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Indian and African plate motions driven by the push force of the Reúnion plume head

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Two classic plate tectonic puzzles are 1) the fast motion of India in the Late Cretaceous and Early Cenozoic and 2) the decreased convergence rate between Africa and Eurasia in the Paleocene corresponding to a period of tectonic quiescence in the Alps (Trümpy's "Paleocene restoration"). We have reexamined plate motion constraints in the Indo-Atlantic Oceans and tied together a series of related observations that suggest that both of these events were strongly influenced, and perhaps even driven, by the arrival of the Reunion plume (Cande and Stegman, 2011). Fast motion of India, as recorded by sea floor spreading, began around 68 Ma and ended around 45 Ma. The period of fast spreading started with a short pulse of superfast spreading between 66 and 63 Ma that peaked (Ind-Ant = 200 mm/yr) during Chron 29R, the time of the maximum eruption rate of Deccan flood basalts, and was followed by a longer period of fast (but not superfast) spreading (Ind-Ant = 130 mm/yr). A few Ma before the start of the fast motion of India, around 70 Ma, Africa started an unusual 30 Ma episode of variable motion. This consisted of a 15 Ma gradually intensifying slowing of Africa's rate of rotation about the Euler pole for Africa-Eurasia convergence (near 32°N, 16°W), followed by a 15 Ma period in which Africa's rate of rotation gradually recovered. The gradual slowing down and speeding up of Africa caused the stage poles of Afr-NoAm, Afr-SoAm, Afr-Ant and Afr-Mantle to migrate in a systematic way, first away from and then back towards the Africa-Eurasia Euler pole. These excursions are reflected in the large bends of the fractures zones and the systematic changes in spreading rates on all three ridge systems between 70 and 40 Ma. Additionally, coeval bends in the Tristan da Cunha and St. Helena hotspot tracks are consistent with this variable motion of Africa. The retarding motion peaked between 57 and 54 Ma and then gradually faded away with the motion of Africa returning roughly to its pre-70 Ma motion by 40 Ma.

Together, the fast northward motion of India and the retarding motion of Africa appear to form a coupled system of plate motions in which India and Africa are responding nearly synchronously to the arrival of the Reunion plume, although in opposite directions depending upon whether on the eastern or western side of the plume. This suggests the plume had a major influence on the motions of these plates for a period of 30 Ma, thus we believe we have identified a potentially new driving force for plate tectonics, which we termed the "plume-push" force. We note that the Reunion plume was roughly 90°away from the Africa-Eurasia Euler pole, in a position which would maximize the effective torque of a southwestward directed force on the base of the African plate near the plume. The retarding motion of Africa accounts for the observed minimum in the Africa-Eurasia convergence rate in the Paleocene. The simultaneous waning of the retarding motion of Africa and the slowing down of India between 52 and 45 Ma suggests that the slowing of India may not be related to the collision of India with Eurasia, as is commonly portrayed, but rather reflects the waning influence of the Reunion plume on its motion. The initial collision of India with Eurasia might have been coincident with the sharp change in direction of Africa-India spreading at 43 Ma. The physical mechanism for how this new force acts to drive plate motions needs to be explained, and then incorporated into global and regional geodynamic models.