

Atomic Views of Martian Evolution

D.E. MOSER^{1*}, D. A. REINHARD², D. OLSON², P. H. CLIFTON², D. J. LARSON², J.R. DARLING³, K.T. TAIT⁴, M. BUGNET⁵, B. GAULT⁵ AND I.R. BARKER¹

¹Univ. of Western Ontario, London, Ont., CAN N6A 5B7
(*correspondence: desmond.moser@uwo.ca); ²CAMECA, Madison, WI 53711, USA; ³University of Portsmouth, UK; ⁴Royal Ontario Museum, Toronto, Ont. CAN M5S 2C6; ⁵CCEM, McMaster University, Hamilton, Ont. CAN

The extremely sluggish volume diffusion rates of U and Pb in minerals such as baddeleyite and zircon, together with their resistance to breakdown during shock metamorphism, make them ideal recorders of inner Solar System evolution. In the case of highly shocked basaltic shergottite NWA5298, our discovery of igneous (187±33 Ma) micro-baddeleyite, with micron-wide reaction rims of much younger launch-generated zircon, promises further information on young Mars evolution if afforded high spatial resolution techniques.

Here we present the first atomic resolution STEM (HAADF detector) imaging of baddeleyite and zircon microstructure, and our progress toward their combination with atom probe tomography (CAMECA LEAP[®]) results for extraterrestrial phases. Conventional EBSD analysis indicates that euhedral baddeleyite CL zones are now amorphous at 50 nm length-scales, whereas high resolution STEM results reveal a mosaic of slightly misoriented nanocrystalline domains overgrown by unshocked zircon in single orientation. Rare dislocation trains in zircon are perhaps due to thermal stress on transit to outer space and Earth. Atom probe results for terrestrial reference zircon BR266 reveal a generally homogeneous distribution of radiogenic Pb²⁺. The goal of LEAP analyses is to map Pb and trace element distribution in martian ejectic zircon rims, the age of which is constrained to lie between the youngest shocked baddeleyite date of 22±2 Ma [1] and the cosmic ray exposure ages of ~3 Ma for similar shergottites [2]. These techniques open the door to direct analysis of atom-scale mineral records of the evolution of Mars and the interplanetary travel of martian crust.

[1] D.E. Moser *et al.* (2012) Microstructure and U-Pb dates of martian baddeleyite rimmed by zircon indicate a 'young' igneous and metamorphic history for shergottite NWA 5298. *Lunar Planet Sci Conf. XLIII* Abs. 2173. [2] O. Eugster *et al.* (1997) Ejection Times of Martian Meteorites. *Geochim.Cosmochim. Acta.* **61**, 2749–2757.

Effect of the isotopic composition of nitrite on the enrichment factor during benthic denitrification

AURELIE MOTHET^{1*}, MATHIEU SEBILO¹, ANNIET M. LAVERMAN², VERONIQUE VAURY¹
AND ANDRE MARIOTTI¹

¹UPMC Univ Paris 06, UMR Bioemco, 4 place Jussieu, 75252 Paris Cedex 05, France, aurelie.mothet@upmc.fr (*presenting author)
²UPMC Univ Paris 06, UMR Sisyphe, 4 place Jussieu, 75252 Paris Cedex 05, France

Mediated by denitrifying bacteria under anoxic conditions, denitrification plays an important role reducing nitrate pollution in surface and groundwater. Denitrification can be traced by isotopic biogeochemistry; the isotopic enrichment factor associated with denitrification may vary significantly (i.e. for nitrogen, ϵ vary from -30 to 0‰). This large range might be due to the presence of nitrite, an intermediate during denitrification, not accounted for in the enrichment factor. The presence of nitrite, either transient or continuous, during denitrification is regularly observed. Variations in nitrite concentrations (production and/or reduction), depleted in ¹⁵N and ¹⁸O could modify the enrichment factor for nitrate, when the isotopic composition of nitrite and nitrate are measured together.

Therefore, the objective of this study was to determine the nitrogen and oxygen isotopic fractionation ($\epsilon^{15}\text{N}$, $\epsilon^{18}\text{O}$) associated with both nitrate and nitrite during denitrification by environmental benthic denitrifying communities. Denitrification rates were determined in sediments from four different locations in the Seine bassin (France). Nitrate reduction rates as well as nitrite production and reduction rates were determined and the ¹⁵N and ¹⁸O of both compounds were analysed. As expected, our results show that the isotopic composition of nitrite (¹⁵N and ¹⁸O) is depleted. With a maximum nitrite concentration of about 1% of the initial nitrate concentration, the isotopic enrichment factor shows a significant isotopic shift (-2‰ for nitrogen and oxygen). This indicates the importance of considering a correction of the enrichment factor for denitrification taking into account nitrite.