

## What can spectral properties of SNCs and Martian surface tell us about crust-mantle system evolution?

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The SNC meteorites are the only samples of Mars available for analysis on Earth, providing unique insights into the formation and evolution of the Martian crust-mantle system. However, the absence of identified source regions and the debate surrounding the age of shergottites limits exploitation of the mineralogical and geochemical information provided by these rocks. With this in mind, a comparison between the near-infrared (NIR) spectral properties of the SNCs and spectra of the Martian surface from the NIR imaging spectrometer OMEGA/MEx has been made. We show that shergottite spectra are comparable to those of early Hesperian volcanic provinces such as Syrtis Major, consistent with an age of these meteorites more ancient than the Amazonian [1]. This result is largely controlled by the fact that the pyroxene mineralogy inferred for Hesperian terrains is comparable to that of the basaltic shergottites.

Additional constraints on the formation and evolution of the crust-mantle system can be provided by the study of olivine, which is a precious marker of magmatic processes. The global distribution of olivine as seen with OMEGA shows that olivine is mainly associated with three different geological settings [2]: (1) ejecta around the Hellas basin with an intermediate to forsteritic composition suggesting a Mg# >50 for the excavated upper mantle, (2) large impacts and crustal outcrops that argue for olivine in deeper sections of the crust in the form of cumulates or alternatively in a global layer of older (early Noachian) rocks, (3) early Hesperian lava flows throughout the Martian surface suggesting a planetary event of olivine-enriched fissural volcanism. In contrast, olivine is not detected in Noachian terrains that formed the major part of the southern highlands. This fact could be related to an evolution in magma composition or in the degree of olivine fractionation between these two epochs.

These results will be discussed in light of the predictions of petrologic models for the formation and evolution of the Martian crust-mantle system [3,4].

[1] Bouvier *et al.*, 2009, *EPSL*, 280, 285-295. [2] Ody *et al.*, 2013, *JGR*, 117, E00J14. [3] Elkins-Tanton *et al.*, 2005, *JGR*, 110, E12. [4] Baratoux *et al.*, 2013, *JGR*, 118, 1-6.

## Reversibility of calcium and magnesium isotopic signatures during ambient temperature fluid-carbonate mineral interaction

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The interpretation of mineral isotopic signatures in low temperature fluid-rock systems commonly relies on the assumption that they remained unchanged since their precipitation over geologic time, despite potentially being out of isotopic equilibrium with their co-existing fluids (e.g. the use of carbonate isotopic compositions to deduce paleo temperatures). Similarly, fluid compositions are frequently interpreted assuming that isotopes are conservatively transferred from minerals to fluids as they dissolve.

In an attempt to test such assumptions, we have dissolved both calcite and hydromagnesite ( $\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 4\text{H}_2\text{O}$ ) in closed-system reactors from far to near to equilibrium conditions in aqueous  $\text{NaHCO}_3/\text{Na}_2\text{CO}_3$  solutions at constant pH from 6.5 to 9. Ca and Mg were strongly fractionated during the stoichiometric dissolution of these minerals; in each case the fluid is significantly isotopically heavier than the dissolving mineral. For example, calcite dissolution at pH ~6.8 yielded a fluid phase that was ~0.65‰ heavier than the dissolving mineral during the 3 days required to attain equilibrium. Correspondingly, the calcium in the solid phase became ~0.14‰ higher during this experiment. Isotope fractionation during stoichiometric dissolution is interpreted to stem from the two way transfer of material to and from the mineral as equilibrium was approached, consistent with the concept of microreversibility. Preliminary mass balance calculations suggest that more than 20% of the Ca contained in the calcite present in this experiment must have passed through the fluid phase to attain this degree of fractionation. Similarly, hydromagnesite dissolution at ~pH 8.4 yielded a fluid phase that was ~0.3‰ heavier than the dissolving mineral during the 3 days required to attain equilibrium. In some cases, the isotopic composition of the fluid continues to evolve after the mineral attained elemental equilibrium. These observations clearly contravene the concept of conservative isotopic mass transfer during mineral dissolution and questions the degree to which mineral isotopic signatures can be preserved in low temperature systems.