

The redox control upon the rhenium crystal/silicate-melt partitioning

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The full development of the potential of the Re-Os isotopic system is currently hindered by the poorly understood behaviour of Re and Os during mantle melting and magma genesis. Experimental studies have appeared to show that Re is incompatible in olivine, pyroxenes, and spinel [1-4], and compatible in garnet [2], but they have underestimated the effect of oxygen fugacity (f_{O_2}). Rhenium is a heterovalent element, and its solubility in silicate melts shows that it dissolves as both Re^{4+} and Re^{6+} [5], with the changeover from one oxidation state to the other occurring over the range of f_{O_2} s pertinent to the Earth's mantle.

We have studied the partitioning behaviour of Re between the common upper mantle minerals (garnet, spinel, clinopyroxene, orthopyroxene, and olivine) and Fe-free silicate melts under temperature (1275 to 1450°C) and pressure (1.5 to 3.2 GPa) conditions relevant for basaltic magma genesis, over a range of f_{O_2} s large enough (QFM +5.6 to -1.3) to demonstrate the effects of changing the oxidation state of Re from 4+ to 6+. Experiments were run in the piston-cylinder apparatus, with f_{O_2} controlled either by equilibrium with Re metal, or using the Ru+RuO₂ buffer. Run products were analysed by electron microprobe, and for Re and some other trace elements, by laser-ablation ICP-MS. Rhenium crystal/silicate-melt partition coefficients for pyroxenes, garnet and spinel vary by four to five orders of magnitude, from compatible to highly incompatible, as the oxidation state of Re changes from 4+ to 6+ as a function of f_{O_2} , but Re in either oxidation state is incompatible in olivine. Whole-rock crystal/silicate-melt partition coefficients are averages of both oxidation states, and are therefore expected to vary significantly according to the oxidation state of the system. For instance, assuming average f_{O_2} s of QFM -0.9 and +1.1 for mid-ocean ridge and island arc basalts, respectively, a difference of one order of magnitude is predicted for bulk Re partition coefficients. Our results also demonstrate that Re^{4+} has a partitioning behaviour similar to Ti^{4+} rather than to Yb, and as such is not a sensitive indicator of garnet in the source.

References

- [1] Watson et al. (1987) *Chem. Geol.* **62**, 191-208.
- [2] Righter and Hauri (1998) *Science* **280**, 1737-1741.
- [3] Brenan et al. (2003) *EPSL* **212**, 135-150.
- [4] Righter et al. (2004) *GCA* **68**, 867-880.
- [5] Ertel et al. (2001) *GCA* **65**, 2161-2170.