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Application of in situ SHRIMP U–Pb geochronology to orogenic gold exploration

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Knowing the age of the host rocks to ore deposits and the timing of hydrothermal mineralization can significantly improve exploration targeting, and reduce the risks to explorers. Precise dating of orogenic gold mineralization is inherently difficult due to a lack of minerals suitable for geochronology, and the ease of isotopic resetting of common chronometers during subsequent metamorphism and deformation. However, in situ Sensitive High-Resolution Ion Microprobe (SHRIMP) U–Pb analysis of hydrothermal monazite and xenotime is an effective way to date orogenic gold mineralization and hydrothermal events. These phosphate minerals are robust chronometers that commonly form during hydrothermal activity, yield precise ages, and are resistant to isotopic resetting over a range of temperature and pressure conditions.

Paulsens is a mesothermal orogenic gold deposit hosted within low-grade metasedimentary and metavolcanic rocks of the 2.77–2.63 Ga Fortescue Group, in the southern Pilbara region of Western Australia. Auriferous quartz–sulfide veins are hosted within a folded and faulted gabbro sill. In situ dating of magmatic baddeleyite indicates that the gabbro crystallised at c. 2.70 Ga. In situ dating of monazite and xenotime from the veins and hydrothermally altered country rocks reveals three distinct periods of regional-scale hydrothermal activity, at c. 2.40, 1.73, and 1.68 Ga. The auriferous quartz–sulfide veins were emplaced at c. 2.40 Ga accompanied by pervasive alteration of local host rocks. Subsequent regional-scale hydrothermal events at c. 1.73 and 1.68 Ga were responsible for replacement of porphyroblasts in the phyllites, emplacement of thin carbonate veins, and remobilization of gold along fractures within pyrite grains.

The three dated hydrothermal events at Paulsens do not correspond to any known deformation events along the southern Pilbara margin. However, monazite growth in shales across the Pilbara Craton [1], as well as resetting of high–U zircons in tuffaceous mudstones of the Hamersley Group [2], have been recorded between c. 2.43 and 2.40 Ga. The c. 1.73 Ga hydrothermal event is possibly coeval with gold mineralization at the nearby Mt Olympus gold mine, dated at c. 1.74 Ga [3]. The emplacement of carbonate veins and hydrothermal growth of secondary xenotime at c. 1.68 Ga, are synchronous with

high-temperature metamorphism and deformation during the 1.68–1.62 Ga Mangaroon Orogeny in the Gascoyne Province to the south.

In situ dating of accessory phosphate minerals can not only provide robust ages for mineralization, but also help unravel the regional low-temperature, tectonothermal history of the surrounding region. By identifying the timing of mineralization, we can reduce the exploration search area by targeting rocks and hydrothermal events of prospective ages, in turn increasing the odds of exploration success.

[1] Rasmussen B et al. (2005) Geology 33: 773–776
[2] Pickard A (2002) AJES 49: 491–507
[3] Şener A et al. (2005) Geology 33: 225–228