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Crustal structure of a Proterozoic craton boundary: east Albany-Fraser Orogen, Western Australia, imaged with passive seismic and gravity anomaly data

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We use passive seismic and gravity data to characterize the crustal structure and the crust-mantle boundary of the east Albany-Fraser Orogen in Western Australia, a Proterozoic orogen that reworked the southern and southeastern margin of the Archean Yilgarn Craton. The crustal thickness pattern retrieved from receiver functions shows a belt of substantially thickened crust - about 10 km thicker than the surrounding regions - that follows the trend of the orogen, but narrows to the southwest. Common conversion point profiles show a clear transition from a wide, symmetric Moho trough in the northeast to a one-sided, north-western Moho dip in the southwest, where the Moho appears to underthrust the craton towards its interior. The change from a Moho trough to an underthrust Moho appears to coincide with the inferred trace of the Ida Fault, a major terrane boundary within the Yilgarn Craton. Bulk crustal v_p/v_s ratios are mostly in the felsic to intermediate range, with clearly elevated values ($\geq$1.8) at stations in the Fraser Zone granulite facies, dominantly mafic metamorphic rocks.

Forward modelling of gravity anomaly data using the retrieved Moho geometry as a geometric constraint shows that a conspicuous, elongated gravity low on the northwestern side of the eastern Albany-Fraser Orogen is almost certainly caused by thickened Archean crust. To obtain a model that resembles the regional gravity pattern the following assumptions are necessary: high-density rocks occur in the upper crustal portion of the Fraser Zone, at depth inside the Moho trough and in parts of the eastern Nornalup Zone east of the Moho trough. Although our gravity models do not constrain at which crustal level these high-density rocks occur, active deep seismic surveys suggest that large extents of the east Albany-Fraser Orogen's lower crust include a Mesoproterozoic magmatic underplate known as the Gunnadorrah Seismic Province. The simplest interpretation of the imaged crustal structure is that the Gunnadorrah Seismic Province is underthrust beneath the Yilgarn Craton, most likely as a consequence of crustal shortening during accretion further east. The imaged geometry overall appears to show a wedge of Archean lower crust that was driven between the exhumed Fraser Zone and the Gunnadorrah Seismic Province, effectively splitting the Paleo- to Mesoproterozoic crust of the east Albany-Fraser Orogen. The vertical splitting of Proterozoic crust by a cratonic crustal wedge, comparable to what we image in this study, may be a process that contributed to forming many craton margins around the world.