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Fluid-Mobile-Elements partitioning during serpentine formation: an experimental approach

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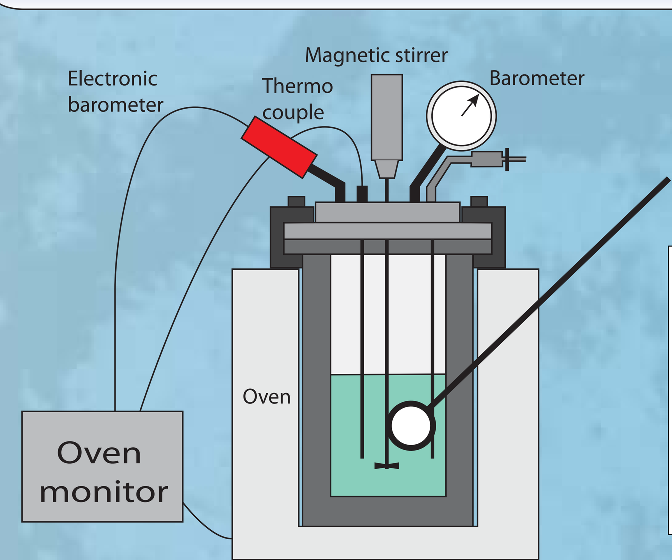
Introduction

This experimental study attempts to determine the **solid-liquid partitioning** of FME and the element-trapping mechanisms into/onto serpentines.

We developed **two experimental protocols** involving different mechanisms of serpentine nucleation and growth in alkaline medium. High pH conditions favor a very fast kinetic and avoid secondary phases formation (1-2).

We characterized **chrysotile textural properties from macroscopic to nanoscopic scale** (TGA, XRD, N_2 sorption isotherms, FESEM, and TEM). Moreover **sequestration and distribution of FME** during serpentinization was determinate by using ICP-MS measurements and EMP.

FME partitioning between chrysotile and fluid ...



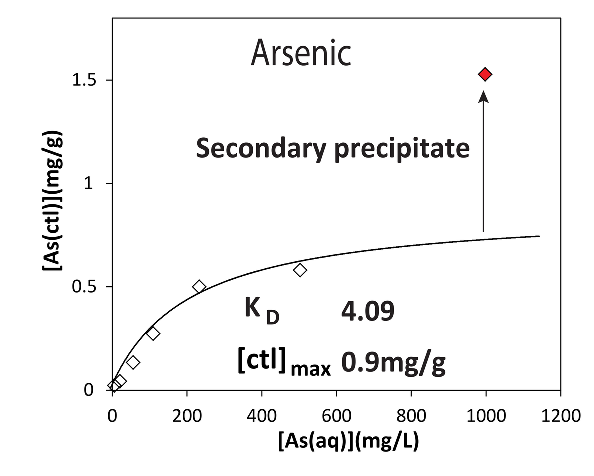
(0.1 M Mg and 0.67 M Si) in (0.25 L of H_2O + 1M NaOH)
(Li, Cs, Sb, As or B) from 5 to 200 ppm
>At 300°C (Psat) during 30 hours

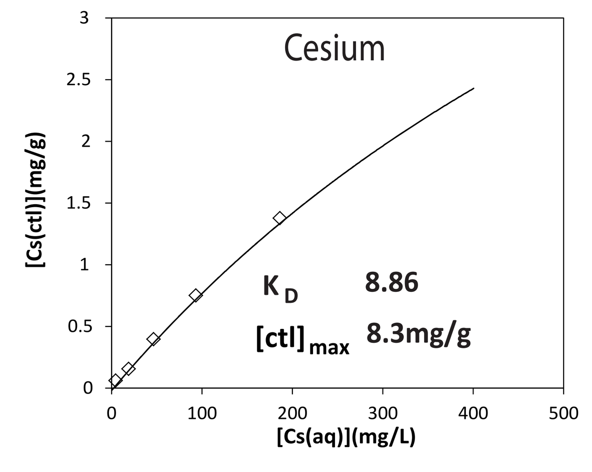
◇ Experimental data
◆ Experimental data not considered in model
— **Saturation model using Langmuir equation**

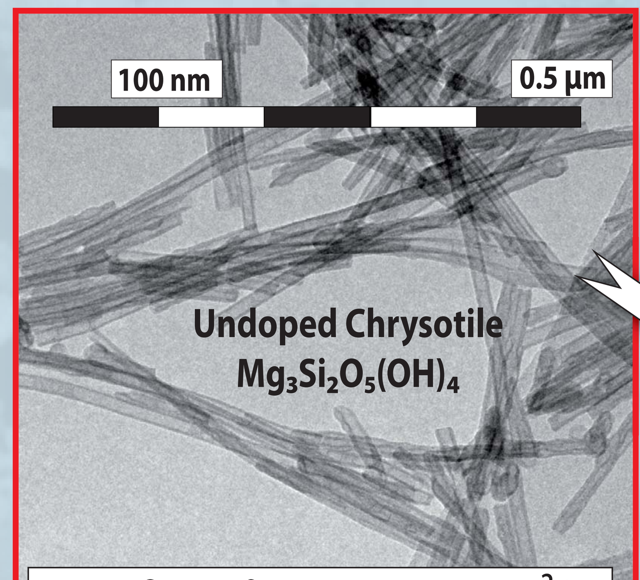
$$[ctl]=\frac{[ctl]_{max}K_L[aq]}{1+K_L[aq]}$$

$$K_L=\frac{K_D}{[ctl]_{max}}$$

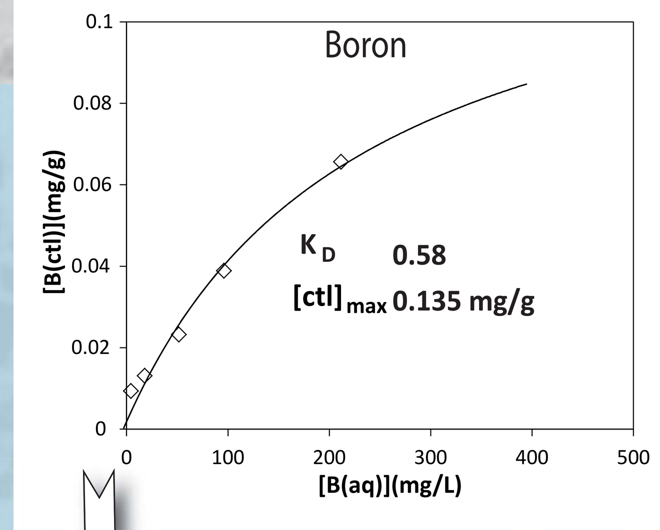
... and effect on textural properties

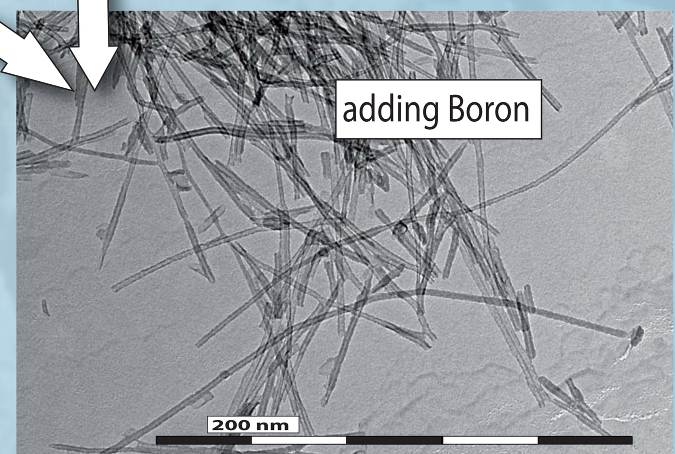




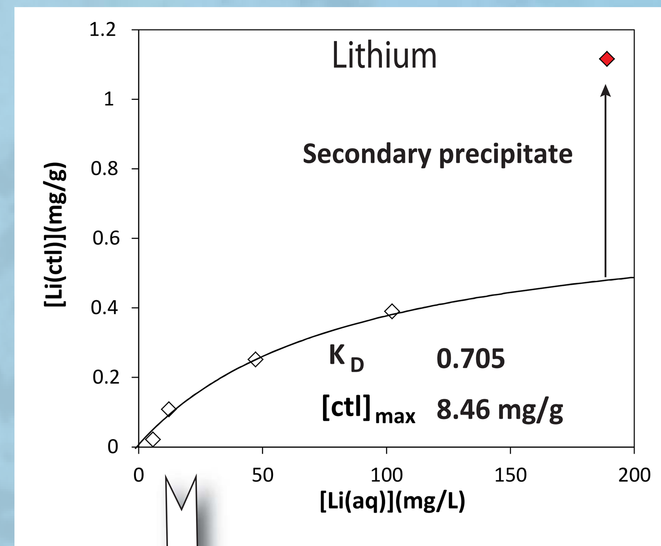


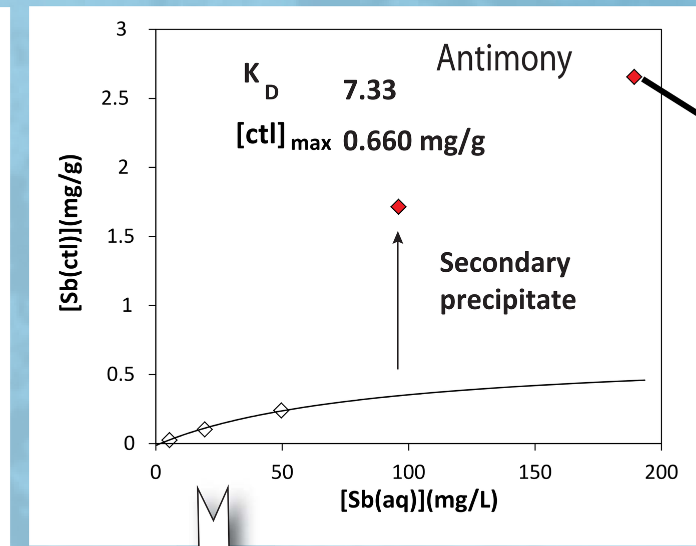
Specific surface area = 185 m²/g

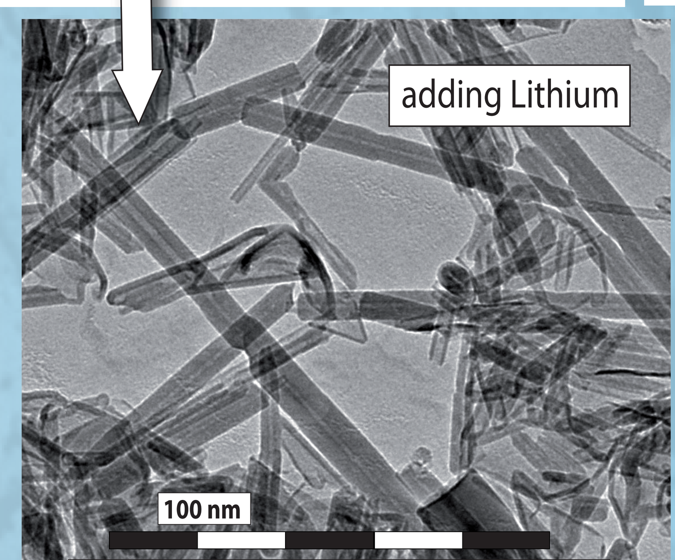




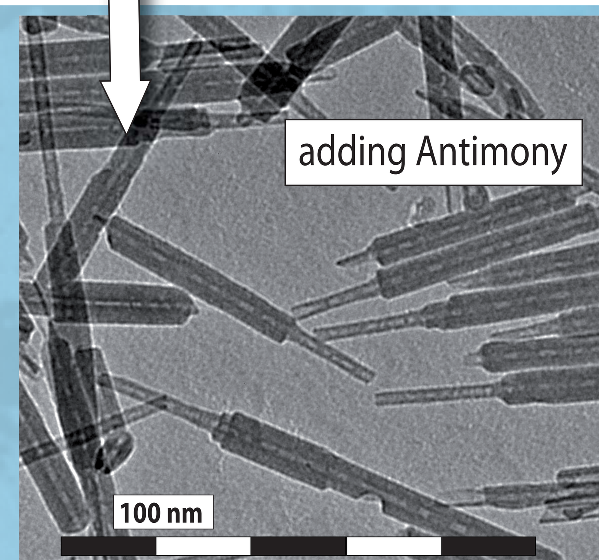
Specific surface area = 191 m²/g





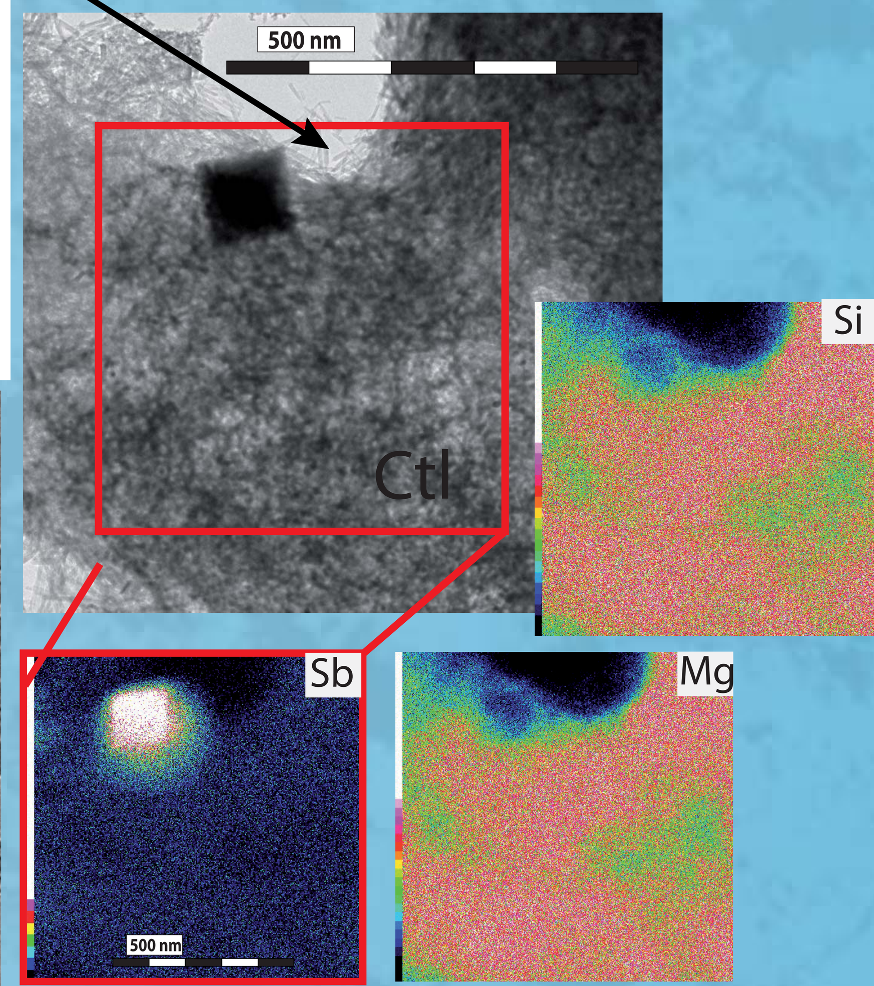


Specific surface area = 124 m²/g

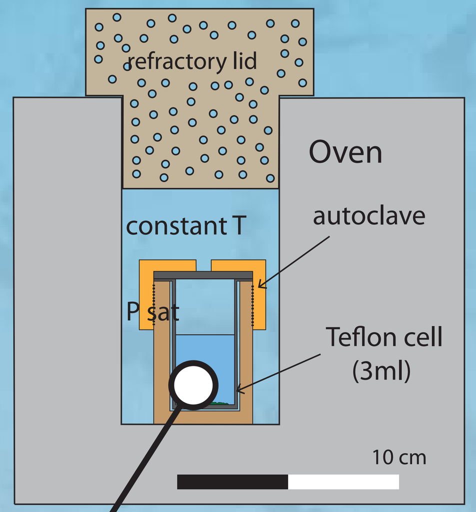


Specific surface area = 160 m²/g

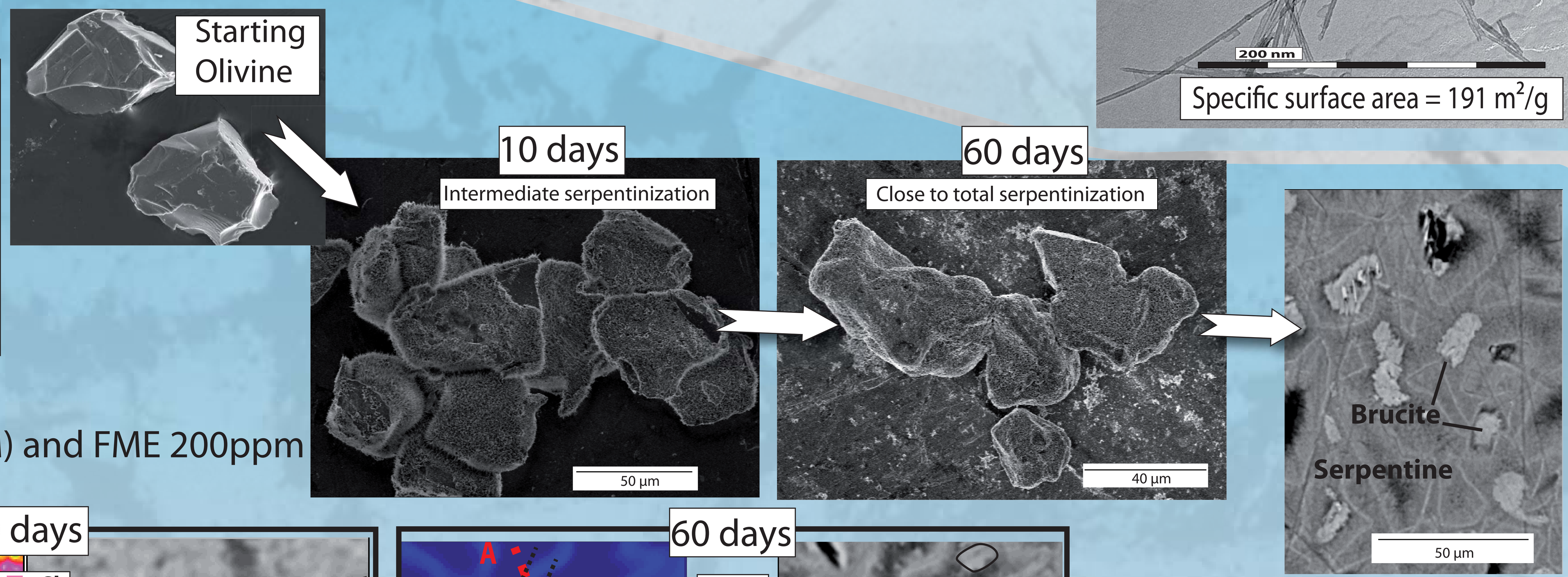
FME-rich microphases precipitation

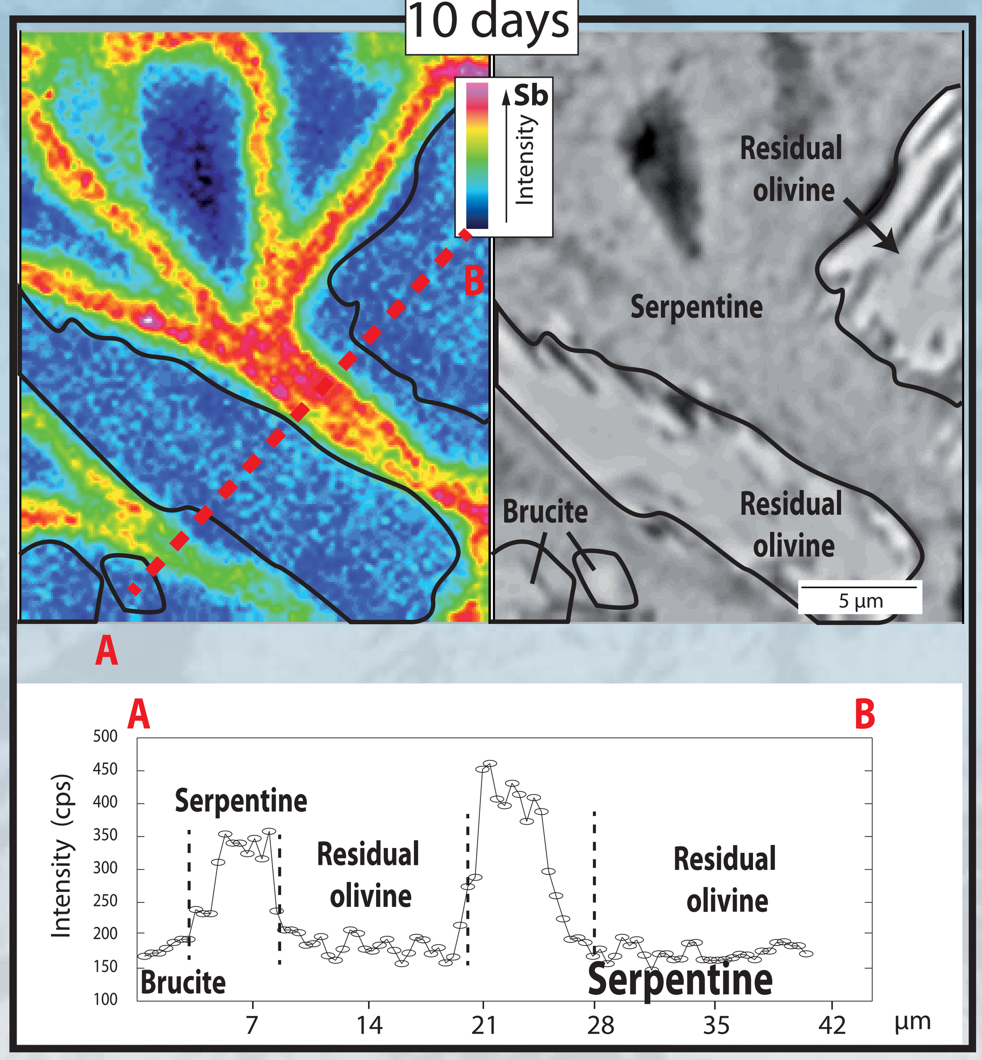


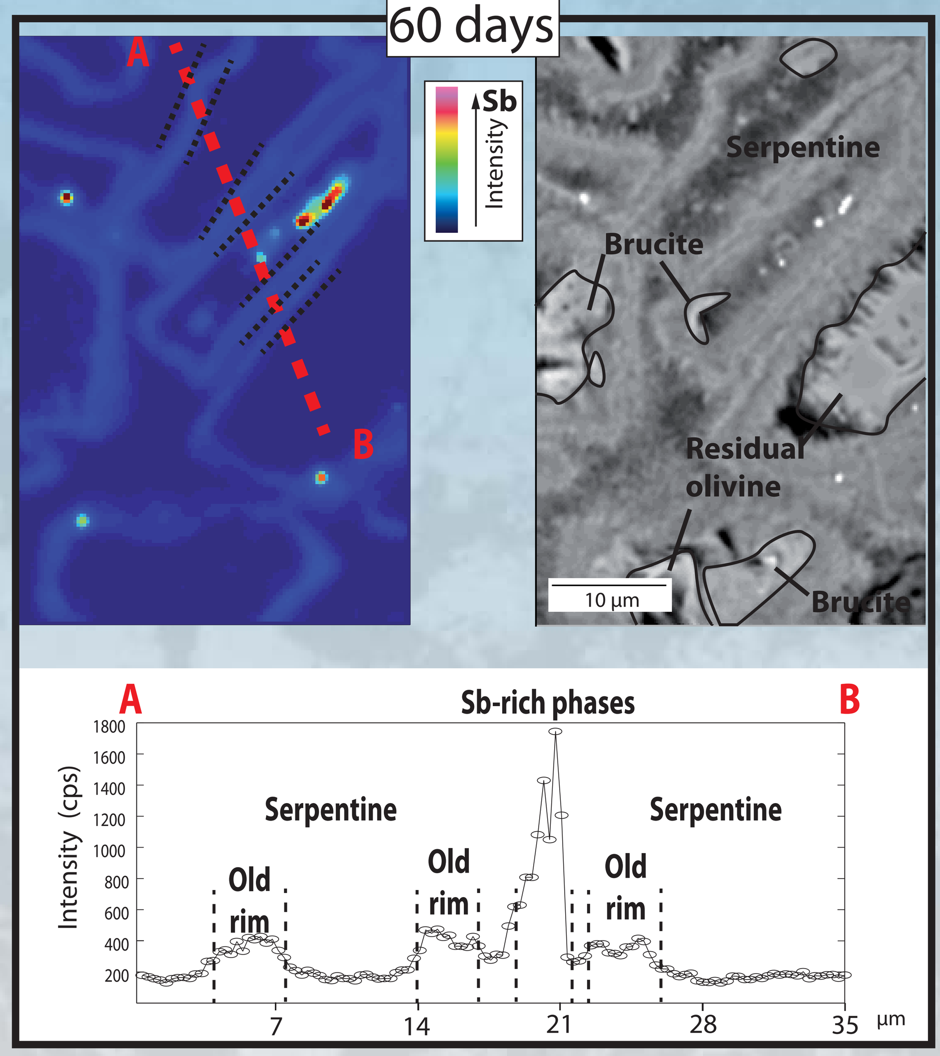
Hydrothermal alteration

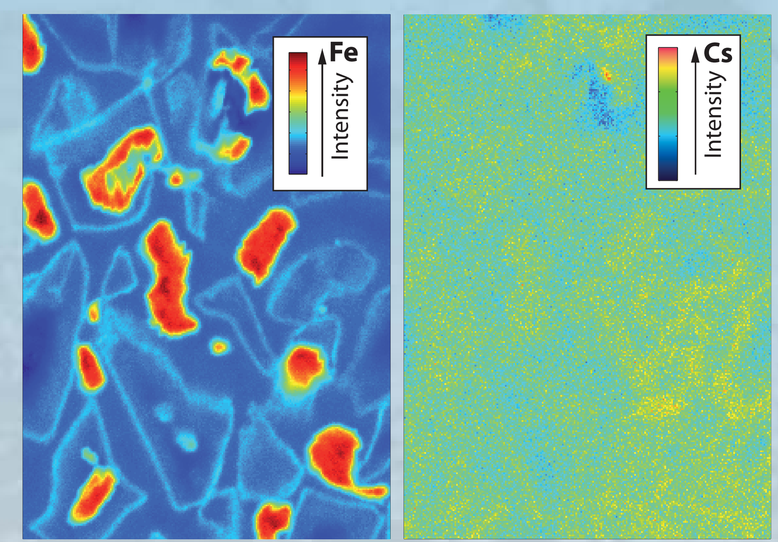


Olivine (30-56 µm)
Solution : NaOH (1M) and FME 200ppm









From Mossbauer measurements:
$Mg_{1.8}Fe_{0.2}SiO_4 + 3H_2O$ Olivine + water
=> $(Mg_{0.86}\mathbf{Fe(II)_{0.14}})(OH)_2$ => Fe-rich brucite
$+(Mg_{0.98}\mathbf{Fe(II)_{0.02}}\,\mathbf{Fe(III)_{0.02}})_3\mathbf{Fe(III)_{0.14}}Si_{1.80}(OH)_4$ + Chrysotile

Conclusions

Natural serpentinites observed in oceanic lithosphere and subducted ultramafic rock contain **high levels of Fluid-Mobile-Elements** (FME such as Li, As, Sb, B and Cs) relative to primitive mantle. FME concentrations are mainly controlled by fluid-rock interactions and represent excellent mass transfer's markers from mid-ocean ridge to subduction environment.

We highlight that **Sb, As, Li and B sequestration influence strongly Chrysotile textural properties** and that secondary FME-rich phases could precipitate. Cs has no effect on chrysotile size and morphology.

From alteration experiments under high alkaline conditions we indicated that olivine replacement **leads to Fe-rich brucite precipitation**. Overall, **FME distribution in experimental product vary strongly depending of the considered element**. For example, distribution is not homogeneous for Sb and sequestration vary with reaction advancement.

References:
> R. Lafay, G. Montes-Hernandez, E. Janots, R. Chiriac, N. Findling, F. Toche, Mineral replacement rate of olivine by chrysotile and brucite under high alkaline conditions, *Journal of Crystal Growth*. 347 (2012) 62–72.
> R.Lafay, G. Montes-Hernandez, E. Janots, R. Chiriac, N. Findling, F. Toche, Nucleation and growth

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Photo Serpentine mesh (Chenaillet ophiolite)