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Pressure-Temperature Constraints for ca. 2.6 Ga Metamorphism in the Narryer Terrane, near the Jack Hills Metasedimentary Belt, Western Australia

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The “Discovery Outcrop” in the Jack Hills Metasedimentary Belt of Western Australia containing Earth’s oldest known terrestrial material - the Jack Hills zircon - is a critical source of information about the Hadean lithosphere, atmosphere, and hydrosphere. While the zircon grains and their inclusions have been intensively studied with a focus on Hadean and early Archean geologic history, high-precision constraints on the timing and conditions associated with post-depositional metamorphism impacting the zircon and their associated metasediments during craton assembly have been difficult to establish. Samples JH03023 and JH03024 in this study are a part of the Narryer Gneiss Terrane, within 4 kilometers of the “Discovery Outcrop,” and are constituents of the Meeberrie Gneiss and interbedded metasedimentary units. High-precision Sm-Nd garnet geochronology for these samples yields metamorphic age constraints of 2592.0 ± 9.2 Ma (MSWD=5.2, n=5; JH03023) and 2575.4 ± 4.4 Ma (n=2; JH03024) on the regional metamorphic event attributed to the collision between the Youanmi and Narryer terranes during the formation of the western Yilgarn Craton.

Frequently cited pressure-temperature constraints on this regional metamorphism in the Jack Hills Metasedimentary Belt are derived from a field guide reporting observations of grunerite in BIF, quartz-biotite-chloritoid assemblages, and the association of calcic plagioclase with hornblende, indicating the “Discovery Outcrop” experienced greenschist to low amphibolite facies metamorphism [1]. Further quantitative constraint was provided by conference abstracts giving Ti-in-quartz thermal maximum estimates of 509 ± 80 °C or lower [2,3]. We have undertaken thermodynamic modeling using whole rock XRF data in the program Perple_X and electron microprobe-based geothermometry, including garnet-biotite and Zr-in-rutile thermometry, to provide updated regional pressure-temperature constraints paired with geochronology.

Modeling and geothermometry support greenschist to low-amphibolite facies conditions and allow assignment of numerical temperature and pressure ranges. While these post-depositional, low-grade conditions would not reset Jack Hills zircon geochronology, the duration and conditions associated with post-depositional metamorphism should be considered when interpreting systems potentially susceptible to metamorphic resetting and citing regional geologic context.

[1] Wilde & Pidgeon (1990), Excursion Guidebook for the Third International Archaean Symposium; [2] Menneken, Nemchin, & Geisler (2011), Goldschmidt; [3] Ackerson, Tailby, & Watson (2014), Goldschmidt