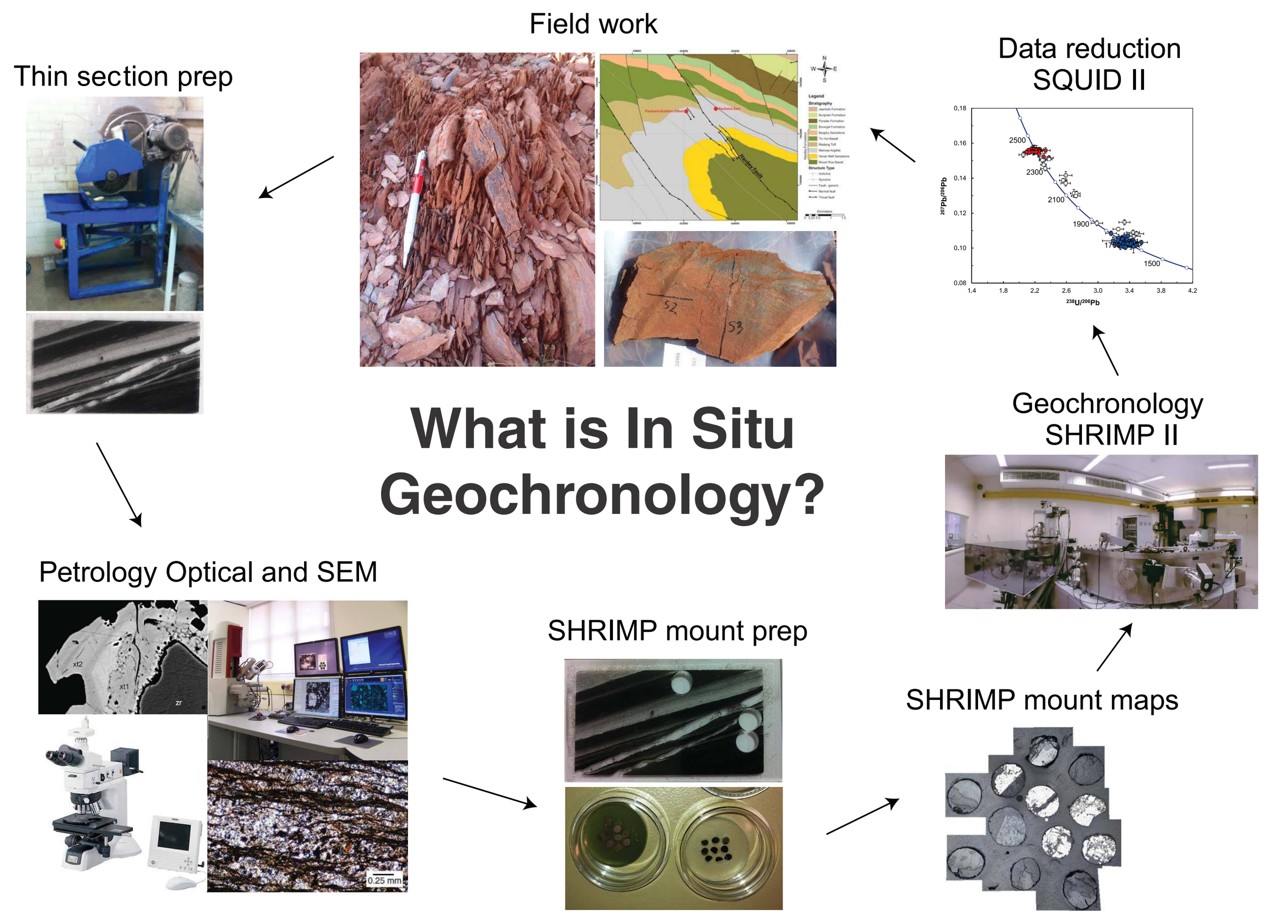
⑤ GOLD MINERALIZATION
PAULSENS

Introduction

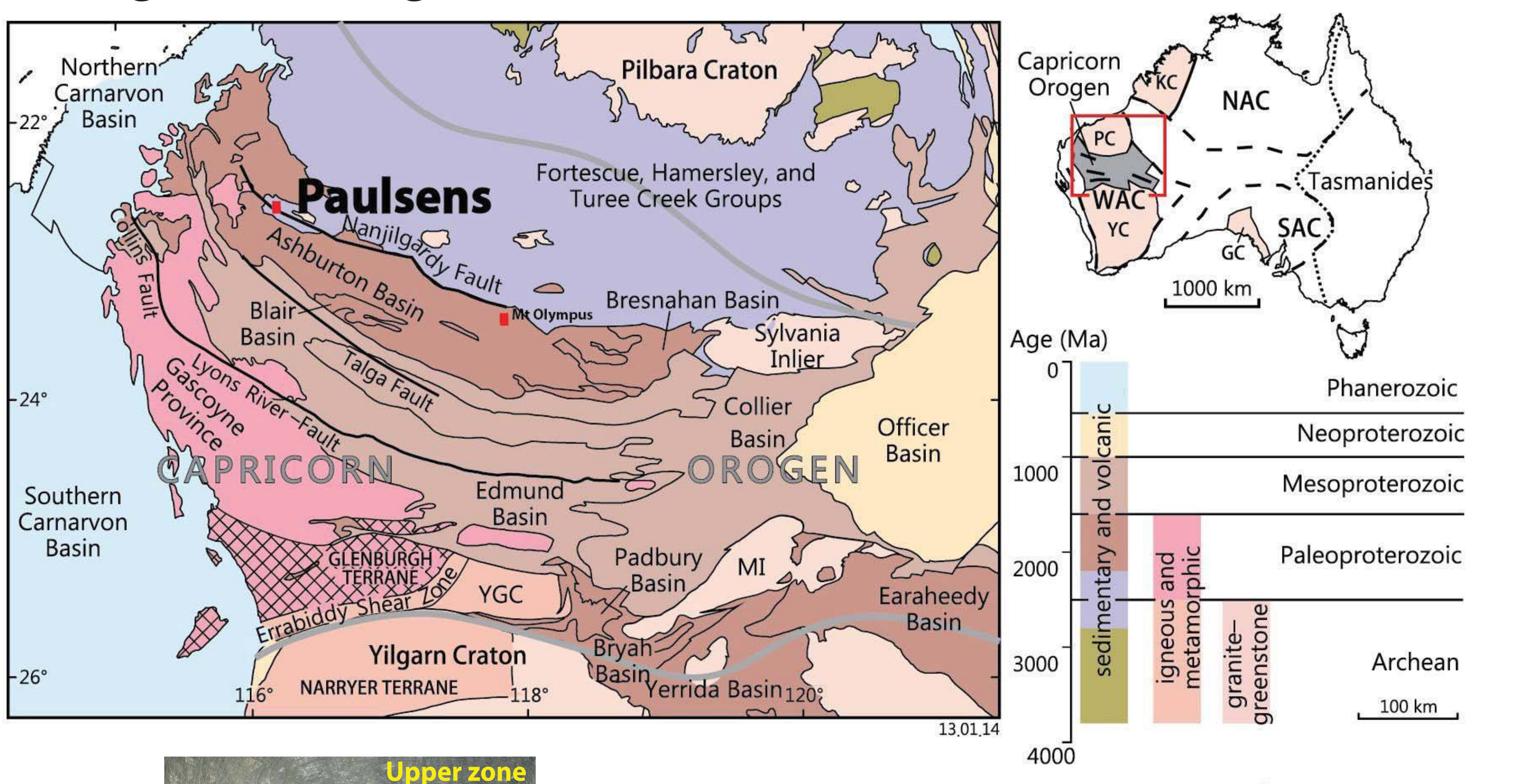
Exploration targeting of gold deposits can be significantly improved by understanding metallogenic events in both space and time. By knowing the ages of hydrothermal mineralization, the host rocks, and surrounding tectonothermal events, the search space can be refined, and the risk to explorers greatly reduced. However, precisely dating orogenic gold is extremely difficult, so that the ages of many gold deposits worldwide are poorly known. Many common chronometers are scarce in orogenic gold deposits, or they are susceptible to isotopic resetting during subsequent metamorphism and deformation. Nevertheless, many orogenic gold deposits contain trace amounts of monazite or xenotime intergrown with ore-bearing minerals.

Paulsens is the only operational gold mine in the northern Capricorn Orogen with a total endowment of approximately 1.2 Moz of gold. Despite its economic importance, there are no direct dates on the gabbroic host, mineralization and hydrothermal alteration or deformation and metamorphism. The lack of radiometric dates have led to poorly constrained models for gold mineralization and hampered exploration. The timing of the mineralization was postulated to be related to the 1820–1770 Ma Capricorn Orogeny, or to younger c. 1740 Ma orogenic gold mineralization at Mount Olympus.

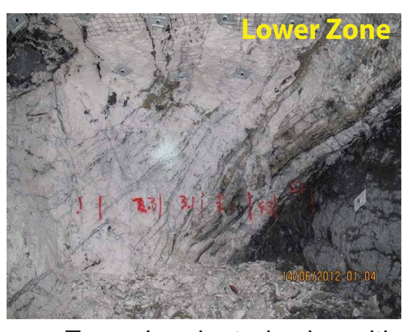


Textural relationships are retained by drilling the mineral to be dated (and surrounding minerals) out of a polished thin section. By using in situ geochronology we can directly date phosphates and, hence, provide ages for hydrothermal activity and mineralization in orogenic gold deposits and link this back to what is observed on both a micro (thin section) and macro (outcrop) scale.

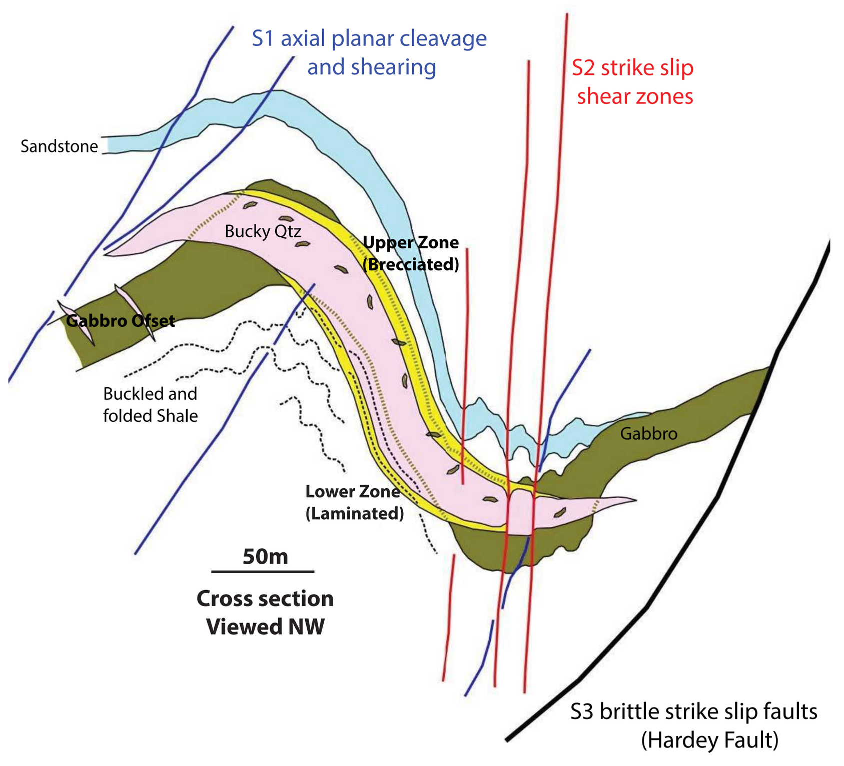
Geological Setting



Upper Zone: Massive pyrite with rare visible gold in hand specimen



Lower Zone: Laminated veins with abundant visible gold

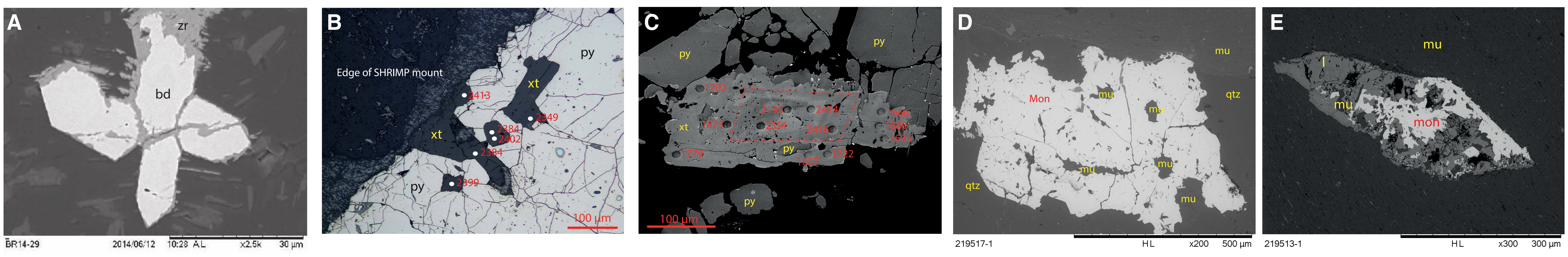


Paulsens is a mesothermal orogenic gold deposit hosted within low-grade metasedimentary and metavolcanic rocks of the 2775–2629 Ma Fortescue Group in the northern Capricorn Orogen, Western Australia.

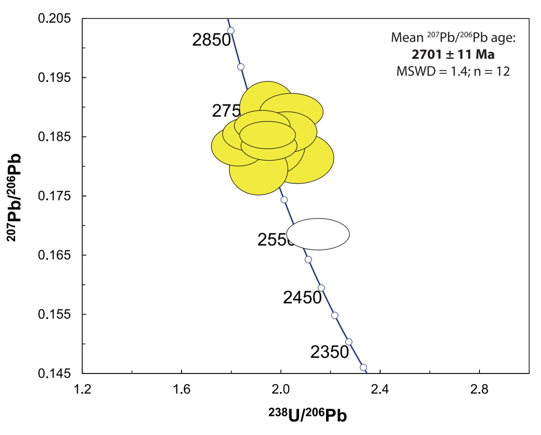
The orebody is contained within a structurally controlled 40 m-thick auriferous quartz-sulfide vein within the Paulsens gabbro where it crosscuts fine-grained sandstones and siltstones. Rheological contrasts between the gabbro and surrounding sedimentary rocks resulted in brittle fracturing of the gabbro during regional-scale F1 folding allowing for the deposition of the auriferous quartz-sulfide vein.

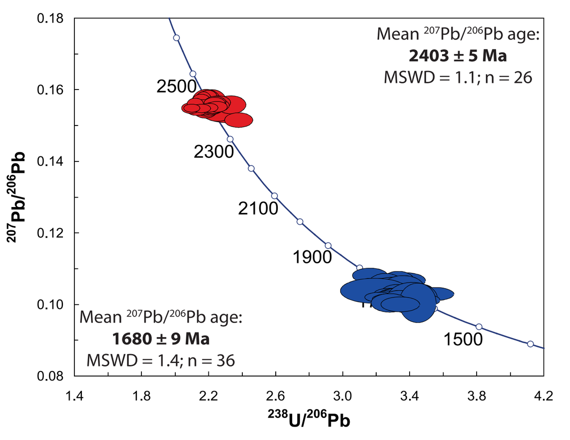
Mineralization is located at the margins of the vein and referred to as Paulsens Upper Zone and Paulsens Lower Zone mineralization.

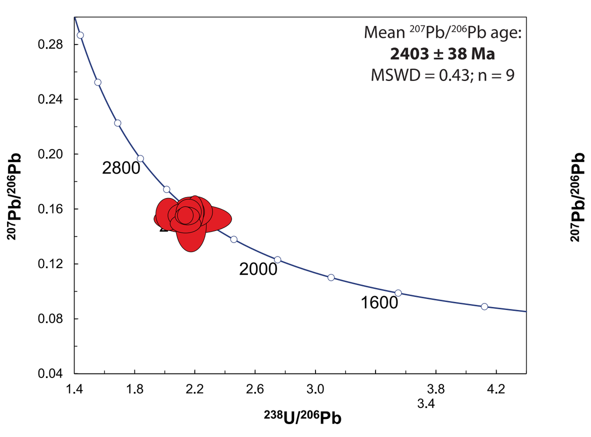
Textures and results

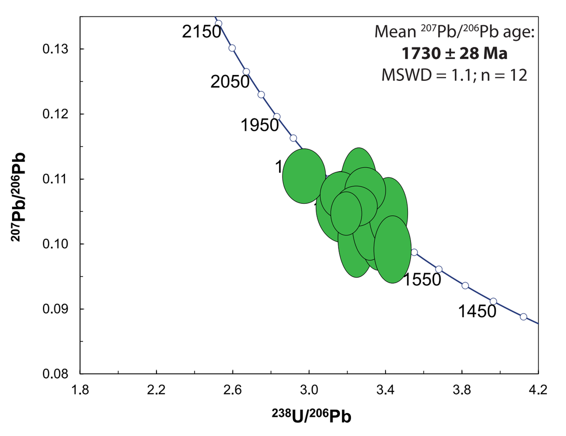


A: baddeleyite in Paulsens gabbro dated at c. 2700 Ma
B: euhedral xenotime grains interlocking with pyrite dated at c. 2400 Ma and associated with rounded gold inclusions in pyrite
C: zoned xenotime that has undergone dissolution-reprecipitation reactions forming a c. 2400 Ma core and c. 1680 Ma rim. The rim zone is associated with remobilization/introduction of gold along fractures in brecciated pyrite
D: large monazite in matrix of carbonaceous phyllite, containing inclusions of alteration assemblage
E: monazite–florencite porphyroblasts dated at c. 1730 Ma





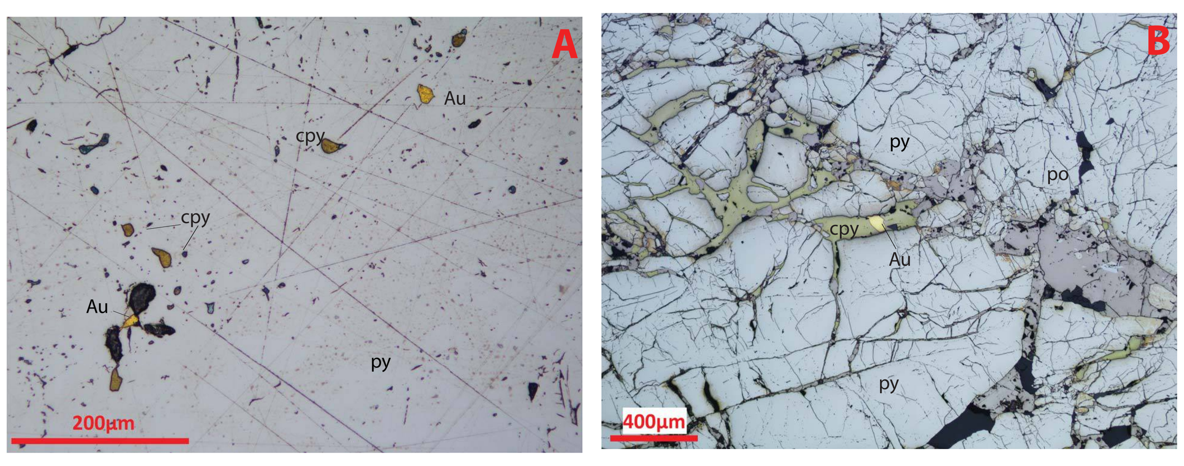




Styles of gold mineralization

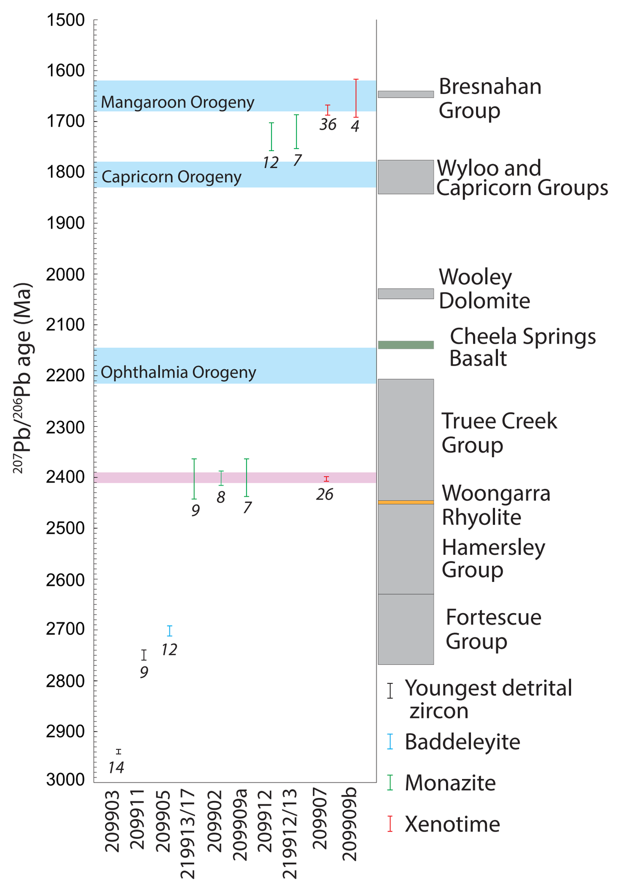
Gold occurs in two distinct forms in the quartz-sulfide veins

1. rounded gold inclusions within the pyrite,
2. free gold along cracks of fractured and brecciated pyrite, vein margins or stylolites



Geochronology

SHRIMP U–Th–Pb geochronology has been used to define the age of the host rocks to gold mineralization, and the timing of hydrothermal activity.



Host rocks

Maximum deposition of quartz sandstones occurred at 2750 ± 10 Ma. Crystallization age of the Paulsens gabbro (host to mineralization) at 2701 ± 11 Ma

Mineralization

Xenotime intergrown with, and contained entirely within, auriferous pyrite dated at 2403 ± 5 Ma.
Pervasively altered wall-rock margins to auriferous quartz-sulfide veins is dated at 2403 ± 38 Ma.

Hydrothermal events

Three discrete hydrothermal events are identified at c. 2400, 1730 and 1680 Ma.

c. 2400 Ma: hydrothermal alteration and monazite porphyroblast growth (2401 ± 14 Ma) and emplacement of auriferous quartz-sulfide veins.

c. 1730 Ma: monazite growth at 1730 ± 28 Ma and 1721 ± 32 Ma.

c. 1680 Ma: dissolution-reprecipitation of xenotime at 1680 ± 9 Ma and emplacement of auriferous carbonate veins.

Conclusions and regional implications

Results indicate a significantly different, and more complicated low-temperature tectonothermal evolution for the southern Pilbara region than previously thought.

In situ phosphate geochronology identified three hydrothermal events at c. 2400, 1730 and 1680 Ma.

c. 2400 Ma: emplacement of auriferous quartz-sulfide veins with the growth of monazite in phyllites across the Pilbara [1], as well as resetting of high–U zircons in tuffaceous mudstones of the Hamersley Group [2],

c. 1730 Ma: growth of monazite porphyroblasts and gold mineralization at the nearby Mt Olympus gold mine which is dated at c. 1738 Ma [3]

c. 1680 Ma: emplacement of carbonate veins, secondary growth of hydrothermal xenotime and remobilization of gold along pyrite fractures, synchronous with high-temperature metamorphism and deformation of the 1680–1620 Ma Mangaroon Orogeny in the Gascoyne Province.

The timing of orogenic gold at Paulsens was previously linked to the Capricorn Orogeny. However, results from this study show the mineralization was much older, occurring at c. 2400 Ma. This does not correlate to any known orogenic event in the northern Capricorn Orogen, including the Ophthalmia and Capricorn Orogenies. However, evidence for uplift, erosion and hydrothermal activity throughout the Pilbara possibly represent a currently undefined orogenic event. This has significant impacts on exploration targeting since Paulsens shows many characteristics of an orogenic gold deposit. Firstly by linking the timing of orogenic gold mineralization to the correct orogenic event responsible for its formation; and secondly it can minimize the exploration search area by allowing explorers to target prospective aged stratigraphy.

[1] Rasmussen, B, Fletcher, IR and Sheppard, S 2005, Isotopic dating of the migration of a low-grade metamorphic front during orogenesis: Geology, v. 33, p. 773–776.
[2] Pickard, A.L., 2002, SHRIMP U-Pb zircon ages of tufaceous mudrocks in the Brockman Iron Formation of the Hamersley Range, Western Australia: Australian Journal of Earth Sciences, v. 49, p. 491–507.
[3] Şener, AK, Young, C, Groves, DI, Krapež, B and Fletcher, I 2005, Major orogenic episode associated with Cordilleran-style tectonics related to the assembly of Paleoproterozoic Australia?: Geology, v. 33, no. 3, p. 225–228.

Curtin University · Geological Survey of Western Australia · John de Laeter Centre · Exploration Incentive Scheme · Australian Government Australian Research Council LP130100922 · Northern Star

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