

Experimental study of element dissolution to liquid CO₂ from artificial seawater and hydrothermal vent chimney

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Pools of carbon dioxide (CO₂) fluid have been found under the ocean floor in the vicinity of a few hydrothermal vent sites (Sakai et al., 1990; Konno et al., 2006; Lupton et al., 2006; Pedersen et al., 2010; Zhang et al., 2020). CO₂ fluid acts as hydrophobic solvent under a certain range of temperature and pressure due to its non-polar property (Hyatt, 1984). Because various hydrophobic compounds such as organometallic complex, amides, alcohols, carboxylic acids and phenols can dissolve into CO₂ fluid (Škerget et al., 2011; Knez et al., 2018), the pools of CO₂ fluid have the potential to behave as a distribution and condensation field for those compounds. Indeed, Stensland et al., (2019) suggested that heavy metals are transported to shallower part of a water column by upwelling of CO₂ hydrate released from CO₂ pools and hydrothermal vents.

Even in the Hadean ocean, liquid/supercritical CO₂ is presumed to have acted as a solvent for hydrophobic molecules and elements related to origin of life and as a reaction field providing condensation, and as reaction field (Shibuya and Takai, 2017, Zhang et al., 2020). Despite utilization in industrial technologies such as extraction, dry cleaning, and homogenization, particularly in the form of supercritical CO₂ (Beckman, 2004), geochemical roles of CO₂ fluid in natural environments are poorly understood.

In this study, we developed a corrosion-resistant high-pressure reactor and extraction/analytical methods of CO₂ fluid. Then, we experimentally simulated distribution of major elements in artificial seawater and heavy metals included in hydrothermal vent chimney samples to liquid CO₂. As a result, dissolution of major elements; Na, Mg and heavy metals; Cu, Mg, Zn, and etc., were observed from artificial seawater and hydrothermal vent chimneys, respectively. The results suggest that transition metals and the elements in boron group (Al, Ga, In, Tl) form complexes with CO₂. We will further discuss about implications of modern and Hadean hydrothermal systems.

Keywords: liquid CO₂, elemental distribution, hydrothermal vent, origin of life, Hadean eon