Experimental investigation on the equilibrium V isotope fractionation between metal and silicate melts and implications for planetary differentiation

H. L. ZHANG[1,2], S. Y. ZHANG[1], F. HUANG[1]

[1] CAS Key Laboratory of Crust–Mantle Materials and Environments, School of Earth and Space Sciences, University of Science and Technology of China, Hefei, Anhui, 230026, China

[2] State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing, 100083, China

Stable isotope composition differences among primitive chondritic meteorites, Earth and other differentiated planetary bodies may reveal their accretion or differentiation histories. Samples, which represent the mantles of Earth, the Moon and Mars, show significant variations in vanadium (V) isotope compositions, and have higher $\delta^{51}V$ than chondritic meteorites [1-5]. Various mechanisms have been invoked to explain the heavy V isotope compositions of differentiated rocky bodies, such as nucleosynthetic heterogeneities and cosmogenic effects. Core formation may be another possible mechanism, as V should partition, to some extent, into the planetary cores owing to required ${}^{metal/silicate}D_V$ ranging from 1.5 to 15 for Earth, the Moon and Mars [6-8]. However, Nielsen et al. (2014) [2] showed no resolvable V isotope fractionation between pure Fe metal and $An_{50}Di_{28}Fo_{22}$ composition melts at 1.5 GPa, 1650 °C. Because metal melt compositions (e.g., light elements contents) could affect V isotope fractionation between metallic and silicate melts, as the cases observed in iron, chromium, zinc and copper isotope systems. Therefore, we experimentally investigated equilibrium V isotope fractionation between Fe metallic and basaltic melt, with particular focus on the effect of Ni and C in metal melts. Experiments were performed at 1 GPa, 1600 °C using a 3/4″ end-loaded piston cylinder. The isotope equilibrium was assessed using time series experiments combined with the reverse reaction method. We found that carbon saturation experiments result in no resolvable V isotope fractionation within 0.10‰ (2 sd), but increasing nickel content in the metal significantly increases the fractionation, with metal melts preferentially sequestering the light vanadium isotope. The results suggest that core formation will leave the planetary mantle with slightly heavier V isotope composition compared to chondrites.

1. Prytulak et al., 2013, EPSL; 2. Nielsen et al., 2014, EPSL; 3. Nielsen et al., 2019, EPSL; 4. Xue et al., 2018, Acta Geochimica; 5. Hopkins et al., 2019, EPSL; 6. Wade and Wood, 2005, EPSL; 7. Rai and van Westrenen, 2014, EPSL; 8. Righter and Chabot, 2011, MPS