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A Hadean–Eoarchean crustal vestige beneath the SW Yilgarn Craton (Western Australia)

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The understanding of Earth's earliest crust remains fragmentary due to the paucity of well-preserved Hadean–Eoarchean material. Although crustal recycling may obscure ancient crust, its isotopic legacy may be retained in the continental crust and its denuded remains. Here, we present U–Pb and Lu–Hf isotopic data of detrital zircon and baddeleyite from sediments in SW Australia. These minerals are primarily sourced from the Archean Yilgarn Craton and adjacent terranes, namely the Proterozoic Albany-Fraser Orogen and the Neoproterozoic–Paleozoic Pinjarra Orogen. The detritus represents an archive of almost 3 Gyr of the polyphase crustal evolution of SW Australia and provides an opportunity to search for isotopic remnants of ancient crust. Hf data reveals at least three vertical $\varepsilon Hf_{(t)}$ arrays, characteristic of mixing juvenile and ancient crustal sources. The lower bounds of these mixing arrays form an evolution trend towards a Hadean–Eoarchean mantle extraction. Such extraction is consistent with two-stage depleted mantle model age calculations of the most evolved minerals. These results are interpreted in the context of a Hadean–Eoarchean crustal vestige that has stayed remarkably isotopically coherent over 2 Gyr of episodic crustal recycling. A $^{176}Lu/^{177}Hf$ value of *c.* 0.013, obtained from the $\varepsilon Hf_{(t)}$/Ma slope of the proposed protocrust evolution array, could imply an intermediate composition but is better explained by a mixed source composition, similar to the average of Archean granite-greenstone crust. The latter interpretation implies an early Yilgarn protocrust with more mafic composition than the current exposed crustal average and an age of at least 3.8 Ga for this nucleus. The spatial extent of these isotopic observations coincide with a geophysically anomalous area in the SW Australia that reflects perhaps some *c.* 100,000 km^2 of c. >3.8 Ga ancient protocrust beneath the SW Yilgarn Craton. A global comparison of Hf data reveals similar trends in Hf data on most cratons (excluding Acasta and Jack Hills) implying significant crustal reservoir extraction (or preservation) at around 3.8 Ga, towards the end of the Late Heavy Bombardment. In contrast, Acasta and Jack Hills Hf arrays point to an earlier but distinct crust formation process.