Cosmogenic controls on vanadium isotopes in lunar basalts

S.S. HOPKINS*[1], J. PRYTULAK[2], J. BARLING[1], S.S. RUSSELL[3], B.J. COLES[4], A.N. HALLIDAY[5]

[1]Dept. of Earth Sciences, University of Oxford, OX1 3AN, UK (correspondence: sean.hopkins@stx.ox.ac.uk)
[2]Dept. of Earth Sciences, Durham University, DH1 3LE, UK
[3]Natural History Museum, London, SW7 5BD, UK
[4]Dept. of Earth Sciences & Engineering, Imperial College, SW7 2AZ, UK
[5]The Earth Institute, Columbia University, NY 10025, USA

Vanadium isotope ratios have been proposed as a monitor of irradiation in extra-terrestrial materials, with ^{50}V enrichment a result of high-energy particle reactions [1,2]. Analyses of meteorites and terrestrial igneous rocks show the bulk silicate Earth (BSE) to have the heaviest V isotopic composition of all planetary materials analysed to date [3]. A growing body of isotopic evidence suggests the lunar mantle is indistinguishable from BSE for a number of elements [4,5], but measurements of V isotope ratios in lunar materials have not yet been made.

Nineteen lunar basalts were measured for their V isotope ratios and trace element concentrations. These samples show a range in V isotope ratios larger than all measured terrestrial magmatic rocks but which are also signficantly lighter. Unlike on Earth, magmatic processes (including oxide crystallisation) do not appear to be the primary control on isotopic compositions. There is a correlation with sample exposure age (the length of time that samples have spent on, or near to, the lunar surface). Isotopes of gadolinium (Gd) have previously been used to measure the time-integrated cosmogenic neutron flux in lunar samples [6]. For samples that have also been measured for V isotopes there is a strong correlation with $^{158}Gd/^{157}Gd$. This provides additional evidence that the wide range in V isotope ratios is dominated by cosmogenic effects. Correcting for sample exposure age gives a uniform pre-exposure lunar basalt V isotopic composition overlapping with that of terrestrial basalts, supporting the growing body of evidence pointing to an isotopic similarity between BSE and the Moon.

REFERENCES

[1] Gounelle et al. (2001) Astrophys J. 548. 1051-1070 [2] Sossi et al. (2017) Nat. Astr. 1, 1. [3] Nielsen et al. (2014) EPSL, 389, 167-175. [4] Zhang et al. (2012) Nat. Geosci. 5, 251-255 [5] Wiechert et al. (2001) Science, 294, 345-348 [6] Eugster et al. (1970) EPSL, 8, 20-30.