Plume Flux, Spreading Rate, and Obliquity of Seafloor Spreading

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Most of Earth’ s surface is created by seafloor spreading, a fundamental global tectonic process. While most seafloor spreading is orthogonal, i.e., the strike of mid-ocean ridge (MOR) segments is perpendicular to transform faults, obliquity of up to ~45° occurs. Here, building on the work of DeMets et al. [2010] we investigate the global relationship between obliquity of seafloor spreading, spreading rates, and the flux of nearby plumes. While we confirm the well-known tendency for obliquity to decrease with increasing spreading rate [Atwater and Macdonald, 1977], we find exceptions at both intermediate (up to 18°) and ultra-fast (up to 12°) rates of spreading. Thus, factors other than the minimization of power dissipation across mid-ocean ridges and transform faults [Stein, 1978] may influence the amount of obliquity.

Abelson & Agnon [1997] modeled spreading centers as fluid-filled cracks and found that the variation of segment orientation depends on the ratio of the magma overpressure to the remote tectonic tension that drives plate separation. A high ratio promotes oblique spreading and a low ratio promotes segmentation that results in orthogonal spreading. They further argued that if a hotspot lies near a MOR segment, the hotspot contributes to magma overpressure along the segment. We quantify their argument as follows: (1) that magma overpressure increases with increasing flux of a plume. (2) that effective magma overpressure decreases with increasing distance between a MOR segment and a plume. From this we estimate the effective plume flux delivered to each mid-ocean ridge using published plume flux estimates.

Not only does obliquity tend to decrease with increasing spreading rate, but also it tends to increase with increasing effective plume flux delivered to a MOR segment. Many exceptions occur, however. Along slow spreading centers, many segments are less oblique than along the Reykjanes Ridge and western Gulf of Aden despite having higher effective plume flux. Similarly, along intermediate spreading centers, some ridge segments are less oblique than along the western Galapagos spreading center, despite having greater effective plume flux. We conclude that neither the minimum power dissipation model nor the hotspot proximity model fully explain the globally observed variations of oblique spreading.

Keywords: Plume Flux, Obliquity of Seafloor Spreading

