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Time capsules from the deep; a window into the ancient basement of the Yilgarn Craton, Western Australia

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The deep basement geology of continental crust can be difficult to access, without drilling, direct observation is restricted to limited exhumed and comprehensively reworked exposures. Recourse to geophysical techniques is usually made to infer the orientation, thickness, and broad composition of deep basement terranes. Success in determining the age and composition of basement geology has also been gleaned through indirect isotopic modelling approaches, either on the whole rock, primary magmatic, or xenocrysts grain scale. Other approaches have utilised the detrital mineral cargo of subsequent basins to infer older crustal components. Here we present an alternative approach, where direct grain sampling of a basement component in the South West Terrane of the Archean Yilgarn Craton by a Proterozoic basaltic andesite dyke provides, arguably, the first directly dated evidence for the most ancient crystalline substrate in this region. The results of U–Pb geochronology on this dyke reveal an entrained c. 3440 Ma Paleoarchean zircon component as inclusions within titanite. This zircon was protected from overprinting fluids that obliterated isotopic records in unshielded crystals. Such fortuitous geological preservation implies an ancient basement component identical in age to components of the Narryer Terrane, the oldest crust within Australia, residing at depth along the southwestern margin of the Yilgarn Craton, along a major translithospheric fault system. Given age, isotopic, and geochemical relationships, the most parsimonious interpretation is that the protolith to this amphibolite dyke was a 1390–1360 Ma subcontinental lithospheric magma, which entrained zircon either in its source or emplacement pathway. Some resolution on the from of this ancient crustal substrate is provided by regional isotopic maps (Pb, Nd, Hf) and regolith geochemistry anomalies (Hg) which hint at the current deep architecture. Ultimately, we posit that a swathe of Paleoarchean, and perhaps even Eoarchean deep basement (based on Nd and Hf isotopic arrays extending to 3.8 Ga), is situated underneath the western part of the Yilgarn Craton, which served as the nucleus for crustal growth of the craton.