

## Silicon isotope constraints on the formation of the Moon

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The formation of the Moon by a giant impact could have significantly affected the isotope composition of moderately volatile elements such as silicon. The analysis of Si isotopes in lunar rocks, compared with terrestrial rocks and chondrites, can thus potentially provide insights into the Moon-forming event.

The Si isotope compositions of several high- and low-Ti mare basalts were measured with the MC-ICPMS NuPlasma 1700. The Si isotope composition of the silicate Earth and Moon is identical within error while it is distinct from that of the chondrites [1, 2].

At the time of the impact, the  $\delta^{30}\text{Si}$  of the Earth's mantle is well represented by the measured modern value, given that most of the Earth's core must have formed before the Moon-forming giant impact [3]. Therefore, at that time, the Earth's mantle already had its heavier-than-chondritic Si isotope composition. In order to account for the similarity of other isotope systems between Earth and Moon silicate phases [4-6], a model involving isotope equilibration through turbulent fluid exchange between the terrestrial magma ocean and the surrounding melt-vapor proto-lunar disk following the giant impact has been suggested [7]. Since the isotopic homogeneity of the Earth-Moon system includes both volatile and refractory elements, turbulent exchange may have involved both the silicate vapor and the suspended liquid droplets, isotopically homogenizing all elements irrespective of their volatility. In such a scenario, the terrestrial value of the Si isotope composition of lunar samples can be explained through inheritance from Earth's mantle. The vaporization of silicates in the proto-lunar disk could also have produced Si isotope compositions distinct from the terrestrial value by equilibrium liquid-vapor Si isotope fractionation. Depending on the amount of phase separation that occurs, this scenario can result in a lunar Si isotope composition that is lighter than the terrestrial value [8]. The precision of the Si measurements ( $\approx$ maximum  $\Delta^{30}\text{Si}_{\text{Moon-Earth}}$ ) constrains the scenario of liquid rainout in the post giant-impact atmosphere of the Earth.

[1] Fitoussi *et al.* (2009) *EPSL* **287**, 77. [2] Georg *et al.* (2007) *Nature* **447**, 1102. [3] Rudge *et al.* submitted. [4] Wiechert *et al.* (2001) *Science* **294**, 345. [5] Touboul *et al.* (2007) *Nature* **450**, 1206. [6] Trinquier *et al.* (2008) *GCA* **72**, 5146. [7] Pahlevan & Stevenson (2007) *EPSL* **262**, 438. [8] Pahlevan *et al.* submitted.

## Structure-catalytic activity relationship of biogenic Pd nanoparticles

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We have identified a highly efficient microbial process that produces Pd nanoparticles (bio-Pd) with unique catalytic activity in the reductive precipitation of hexavalent chromium ions, both in pure cultures and under simulated sandy aquifer conditions. Both the formation kinetics and activity of these bioPd nanoparticles, which are produced by *Clostridium* sp. BC1 via the reductive precipitation of Pd (II) ions, contrast markedly with bioPd nanoparticles of comparable shape and morphology produced by *Shewanella* and *Desulfovibrio* [1, 2]. This presentation will describe the application of x-ray absorption spectroscopy (XAS) to investigate the structural basis for the different catalytic activities of these bioPd nanoparticles.

Electron microscopy images of bioPd-loaded biomass show how Pd nanoparticles and nanoparticle aggregates are predominantly associated with the cell wall, but also occur within the cytoplasm. Transmission electron microscopy images did not resolve lattice spacings in any nanoparticles even though x-ray diffraction results indicate that crystalline nanoparticles form in all cases. Systematic changes in the lattice parameter of the different bioPd nanoparticles, however, are discernable in the extended x-ray absorption fine structure (EXAFS) region of XAS spectra. Once corrected for nanoparticle size, the EXAFS fit results show a lattice expansion in the catalytically active bioPd which is consistent with the presence of interstitial hydrogen [3]. This finding explains the unique catalytic activity and is consistent with the predominant bioPd synthesis pathways of the different microbial species. This work serves as an ideal case study of the potential applications of XAS to investigate structure-reactivity relationships of both naturally-occurring and engineered nanoparticles in light of uncertainties in the coherence of particle size with the size of ordered domains within the nanoparticles themselves.

[1] De Windt *et al.* (2005) *Environ. Microbiol.* **7**(3), 314–325.  
[2] Lloyd *et al.* (1998) *Appl. Environ. Microbiol.* **64**(11), 4607–4609. [3] Sun *et al.* (2006) *Langmuir* **22**, 807–816.