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Using platinum-group element geochemistry to constrain mid-ocean ridge magmatic processes

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Magmatism at the globe-encircling mid-ocean ridges is responsible for 75% of Earth's basaltic volcanism, covering ~70% of the planet's surface. It has long been recognized that mid-ocean ridges are underlain by open magma chambers that experience regular cycles of replenishment, mixing, eruption and fractionation [1-3]. Existing models, which use major and incompatible trace elements to model these open systems, conclude the initial replenishment rate is high but declines during magmatic evolution [4, 5]. We report major and trace element abundances, emphasizing the highly compatible platinum-group elements, for glasses and whole rocks from the East Pacific Rise (EPR), Siqueiros transform zone and Mid-Atlantic Ridge (MAR). Following early sulfide saturation, mid-ocean ridge basalts (MORBs) show no evidence of further decline in Pd with decreasing MgO, which is attributed to the replenishment of primitive magma into the MOR magma chambers. We combine the highly compatible palladium abundances, with strongly incompatible elements (Th and La), to produce a replenishment model that successfully accounts for the variations of both classes of elements in the MORBs. We show that the sulfide-saturated MOR magma chambers experience frequent small replenishments between ~1% and 4%, rather than large initial inputs that systematically decrease in magnitude as the system evolves.

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