The Geodynamic Evolution of the Junction Plate: Linking observations to high-resolution models

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The Geoscience community faces an explosion of global geological data. While current GIS software packages are good at visualising data for the present day, many geological processes have complex time dependent relationships which current GIS tools cannot model. The integration of such complex digital geo-data in four dimensions with high-resolution geological models is fundamental in order to take advantage of this data explosion.

Plate tectonics and mantle convection form a dynamically coupled system that has shaped the Earth for billions of years. Modeling these processes allows the fundamental parameters to be examined that drive the geological evolution of the Earth, including surface uplift and subsidence, erosion, sedimentation, and volcanism through time. Ultimately this will allow us to better understand the past and present configuration of the plates and mantle [2]. Advances in high performance computing, improvements to modeling software as well as a swathe of global time dependant geological datasets are facilitating higher resolution exploration of geodynamic and tectonic processes. We connect the geodynamic modeling code *Terra* with the GPlates[1] plate reconstruction software, to couple the Earth's plate motion history and the configuration of plate boundaries over the last 200 Ma to mantle convection. This approach allows us to construct a high-resolution model over the timeframe of one complete overturn of the mantle convective system, from the breakup of the supercontinent Pangaea to the present.

Here we use this methodology to focus on the Junction between Australia, the Eastern Neo-Tethys and Panthalassa, one of the most ill constrained plate boundaries through time due to a lack of preserved in-situ oceanic crust [3]. This lack of in-situ crust means that traditional plate reconstruction methodologies using marine magnetic and gravity anomalies cannot be applied to this region. This presents a challenge as the geodynamics of this area have profound impacts on our understanding of the evolution of the Northern and Eastern Australian margins, and the tectonically complex South East Asian region during the early Mesozoic. The flow of material and heat in the mantle is also controlled by the interaction of surface and deep earth processes and greatly influences the formation and spatial distribution of hydrocarbons. Australia's North West shelf, a prime hydrocarbon exploration area falls within the bounds of our modeling target. Our forward geodynamic models assimilate data describing dynamically closing plate boundaries, plate motions for the last 200 Ma and mantle rheology. By coupling plate kinematics with mantle convection we are able to use seismic mantle tomography to constrain the evolution of this area. Seismic tomography images slabs of oceanic lithosphere in the mantle that have been subducted along this junction since the Jurassic Period, representing the history of surface kinematic evolution in the deep mantle [4-5]. Coupling mantle convection and plate tectonics provides a holistic approach to modeling Earth evolution and has only been possible through the integration of new methodologies linking high performance computing, improved modeling software and global datasets.

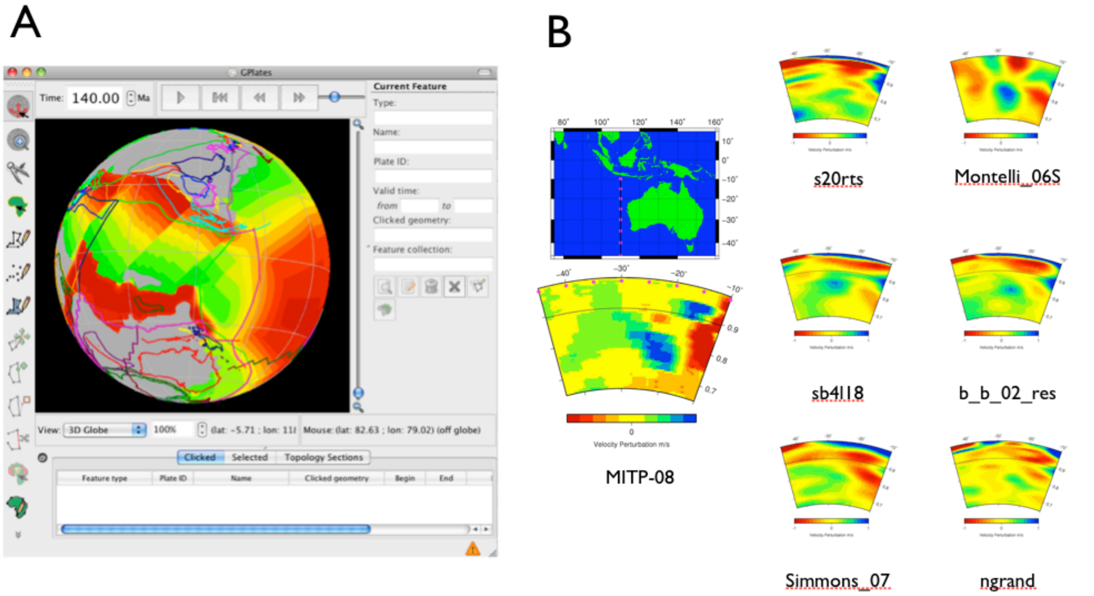

Figure 1: A. The Junction between the Tethys and Panthalassa at 140 Ma. The GPlates GUI allows simultaneous displaying of time dependant geological and geophysical data. The coloured blocks represent the age of the oceanic lithosphere at 140 Ma. Lines represent plate margins reconstructed at 140 Ma. B. Seismic tomography images from an number of models[4] of the present day mantle imaging material subducted during the Cretaceous. Seismic tomography is a technique for imaging the Earth's interior by measuring the speed of elastic wave propagation. Anomalously fast velocities (blue areas) correspond to cold regions of the mantle, and anomalously slow velocities (red areas) correspond to hot regions.

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