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A Globally Self-Consistent Model of Plate Motions Relative to the Hotspots for the Past 48 Million Years

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Hotspots are volcanic anomalies, either in an intraplate setting or in the form of excessive volcanism along the plate boundaries, not explained by classic plate tectonics. In the early 70's, along with a deep mantle origin, hotspots were proposed to move so slowly relative to one another such that they could be used as a reference frame fixed in the deep mantle for describing plate motions in an "absolute" sense. Ever since the idea was first introduced, however, the rates of relative hotspot motion, and thus the limits of the hotspot frame of reference, have remained a source of heated debate with suggestions ranging from apparent fixity to rapid motion between the hotspots.

The question of inter-hotspot motion is closely related to the estimation of true polar wander—rotation of the whole solid earth relative to the spin axis. A fundamental problem of global tectonics and paleomagnetism is determining which part of apparent polar wander—the apparent movement of age-progressive paleomagnetic poles relative to the continent in question—is due to plate motion, and which part is due to true polar wander. One approach for separating these is available if the hotspots are indeed tracking the motion of the mantle beneath the asthenosphere and are moving slowly relative to one another. In this case, a model of plate motion relative to the hotspots can be used to predict the positions of past paleomagnetic poles relative to the spin axis and thus estimate the amount of true polar wander.

Cumulative improvements in the age progression along the hotspot tracks, the geomagnetic reversal time scale, and relative plate reconstructions lead to significant changes in earlier results. In this study, we build on a new method for objectively estimating plate-hotspot rotations and their uncertainties, and on our recent results that have demonstrated no significant motion between the Pacific and Indo-Atlantic hotspots since 48 Ma, and present a globally self-consistent model of plate motions relative to the hotspots for the past 48 million years. To obtain the model, we use the tracks of the Hawaiian, Louisville, Tristan da Cunha, Réunion and Iceland hotspots. All the hotspot tracks used in this analysis are among the most widely accepted candidates for a deep mantle origin. The poles of rotation are estimated for ages corresponding to some key magnetic anomalies used in plate reconstructions.

The new set of plate reconstructions presented here provide a firm basis for estimating absolute plate motions for the past 48 million years and, in particular, can be used to separate paleomagnetically determined apparent polar wander into the part due to plate motion and the part due to true polar wander.