Precious metals in mid-ocean ridge chambers: quantifying the mass proportions of recharge, eruption and fractionation

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Basalts from the East Pacific Rise (EPR), Siqueiros transform zone and mid-Atlantic Ridge (MAR) have been analysed for the platinum-group elements (PGE) and a wide range of incompatible elements. The low PGE content of the most primitive mid-ocean ridge basalts (MORB) suggests that they leave the mantle sulfide-saturated but become sulfide under-saturated, as a consequence of decompression, during their ascent from the mantle to the MOR magma chamber. Because the pressure drop is relatively small, the ascending magma enters the magma chamber only slightly sulfide under-saturated and requires only a small amount of fractional crystallization to return it to sulfide-saturation. Sulfide-saturation is marked by the Pd content of the melt falling by over an order of magnitude at ca. 9.5 wt.% MgO. However, once a magma has become sulfide-saturated, evolved melts show no evidence of further decline in Pd with decreasing MgO. This must result from regular replenishment of the underlying axial magma chamber by fresh batches of primitive magma. Most replenishments occurr when the MgO content of the resident melt in the magma chamber is between ~9 to 6.5 wt.% MgO. We combine the tight constraints imposed by highly compatible Pd abundances, with those imposed by strongly incompatible elements (Th and La), to produce the first model that successfully accounts for the variations of both classes of elements in open system mid-ocean ridges magma chambers. We show that the lack of decline in the Pd content of the sulfide-saturated MORB, with decreasing MgO, requires frequent small replenishments between ~1% and 4%, rather than large initial inputs that systematically decline from 100% to zero during the life of an individual ridge system.