

Infiltration-driven metamorphism of dolomite rock

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Marble with brucite and calcite is commonly the result of metamorphism of dolomite rock in the presence of an H₂O-rich fluid through the reaction dolomite = periclase + calcite + CO₂ with subsequent replacement of periclase by brucite. We have conducted laboratory experiments to determine the rate and mechanism of the breakdown of dolomite and have found that dolomite converts to the product assemblage by the shrinking-core process, in which H₂O and CO₂ diffuse through a reaction rim of calcite and periclase. The reaction rate is diffusion controlled with an average rate given by $\langle d\xi/dt \rangle = 0.01 t^{-0.75}$ ($\mu\text{mol}/\text{mm}^2 \cdot \text{s}$). The rate is a function of the composition of the fluid and approaches zero at the equilibrium value of x_{CO_2} , which is about 0.23 at the conditions of the experiments, 700 °C, 100 MPa. With these data, we can construct a kinetic model for metamorphism of dolomite rock in an infiltration system, as might occur in contact-metamorphic aureoles. The goal of the model is to compare the extent of reaction accounting for the finite reaction rate with the extent expected simply by assuming local equilibrium only. The model is isothermal and isobaric, to use the kinetic parameters determined by our experiments, and one-dimensional. Adjustable parameters include the flux at the inlet, the composition of the infiltrate, and the initial hydraulic conductivity of the dolomite. The model accounts for the production of porosity during reaction and the fluid pressure resulting from the change in composition during reaction. As an example, Figure 1 shows the composition of the fluid after infiltration of 1 mol H₂O/m²·y for three times. For a dolomite rock with 1.52×10^4 mol dolomite/m³, two orders of magnitude more time are required for the downstream fluid composition to change, and reaction is confined to the first meter. Even though the rate of dolomite breakdown is fast, its finite value can result in reaction over a zone a few meters wide.

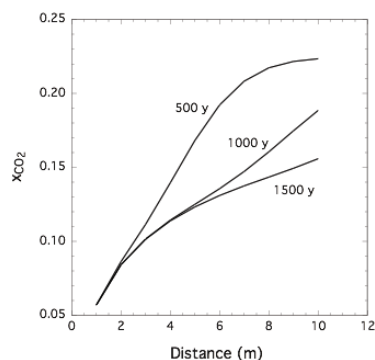


Figure 1: Fluid composition during infiltration with a flux at the inlet of 1 mol/m²·y

Experimental study for determination of trace element sequestration in chrysotile

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Introduction

Olivine alteration by serpentine is crucial to understand the fluid-mobile-elements cycle in geological systems. However, few hydrothermal experiments have quantified the partitioning of trace elements during serpentine precipitation is still poorly known and new experimental data are required.

Experimental protocols

In this study we characterized the trace elements (B, Li, As, Sb, Cs) partitioning between serpentine and alkaline fluids using two distinct experimental protocols. Alkaline conditions were chosen for the fast kinetic of reaction and the formation of few secondary phases. First, chrysotile nanofibers were synthesized from H₂SiO₃-MgCl₂-NaOH "silicagel system" at 300°C, Mg/Si=1.5, P_{sat}, (pH=13.5 at 25°C) in presence of a single trace element (5 to 200mg/L in solution in the starting fluid) to model equilibrium isotherms (Fig.1b). The second protocol, "alteration system", consists in serpentinisation of olivine grains at 200°C, fluid/rock=15, (pH=13.5 at 25°C), 3h<t<6 months with three olivine starting grain size. Serpentinisation reaction was characterized using XRD, FESEM (Fig.1a,c) and FTIR. Thermogravimetric analyses (TGA) was used as an innovative method to determinate kinetic of serpentinization.

Results

Fast serpentinization is observed in this "alteration system" leading to full olivine replacement by a porous assemblage of chrysotile nanotubes and Fe-rich hexagonal brucite in less than 30 days (for <30µm grain size). Chrysotile fibrous growing from "silicagel system" are very homogeneous and the presence of trace elements influence the size and morphology of partiles.

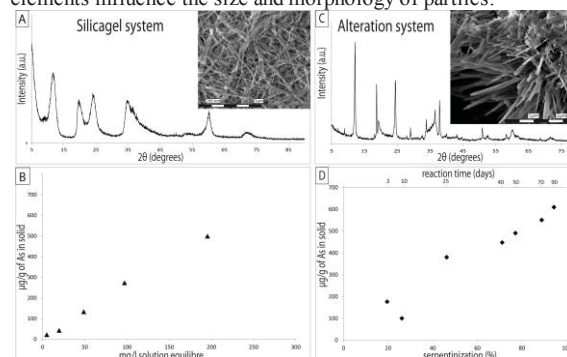


Figure 1: Example of results obtained in the two protocols

Results indicate that trace elements are significantly sequestered by chrysotile in the both systems (e.g. up to 2000 ppm for Sb). Surprisingly, boron is the element with the lowest partitioning in serpentine in alkaline condition. In alteration systems, As (Fig.1d) and Cs incorporation follow rationally serpentinization advancement, Li and B seems not only controlled by chrysotile growth.