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Polyphase Evolution of Orogenic Gold Systems Revealed by in situ Pyrite Fluid Inclusions and Textures

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Studying quartz-hosted fluid inclusions in Archean orogenic gold deposits is commonly hindered by intense quartz deformation, widespread secondary fluid inclusion assemblages, poorly constrained timing between quartz veining and gold precipitation. Consequently, the physicochemical characteristics of auriferous fluids remain poorly defined. Pyrite, a major host for gold that is less affected by deformation, can preserve pristine fluid inclusions and is transparent under near-infrared (NIR) light.

Detailed NIR petrography of pyrite grains from the Triangle and Ormaque orogenic gold deposits (Val-d'Or, Abitibi) allows the identification of seven pyrite textures in shear-hosted veins and three in extensional veins, based on cross-cutting relationships and inclusion patterns. These include primary growth textures (Py1–Py2) and remobilization textures (Py3–Py6, e.g., dissolution-reprecipitation). Primary and deformation textures (Py1–Py3) are consistent with repeated fluid-pressure fluctuations characteristic of the fault-valve model. Gold occurs in pyrite as inclusions within primary textures (Au1), along dissolution fronts (Au2), within healed-cracks (Au3), and as fracture-filling (Au4).

Well-preserved primary aqueous-carbonic fluid inclusions occur within pyrite growth zones and as planes of secondary fluid inclusions (S1, S2, S3). Primary and S1 inclusions are aqueous–carbonic with low salinity (0.2–1.6 wt.% NaCl eq.) and 245 to >320 °C homogenization temperatures (Th). The S2 aqueous-carbonic inclusions displays higher salinity (11.1–11.2 wt.% NaCl eq.), whereas S3 fluid inclusions are aqueous, moderately saline (4.65–7.45 wt.% NaCl eq.), low Th (~165 °C). The coexistence of these secondary fluid inclusion types reflects multiple fluid events. Isochore calculation from the primary fluid inclusions hosted in Py2 are contemporaneous to Au1 mineralization constrains vein formation to mid-crustal depths of ~6–7km if a trapping temperature of ~350 °C, and lithostatic pressure are assumed. The chemistry of fluids trapped in pyrite is consistent with some quartz-hosted inclusions in Abitibi orogenic gold systems, but offers a more restricted, gold-proximal record of mineralizing fluids.