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Serpentinization in formate-bearing fluids: an experimental approach at 300 °C-25 MPa.

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One of the principal theories about the origin of life is based on the abiotic reduction of inorganic carbon to various organic molecules in hydrothermal systems. This synthesis is most favored in ultramafic environments undergoing hydrothermal alteration where the serpentinization reaction efficiently produces H_2. Nevertheless, decades of hydrothermal experiments hardly succeed to produce abundant organic volatiles such as CH_4 and short hydrocarbons. Alternatively, natural observations increasingly show the occurrence of other abiotic compounds such as organic acids in fluids and carbonaceous matter (CM) within serpentinized rocks. The formation mechanisms of CM are poorly constrained, notably because we lack experimental evidences.

Here we tried to serpentinized a peridotite using a fluid enriched in labeled formate ($H^{13}CO_2^-$), to mimic the more evolved fluids that can circulate in natural systems. Effects on the serpentinization reaction and on carbon speciation in fluids and solids are investigated. Experiments of 2 and 4 months were performed at 300 °C - 25 MPa using peridotite powder (<40 microns) in a 0.29 M sodium formate solution. For both durations, H_2, $^{13}CO2$, $^{13}CH_4$, and short alkanes were measured in the fluid, and the powder was completely indurated. A control experiment shows the decomposition of sodium formate to CO_2, H2, and CO at this T, but no detectable CH_4 was produced. The analysis of the solidified powders showed the advancement of the serpentinization reaction, and the incorporation of carbon compounds into the solid phase. SEM-EDX observations showed serpentinite with larger magnetite grains mixed with C-enriched areas of long chrysotile fibers. FT-IR measurement confirmed the formation of complex carbonaceous materials widespread in the solid phases. These results suggest that advanced stages of serpentinization keep providing additional H_2 to the system but also allow the precipitation of metastable carbonaceous material, possibly helped by mineral surfaces. The nature and reactivity of such CM remains to be addressed but this opens new paths for organic synthesis under hydrothermal conditions.