

## Identifying 'Invisible' Grade Boundaries at the Fracture-Controlled Sukari Orogenic Gold Deposit, Egypt, Arabian-Nubian Shield

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Sukari is a granodiorite-hosted orogenic gold deposit and the largest active gold mine in the Arabian-Nubian Shield, with over 6 Moz of gold produced to date. Genetic models have historically attributed structural control on gold orebodies to NNE-striking and ESE-dipping thrust faults. However, these models fail to explain abrupt terminations of hydrothermal alteration, gold mineralization and vein formation perpendicular to the strike of the thrusts, located at seemingly 'invisible' boundaries.

High-resolution drone imagery of the Sukari open pit was processed by contrast-stretching the RGB channels and applying principal component analysis (PCA) to isolate subtle color variations in the host rock that may otherwise be difficult to discern. This revealed a previously unrecognized NW–SE-striking and subvertical fracture set that crosscuts the mineralized NNE-striking thrust faults and acts as a boundary to gold orebodies including veins and hydrothermal alteration zones. By quantifying mine-scale gold assay data (n=438) relative to fracture distance, it is demonstrated that mean gold grade drops up to 50% across a fracture within 2 m. Hence, the fractures compartmentalize the deposit into relatively high-grade (~1.65 g/t Au), and low-grade (~0.83 g/t Au) ore blocks perpendicular to the strike of the thrust faults.

At the Sukari gold deposit, deposit-scale hydrothermal alteration and gold mineralization patterns are primarily fracture-controlled, and gold mineralization is preferentially hosted along thrust segments bounded by the crosscutting fractures. This resolves grade asymmetries parallel to the strike of the thrusts, a feature inconsistent with a simple thrust model. Recognition of such fracture-controlled grade boundaries directly improves: 1) accurate delineation of ore blocks, 2) resource estimation, by preventing domain smoothing, and 3) exploration targeting of concealed orebodies. Finally, the desktop-to-field methodology utilized in this study can be readily applied to locate 'invisible' grade boundaries potentially characterizing other epigenetic deposits.