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Deep structure offshore Eastern Australia from wide-angle seismic data: what controls crustal segmentation along the rifted oceanic basins and the Lord Howe Rise?

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The eastern Australian margin was shaped during the fragmentation of eastern Gondwana in the Late Cretaceous. This led to the opening of the Tasman Basin and to the formation of sub-parallel ridges and basins, including the Lord Howe Rise. The driving forces controlling the rifting are not fully understood and two processes can be invoked: slab rollback associated with upper-plate extension or a plume impinging on the lithosphere. However, the deep structure of the area is still unknown. In March-April 2016 using the R/V Kairei, the first large-scale crustal experiment of this region was conducted by JAMSTEC and Geoscience Australia with the deployment of 100 ocean-bottom seismometers (OBS) along a 680km profile at 27.2°S. The OBSs register clear refracted arrivals from the crust and the mantle that are recorded at very large offsets (up to 300km). The important variation in the offset of the triplication point between these two refracted arrivals suggests strong crustal thickness variation along the profile. We performed first-arrival tomographic inversion using two initial models with almost uniform lateral layering: (a) a four-layer model using the two-way reflection travel times from the basement interpreted from the multi-channel seismic data and (b) a five-layer model including a Moho interface, thereby allowing inversion of Moho reflections interpreted from the OBS data. The final tomographic Vp model confirms the strong variations in crustal thickness and allows the identification of distinct crustal domains along the profile: the Tasman Basin is an oceanic domain with 6 to 8km thick crust; further east a thicker crust is present below the Dampier Ridge (18-21km) where granitic rocks have been dredged; directly east of the Dampier Ridge the crust thins to 8km below the Middleton Basin, and the northern Lord Howe Rise is floored by a 24km thick crust. Below the northern Lord Howe Rise, lateral variations in upper-crustal velocities are observed with some areas showing higher velocities (Capel Basin) compared to the surrounding area (Faust Basin). These variations are associated with Moho relief at depth. We propose that these lateral variations can be explained by the prolongation of the SW-NE oriented Barcoo-Elisabeth-Fairway fracture zone, which is well-expressed in the Tasman Basin, through the northern Lord Howe Rise. Similar variations are observed towards the west below the Dampier Ridge where there are also variations in Moho depth. Based on these observations, we further suggest that the SW-NE-trending major fracture zones active during the opening of the Tasman Basin may have strongly controlled the latitudinal segmentation of the Lord Howe Rise, the Dampier Ridge and adjacent areas.