Geophysical Research Abstracts
Vol. 16, EGU2014-10350, 2014
EGU General Assembly 2014

Seismic tomographic constraints on the Antarctic-Eastern Australian margin of Gondwanaland in the Mesozoic

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Well-studied seafloor magnetic anomalies document the breakup of East and West Gondwanaland at ∼180 Ma and the India-Antarctica breakup at ∼130 Ma, which are two major tectonic events that affected the motions of the Antarctica-Australia southern margin of Eastern Gondwanaland. Published plate tectonic reconstructions indicate that Antarctica-Eastern Australia moved ∼2000 km SSE from 180 to ∼110 Ma relative to a mantle reference.

We have mapped a distinct swath of flat slabs at depths of 1900 to 2500 km below present-day West Antarctica and adjacent southernmost Pacific and Atlantic Oceans. Other slabs were mapped at similar depths offshore of SE Australia and east of South America. When unfolded and compared to published global plate-tectonic reconstructions, these mapped slabs occupy a minimum area of 5000 x 5000 km. Their restored positions show a remarkable fit opposite the southern margin of Gondwanaland at 180 Ma, suggesting that they record the oceans that were adjacent to the pre-breakup southern Gondwanaland margin.

Here we present a plate tectonic reconstruction that incorporates these mapped slab constraints, with the following implications: (1) The mapped slab edges constrain the 180 Ma pre-breakup position of Gondwanaland in a lower mantle reference frame. (2) The mapped slabs were oceans that were partly overrun and subducted under the SSE-moving Antarctica-Eastern Australia from 180 to ∼110 Ma. (3) The remaining slabs were subducted within the adjacent proto-Pacific realm, proximal to the complex seafloor spreading patterns that formed at the Ellice Basin and Osbourn Trough, which are seafloor features in the present-day Pacific directly north and east of the Tonga-Kermadec subduction zone.

The slabs were mapped in 3D primarily using the global mantle S-wave tomography model TX2011 (Grand and Simmons, 2011), and compared with the global P-wave tomography models MIT-P08 (Li et al, 2008) and LLNL-G3Dv3 (Simmons et al., 2012). The mapped slabs were unfolded and structurally restored to the surface in a spherical Earth model and analyzed using Gplates plate reconstruction software.