Using Borehole Data to Discriminate Magmatic and Hydrothermal Processes for Orogenic Gold Exploration

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This paper demonstrates how integrated drill hole geochemistry, petrophysics, and geological observations can enable identification of geological processes related to an orogenic gold mineral system. The Yilgarn craton in Western Australia, one of the most well-endowed Au terranes in the world, is used as a case study area. Data patterns discriminate magmatic differentiation of the protolith from alteration footprints. In particular, whole-rock geochemical data exhibit patterns that align with in situ magmatic fractionation in the predominantly mafic host rocks, whereby Ti, Fe, and P positively correlate and Mg negatively correlates with Zr. Titanium and Fe reach a "transition point" between ~90 to ~130 ppm Zr consistent with the crystallization of magnetite during the later fractionation stages and supported by these zones preserving high magnetic susceptibility (>30 × 10^{-3} SI). We interpret these zones as the upper parts of dolerite sills that fractionated in place during crystallization.

Multielement geochemistry clustering analysis shows a relationship between Au and S, As, Sb, Cu, K, and Te. This is interpreted to reflect hydrothermal processes related to Au mineralization, suggesting S, As, Sb, Cu, K, and Te are pathfinder elements that can be used to delimit Au system targets. Enrichment of Au pathfinder elements is seen within core logged as felsic magmatic rocks and corresponds with zones of visibly strong alteration. The logged felsic samples have densities of ~2.85 g/cm^3, which is more typical of mafic rocks rather than felsic volcanic rocks (~2.4 g/cm^3). Therefore, the logged felsic magmatic rocks are interpreted here to be altered mafic rocks.

The outcomes of this study demonstrate how integration of multiscale, multifaceted data sets may be used to provide insight into magmatic processes and alteration zones related to mineralization, and may therefore be used to inform exploration programs targeting orogenic gold in the Yilgarn craton, Western Australia.