Geophysical Research Abstracts
Vol. 18, EGU2016-2201, 2016
EGU General Assembly 2016

Crustal and uppermost mantle structure of the eastern margin of the Yilgarn Craton (Australia) from passive seismic data

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The Yilgarn Craton in Western Australia is one of the largest units of Archean lithosphere on earth. Along its southern and southeastern margin, it is bounded by the Albany-Fraser Orogen (AFO), a Paleo- to Mesoproterozoic extensioal-accretionary orogen. In this contribution, we investigate the crustal and upper mantle structure of the AFO and adjacent regions using passive seismic data collected during the recent ALFREX experiment. Since the entire region has not been significantly reactivated since the Mesoproterozoic, the old signature of craton edge modification should have been well preserved until today.

From November 2013 until January 2016, we operated a temporary passive seismic network consisting of 70 stations in the eastern Albany-Fraser Orogen. The array had an average station spacing of about 40 km and was designed to fill the gap between recently acquired active seismic profiles.

We present results from the analysis of P receiver functions and ambient noise tomography using the ALFREX data. Receiver functions were used to derive a Moho depth map via H-K stacking, for direct imaging (common conversion point stacking) as well as joint inversion with surface wave dispersion data to derive 1D S-velocity profiles beneath the stations. The obtained receiver functions show a marked change of character from west to east across the array. Whereas they feature clear and sharp Moho phases for stations on the Yilgarn Craton, significantly more crustal complexity and fainter Moho phases are seen throughout the AFO. Crustal thickness increases from 36-39 km for the Yilgarn Craton to values between 42 and 48 km across the AFO, decreasing to around 40 km in the east.

Ambient noise cross-correlations were used to derive maps of phase and group velocities of Rayleigh waves at periods between 1 and 30 seconds. A three-dimensional model of S wavespeeds throughout the area was then computed by pixelwise inversion of dispersion curves. Obtained S wavespeeds are generally very fast even in the shallowest crust (around or even above 3.5 km/s), with the AFO featuring even higher velocities than the Yilgarn Craton. The most notable feature in the S-velocity map are clearly elevated velocities in the Fraser Zone, a 450 km long elongated region of exhumed lower crustal metagabbros within the AFO. The footprint of the array limits the resolvable depth to about 40 km, hence we image mantle S velocities only in regions with relatively thin crust, i.e. for the Yilgarn Craton and the eastern and southernmost parts of the AFO.

Due to the use of Bayesian inversion methods, the obtained results come with robust uncertainty estimates, which is an advantage in interpretation. We combine our results with evidence from active seismic experiments and potential field data to derive a three-dimensional model of the present structure of the region. This is ongoing work and most likely still in a preliminary stage at the time of the presentation. This model will be used to inform existing evolution models of the AFO and processes of modification of Archean crust.