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Global plate motion reference frame based on model of hotspot motion

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Relating mantle dynamics and plate tectonics requires a common reference frame for both flow in the mantle and plate motions. However, such a reference frame is still uncertain. In particular, it is difficult to establish for times before about 120 Ma, when little remains of hotspot tracks exist. Here we present a few thoughts that may lead towards such a reference frame further back towards the times of Pangaea. For the past 83 Ma, we compute the motion of hotspots based on a global mantle flow model. We can therefore compute plate motions in a "mantle reference frame" that takes hotspot motion into account. For relative plate motions between Pacific and Africa plates, we use a chain through Antarctic, Australian and Lord Howe plates. This model allows a fit to hotspot tracks globally back to about 65-75 Ma. African plate motion thus determined after 83 Ma is not substantially different from its motion in a fixed hotspot reference frame. We thus tentatively extend the reference frame with fixed hotspots back to 130 Ma. True polar wander in that reference frame is small except for a possibly significant episode between 100 and 110 Ma, corresponding to a counterclockwise rotation of the Gondwana continents around an axis through central Africa, which does not occur in the hotspot reference frame. Such a direction of true polar wander is geodynamically plausible, if there are two persistent geoid highs associated with two roughly antipodal large-scale upwellings beneath the Pacific and the Gondwana continents. Mean lithospheric rotation in that reference frame over the past 65 Ma is dominated by Pacific plate motion, but if we exclude oceanic plates and those continental plates with a substantial subduction zone attached (India and Australia), we find that, for the remaining plates, the areal average rotation is approximately 0.1 deg/Myr around an axis between about 60 and 90 degrees W, close to the equator, i.e. an av-

erage northward motion of the continents. This is probably related to a degree-one component of mantle flow corresponding to upwellings being stronger in the southern hemisphere. A corresponding degree-one component in mantle seismic anomalies is also observed. Conversely, in the Pacific hemisphere, plates are moving, on average, northward even faster.

Since our model yields little average longitudinal motion of the continents that were assembled in Pangaea earlier on, and there were probably no substantial amount of slabs attached to Pangaea either, we propose, for earlier times, to complement the paleomagnetic reference frame by the assumption of zero average longitudinal motion of Pangaea continents. Furthermore, we suggest that Pangaea rotations around an equatorial axis close to its center of mass are more likely caused by true polar wander, whereas an average northward or southward motion of Pangaea more likely represent plate motions relative to the underlying mantle.