

## Stable isotope systematics of volatiles in Apollo 15 lunar volcanic glasses

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The presence of magmatic water in lunar volcanic glasses (LVGs) [1] requires a re-evaluation of conventional wisdom that the Moon was entirely dehydrated following its formation via giant impact. The LVGs are the most primitive melts erupted on the surface of the Moon, and the presence of water and chlorine in these magmas indicates the presence of a deep volatile-bearing mantle source within the Moon.

New volatile abundance data for over 200 individual Apollo 15 lunar glasses [2] show an increase in the highest volatile concentrations by a factor of 2 over previously reported data (up to 70 ppm H<sub>2</sub>O, ref. 1). D/H ratios range from +700‰ to +5400‰ and are inversely correlated with water contents. The presence of tritium (T) in lunar samples [3] requires the presence of a spallogenic component of volatile isotopes from interactions with solar and galactic cosmic rays, but the distribution (surface vs interior) of this component within LVGs remains poorly defined. At the lowest H<sub>2</sub>O contents, spallogenic D can potentially account for half of the abundance of D (and less than 0.005 ppm of the H) in the interiors of the glass beads based on estimated T, D and H production rates [3, 4], but the production rates would have to be underestimated by a factor of 100 to account for the D/H ratios of LVGs with high H<sub>2</sub>O. The D/H ratios of magmatic water in H<sub>2</sub>O-rich LVGs are thus undisputably fractionated from terrestrial values. The data are consistent with kinetic fractionation of D from H during post-eruptive degassing, from a pre-eruptive H<sub>2</sub>O-D/H composition similar to terrestrial basalts, provided that H and D diffuse as protons/deuterons. Alternatively, the high D/H ratio of LVG water could be inherited from gas condensed within the Moon from a residual atmosphere surrounding the proto-lunar disk after the giant impact.

The stable isotope composition of other volatile elements in LVGs will also be discussed at the meeting.

[1] Saal *et al.* (2008) *Nature* **454**, 192-195. [2] Saal *et al.*, this volume. [3] Bochsler *et al.* (1971) *LPSC* **2**, 1803-1812. [4] Merlivat *et al.* (1976) *LPSC* v. **7**, 649-658.

## Determining trace metal-nanoparticle associations in contaminated sediment using analytical TEM and FFF coupled to MALLS and HR-ICPMS

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Analytical electron microscopy (AEM) and flow field-flow fractionation (FIFFF) are being used to study the associations between trace metals and nanoparticulate materials in sediment. Six samples have been taken from the channel of the Clark Fork River system in western Montana, USA. A large dam-removal and channel re-construction project has released reservoir sediment contaminated with toxic trace metals (Pb, Zn, Cu, As) from over 150 years of base-metal mining activities upstream. Digestion and analysis by inductively coupled plasma atomic emission spectroscopy (ICPAES) revealed that all samples contained elevated amounts of the trace metals of interest. Nanoparticles were recovered from the sediment samples by aqueous extraction and analyzed using FIFFF coupled to multi angle laser light scattering (MALLS) and high resolution inductively coupled plasma mass spectroscopy (HR-ICPMS). Aliquots of the extracts were also used to prepare samples for analysis with a FEI Titan high resolution scanning/transmission electron microscopy (S/TEM) equipped with EDS and EELS detectors. Results to date indicate extensive association of these toxic trace metals with the nanoparticulate size fraction in the sediments. In addition to the comparably large surface area to mass ratio of nanoparticles, the properties of nanoparticles have been shown in many cases to be dramatically altered from that of similar material at larger sizes. These property changes and potentially increased reactivity may have a large impact on the cycling of trace metals in natural systems. This has major implications for stream health in other dam-removal projects that may release contaminated sediments downstream.