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Experimental constraints on hydrogen generation and their linkage to the eco-system in ridge system

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Deep-sea hydrothermal vents were discovered in the late 1970s (Corliss et al., 1979; Edmond et al., 1979). Since then, they have been considered as a possible environment for the origin and early evolution of life on Earth (e.g., Yanagawa and Kojima, 1985; Russell and Hall, 1997). In addition, some researchers proposed that microbial ecosystems in the hydrothermal vents are primary producers which sustain most of the lives in the ocean (Jannasch et al., 1985 and our TAIGA project [http://www-gbs.eps.s.u-tokyo.ac.jp/~taiga/en/index.html]). It is important, therefore, to figure out the hydrothermal reactions in the ocean floor for better understanding of the ecosystems in the ocean. Especially hydrogen generation is one of the most crucial processes in the hydrothermal systems, because multidisciplinary studies suggest that the most ancient microbial ecosystems were originated and maintained in the vicinity of H_2-rich hydrothermal fluids (Russell and Hall, 1997; Sleep et al., 2004; Kelley et al., 2005; Canfield et al., 2006). Such communities are possibly composed of hyperthermophilic subsurface lithoautotroph methanogene (Takai et al., 2006).

The supply of abundant hydrogen to power such primary producers is the most likely coupled to hydrothermal serpentinization of ultramafic rocks. In the modern ocean, H_2-enriched hydrothermal fluids are commonly associated with slow-spreading mid-ocean ridge (MOR) setting dominated by peridotite (Kelley et al., 2001; Fruh-Green et al., 2004). The serpentinization of abyssal peridotite has been well investigated both experimentally and theoretically. The investigations indicate that the peridotite-water reaction provides an extraordinarily high concentration of H_2 in the fluids (e.g., Seyfried et al., 1979; Allen and Seyfried, 2003; McCollom, 2007; McCollom and Bach, 2009). In the Hadean and early Archean ocean, however, it is believed that peridotite would be scarce in the ocean floor, and komatiite - hydrothermal reactions are the possible mechanism of hydrogen generation in the ocean floor. Yoshizaki et al. (2009) experimentally revealed that abundant H_2, equivalent to H_2 abundance in the peridotite-hosted hydrothermal solutions, was produced in komatiite alteration. On the other hand, the fault-related H_2 generation has been found by the gas monitoring along surface trace of the active Yamasaki fault (Wakita et al., 1980) and more from the drilling cores near hypocenters of micro-earthquakes along the San Andreas Fault (Erzinger & Wiersberg, 2008). Recently, we showed using our friction experiment system that abundant H_2 generation in the fault systems readily occurs (Hirose et al., 2011).

In this contribution, I will briefly introduce the results obtained in our laboratory experimental systems, both hydrothermal and simulated fault types.

Keywords: experiment, hydrogen generation, hydrothermal system, ecosystem, ridge