Nucleosynthetic heritage and origin of Mars

C. BURKHARDT[1], T. S. KRUIJER[1,2], L. E. BORG[2], T. KLEINE[1]

[1]Institut für Planetologie, Westfälische Wilhelms-Universität, 48149 Münster, Germany (burkhardt@uni-muenster.de)
[2]Lawrence Livermore National Laboratory, CA 94550, USA

Nucleosynthetic isotope variations among planetary materials are an exciting new tool for constraining (i) mixing and reservoir formation in the early solar system, (ii) genetic relationships of planetary bodies, and (iii) the accretion history of planets [e.g. 1-6]. While recent work on these topics mostly concentrated on the Earth and its relation to chondrites [e.g., 2-6], here we focus on the nucleosynthetic heritage of Mars. Mars is of particular interest because it is located between Earth and the asteroid belt and is thought to represent an early stage of planetary growth. As such the nucleosynthetic heritage of Mars may provide important information for models of terrestrial planet formation.

In order to reveal the distinct sources of the building materials of Earth and Mars, estimate the $^{142}Nd/^{144}Nd$ ratio of bulk Mars (a critical parameter for unravelling its differentiation history using the ^{146}Sm-^{142}Nd system), and test models of terrestrial planet formation we obtained new Ti, Mo and Nd isotope data of 18 martian meteorites. Relative to the Earth, all samples exhibit nucleosynthetic isotope anomalies that are in between those of enstatite and ordinary chondrites. The Mo and Nd isotopic compositions are correlated and reveal a *s*-process deficit in the martian mantle. Furthermore, the martian mantle plots on a 'cosmic' Mo vs. Nd isotope correlation line defined by Earth's mantle as well as enstatite and ordinary chondrites. Collectively, the data reveal an increasing *s*-process deficit in the order Earth's mantle < enstatite chondrites < Martian mantle < ordinary chondrites < carbonaceous chondrites. This correlation provides a wealth of information about the origin and accretion history of the Earth and Mars, namely that: (i) the material added to the Earth and Mars did not change as accretion proceeded, (ii) Mars can be seen as a mixture of enstatite and ordinary chondrite-like material, consistent with inferences based on O isotopes and the martian mantle FeO [7], (iii) the bulk $^{142}Nd/^{144}Nd$ of Mars is ~15 ppm lower than the terrestrial value, which requires revision of Mars' silicate differentiation history, and (iv) carbonaceous chondrites did not play a significant role in the accretion of either Earth or Mars, possibly due to the formation of Jupiter [1].

[1] Warren (2011) *EPSL* **311**, 93-100. [2] Burkhardt et al., (2011) *EPSL* **312**, 390-400. [3] Burkhardt et al. (2016) *Nature* **537**, 394–398. [4] Dauphas (2017) *Nature* **541**, 521–524. [5] Fischer-Gödde & Kleine (2017) *Nature* **541**, 525–527. [6] Burkhardt et al., (2017) *MAPS* doi: 10.1111/maps.12834. [7] Sanloup et al. (1999) *PEPI* **112**, 43-54.