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Trace elements sequestration during chrysotile formation under high pH conditions

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Serpentine plays a major role for the fluid transfer from oceanic environment to subduction zone (1). In this context, Fluid-Mobile Elements (FME: e.g. As, Li, B…) distribution is strongly controlled by serpentinization processes and serpentine reactivity (e.g. during dissolution/re-precipitation, solid state transition…). However, distribution coefficient and element-trapping mechanisms into/onto serpentines are still poorly documented, and remain to be addressed experimentally. For that purpose, we tackled an experimental study of the liquid-solid partitioning of several FME during serpentine formation. In our study, we have synthesized chrysotile from olivine alteration or from H2SiO$_3$-MgCl2 hydrothermal synthesis, in presence of different concentrations of FME (As, Li, Cs, Sb and B) in NaOH-rich solution (pH: 13.5 at 25°C). Experimental products were characterized from macroscopic to atomic scale. Serpentinization rate was controlled from TGA measurements (2).
Partitioning coefficients for elements of interest, obtained by ICPMS measurements, show that FME are highly sequestered during chrysotile formation. FESEM observations highlighted olivine replacement by dissolution-precipitation processes and the influence of FME on nucleation and growth of chrysotile nanotubes. From EMP mapping and quantification we characterized elements distribution in experimental products.
From our results, we remark that As, Li, Cs, Sb and B are not sequestered in the same way and have different effects on serpentine formation processes. For example, the presence of Li and B have induced the formation of larger chrysotile nanotubes whereas As and Cs seem to have insignificant influence on the particle size. EMP mapping indicates that Sb is heterogeneously distributed in serpentinized product with evidences of co-precipitation. We note also that Li increases serpentinization kinetic rate. These results are crucial because they reproduce well the natural behavior of trace elements in serpentine and provide new insights for understanding the fluid-mobile-elements cycle in geological systems.
(1) Kerrick D. (2002) Science, 298, 1344-1345. (2) Lafay et al. (2012). J. Cryst. Growth, 347, 62-72.