A probabilistic crustal shear-wave velocity model of the east Albany-Fraser Orogen, West Australian Craton

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Located in Western Australia along the southern and southeastern margin of the Yilgarn Craton, the Albany-Fraser Orogen (AFO) comprises Archean crust deformed and modified during the Proterozoic. The eastern part of the orogen separates unmodified Yilgarn Craton crust to the northwest from exotic oceanic-arc crust of the Madura Province to the southeast. The AFO is divided into the Northern Foreland and the Kepa Kurl Booya Province, which in the east is further subdivided into the northeasterly trending Tropicana, Biranup, Nornalup, and Fraser Zones. Early studies suggested that the AFO formed during the continent-continent collision between the Yilgarn and the South Australian Cratons during the Mesoproterozoic. Recent investigations, however, indicate that the two cratons have remained separate and that the orogen recorded a change in regional tectonic regime from continental extension and passive margin formation in the Paleoproterozoic to convergence and the subsequent accretion of an oceanic-arc in the Mesoproterozoic. The AFO differs from the Capricorn Orogen along the northern margin of the Yilgarn Craton, which formed during Paleoproterozoic continental collision events that assembled the West Australian Craton. The AFO thus provides a great opportunity to study different deformation styles during Precambrian times, i.e., continental collision versus craton margin rifting and hyperextension followed by oceanic-arc accretion.

A 70-site passive-source seismic array (ALFREX) has produced the first detailed maps of the crustal seismic parameters for the region. These models suggest a process of horizontal wedge indentation in the lower crust that may have resulted from the accretionary processes. In this study we inverted the phase velocity maps (up to 30s) of the ALFREX array for the 3D crustal shear-wave velocity model beneath the east AFO. We applied a modified Bayesian Transdimensional tomographic inversion technique, which takes into consideration the smooth varying background velocity extracted from the Australian continental reference model AuSREM and Moho topography inferred from the ALFREX receiver function studies. The inverted crustal shear-wave velocity model is then compared along four profiles from north to south with earlier active-source reflection seismic, gravity inversion and receiver function studies of the east AFO.

At the whole crust level, the velocity model shows a good correspondence with the interpreted bedrock geology. The unmodified Yilgarn craton crust is consistently homogeneous with a monotonic velocity increase from the surface to the Moho. In nearly the whole east AFO the mid- to lower crust under the Northern Foreland is relatively high in wave speed compared to the unmodified Yilgarn crust. The Biranup Zone shows a high-velocity upper crustal layer, a slow mid-crust, and a fast lower crust that continues into the Fraser Zone. The Fraser Zone corresponds to a prominent fast velocity anomaly in mid-crust, which may extend to the southwest. The Moho indentation observed in the receiver function data appears closely related to a confined, high-velocity lower crust, likely attributed to a mafic underplate. Along the active-source 12GA-AF3 seismic line, the northeastern Nornalup Zone is slow in wavespeed within the whole crust, although significantly faster lower crust is present to the southwest. The newly inverted shear-wave velocity model will be combined with gravity forward modeling to fine-tune the regional crustal architecture evolution models.