Abiotic synthesis of carbonaceous matter during experimental serpentinization: a deep source of energy for early life

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Carbon and water are transported from Earth's surface to the mantle in subduction zones since the Eoarchean, at least. Among the variety of processes at play in subduction, serpentinization of forearc mantle by slab-released C-O-H fluid could capture large amount of carbon as it does for water, and constrain the long-term volatile recycling deeper into the mantle over geological time. Transformation of carbon during serpentinization of forearc mantle is not yet constrained, as our understanding of the speciation of carbon in those conditions has drastically changed over the last years. In this study, we experimentally simulate the high-pressure serpentinization of olivine with different Fe contents in C-O-H fluid (acetate aqueous solution) in the diamond anvil cell. Phase transformation of both mineral and fluid are monitored by in situ Raman spectroscopy. Experiments show that, during serpentinization of Mg-rich olivine at forearc mantle conditions, C-O-H fluid transfers into carbonate mineral or ion and carbonaceous matter. In contrast, hydrothermal alteration of Fe-rich olivine at forearc mantle conditions leads to the formation of goethite/hematite and most of C-O-H fluid transfers into carbonate mineral or ion and immiscible isobutane hydrocarbon, along with minor amount of carbonaceous matter. Fourier transform infrared measurements show that carbonaceous matter contains significant amounts of aromatics and aliphatic chains. In comparison with previous results on the high-pressure transformation of aqueous acetate in similar conditions (Huang et al., 2017), the present study shows that serpentinization is mandatory to the formation of the abiotic carbonaceous matter and that carbonaceous matter could capture and store much more carbon than carbonate in serpentinized forearc mantle. These new results have profound consequences on both the carbon speciation at depth and the carbon flux in subduction zones. More importantly, abiotic carbonaceous matter and/or lighter mobile hydrocarbon formed during serpentinization of forearc mantle at plate convergent margin may be a deep source of industrial energy at forearc basin and provide potential nutrients and energy for extant and extinct deep subsurface biosphere, and for the emergence of Life in these deep environments that are potential cradle of Life on Earth and other planetary bodies.

Mots-Clés : deep serpentinization, abiotic carbonaceous matter, geological carbon flux; deep energy

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