Crustal structure underneath the Browse Basin (North-West Australia): a new look from vintage refraction and wide-angle seismic data

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The Browse Basin is located offshore on the rifted passive continental margin of NW Australia. It covers an area of about 140,000 km2 and contains up to 15 km of Paleozoic to Cenozoic sediments. We present a reinterpretation of previously-unpublished deep seismic sounding data that were acquired in 1995/96 by the Australian Geological Survey Organisation (Survey 168) on a 500 km long , NW-SE profile across the basin center (lines 168/301 & 168/302). The seismic data were recorded on twenty ocean bottom seismometers (OBS) at an average station spacing of 25 km. Refracted arrivals and wide-angle reflections were observable up to source-geophone offsets of 50 to 200 km, depending on the signal to noise ratio.

The wide OBS spacing resulted in sparse subsurface coverage that required an iterative interpretation procedure. The first step was to use travel time picks of groups of neighboring OBS to determine average 1D velocity-depth functions for the three major tectonic segments, namely oceanic crust, extended continental margin (Browse Basin including the Scott Plateau and the inboard Seringapatam and Caswell sub-basins) and continental shield. Secondly, the 1D velocity-depth functions were used to generate a continuous 2D model that was refined by interactive ray-tracing. We computed synthetic seismograms for checking the amplitude response resulting from the model, especially the amplitude distribution caused by a suspected low-velocity zone. In the final step, the resulting model was tuned using travel-time tomography.

A 2.5D forward gravity model, constrained by the wide-angle reflection and refraction seismic model, is consistent with the presence of three different crustal domains across the margin, i.e. oceanic crust in the NW, a wide transition zone below the Scott Plateau and the inboard rift basins, and continental crust in the SE. Crustal thickness in the final 2D velocity model is about 10 km in the oceanic domain, increasing to about 25 km under the Browse Basin and to 35 km under the continental shield. The Browse Basin shows a sequence of sub-basins with seismic velocities of 4.5–5.0 km/s, densities of 2.0–2.5 g/cm3 and depth increasing from 5 km in the NW to 12 km in the SE.

The upper crust has a relatively constant thickness of ~10 km under the Scott Plateau and is thinnest under the Seringapatam Sub-basin, a failed rift. In the SE, a narrow and thin low-velocity layer is evident at the top of the upper crust adjacent to highly extended upper crust at the boundary between the Scott Plateau and the inboard sub-basins. The cause of this low velocity zone remains unclear, but it may reflect weathered volcanics at the base of the sedimentary sequence. Beneath the ~200 km wide Scott Plateau the lower crust has a relatively constant thickness of about 15 km and is characterized by velocities of 6.8–7.3 km/s and a density of about 3.0 g/cm3. The higher velocities and density suggest that the lower crust may be intruded or underplated by magmatic rocks. The Moho under the Scott Plateau is relatively flat.

Overall, modeled Browse Basin crustal seismic velocities and densities are characteristic of a volcanic rifted margin that evolved to form a broad, extensional outer plateau and deep inboard rift basins adjacent to rigid crust of the continental shield.