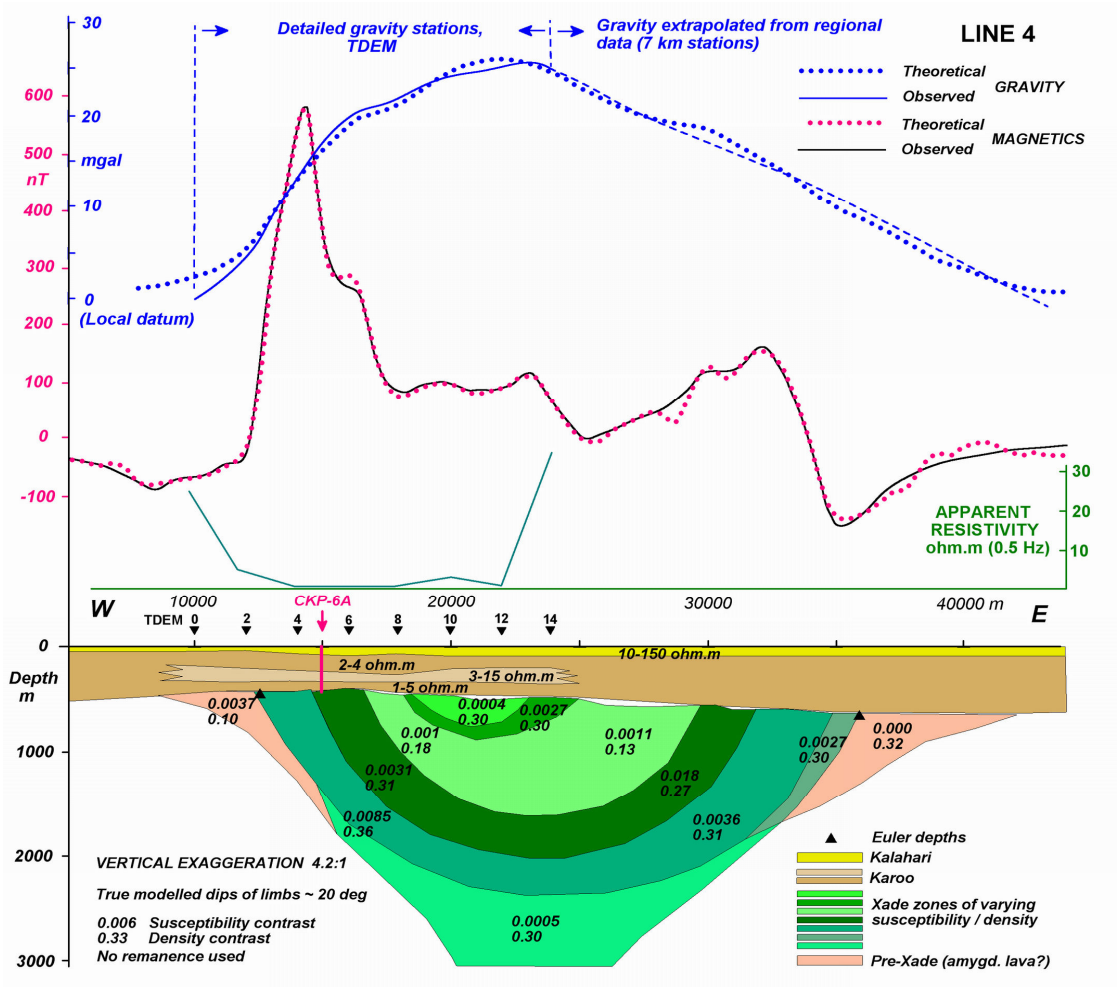


Figure 4. Forward magnetic and gravity model of Line 4 (see Figure 1 for locality), showing the lopolithic structure.