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The formation of dome-and-keel structures at 3.32 Ga in the Pilbara Craton

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The East Pilbara Craton is a classic example of a dome-and-keel granite-greenstone terrain. As these rocks are among the oldest on Earth, their origin is fundamentally important for understanding how the earliest continents formed. One theory is that dome-and-keel structures are the result of a buoyancy-driven crustal overturn process which predated mobile-lid tectonics on Earth. We address this problem with five well-preserved metarhyolitic rocks collected from the Warrawoona Greenstone Belt in the East Pilbara Craton. These rocks contain both zircon and garnet. We use zircon U-Pb dates to determine the crystallization age of these rhyolites, and Hf isotopes to understand melt sources. We use garnet Lu-Hf and Sm-Nd dates to help understand the timing of the deformation associated with the formation of these dome-and-keel structures. Furthermore, we integrate the microstructures in these rocks with garnet Lu-Hf and Sm-Nd ages to date the formation of the dome-and-keel structures in the East Pilbara. Zircon in these 5 samples have U-Pb ages between 3.45 and 3.46 Ga and have relatively uniform $\varepsilon_{Hf(i)}$ between +0.2 and +0.8, indicating these rocks were derived from a reservoir with a time integrated chondritic Lu/Hf. Garnet Lu-Hf ages of two samples record garnet growth at 3.42 Ga, which we interpret as recording a cryptic metamorphic event early in the evolution of the Pilbara Craton. The other three samples have garnet Lu-Hf ages between 3.33 and 3.29 Ga, which coincide with intrusion of granitic rocks throughout the Pilbara Craton. Using microstructures in these rocks, we suggest this younger garnet growth event overlapped with the beginning of dome-associated deformation of the Warrawoona Greenstone Belt. This relationship also constrains the beginning of dome-and-keel formation in the East Pilbara at ~3.32 Ga. All samples have systematically younger garnet Sm-Nd ages, between 3.35 and 3.22 Ga. These younger Sm-Nd ages record protracted dome formation associated with continued granitic magmatism in the East Pilbara until cooling of the system at ~3.22 Ga. Ultimately, our data indicate that the East Pilbara dome-and-keel structures formed at ~3.32 Ga, and there is a close relationship between the 3.3-3.2 Ga granitic magmatism and dome formation.