

Carbonation of olivine at CO₂ supercritical conditions: Reactivity differences between synthetic and natural olivines

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The carbonation of ultramafic and mafic rocks has been proposed as a carbon capture and storage (CCS) method. This method is promising because CO₂ would be captured in carbonate minerals that are stable for geological time spans. The challenge, however, is that the reactions which lead to the formation of carbonates are very slow. Learning more about it might offer the possibility of enhancing reaction kinetics.

Forsterite (Mg₂SiO₄) is an abundant mineral in mafic and ultramafic rocks. The purpose of this study was to investigate the differences in reactivity between synthetic and natural forsterite when exposed to pure deionised water and supercritical CO₂ (120 °C, 80 bars and 7 days of reaction). Solids were characterised with scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy dispersive X-ray spectroscopy (EDXS), X-ray powder diffraction (XRD) and X-ray photoelectron spectroscopy (XPS) and solution composition, with atomic absorption spectroscopy (AAS).

After reaction, synthetic forsterite had transformed partly to magnesite (MgCO₃), with well defined crystals of up to 25 μm in size and to spherical particles, consisting dominantly of SiO₂.

Unreacted natural forsterite (Fo_{91.1}) had highly heterogeneous surface composition and morphology. Reaction produced very fine grained alteration products that were difficult to identify unambiguously. Thus, only a few indications of carbonate mineral formation could be observed. Our results show that natural and synthetic forsterite react very differently. After reaction, etch pits are visible on the natural samples and AAS shows Mg in solution, suggesting that the different behaviour could be caused by inhibited magnesite nucleation and growth. This implies that the complex nature of natural material should be taken into account when predicting mineral carbonation.

Dissolved and particulate iron concentrations and isotopic compositions in the South Atlantic and Southern Ocean

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Iron is an essential micronutrient for phytoplankton. It has been shown that in High Nutrient Low Chlorophyll areas (HNLC), Fe is a limiting factor for phytoplankton growth. Therefore, Fe has an influence on the carbon cycle. Its sources to the ocean remain a matter of debate. It has been suggested that aerosol inputs and reductive dissolution within oxygen depleted sediments were the main sources of Fe to the water column, although recent studies highlighted that the non-reductive dissolution within oxic basins is another potential source of Fe.

We obtained new results on Fe concentrations and isotopic compositions in both the particulate and dissolved phases of Fe (PFe and DFe) in seawater, in the oxic South Atlantic and Southern Ocean, off the South African coast towards Antarctica. During the Bonus GoodHope cruise in 2008, seawater samples have been taken from five stations, along a section from 36.50°S 13.12°E to 57.55°S 0.04°E. Dissolved and particulate Fe concentrations range from 0.05 to 0.72 nmol.L⁻¹ and from 0.13 to 4.65 nmol.L⁻¹, respectively. Particulate Fe and Al concentrations are correlated for three stations in the Northern part of the section suggesting lithogenic inputs of particulate iron originating from the Agulhas Current.

Iron isotopic compositions obtained so far range from -0.04‰ to 0.32‰ in δ⁵⁶Fe for PFe and from -0.71‰ to 0.27‰ for DFe. With an average isotopic composition of 0.09‰ in the Northern part of the section –close to that of the continental crust, ~-0.07‰ - the signature of the particles confirm their lithogenic origin. The lighter isotopic signatures for both DFe and PFe in the Upper Circumpolar Deep Water (UCDW) may be related to the remineralization of organic matter.

Isotopically slightly heavier DFe than PFe at the northernmost station of the transect (~500 km away from the African margin) suggests a non-reductive release of DFe from the African margin sediments. This could be a major source of Fe in oxic basins, which are much more widespread than oxygen minimum zones in the global ocean.