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East Pacific Rise: Kinematics and Dynamics

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Earth's tectonic plates are generally considered to be driven largely by negative buoyancy associated with subduction of oceanic lithosphere. In this context, mid-ocean ridges (MORs) are passive plate boundaries whose divergence accommodates flow driven by subduction of oceanic slabs at trenches. We show that over the past 80 million years (My), the East Pacific Rise (EPR), Earth's dominant MOR, has been characterized by limited ridge-perpendicular migration and persistent, asymmetric ridge accretion that are anomalous relative to other MORs. We reconstruct the subduction-related buoyancy fluxes of plates on either side of the EPR. The general expectation is that greater slab pull should correlate with faster plate motion and faster spreading at the EPR. Moreover, asymmetry in slab pull on either side of the EPR should correlate with either ridge migration or enhanced plate velocity in the direction of greater slab pull. We also calculate the resulting subduction-related torques associated with the Pacific and Farallon/Vancouver/Nazca/Cocos/Juan de Fuca plates since 80 Ma. Based on our analysis, none of the expected correlations are evident. This implies that other forces significantly contribute to EPR behavior. We explain these observations using mantle flow calculations based on globally integrated buoyancy distributions that require core-mantle boundary heat flux of up to 20 TW. The time-dependent mantle flow predictions yield a long-lived deep-seated upwelling that has its highest radial velocity under the EPR and is inferred to control its observed kinematics. The mantle-wide upwelling beneath the EPR drives horizontal components of asthenospheric flows beneath the plates that are similarly asymmetric but faster than the overlying surface plates, thereby contributing to plate motions through viscous tractions in the Pacific region.