

Evolution of Osmium Isotopes In Komatiite Sources

RICHARD J. WALKER

Department of Geology, University of Maryland, College Park, MD 20742, USA (rjwalker@geol.umd.edu)

Komatiitic and picritic lavas associated with plume-related volcanism are potentially valuable tracers of the Os isotopic composition of plume sources because of their typically high Os concentrations and relatively low Re/Os. High precision Re-Os data are now available for a variety of Phanerozoic, Proterozoic and Archean komatiites and picrites. As with modern plumes, the sources of Archean and Proterozoic komatiites exhibit a large range of initial $^{187}\text{Os}/^{188}\text{Os}$ ratios. Most komatiites are dominated by sources with chondritic Os isotopic compositions (e.g. Vetryny; Norseman-Wiluna; Pyke Hill; Alexo). The results suggest that these komatiites were derived for sources with long term Re/Os indistinguishable from the convecting upper mantle at the time of their formation. If derived from the lower mantle, these sources evidently contained a full complement of Re, Os and presumably other highly siderophile elements.

The sources of at least two Archean komatiites are enriched in ^{187}Os (Kostomuksha, Russia; Belingwe, Zimbabwe), with initial ratios enriched by 2-3% relative to the contemporary convecting upper mantle. These results suggest that if the enrichment was due to the incorporation of minor amounts of recycled crust into the mantle source of the rocks, the crust formed very early in Earth history. Thus, the Os results could reflect derivation of melt from hybrid mantle whose composition was modified by the addition of mafic crustal material that would most likely have formed between 4.2 and 4.5 Ga. Alternately, the mantle sources of these komatiites may have derived a portion of their Os from the putative ^{187}Os - ^{186}Os -enriched outer core. For this hypothesis to be applicable to late Archean rocks, an inner core of sufficient mass would have to have crystallized sufficiently early in Earth history to generate an outer core with ^{187}Os enriched by at least 3% relative to the chondritic average.

Vapor Saturation in Felsic Magmas & Vapor-Melt Partitioning of Sulfur

PAUL J. WALLACE

Dept. of Geological Sciences, University of Oregon, Eugene, OR, U.S.A. (pwallace@darkwing.uoregon.edu)

Over the past 25 years there has been a growing body of evidence based on petrologic, remote sensing, and volcanic gas data that andesitic, dacitic, and rhyolitic magmas in crustal reservoirs are saturated with a multicomponent C-O-H-S vapor phase before eruption. A key piece of evidence for magmatic vapor saturation is the "excess" S problem: the common observation that much more S is released by explosive eruptions than was originally dissolved in the erupted volume of silicate melt. If all of the "excess" S is derived from a magmatic vapor phase, then felsic magmas must commonly contain several wt% exsolved vapor prior to eruption (Wallace, 2001). The large amounts of volatiles implied by these estimates suggest that exsolved vapor accumulates in the apical regions of magma bodies during repose periods between eruptions. The presence of such large mass fractions of exsolved vapor in the roof zones of crystal-poor magma bodies is important for understanding fluxes of magmatic volatiles and metals into associated hydrothermal systems.

The concentration of complexing ligands such as Cl and S in the vapor phase control metal fractionation between silicate melt and vapor. Recently published experimental data on melt-vapor partitioning of S (Scaillet et al., 1998; Keppler, 1999) show that S partitions strongly into the vapor phase under conditions relevant for most felsic magmas. Using these data, I have developed a thermodynamic model that can be used to calculate the mole fractions of both SO_2 and H_2S in a magmatic vapor phase if the temperature, pressure, oxygen fugacity, and dissolved H_2O and S contents of the silicate melt are known. The model explicitly accounts for homogeneous equilibrium between oxidized and reduced S species dissolved in silicate melt and between H_2O -S species in the vapor phase. The model is calibrated for dacitic to rhyolitic melts from 780-900°C, 2-4 kbar, ΔNNO from +0.5 to +2.6, and 30-1400 ppm dissolved S. Because S solubility increases strongly with increasing temperature, the weight ratio S (vapor) / S (melt) decreases from ~1000 at 750-780°C to ~100 at 900°C. At constant temperature, an increase in oxygen fugacity results in an increase in S (vapor) / S (melt). Using published data for well studied eruptions, the pre-eruptive magmatic vapor phase for felsic magmas is estimated to contain 0.5 to 6 mol% total S, but may be as high as 13 ± 2 mol% for the 1982 El Chichón magma.

References

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