Experimental determination of trace element sequestration in chrysotile

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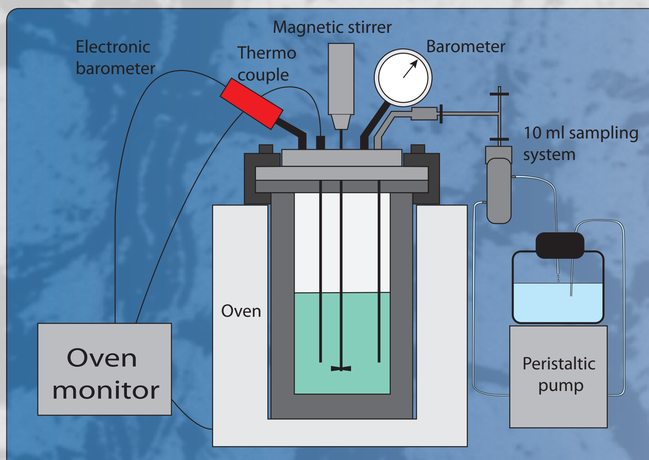
Introduction

Understanding serpentinization is crucial to better interpret the fluid-mobile-elements (FME such like As, B, Li, Cs, Sb) behaviour in geological systems. However, few hydrothermal experiments have quantified the partitioning of FME during serpentine precipitation and new experimental data are required. In this study we developed **two methods** involving different mechanisms of serpentine nucleation and growth in alkaline medium. We determine reaction advancement and kinetic rate by using several analytical methods (TGA, FTIR, FESEM, XRD). Moreover **sequestration of FME** during serpentinization was determinate by using ICP-MS .

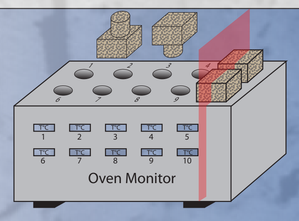
Protocols

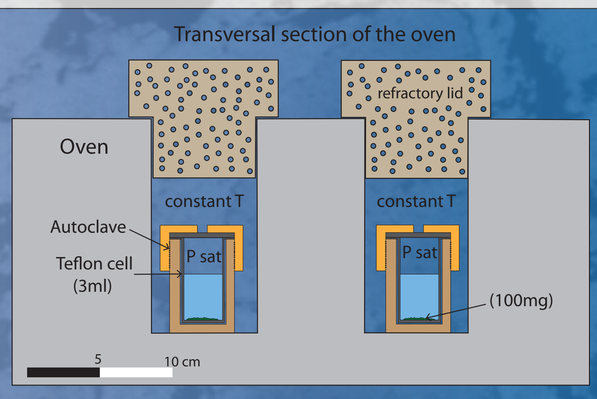
Synthesis System



0.25 L of H_2O + 1M NaOH + 0.1 M Mg + 0.67 M Si + **1 FME (5 to 200 ppm)**
> At 300°C (Psat) during 30 hours
> Sampling system to follow reaction advancement

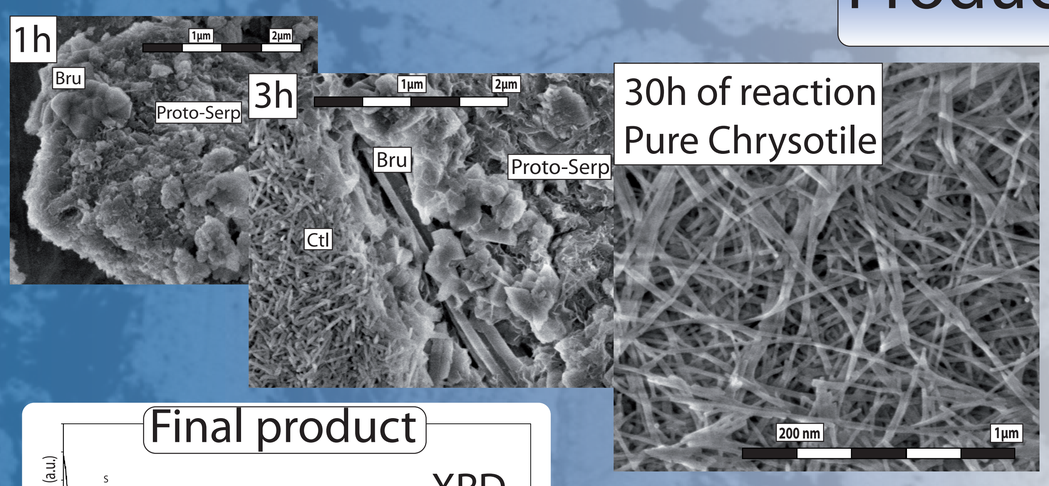
Alteration System



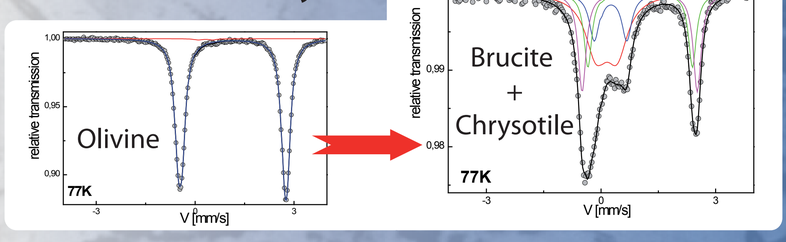


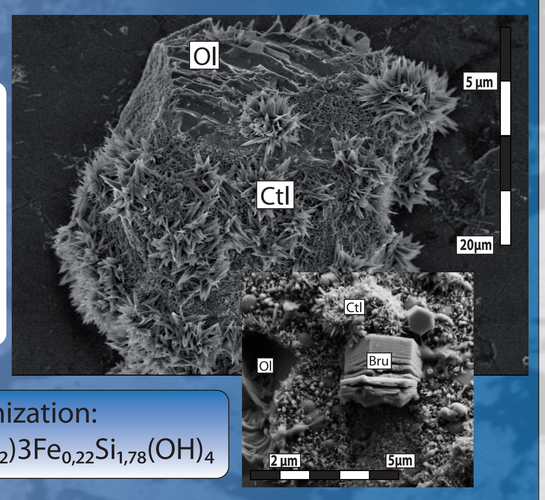
1.5ml of NaOH (1M) + **1 FME (200 ppm)**
+100mg of San Carlos Olivine
At 200°C (Psat) from 1 days to 90 days <
Grain size (<30µm, 30-56 µm and 56-150µm)<

Product Characterization



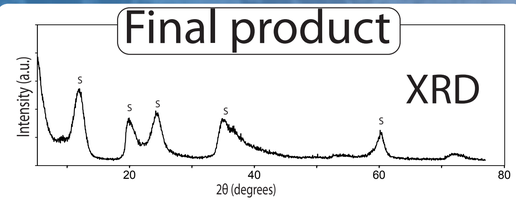
Mossbauer Analyses

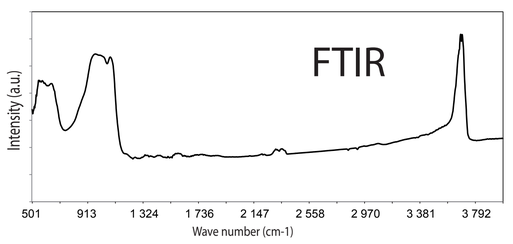


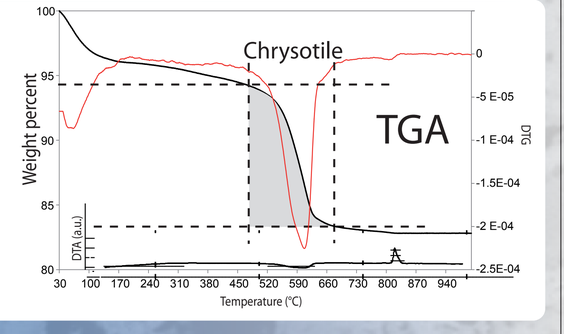


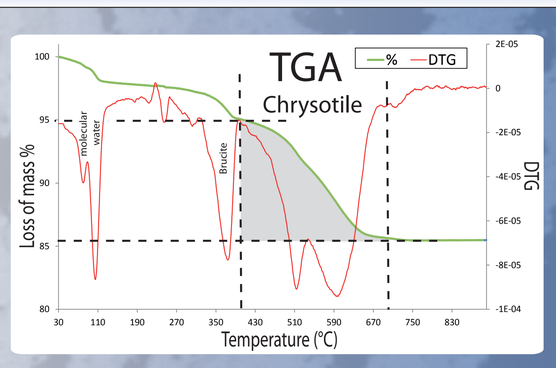
To clearly determinate the behaviour of Fe during serpentinization:
$Mg_2Mg_{1,8}Fe_{0,2}SiO_4 + 3H_2O = (Mg_{0,84}Fe_{0,12})(OH)_2 + (Mg_{0,96}Fe_{0,02})3Fe_{0,22}Si_{1,78}(OH)_4$

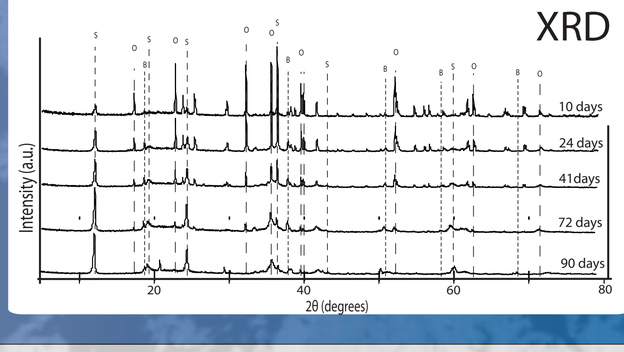
Final product



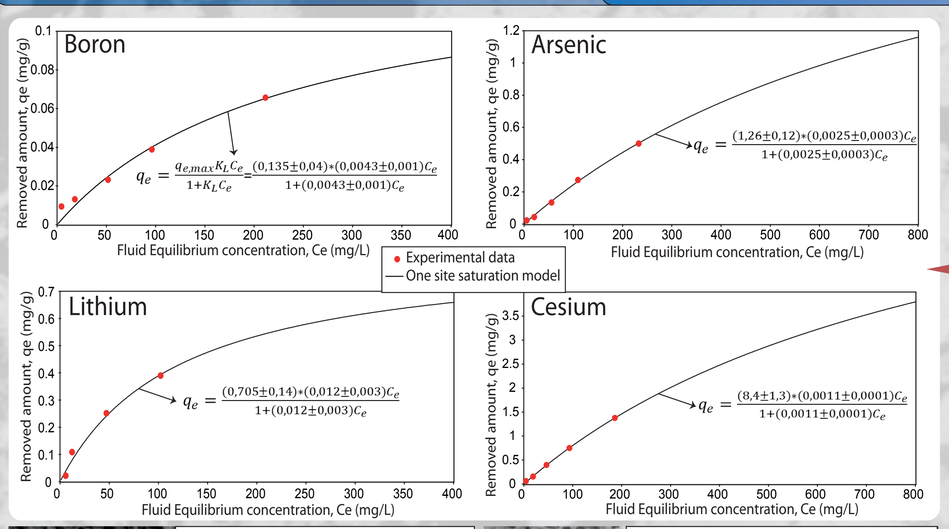


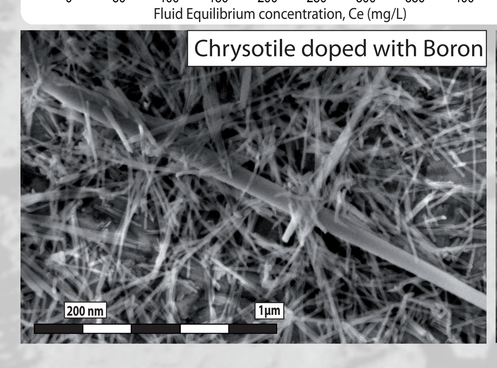


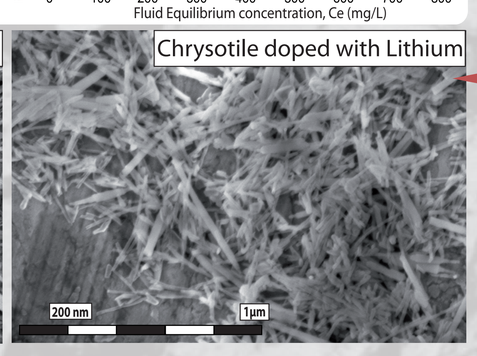




TGA/SDTA allow us to determinate chrysotile content and thus serpentinization extent as a function of time. **New kinetic determination method** was proposed (Lafay et al., 2012)







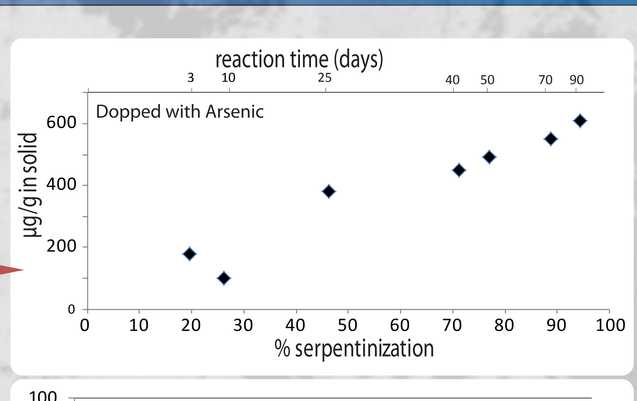
FME sequestration

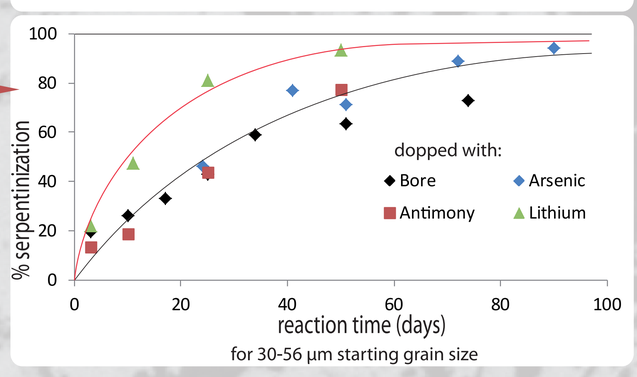
FME are significantly sequestered by chrysotile **in synthesis system.** We model **equilibrium isotherms** by using Langmuir equation (e.g. Montes-Hernandez et al. 2009)

In alteration systems, As and Cs incorporation increas linearly with serpentinization advancement. This is not the case for Li and B.

Our results indicate that **Li affect reaction kinetic like a catalyzer.**

Tested elements have a strong **influence on morphology and size** of precipitate particles (thicker and longer tubular chrysotile





Conclusions and Perspectives

> Our results indicate a **very fast serpentinization in alkaline conditions** compared to neutral condition (for example twenty time faster for <30µm starting olivine grain size). For alteration system, **Only brucite and chrysotile** are produced and Fe contained in olivine is mainly **incorporated as Fe(III) by chrysotile**.
> We observed that the synthesis of pure chrysotile is the result of a **complex reaction pathway** conducting to the precipitation of brucite an proto-serpentine as transition phases.
> We observed **a significant sequestretion of FME by serpentine in both systems**. Moreover, **FME sequestration affects strongly chrysotile nanotubes morphology and size**.
> As perspectives, we will try to **clearly determinate the mechanism of FME trapping:** interlayer or structural (octahedral or tetrahedral) incorporation, microphases, surface adsorption... by using XAS or TEM measuements.

References:
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> G. Montes-Hernandez , N. Concha-Lonzano , F. Renard, E. Quirico, Removal of oxyanions from synthetic wastewater via carbonation process of calcium hydroxide : Applied and fundamental aspects, *J. Hazard. Mater.*, 166, (2009), 788-795.

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