Transformation of carbon during high-pressure serpentinization: implication for deep carbon storage at forearc mantle

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Most of carbonaceous matter (CM) are known to form during carbonization and graphitization of biotic organic compounds [1]. Recently, significant amounts of abiotic CM were thermodynamically predicted and reported in low-pressure serpentinized oceanic crust[2, 3]. Serpentinization of the forearc mantle, by slab released C-O-H fluid at high-pressure and low-temperature condition, plays a significant role in the deep Earth water and carbon cycle [4, 5]. In this study, we conducted high-pressure experiments on the serpentinization of olivine in an acetate aqueous solution using externally heated diamond anvil cell. Changes in both the fluid and mineral phases were monitored in situ by Raman spectroscopy. During serpentinization of forsterite and olivine Fo90 {$Mg^{\#}$ = Mg / (Fe + Mg) *100 = 90} to lizardite and brucite at high-pressure (~ 3 GPa) and high-temperature (340 °C) condition, acetate decomposed to oxidized carbonate mineral/ion and reduced immobile CM. During serpentinization of Fe-rich olivine Fo34 and fayalite to lizardite and goethite, acetate decomposed to oxidized carbonate mineral/ion and reduced immiscible liquid hydrocarbons. Raman spectra of the CM show strong similarities with the CM in altered chondrite and terrestrial cherts. Ex situ FT-infrared measurements showed the CM contains significant amounts of aromatics and long aliphatic chains. Formation of abiotic CM and carbonate during high-pressure serpentinization has important implication for the deep carbon cycle. Significant amount of C-O-H fluids released from subduction slabs might serpentinize the forearc mantle and store as immobile carbonate and CM under the forearc. Released hydrocarbons in CM from serpentinized forearc mantle during serpentinite diapirism is the most possible hydrocarbon source for mud volcanoes at forearc setting.

[1] Buseck & Beyssac (2014) Elements 10, 421-426. [2] Milesi et al., (2016) GCA 189, 391-403. [3] Sforna et al. (2018) Nature Communications 9, 5049. [4] Hyndman & Peacock (2003) EPSL 212, 417-432. [5] Sieber et al. (2018) EPSL 496, 178-188.