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Seismic anisotropy and heterogeneity in the crust beneath southeast Australia from ambient noise tomography

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The lithosphere beneath eastern Australia was formed during a protracted period of Palaeozoic orogeny that began in the Early Cambrian and terminated in the Middle Triassic. Accretion of new and reworked lithosphere occurred outboard of the proto-Pacific margin of Gondwana, which at that time extended some 20,000 km along the east margin of Precambrian Australia, through west Antarctica and into western Argentina. In southeast Australia, the outward-stepping nature of the accretion can be observed in the Delamerian, Lachlan and New England orogens, which extend from the eastern margin of Precambrian Australia to the Tasman Sea. Although the basic building blocks of the region have been recognised, extensive Mesozoic and Cainozoic cover sequences have masked large regions of the Palaeozoic basement, which complicates the task of unravelling the tectonic evolution of this portion of the Australian plate.

Over the last 14 years, a transportable seismic array project called WOMBAT has traversed much of southeast Australia with high density seismic arrays. To date, over 600 stations have been deployed as part of 14 separate array movements, making it the largest experiment of its type in the southern hemisphere. With a maximum station spacing of approximately 50 km, passive imaging of the crust and uppermost mantle is possible using a variety of techniques, including ambient noise tomography, which is the focus of this study.

Interstation group and phase velocity curves corresponding to Rayleigh wave propagation have been extracted from ambient seismic noise recorded by WOMBAT. Group and phase velocity maps over a range of periods (1-20 seconds) are then constructed by traveltime inversion using all available station pairs. Two different approaches are used: the first assumes isotropic velocity variations but accounts for wavefront focusing and defocusing in response to heterogeneity; the second assumes great circle path propagation but accounts for azimuthal anisotropy. In the latter case, spatial resolution is decreased to offset the need for the additional parameters necessary to describe azimuthal anisotropy (since heterogeneity and anisotropy trade-off against each other). A comparison of the two results shows that the long wavelength heterogeneity of the two models are similar. In particular, the low velocity region associated with the vast intracratonic Murray Basin, the elevated velocities that closely correlate with outcropping igneous and metamorphic rocks of the Southern Highlands, and the lower velocities that underpin the Newer Volcanics in western Victoria. However, there is a pronounced velocity low beneath the northeast part of the Murray Basin that is present in the anisotropic model but not the isotropic model; interestingly, this appears to correlate with a region of weak anisotropy. The most striking feature of the anisotropic models - for periods 5 s and above - is the dominant alignment of the fast axis of anisotropy in the N-S direction, with magnitudes exceeding 4%. This orientation correlates closely with the dominant geological fabric of the Palaeozoic orogens, and is consistent with a prevailing direction of compression that was perpendicular to the proto-Pacific margin of Gondwana.