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Evaporation of Cr, Mo, W and P from lunar silicate melts at 1 bar at different temperatures, oxygen-, and water fugacities

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Condensation of elements from the solar gas in the early Solar System and their evaporation during its post-nebular phase, have shaped the chemical budgets of terrestrial planets [1-3]. In particular, the Group VI elements, Cr, Mo and W are noteworthy for having stable oxide gas species, and therefore could have behaved in a volatile manner at conditions relevant to the formation of the Moon [3-4]. Previous experimental studies were performed in mixtures of CO-CO_2 gases at 1 atmosphere (atm), yet, in H-bearing systems such as that of the primitive Moon or solar nebula, the evaporation of hydroxide species is expected. Accordingly, we have performed 1 atm experiments in CO_2-H_2-Ar mixtures in vertical-tube- and aerodynamic levitation furnaces in which synthetic lunar silicate glasses doped with 1000 ppm of Cr, Mo, W and P were heated between 1400- and 2200 °C and fO_2 ranging from 2 $\log_{10}$ units below the Fayalite-Magnetite-Quartz (FMQ) buffer to air ($10^{-0.68}$ bar). We show that, at constant temperature and run duration, Cr becomes more volatile at higher fO_2, while P shows the opposite behaviour. On the other hand, Mo and W are least volatile at around ΔFMQ = +2 and become more volatile at both higher- and lower fO_2. This behaviour can be rationalised by the change in partial pressures of the stable hydroxide- and oxide gas species at different fO_2 and fH_2O, depending on the stoichiometry of the evaporation reaction with the general form $M^{x+n}O_{(x+n)/2}(l) + (x/6)H_2O(g) = O_{x/3}M^x(OH)_{x/3}(g) + (n/4)O_2$. We expand on the theoretical framework of [3] to quantify evaporation loss as a function of T, fO_2, time and water fugacity (fH_2O). The relative losses of Group VI elements from planetary bodies can be used to constrain the fugacity of H_2O in the vapour phase during their evaporation from silicate liquids, thereby distinguishing nebular- from post-nebular environments.

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