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Using global, quantitative models of the coupled plates/mantle system to understand Late Miocene dynamics of the Pacific plate

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Knowledge of the evolution of continents, inferred from a variety of geological data, as well as observations of the ocean-floor magnetization pattern provide an increasingly-detailed picture of past and present-day plate motions. These are key to study the evolving balance of shallow- and deep-rooted forces acting upon plates and to unravel the dynamics of the coupled plates/mantle system.

Here we focus on the clockwise rotation of the Pacific plate motion relative to the hotspots reference frame between 10 and 5 Ma, which is evidenced by a bend in the Hawaiian sea mount chain (Cox & Engebretson, 1985) as well as by marine magnetic and bathymetric data along the Pacific/Antarctica Ridge (Croon et al., 2008). It has been suggested that such a kinematic change owes to the arrival of the Ontong-Java plateau, the biggest oceanic plateau on the Pacific plate, at the Australia/Pacific subducting margin between 10 and 5 Ma, and to its collision with the Melanesian arc. This could have changed the local buoyancy forces and/or sparked a redistribution of the forces already acting within the Pacific realm, causing the Pacific plate to rotate clockwise. Such hypotheses have never been tested explicitly against the available kinematic reconstructions.

We do so by using global numerical models of the coupled plates/mantle system. Our models build on the available codes Terra and Shells. Terra is a global, spherical finite-element code for mantle convection, developed by Baumgardner (1985) and Bunge et al. (1996), and further advanced by Yang (1997; 2000) and Davies et al. (2013), among others. Shells is a thin-sheet, finite-element code for lithosphere dynamics (e.g., Bird, 1998). By merging these two independent models we are able to simulate the rheological behavior of the brittle lithosphere and viscous mantle. We compare the plate velocities output by our models with the available kinematic reconstructions to test the above-mentioned hypotheses, and simulate the impact of the evolving mantle buoyancy-field and plate-boundary forces on the Pacific plate motion. Our approach allows linking geodynamical models and observations on the recent dynamics of the Pacific plate.