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Tectonostratigraphic evolution of an inverted rift basin inferred from multi-scale aeromagnetic and gravity datasets: a case study from the Ghanzi Ridge portion of the Kalahari Copperbelt, Botswana

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The Kalahari Copperbelt (KCB) in Namibia and Botswana represents an inverted, northeast-southwest trending, Meso- to Neoproterozoic rift basin on the northwestern margin of the Kalahari Craton. The tectonic evolution of this rift basin remains poorly understood due to extensive Kalahari sand cover. The Ghanzi Ridge area of Botswana is the current focus of exploration and development of copper-silver deposits in the KCB. Regional exploration drilling targeting Cu-bearing metasedimentary rocks of the Ghanzi Group and an array of regional- and district-scale high-resolution aeromagnetics, ground magnetics, and gravity surveys make this a key site for developing a framework for the tectonostratigraphic evolution of the rift basin. High-resolution aeromagnetic datasets (75 x 750m line spacing) combined with processing of traditional filters (RTP, AS, VD1) allow for mapping and interpretation of gross structure and stratigraphy within the belt. Application of a second total horizontal derivative filter provides a high resolution dataset that allows definition of magnetostratigraphic form lines and architectural details within the sedimentary succession such as downlap, onlap, toplap, truncation, and unconformable surfaces, which can be utilized for sequence stratigraphic interpretation and inference of tectonostratigraphic relationships.

In the vicinity of the Kgwebe Hills, the magnetostratigraphic architecture of the Ngwako Pan Formation shows significant lateral thickness changes including near stratigraphic pinch-outs, and form lines that onlap the unconformably underlying Kgwebe Formation in both the southwest and northeast, suggesting that a sub-basin flanked by paleotopographic highs formed in this area. The magnetostratigraphic architecture of the underlying Kgwebe Formation and overlying syn-rift fill resemble a half-graben structure characterized by normal faults, subsidence, and probable alluvial fan deposits on the southwest margin and coeval uplift on the northeast margin. The fulcrum point for block tilting is inferred to occur where form lines in the upper Ngwako Pan Formation changeover from conformable surfaces to truncations, reflecting continued uplift and erosion/redistribution of previously deposited sediments in the northeast. Similar magnetostratigraphic characteristics and inferred half-graben features are repeated on the northeastern end of the Kgwebe Hills and along strike to the southwest in the Ngunaekau and Mabeleapodi Hills. However, stratigraphic thickness changes are less prevalent and stratigraphic pinch-outs do not appear to be present in these areas.

The Ngwako Pan-D'Kar formation contact represents a major basin-scale flooding surface. Areas where the contact truncates underlying form lines indicate an erosional wave ravinement surface. Form lines within the lower D'Kar Formation appear conformable to the southwest of the paleotopographic high located on the northeastern flank of the Ngunaekau Hills. An apparent increase in stratigraphic thickness and offlapping form lines that downlap the regional contact occur to the northeast of this; the overall geometry is suggestive of a progradational to aggradational wedge composed of deltaic clinothem sets. Observed stratigraphy within drill holes indicates a transition from delta front deposits in the southwest to prodelta cyclothems and finally basinal deposits and/or condensed sections to the northeast in the vicinity of the Zeta Cu-Ag deposit. The abrupt thickness and facies changes suggests that normal faulting may have been active during deposition of the lowermost D'Kar Formation. Although further analysis is needed to constrain the orientation of the proposed normal faults, post-inversion north-northeast trending faults with apparent strike-slip displacement transect the basin along the same corridors of the proposed normal faults. These faults appear to follow major linear boundaries formed between regions of contrasting high and low gravity anomalies observed in regional Bouguer anomaly gravity surveys, suggesting a major basement control the fault architecture.