Utilizing High-Resolution Aeromagnetic Datasets for Sequence Stratigraphic Analysis of the Kalahari Copperbelt, Botswana and Namibia, and Implications for Sedimentary Rock-Hosted Cu-Ag Mineralization

Wesley S. Hall,[1,*] Piret Plink-Bjorklund,[1] Murray W. Hitzman,[1] Yaoguo Li,[1] Bruce D. Trudgill,[1] and M. Stephen Enders[1,2]

[1]Colorado School of Mines, Golden, Colorado 80401
[2]Cupric Canyon Capital, Scottsdale, Arizona 85258

*E-mail, whall@mines.edu

The Ghanzi basin, hosting Cu-Ag deposits of the Kalahari Copperbelt, is one of several Meso- to Neoproterozoic sedimentary basins on the western and northern margins of the Kalahari craton. Initial rifting at approximately 1.1 Ga resulted in emplacement of the Kgwebe Formation bimodal volcanic rocks. Faulting and basin formation resulted in deposition of continental red bed clastic rocks of the Ngwako Pan Formation, which are in turn overlain by mixed marine siliciclastic-carbonate rocks of the D'Kar Formation. The basin underwent inversion during the Pan-African (600–480 Ma) Damara orogeny. The area is presently covered by Cenozoic to recent Kalahari Group sediments with little outcrop of the Paleozoic sequence.

Mineralization in the district appears to have occurred both during diagenesis, as vertically and laterally zoned disseminated sulfide grains within the basal D'Kar Formation, and again during basin inversion as structurally controlled sulfides within the basal D'Kar and uppermost Ngwako Pan formations. Examination of drill holes from throughout the belt suggests that the D'Kar Formation (1) acted as an impermeable trap for migrating diagenetic mineralizing fluids, (2) provided sufficient sulfur for the system in the form of diagenetic pyrite, (3) provided a stratigraphic seal for mobile reductants during inversion, and (4) provided a rheological contrast with the underlying sandstones of the Ngwako Pan Formation during subsequent flexural slip deformation, which allowed for focusing and trapping of metamorphogenic hydrothermal fluids. It appears that areas with increased thicknesses of reduced mudstone-siltstone and/or carbonate rocks in the basal D'Kar Formation are most favorable for the development of significant copper deposits.

Recently acquired high-resolution aeromagnetic datasets (75 × 750-m line spacing) combined with processing of traditional filters (RTP, AS, VD1) allow for mapping and interpretation of gross structure and stratigraphy within the belt. The Ngwako Pan-D'Kar formations contact is readily interpreted from the contrasting magnetic susceptibility signature between the hematitic (oxidized) and pyritic (reduced) rocks. Application of a second total horizontal derivative filter provides a high resolution dataset that allows definition of magnetostratigraphic architectural details within the succession such as truncation, downlap, onlap, and toplap surfaces. The Ngwako Pan-D'Kar formation contact is characterized by truncation of the underlying sandstone units, indicating a regional-scale, transgressive, wave ravinement/flooding surface. The D'Kar Formation is characterized by several transgressive-regressive deltaic clinothem sets that downlap the regional contact and prograde along the basin axis from southwest to northeast. Deep-water channel forms within the D'Kar Formation suggest the presence of slope-to-floor turbiditic distributary channel complexes. Areas containing thicker, coherent, mudstone-siltstone and/or carbonate strata correlate to condensed sections in the magnetostratigraphy, which often contain abundant diagenetic pyrite and commonly act as both a source and reservoir rock in hydrocarbon basins. Mapping of these relationships allows for a sequence stratigraphic interpretation and provides a powerful tool for evaluating the tectonostratigraphic evolution of the basin. Ongoing research involves creation of regional sections from inversions of the aeromagnetic data and construction of three-dimensional models, which yield data similar to 3-D seismic surveys used in the hydrocarbons industry.