Sediment-Hosted Cu in Zambia: Mineralization Controlled by Ductile Deformation, Basin Architecture, or Both?

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Cu(Co-Ni-Au-Mo) deposits in the Zambian Copperbelt are often regarded as the archetypical examples of sediment-hosted Cu mineralization. For decades, deposits in this area have been linked to features that define synrift basin architecture, e.g., specific stratigraphic horizons or changes in thickness of stratigraphic horizons due to growth faults in the basin. Exploration was driven by following a specific horizon near the base of the stratigraphy, the Lower Roan or the Congolese Mine Series, and identifying anomalies in the thickness of these horizons. More recently, carbonaceous stratigraphy anywhere in the stratigraphic column has been targeted. Examples are the Mwashya Subgroup at the Frontier deposit and the Grand Conglomérat at the newly discovered Kamoa deposit. Similarly to lower in the sequence, thickness variations, sometimes in fold hinges, and stratigraphic pinchouts form exploration targets.

Cu deposits in the North-Western Province of Zambia appear different from those in the classical copperbelt, in that the deposits are more strongly affected by ductile deformation and associated metamorphic mineral growth. Synrift architectural controls, if present, are usually cryptic. Common to all these deposits is the presence of a variably developed low-angle ductile fabric that is a pervasive element at the basin-basement contact. In several deposits, the low-angle fabric is associated with asymmetric inclined to recumbent folds that may be overprinted by upright folds, with or without an axial planar cleavage. Both of these ductile deformation features resulted in thickness changes of lithologies during shearing and folding and established potential fluid pathways, in particular along the earlier, low-angle foliation. The world-class Kansanshi and Sentinel Cu deposits in the North-Western Province are largely controlled by such low-angle structures, which are related to shearing and asymmetric recumbent folding. Subhorizontal shearing established fluid conduits in the form of low-angle shear zones, while simultaneously thickening favorable lithologies in fold hinges of recumbent folds, leading to high-grade Cu mineralization along fold hinges and associated structures. Similar ductile-controlled mineralization pathways may be underappreciated in the classical Zambian Copperbelt. At the Nchang and Chambishi Cu-Co deposits, ductile deformation resulted in folding above a ductile detachment surface. The detachment surfaces are mineralized; the fold hinges above the detachment benefited from structural thickening of favorable host lithologies and are also mineralized. However, below the detachment surfaces, subbasin features were not affected by ductile deformation but can also host economic Cu mineralization. This implies both synrift architecture and ductile deformational controls for mineralization at these deposits.

Geochronological work in the Central African Copperbelt indicates that much of the mineralization indeed occurred during ductile deformation. Thus, understanding ductile architecture in this region, in addition to the original basin architecture, is critical for continued exploration.