

Nanoscale alteration of amorphous Fe-silicate in meteorites

C. LE GUILLOU^{1,2}, R. DOHMEN¹, T. MÜLLER^{1,3},
C. VOLLMER⁴, D. ROGALLA⁵ AND H. W.
BECKER⁵

¹Ruhr-Universität Bochum, Germany

²UMET, Univ. Lille1, Villeneuve d'Ascq, France

³Leeds University, UK

⁴Universität Münster, Inst. für Mineralogie, Germany

⁵RUBION facility, Ruhr-Universität Bochum,
Germany

Chondrites may have accreted - among other space oddities - amorphous Fe-rich silicate together with water, which have later reacted within the asteroids during low temperature hydrothermal episodes (<150°C). To constrain temperature and timescales of these hydrothermal reactions, we studied the mechanisms and kinetics of Fe-amorphous silicate serpentinization. We used an original experimental setup: a thin (~ 1 μm) layer of amorphous "FeMgSiO₄" is deposited on a substrate using pulsed laser deposition (laser ablation → plasma condensation) [1]. The film is then reacted in water at pH 9. We follow the evolution of the reaction front by FIB/TEM, Rutherford Back-Scattering (Fe/Mg/Si concentration), Nuclear Reaction Analysis (water content) and XANES (Fe valence). We performed time (2h→6 months) and temperature series (60°C→150°C). The roles of silicate composition, water/rock and redox are investigated.

Two hydrated (~ 15 H₂O wt. %), oxidized ($\Sigma\text{Fe}^{3+}/\text{Fe} > 60\%$) and amorphous layers of serpentine-like composition progress from the surface towards the pristine material: a fibrous/porous Mg-rich one on top and a compact Fe-rich one below. Each layer evolves from an initial Fe# of ~ 50% towards pure Fe and Mg endmembers. Chemical gradients at layers boundaries are sharp, which was interpreted in glass alteration studies [2] as the result of reactions kinetically-controlled by interfacial dissolution-precipitation. Solid state diffusion being too slow at T<200°C, it could imply that Mg-transport from the raw material through the Fe-layer occurs in the fluid present in a -so far speculative- nanoporosity.

The products, despite some differences, share strong similarities with amorphous silicates of CM, CR and CO chondrites which validates our approach. H₂ escape during alteration may explain the high Fe³⁺ content [3]. Time-temperature diagrams suggest short hydrothermal episodes (~ year), even at temperatures < 50°C.

[1] Le Guillou et al., 2015. *Chem.Geol.* [2] Hellmann et al., 2015. *Nat. Comm.* [3] Le Guillou et al., 2015. *ESPL*.