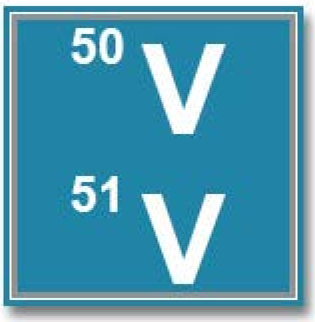
Using Vanadium Isotopes to Investigate Chondrites, Earth, and Moon



Recent advances in chemical separation techniques and procedures for measuring vanadium (V) ***isotopic*** compositions have resulted in more data from a variety of Solar System materials. Teams of researchers including Sune Nielsen (Woods Hole Oceanographic Institution) and Sean Hopkins (University of Oxford) and colleagues from the U.S. and U.K. are developing the vanadium isotope system to investigate Solar System processes, including planetary formation. Their two recent papers are examples of the efforts being made to explain the causes of V isotope variations in Solar System materials.

Nielsen and coauthors recently reported new V isotopic compositions for a suite of 10 carbonaceous and 11 ordinary ***chondrites***. Though the 21 chondrites showed a limited range of V isotope compositions (that they express as an overall $\delta^{51}V_{AA}$ = -1.20 ± 0.22‰ (2sd)), differences between several meteorite groups emerged. Data for charbonaceous chondrites have a strong positive correlation with ***nucleosynthetically***-derived excesses in ^{54}Cr reported previously in the literature. The correlation suggests a common origin for the variation of the two isotopic systems, but Nielsen and coauthors evaluated three possible explanations for the variation: stable isotope fractionation processes, variable proportions of irradiated material, or heterogeneous distribution of nucleosynthetically-anomalous material. And in the end, they suggest the V isotopic variations are most likely due to heterogeneous distribution in our Solar System of nucleosynthetically-anomalous material (e.g., ***presolar grains***). Planet Earth's V isotopic composition (estimated from mantle rocks, such as ***peridotites***) is heavier than the meteorites analyzed to date. If this holds true with more data, then Nielsen and colleagues suggest Earth accreted from material, perhaps a significant portion, which was non-chondritic and which has not yet been sampled in our meteorite collections.

Hopkins and coauthors reported new V isotopic compositions for 19 lunar basalts. They report $\delta^{51}V_{AA}$ = -3.47‰ to -1.00‰ with three of their lunar samples showing V isotopic compositions within the published range estimated for Earth. Hopkins and coauthors found V isotopic compositions correlate with ***exposure age***, meaning the longer a lunar surface rock is exposed to the bombardment of high-energy ***cosmic rays***, the lighter its V isotopic composition. They suggest their data support the idea that the dominant cause of V isotopic variations in our Solar System is cosmogenic effects–due to exposure to and interaction with cosmic rays. Hopkins and coauthors further argue that pre-exposure V isotopic compositions would have been similar among chondrites, bulk silicate Earth, and the Moon.

Future work will not only help advance our understanding of vanadium isotopic compositions and the processes responsible for the variations, but also of the broader issues of planetary and ***solar nebular*** processes, and ultimately our understanding of the building blocks of Earth and Moon.

See References:

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Chondritic Meteorites, *Earth and Planetary Science Letters,* v. 505, p. 131-140, doi: 10.1016/j.epsl.2018.10.029. [**abstract**]

- Hopkins, S. S., Prytulak, J., Barling, J., Russell, S. S., Coles, B. J., and Halliday, A. N. (2019) The Vanadium Isotopic Composition of Lunar Basalts, *Earth and Planetary Science Letters,* v. 511, p. 12-24, doi: 10.1016/j.epsl.2019.01.008. [**article**]

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