

Mantle xenoliths from Bir Ali (Yemen)

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Mantle xenoliths from the Bir Ali diatrema (southern Yemen) consist of spinel peridotites and clinopyroxenites. In this contribution we present bulk rock (XRF, ICP-MS) and mineral (EMPA, LA-ICP-MS) major and trace element analyses carried out on a collection of 62 samples in order to characterize the lithospheric mantle of the area and constrain its relative petrological evolution. Peridotites are mainly equilibrated at 950-1000 °C and include fertile lherzolites and more refractory harzburgites and dunites, suggesting that partial melting processes variably affected the pristine mantle composition. Subsequent metasomatic reactions are evidenced by: a) glassy films and/or patches; b) interstitial plagioclase; c) rare pargasite amphibole (observed only in one sample). Further evidence of metasomatic interactions is given by anomalously low Fo content (<0.87) of olivine and low Mg# of pyroxene (<0.88). These metasomatic events are confirmed by the bulk rock trace element budget that reveal enrichments in the most incompatible elements, especially in the most refractory dunites (La_N/Yb_N up to 4.1). Coherently, enrichments in the most incompatible elements are also observed in diopsidic clinopyroxene (La_N/Yb_N up to 3.9) and glasses (La_N/Yb_N up to 9.9). Trace element discrimination ratios [1] suggest that the causative metasomatic agents were mainly represented by alkali-silicate melts. Noteworthy, samples characterized by plagioclase impregnation show unfractionated (flat) bulk-rock and clinopyroxene REE patterns suggesting refertilization by subalkaline metasomatic melts. Therefore, the considered lithospheric section appears to be characterized by remarkable heterogeneity, in contrast with what observed in mantle xenoliths collected from the Ethiopian plateau area that display clear evidence of pervasive refertilization by CFB melts [2]. This suggests that the lithospheric mantle of southern Yemen wasn't affected by the thermochemical effects of the Afar plume.

[1] Coltorti *et al.* 2000. *Earth Planet. Sc. Lett.* **183**, 303-320.

[2] Beccaluva *et al.*, 2011. *GSA Special Paper* **478**, 77-104.

Pore-scale simulation of calcite dissolution and precipitation using lattice-Boltzmann method

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Calcium carbonate dissolution and precipitation plays an important role in the context of CO₂ storage in geologic formation, or as a pH buffer during diagenesis of marine sediments. Using the parallel open-source library palabos (www.palabos.org), we have developed a new multi-species pore-scale model based on the lattice Boltzmann method to investigate the effect of physical and chemical heterogeneities on geochemical behavior of carbonate system in a complex porous media. The model has been successfully applied to study the permeability change of a porous medium associated with a given porosity change during dissolution and precipitation and arsenic sorption on Fe-bearing minerals.

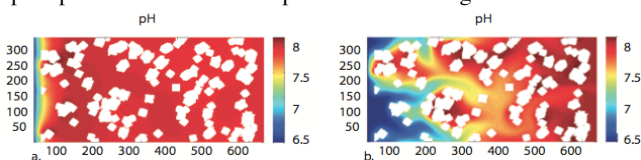


Fig 1. Pore-scale pH distribution at steady-state for a) low Peclet number (Pe=1) and b) high Peclet number (Pe=5).

In this study, we consider standard geochemical pathways for the carbonate system including 7 species (i.e. H⁺, OH⁻, H₂CO₃, HCO₃⁻, CO₃²⁻, Ca²⁺ and CaHCO₃⁺) and 5 mixed kinetic-equilibrium reactions. The focus of our study is to investigate how spatial distribution of the pH is affected by: 1) the kinetic rates of heterogeneous calcite dissolution and precipitation (i.e. pH-dependent vs. pH-independent rate constants), 2) transport regime (i.e. Peclet numbers) and 3) chemical composition of initial and boundary conditions resulting in spatially variable saturation index with respect to calcite. Results showed that the development of pore-scale concentration gradients is a combined effect of heterogeneous reactions and pore-scale flow within the porous medium. In high Pe simulations (Fig 1.a), both depth of penetration and spatial heterogeneity increase compared to low Peclet scenario (Fig 1.b). Calculated minimum, maximum and average pH values in the computational domain are function of Pe, chemical composition of inflow and initial solution in the domain, and type of rate constants.