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Vanadium-Magnesium Isotope Systematics of Planetary Materials as a Tracer of High-Temperature Parent Body Processes

LIAM PETERSON[1], SUNE G. NIELSEN[2], MAUREEN AURO[1], DAVID V BEKAERT[3], KEVIN RIGHTER[4], LAURENT TISSANDIER[5], KEVIN W BURTON[6], DR. KELSEY PRISSEL[7] AND ANDY W. HEARD[1]

[1]Woods Hole Oceanographic Institution
[2]Centre de Recherches Pétrographiques et Géochimiques, CNRS, Université de Lorraine
[3]Université de Lorraine, CRPG, CNRS
[4]University of Rochester
[5]Université de Lorraine, CNRS-CRPG, France
[6]Durham University
[7]Purdue University

Recent work has demonstrated correlations between vanadium (V) and magnesium (Mg) mass-dependent stable isotopes in rocky planets and planetesimals, which may be explained by kinetic isotope fractionations during partial evaporation/condensation [1]. Modelling kinetic isotope fractionations between melt and vapor critically relies upon fractionation factors, which are frequently determined experimentally [e.g., 2]. To further evaluate the role of evaporation/condensation processes in establishing the observed V-Mg isotopic correlations, we are experimentally determining the melt-vapor kinetic fractionation factors for V and Mg in CAI-like and basaltic materials. Experiments have been conducted at 1550°C, 0.1 – 1 mbar, $fO_2 \geq$ IW −4, and under residual air, CO-CO_2, and H_2-CO_2 atmospheres. Consistent with prior work, we find that Mg evaporation is enhanced in the presence of an H_2-bearing atmosphere [2], whereas V evaporation is insensitive to the atmospheric composition. These contrasting behaviors may imply that the V-Mg isotope systematics of planetary materials serve as a qualitative sensor for evaporation in the presence of a H_2-rich atmosphere, as would be imparted by the solar nebula. The trend defined by chondrites-angrites-HEDs-Mars is intermediate between trends defined by experiments conducted under CO-CO_2 and residual air, potentially implying these bodies experienced significant evaporation in the absence of H_2-rich atmospheres. We emphasize the preliminary nature of this conclusion as the roles of fO_2, pressure, and the bulk composition of the starting material are still being evaluated. Additionally, it is possible that the V isotopic compositions of planetary materials are, in part, influenced by isotopic fractionations during metal-silicate differentiation on the parent body [3]. Ongoing work is largely focusing on the influence of bulk composition (e.g., CAI-like vs. basaltic) on V and Mg kinetic isotope fractionation factors.

[1] Bekaert et al. (2025), *EPSL* 652, 119202.; [2] Mendybaev et al. (2021), *GCA* 292, 557-576.; [3] Nielsen et al. (2020), *GPL* 15, 35-39.