Earth's Oldest Garnet: 3.20 Ga Garnet Ages Robustly Constrain the Timing of Early Metamorphism

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Earth's earliest metamorphic stories have been told using zircon and monazite ages with thermodynamic modeling, but the Archean garnet record has remained largely untapped. Garnet's role as a rock-forming mineral directly tied to growth during metamorphic reactions provides an attractive target for direct determination of linked ages, pressures, and temperatures for Earth's earliest metamorphism.

Earth's Oldest Known Garnet Age

To our knowledge, the only location with published direct garnet ages exceeding 3.0 Ga is the Barberton Granite Greenstone Belt ("BGGB"). A previous study in the BGGB indicated the presence of garnet of extreme age, but Sm/Nd ratios were low, Nd concentrations high, and the garnet textures indicate polymetamorphism leaving room for speculation about the accuracy and averaging of the age [1]. This study provides robust, new Sm-Nd garnet ages for two samples from the Inyoni Shear Zone, bordering the Stolzberg and Badplaas blocks of the BGGB. Sample 115-13 is 3201.6 +/- 5.2 Ma (2σ, MSWD = 1.12), and Sample 21-13 is 3200.7 +/- 5.3 Ma (2σ, MSWD = 0.46). Both Sm-Nd garnet isochron ages yield relatively high Sm/Nd ratios (>0.6) and low Nd concentrations (<0.3 ppm) for garnet, mitigating concerns about age inaccuracy due to mineral inclusions. Garnet ages from the BGGB represent the oldest known garnet ages and provide a solid age constraint for the formation of the Inyoni Shear Zone at 3.20 Ga.

The Inyoni Shear Zone's Metamorphic Story

Updated thermodynamic modeling for the region yields metamorphism at approx 600° C and 8 kbar. The presence of 3.20 Ga garnet ties garnet growth conditions to a prominent Archean structural boundary and robustly constrains metamorphic timing. These *P-T-t* conditions support interpretation of the Inyoni Shear Zone as an early example of accretionary tectonics potentially tied to early subduction.

[1] Cutts et al. (2014) *GSA Bulletin* **126**, 251-270