

Geochemical Signature of Intrusive Rocks Hosting Gold Mineralization and Associated Alteration Assemblages at Wadi Al Jaww, Saudi Arabia

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Intrusion-hosted gold systems within the Arabian Shield commonly exhibit complex overprinting relationships with orogenic mineralization, making genetic classification and exploration targeting challenging. At Wadi Al Jaww deposit, uncertainty exists regarding the magmatic versus tectono-metamorphic contribution to gold mineralization and geochemical criteria distinguishing mineralized from barren intrusions. The study integrates whole-rock geochemistry, mineral chemistry, and hyperspectral data to resolve the petrogenesis and mineralization history of Wadi Al Jaww deposit. Following the discovery of Wadi Al Jaww deposit in 2024, an extensive drilling program indicated that gold mineralization is mainly hosted by granodiorites and quartz-feldspar phryic granites belonging to Kamil suite. Representative samples of intrusive rocks of Kamil suite from surface and diamond core were analyzed by lithium borate fusion with ICP-MS finish. Additionally, over 70,000 of downhole assay results of core samples by four acid digestion with ICP-MS finish were used for petrochemical classifications and geochemical constrains on mineralization and alteration. Whole rock geochemistry indicates that intrusive rocks were derived from reduced, water-poor, calc-alkaline arc-related magmas characterized by low Sc/V, Sr/Y ratios and negative Eu anomaly. Geochemical signatures of immobile and trace elements discriminate between two distinct types of granodiorites. Mineralized and barren granodiorites differ mainly in HREE and the presence of positive Eu-anomaly for unmineralized granodiorites. Immobile elements indicate that mineralized granodiorites are enriched in incompatible elements (HFSE, Ti) and depleted in compatible elements (Sc, Cr, V).

Cross-cutting relationships and mineral association indicate that gold mineralization is associated with two distinctive parageneses: 1) chalcopyrite-bornite-tennantite and 2) native gold-molybdenite. Hydrothermal alteration is generally weak and characterized by chlorite-white mica assemblages, with subordinate silicification and later epidote-prehnite alteration.

Wadi Al Jaww is interpreted as a multistage deposit, with primary intrusion-related mineralization event derived from dry and reduced magmas producing Au-Cu-Ag-Bi-Te mineralization mainly hosted in granodiorite and later Au-Mo-As+Bi+Te orogenic related mineralization.