

TITLE: EXPLORATION OF THE XADE COMPLEX, BOTSWANA

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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 gabbro-norite at 815 m and the other weathered basalt at 419 m, passing into dolerite. The gabbro-norite 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 1998). A single Ambot borehole, drilled on a seismic line traversing the southern portion of the Complex, intersected amygdaloidal lava at 621 m, passing into dolerite and shales assigned to the Waterberg Group. More recently, Manica Minerals Ltd has held licenses over the Complex, having initially drilled a further three boreholes in partnership with Mvelaphanda Resources Ltd. Exploration of the Complex is currently being advanced in a Joint Venture with Australian company Impact Minerals Limited which has earned a majority share in the project. The current phase of exploration, still in progress, has included aeromagnetic re-flying of a selected target area at a high resolution, extensive geochemical surveying using MMITM technology, trial high temperature SQUID time-domain electromagnetic profiling (HTS TDEM), and the drilling to date of a further two deep boreholes. The current target area encompasses a possible feeder (or exit) dyke system and its entry zone into the complex.

This presentation discusses the exploration that we have conducted on the Complex to date. Results of the HTS TDEM trial study are presented in a separate paper in this volume. The datasets used, as presented here, included: (1) the medium resolution aeromagnetic data of the Botswana Department of Geological Survey (DGS; line spacing 200 m); (2) high resolution gradiometer magnetic data acquired under contract to Impact (line spacing of 150 m, height 20 m) over the interpreted feeder zone target area; (3) DGS ground gravity data; (4) a reflection seismic line acquired by Ambot (hardcopy); (5) an early phase of TDEM soundings and detailed ground gravity data, acquired along a number of profiles; (6) MMITM soil geochemical data; and (7) all borehole data, including 3 historical holes and the 5 completed to date in this study.

The interpretation presented here includes: (1) the compilation of a detailed sub-surface geological map of the Complex, and possible feeder zone, showing both structure and magnetically evident lithological zonation; (2) the determination of depths to the top of the Complex applying 2D Euler deconvolution to the aeromagnetic data; (3) forward modelling of the aeromagnetic and gravity data along selected ground profiles; and (4) a regional aspect, placing the Xade Complex within a cratonic setting, with parallels to economic mineral deposits elsewhere.

INTERPRETATION METHODS AND RESULTS: Filter products of the DGS Total Magnetic Intensity data and high resolution gradiometer data (reduced-to-the-pole, RTP, Figure 1), included *inter alia*, First and Second Vertical Derivatives, spectral filters, Analytical Signal, Tilt Derivative and the Total Horizontal Derivative. Euler deconvolution software for (2D) profile analysis (Professional Geophysical Software; Cooper, pers. comm.) was used to determine depths. For this purpose, over 100 grid or line 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. Forward modelled sections incorporated both the magnetic data and 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 magnetic anomaly with two semi-linear anomalies extending to the northwest and northeast in a Y formation (Figures 1, 2). The present geophysical mapping (Figure 2) interprets the zoned kidney-shaped anomaly as being a **Southern Lobe** (SL) of a larger Xade Complex. 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 to the north occurs beneath a thick pile of sediments within the Neoproterozoic Passarge Basin, as evidenced by deep magnetic and gravity anomalies. The SL lobe is clearly zoned magnetically. Forward modelling of two profiles across the SL, indicates that it is a lopolithic feature with a depth extent of approximately 4 km. Forward modelling of 5 profiles across the southeast margin of the NL confirms westerly dips, consistent with deepening to the north and northwest. The possible **feeder dyke system**, roughly 12 km in width, identified in the initial interpretation, comprises the known Rakops (Mopipi) dyke as well as two further dyke swarms to the west thereof (Figure 2). This system, together with its entry zone into the eastern margin of the NL, constitutes the current target area of focus. The high resolution data allowed both significant refinement of the initial interpretation, and improvement of filtering out of the masking effects of the Karoo basalts where present. Portion of this area was geochemically surveyed using MMITM technology. Three trial HTS TDEM sounding profiles were completed in this area, close to magnetically modelled lines, and a further two deep boreholes have been drilled to date.

The Euler deconvolution depth analysis revealed a cover thickness, including both Kalahari and (largely) Karoo strata, varying over the SL from 300 to 900 m, from 250 to 800 m over the southeastern margin of the NL, and from 100 to 600 m over the feeder dyke zone and its entry into the NL. Depths of the northern portion 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. 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, here defined as the SL. This was based on an inversion of the DGS gravity data along the Ambot seismic line (Ambot 1998). Their model and derived depths are consistent with our modelling.

The three boreholes drilled into the Southern Lobe to date (Figures 1, 2) indicate that it comprises a sequence of basaltic lavas, including a highly magnetic upper sequence and a lower sequence of magnetically quiet amygdaloidal lavas. Subordinate gabbro and dolerite was also intersected. Drill core dips support the modelled lopolithic form. The five boreholes drilled to date into the NL (Figures 1, 2), indicate that the NL comprises, in part, an extremely heterogeneous sequence of gabbro-norite, with monzodiorite also having been intersected. One of holes intersected magnetic amygdaloidal basalt. The SL is situated on the Kaapvaal Craton, whereas the NL straddles the northern Kaapvaal margin, extending under the Damara-Ghanzi-Chobe Belt, and eastward across the Zimbabwe Craton margin. The combined extent of both lobes 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 was limited to 3 boreholes. The present study has shown, for the first time, that the Complex comprises two lobes of similar basaltic, but potentially variable intrusive, magmatic character. Structure and magnetic lithologies have been mapped in as much detail as the data will allow, giving focus to a possible feeder dyke system which is the area of interest in the current exploration program. The craton margin setting of the Xade Complex, its size, and Midproterozoic age, hallmark it as a very large differentiated magmatic system, with potential for Ni, Cu and PGE mineralization.

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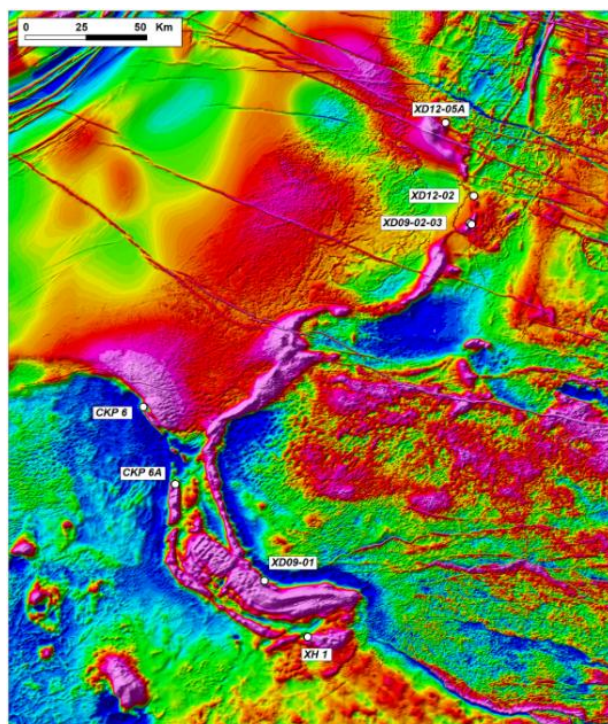


Figure 1. Xade Complex. Total magnetic intensity (RTP), showing historic and current boreholes

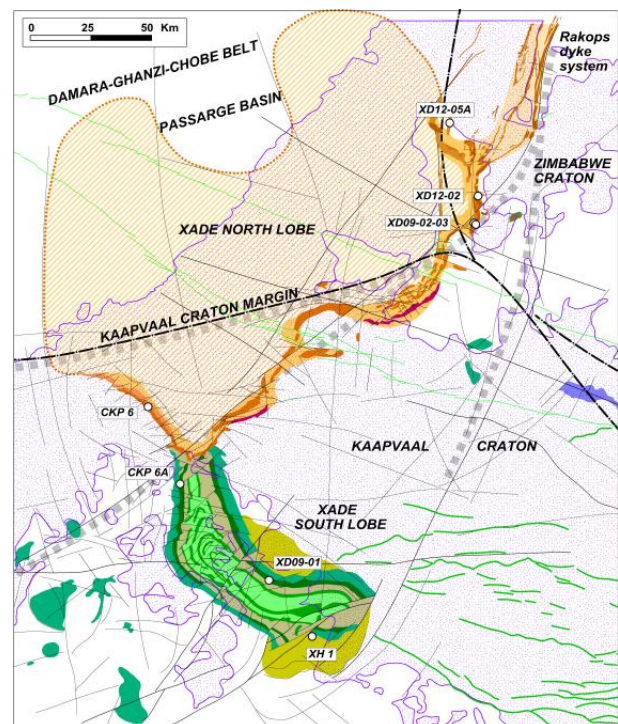


Figure 2. Xade Complex. Interpreted North and South Lobes

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