

Evidence for a primitive terrestrial Mo/W of the bulk-silicate Moon

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We carried out an one-atmosphere experimental campaign that aimed to investigate changes in the partitioning behavior of Mo between silicates (pyroxene, olivine, and plagioclase) and silicate melts as a function of composition and oxygen fugacity. Redox conditions were imposed through a mixture of CO-CO₂ and cover a broad range of fO_2 , ranging from the average expected for terrestrial mantle reservoirs (FMQ -0.6 to FMQ +1.6) to the extremely reduced conditions expected for the lunar mantle, at IW -0.5 and below.

Results show that Mo is volatile above FMQ and that its compatibility into pyroxene and olivine increases three orders of magnitude within the range of oxygen fugacities covered in this study. At FMQ -4, Mo⁴⁺ is dominant, while at values above FMQ, Mo⁶⁺ is prevalent. This indicates that during partial melting in the mantle of the Earth, Mo will be exclusively 6+ and highly incompatible into silicate phases. For the lunar mantle, however, which equilibrated at lower oxygen fugacities, Mo is present exclusively as 4+ and is less incompatible into olivine and pyroxene, because its ionic radius is close to the ideal substitution into these crystals' octahedral sites (0.65 Å). Partial melting models of a lunar mantle consisting of mixed ultramafic cumulates provide evidence for a Mo/W of the bulk silicate Moon similar to the value expected for the terrestrial primitive mantle, in agreement with the hypothesis that the Moon was mainly derived from the Earth's mantle.

The effect of fO_2 on the crystal/silicate melt partitioning of Mo must be considered in any petrological model that attempts to precisely reproduce natural processes, such as mantle partial melting, mass-dependent Mo isotope fractionation, and core formation.