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Moderately volatile element depletion in planetary bodies

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The origin of the marked depletion of many differentiated, planetary bodies in moderately volatile elements (MVEs), relative to chondrites, is subject to long-standing debate. Most commonly, the depletion is thought to have originated in either the solar nebula or at the surface of planetary bodies.

We present element and isotopic evidence that indicate MVEs depletion, especially on small objects, occurred at oxygen fugacities (~IW-1) too high relative to those that characterised the canonical solar nebula (~IW-6). Furthermore, previously identified correlations of element depletion and isotopic fractionations with planetary body mass[1] appear more common than previously thought. Hence, oxidising environments must have existed when planetesimals formed, likely during their growth phase.

Hydrodynamic escape of transient atmospheres above magma oceans on differentiated planetary bodies is a plausible locus for MVEs depletion, because it is characterised by the required, elevated oxygen fugacties. Using potassium as a case study and focussing on magma oceans generated by accretional impacts, we find that such escape can occur from bodies whose masses lie in a narrow window, due to the competition between impact energy available for melting (too low below ~10^{21} kg) and the gravitational force (too strong above ~10^{23} kg). Results from N-body simulations indicate that ~16% of objects that grow above ~10^{21} kg have fractionated K isotope compositions to detectable levels (corresponding to >6% K depletion), implying that this process may play an important role in MVEs depletion. However, objects as small as the eucrite parent body require a different heat source or a different MVEs depletion mechanism.

[1] Day and Moynier (2014). *PTRS-A*. **372**, 20130259.