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North Atlantic plate motions and plumes

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Although relative plate motions are rather well constrained, directions and directional changes of absolute motions, which may indicate plate-driving mechanisms, differ more substantially among various absolute reference frames. Fixed hotspot frames show uniform NE movement of the coupled North American, Greenland and Eurasian plates from 95 to 80 Ma. A marked cusp occurs in the paths at 80 Ma; with all three plates simultaneously changing direction and following a uniform NW-directed motion until c. 20 Ma. Subsequently Eurasia diverges NE, away from the still-NW-moving Greenland and North American elements. The fact that the three plate motion paths share many common features apparently unrelated to the opening of the North Atlantic in this reference frame appears to indicate that plates have been primarily driven by forces other than local ridge push alone. Necessary external forces could include slab pull or unidirectional horizontal flow in the upper mantle.

There is growing evidence that hotspots are not fixed relative to each other and the fixed hotspot reference frame should be replaced with a mantle reference frame in which the motion of plumes in a convecting mantle is considered. We have recomputed two different mantle reference frames, one based on hotspots in the African hemisphere only, another one with hotspots globally and a revised plate circuit connecting both African and Pacific hemisphere, and compared them with a new palaeomagnetic reference frame. We find that mantle reference frames compare well with the global palaeomagnetic frame for the last 100 million years. For older times the moving hotspot frame is uncertain, because simple backward advection will be increasingly inappropriate for reconstructing past mantle density anomalies. We have therefore constructed a hybrid plate reference frame that is based on palaeomagnetic data and keeping the African plate fixed in longitude before 100 Ma.

The North American-Greenland plate motion history is very different with our new

hybrid model, compared to the fixed hotspot model: The hybrid mantle model predicts a principal component of westward drift since 110 Ma. A sharp change in 'absolute' motion at ∼50 Ma for both North America-Greenland (NNW) and Europe (NE) is linked to the opening of the NE Atlantic at c. 54 Ma. The North Atlantic Igneous Province is one of several well-known large igneous provinces, temporally correlated with continental break-up and often linked to a deep plume, the Iceland plume. We examine the predicted location of the Iceland plume in fixed hotspot, mantle and global palaeomagnetic reference frames, compare it with direct palaeomagnetic data, and discuss the conceivable importance of the Iceland plume (and other plumes such as the Azores) in relation to continental break-up and seafloor spreading in the Labrador Sea and the NE Atlantic.