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Pinpointing Paleoarchean magmatic-hydrothermal events during the geodynamic and crustal evolution of the East Pilbara Terrane

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The nature of Paleoarchean (>3.2 Ga) crustal accretion continues to be debated, in particular the onset and timing of subduction-like processes. Crust of this age is typically characterised by dome-and-keel geometry that is widely interpreted to be related to "sagduction" or the episodic dripping of denser, mafic volcanics into the mantle around buoyant silicic cratonic nuclei. This occurs during regional scale crust-mantle overturn events.

The exceptional preservation of the East Pilbara Terrane (EPT) has been instrumental in the development of this model and its role in Paleoarchean continental crust formation. The Emu Pool Supersuite (~3324-3290 Ma) represents a phase of voluminous silicic magmatism that has been attributed to overturn and sagduction within the EPT (e.g. Wiemer et al., 2018). However, the widespread occurrence of magmatic-hydrothermal Cu and Mo mineralisation, reported to be linked to this magmatic episode, have received little attention. Comparisons to Phanerozoic porphyry Cu-Mo deposits have been drawn (e.g. Barley & Pickard, 1999), which is intriguing as such porphyry-type deposits have a clear genetic link to arc magmatism and subduction processes as they require hydrous, Cl-rich magmatism (e.g. Tattich et al., 2021).

To date the chronological relationships of the magmatic-hydrothermal deposits to the major dome forming silicic magmatism is poorly constrained. In one deposit, hydrothermal activity is constrained by ^{187}Re-^{187}Os geochronology (Stein et al., 2007) to late to post Emu Pool Supersuite magmatism, yet this interpretation is hampered by issues relating to the λ^{187}Re uncertainty. Furthermore, interpretation of Paleoarchean geodynamics and magmatic evolution generally relies on micro-beam zircon U-Pb geochronological analyses, typically reported at single ^{207}Pb/^{206}Pb date precision at >±10 Myrs (2s), and presents challenges for accurately resolving geological processes and events.

We demonstrate that high-precision CA-ID-TIMS (Chemical Abrasion-Thermal-Ionisation Mass Spectrometry) zircon U-Pb geochronology, utilising ATONA low-noise detectors, can now routinely obtain precision of ~<±200 kyrs (2s) on ^{207}Pb/^{206}Pb dates of single zircon or fragments at ~3.3 Ga. By combining detailed field relationships, with unprecedented temporal precision, we show that the Mo-Cu hydrothermal mineralisation can be demonstrably linked to their host plutons and formation timescales can even be constrained to ~1 Myrs, comparable to Phanerozoic porphyry deposits. This study identifies that magmatic-hydrothermal systems were not synchronous across

the EPT. Instead they occurred over >7 Myrs during the early phase of Emu Pool Supersuite and silicic magmatism within domes.

Whilst the geodynamic trigger for Mo and Cu magmatic-hydrothermal mineralisation at ~3.3 Ga remains enigmatic, we highlight their timing and occurrence should be accommodated within Paleoarchean geodynamic models. Furthermore, the results illustrate the potential of modern high-precision U-Pb geochronology to routinely examine Paleoarchean magmatic records at timescales that closely approximate known plutonic accretion rates within the Phanerozoic.

References

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