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Interpreting Basin Processes at Local and District Scales Using Aeromagnetic Surveys Combined with Soil and Drill Hole Geochemistry

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The Neoproterozoic Central African Copperbelt located in southern region of the Democratic Republic of Congo (DRC) and the northwestern Zambia contains 48% of the world's cobalt reserves and significant resources of copper, zinc, nickel, and gold. The energy-critical elements are hosted in the Katanga Supergroup carbonate and siliciclastic metasedimentary rocks which were deposited in an epicontinental basin formed during the breakup of Rhodinia and subsequently inverted. Multiphase hypogene mineralization in the Katangan basin occurred over a time frame of >300 million years linked to basin rift and inversion events and salt evacuation and dissolution.

This study uses early-stage exploration data (soil geochemistry and airborne geophysical survey) to understand sedimentary basin processes and target first pass drilling more effectively. Integrated multielement geochemistry and high-resolution airborne magnetic surveys are used as a mapping tool. The syn- and postsalt sediments are divided into prehalokinematic, synhalokinematic, and posthalokinematic strata by tracking unconformities observed in the aeromagnetic data. Chemo marker horizons delineated from soil geochemistry surveys further refine stratigraphic mapping. In addition to mapping stratigraphic units and lithology, it is possible to detect facies changes. This data can be used to interpret the structural development of local sub-basins created by rifting and/or halokinematics.

The mapping technique was developed in the southern Congolese Copperbelt terrane, which covers the Mwashya Subgroup and the Nguba and Kundelungu groups. The study area has poor surface exposure, but is covered by high-resolution geophysical surveys, stratigraphically extensive drill hole coverage, and robust multielement sampling of drill holes and soil surveys. Geochemical and lithofacies logging of drill holes provides "ground truthing" for the soil geochemical data sets and allows documentation of facies and sediment provenance changes during sedimentation of the original sedimentary sequence. This method has been applied to a second location in the Central Copperbelt terrane, covered by lower-resolution geophysical surveys, a widely spaced soil geochemical survey, and extensive drill hole coverage of the Mines Subgroup but limited drill hole intersections outside the Roan Group.

Camp-scale, district-scale, and potential basin-wide processes are interpreted from these data. In the Southern Congolese Copperbelt, local, small-scale (<5-km-long) unconformities can be seen nucleating from discordant megabreccia bodies after evaporites which are identified as highly contrasting and chaotic zones of extreme low and high magnetic response and interpreted as salt diapirs. District scale unconformities at the base of the Katete Formation and the Kundelungu Group are coincident with changes in sediment provenance signals identified in soil geochemistry. Stratigraphic geochemical signatures are comparable between study locations in the central Congolese and the southern Congolese Copperbelt. Comparing the stratigraphic location of unconformities at different locations in the Katangan basin will aid in unraveling the relative influence of eustatic sea level changes associated with the Marinoan and Sturtian glaciations versus basin halokinematic, rift, or inversion processes, which can reroute sediment supply.