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Evidence of micro-continent entrainment in the growth of the east Gondwana margin from Bayesian ambient noise tomography

Simone Pilia (1,2), Nicholas Rawlinson (3), Ross Cayley (4), Thomas Bodin (5), Robert Musgrave (6), Anya Reading (7), Nicholas Direen (7), and Mallory Young (8)

(1) Research School of Earth Sciences, Australian National University, Canberra 0200, Australia, (2) Petroleum Institute, Petroleum Geoscience, Abu Dhabi, United Arab Emirates (spilia@pi.ac.ae), (3) School of Geosciences, University of Aberdeen, Aberdeen AB24 3UE, Scotland, (4) Geological Survey of Victoria, Department of State Development, Business and Innovation, GPO Box 4509 Melbourne, Victoria 3001, Australia , (5) Berkeley Seismological Lab, University of California Berkeley, California, USA, (6) Geological Survey of New South Wales, NSW Trade & Investment, 516 High Street, Maitland, New South Wales 2320, Australia, (7) School of Earth Sciences, Institute for Marine and Antarctic Studies and CODES Centre of Excellence, University of Tasmania, Hobart, Tasmania, 7001, Australia, (8) DownUnder GeoSolutions Pty Ltd, 76 Kings Park Rd., Perth, Western Australia, 6005, Australia

The Phanerozoic Tasmanides (or Tasman Fold Belt System) is located east of the locus of the Neoproterozoic Rodinia breakup and comprises an accretionary system that occupies the eastern third of the Australian continent. The Tasmanides is the result of protracted accretionary growth outboard of the Archean and Proterozoic core of central and western Australia that occurred from the Early Cambrian through to the Jurassic. Its basement structure has proven difficult to study since vast Mesozoic-Cainozoic sedimentary and volcanic cover sequences obscure older outcrops and limit the power of direct observational techniques. The Lachlan Fold Belt, which forms the southern end of the Tasmanides, is thought to be particularly complex and may include an exotic continental block, an amalgamation of multiple linear orogen parallel accretion events, a large orocline and several arc complexes.
Continental growth via subduction accretion along a convergent margin is a well known process. However, simple models involving the gradual outboard accretion of material along curvilinear subduction zones are often inconsistent with field-based evidence. The evolution of accretionary orogens was recently addressed by using 3-D geodynamic models, showing that the entrainment of an exotic continental fragment within a simple subduction system can result in a complex phase of growth that may include the formation of large scale oroclines. Although kinematic models based on structural mapping and high resolution gravity and magnetic maps indicate that the pre-Carboniferous Tasmanides in southeastern Australia may have been subjected to this process, to date there has been little corroboration from crustal scale geophysical imaging.
In this study, we apply Bayesian transdimensional tomography to ambient noise data recorded by the largest transportable seismic array in the southern hemisphere to constrain a detailed (20 km resolution in some areas) 3-D shear velocity model of the crust beneath southeast Australia. We then apply a novel two-stage transdimensional, hierarchical, Bayesian inversion approach that produces 2-D group velocity maps at different periods, from which a composite 3-D shear wavespeed model is obtained through a series of 1-D inversions. One of the advantages of this approach is that the model resolution is variable and adapted to the irregular spatial distribution of the information provided by observations. We find that many of the velocity variations that emerge from our inversion support the recently developed geodynamic and kinematic models. In particular, the full thickness of the exotic continental block, responsible for orocline formation and the tectonic escape of the back arc region, is imaged here for the first time. Our seismic results provide the first direct evidence that exotic continental fragments may profoundly affect the development of an accretionary orogen.