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Review

Regional aeromagnetic and stratigraphic correlations of the Kalahari Copperbelt in Namibia and Botswana

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ABSTRACT

The late Mesoproterozoic to Neoproterozoic Kalahari Copperbelt (KCB) in Namibia and Botswana is widely covered by Kalahari sand, which precludes direct correlations between known stratabound sediment-hosted Cu–Ag districts. We use a combination of review of literature data, and newly processed and interpreted high-resolution aeromagnetic maps in both countries to provide a new correlative cross-border interpretation. Lithostratigraphic control on the aeromagnetic response allows detailed indirect mapping of the Kalahari Copperbelt lithotectonic domains below the sand cover. This enabled us to redefine the width and lateral extent of the KCB as two continuous magnetic domains (the Rehoboth and Ghanzi–Chobe domains) extending from central Namibia to northern Botswana, and helped in resolving problems of stratigraphic correlations across the international border.

The Rehoboth magnetic domain, in the western part of the KCB in Namibia, records continental arc magmatism at ~1200 Ma during orogenic events along the northwestern edge of the Kalahari Craton. This was followed at 1110–1090 Ma by widespread magmatism, identified within the entire KCB, and related to the 1112–1106 Ma Umkondo Large Igneous Province. The basal parts of the Tsumis Group in Namibia and Ghanzi Group in Botswana were deposited in shallow-water environments after a period of erosion and peneplanation. Subsequently, and prior to the Sturtian glaciation, the host-rocks of the Cu–Ag deposits formed by the deposition of chemically reduced shales and siltstones that formed in deeper water and overlie chemically oxidised shallow-water sandstones. This regional interface, which is both a permeability barrier and redox boundary, played a critical role in the formation of the stratabound sediment-hosted Cu–Ag deposits of the Kalahari Copperbelt, and the interface, with its strong magnetic contrast, can be followed through the entire Ghanzi–Chobe magnetic domain of the copperbelt. The whole KCB was affected by the Damara Orogeny during early Cambrian times, which resulted in the formation of a NE–SW trending ~250 km-wide fold-and-thrust belt.

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1. Introduction

The Kalahari Copperbelt, a 1000 km long by up to 250 km wide NE-trending Meso- to Neoproterozoic belt, extends discontinuously from western Namibia (Sinclair Supergroup) to northern Botswana (Kgwebe Formation and Ghanzi Group) along the NW edge of the Palaeoproterozoic Kalahari Craton (Fig. 1) (Borg and Maiden, 1989; Maiden and Borg, 2011). It contains copper–silver deposits that are generally stratabound (i.e. restricted to a particular part of the stratigraphic column, Evans and Moon, 2006, and that may or may not be strictly conformable with bedding, Bates and Jackson, 1980) and hosted in Meso- to Neoproterozoic metasedimentary rocks that have been folded and metamorphosed to greenschist facies during the late Neoproterozoic–Cambrian Pan-African Damara Orogeny (Borg and Maiden, 1989).

Whereas the belt in western and central Namibia is relatively well-exposed, eastern Namibia and most of Botswana are covered by the late Carboniferous–middle Jurassic Karoo Supergroup and Cenozoic Kalahari sand and calcrete (Catuneanu et al., 2005; Haddon and McCarthy, 2005). In addition to the lack of exposure, the paucity in age constraints on the sedimentation precludes direct lateral correlations across the international border (Borg, 1988a; Kampunzu et al., 1998; Ramokate et al., 2000; Watters, 1976). In Botswana, the geology below the Kalahari cover had been extrapolated from a few inliers using aeromagnetic data interpretation and sparse drillholes which resulted in the publication of the 1:1,000,000 scale pre-Kalahari geological map of Botswana (Key and Ayres, 2000). These data were subsequently integrated into the 1:2,500,000 scale sub-Kalahari geological map of southern Africa (Haddon, 2001). In Namibia however, such sub-cover mapping has not been edited and the correlations with the geology of Botswana rely on the 1:2,500,000 scale sub-Kalahari geological map (Haddon, 2001), and on geological inferences in the 1:1,000,000 scale Geological Map of Namibia (Miller and Schalk, 1980). In those maps, the Ghanzi Group is represented as the lateral equivalent of the Neoproterozoic Damara Supergroup, a well-dated sequence that is stratigraphically younger than the Sinclair Supergroup in the Rehoboth Subprovince (Fig. 1). On the other hand, various correlative interpretations based on Rb–Sr ages, multigrain U–Pb zircon ages, and sedimentological and chemical data have been published. They include correlation of the Kgwebe Formation with volcanic rocks of the Sinclair Supergroup (Kampunzu et al., 1998; Schwartz et al., 1996; Toens, 1975), and of the Ghanzi Group with either the lower part of the Damara Supergroup (Haddon, 2001; Kampunzu et al., 1998; Ramokate et al., 2000; Schwartz et al., 1996) or with the upper group of the Sinclair Supergroup (the Tsumis Group, Borg and Maiden, 1987). These different interpretations on cross-border correlations are presented in Fig. 2.

The interest in the geology and spatial extent of the Kalahari Copperbelt has been renewed over the last 10 years since the development of the Boseto copper mine in Botswana (Fig. 1), and the recent discovery of new high-grade occurrences which have been intersected in both Namibia and Botswana (e.g. 2.76% Cu and 89 g/t Ag over 7 m in eastern Namibia, Enders, personal communication).

In this contribution, we present an integrated study in both countries based on a comprehensive compilation of published zircon ages of magmatic and sedimentary rocks and a summary of existing lithostratigraphic descriptions. The spatial continuity of newly defined lithotectonic domains below cover and across the Namibia–Botswana border was inferred using processed high-resolution (200–250 m flight line spacing) aeromagnetic maps. The important lithological control on the aeromagnetic signatures enabled detailed indirect mapping of the units constituting the Kalahari Copperbelt using total magnetic intensity (TMI), reduced-to-pole (RTP), first vertical derivative (1VD), total horizontal derivative (THDR) and analytical signal aeromagnetic maps. Together with the palaeogeographic and chronological correlations, the continuity of these lithotectonic domains from Namibia to northern Botswana across the Namibia–Botswana border allows revision of existing tectonic models for the formation of the Meso- to Neoproterozoic rocks that host the Kalahari Copperbelt.

2. Lithostratigraphy of Meso- to Neoproterozoic rocks in Central Namibia

Meso- to Neoproterozoic rocks in Central and South Namibia crop out in the Konkiep and Rehoboth subprovinces (Fig. 1). Mesoproterozoic rocks are also locally found structurally below the Neoproterozoic rocks of the Damara Supergroup in the Damara Belt. In the Konkiep Subprovince, the rocks of the basal Sinclair Supergroup are unmetamorphosed and undeformed whereas the crust of the Rehoboth Subprovince has been highly deformed at greenschist facies during the Pan-African Orogeny with muscovite and chlorite defining a slaty cleavage in the metapelites that host the mineralisation (Becker et al., 2006; Borg and Maiden, 1987).

2.1. Rocks of Pre-Sinclair Supergroup age

The basement of the oldest peri-Kalahari Craton Mesoproterozoic rocks in Central Namibia is of Palaeoproterozoic age (Becker et al., 2004; Van Schijndel et al., 2011). Pre-Sinclair Supergroup Mesoproterozoic rocks are represented by the Kairab Formation and the Aunis Tonalite in the Konkiep Subprovince and the Billstein Formation in the Rehoboth Subprovince. The Kairab Formation is composed of mafic and felsic