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# Bioenergy production using subterranean microbial community associated with the accretionary prism in Southwest Japan

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The accretionary prism situated along the Pacific side of Southwest Japan is traceable laterally for some 1,800 km and forms thick sediment that accretes onto the non-subducting tectonic plate at a convergent plate boundary. The sediment is composed mainly of non- to weakly metamorphosed sequences of sandstone, shale, alternating beds of both, and local associations of chert and greenstone. The materials are derived from marine sediment scraped from the subducting oceanic crust; therefore, they are rich in complex organic matter. The sediment contains layers of water-bearing permeable sandstone and no water-bearing impermeable shale. Groundwater is mainly recharged by rainfall infiltrating into outcrops or faults. The water flows down through the permeable sandstone and is reserved in a deep aquifer. In addition to the groundwater, it has been reported that dissolved natural gases are present in the deep aquifer associated with the accretionary prism in Southwest Japan.

It is generally believed that natural gas in subsurface environments is formed by microbial production (biogenic origin), nonbiological thermal decomposition of organic matter (thermogenic origin), or geochemical reaction in hydrothermal systems during water-rock interactions (abiogenic origin). These origins have been interpreted based on chemical compositions of gaseous alkanes and stable carbon and hydrogen isotope ratios of methane.

To identify the methane production pathways present in a deep aquifer associated with an accretionary prism in Southwest Japan, a series of geochemical and microbiological studies of natural gas and groundwater derived from a deep aquifer were performed. Stable carbon isotopic analysis of methane in the natural gas and dissolved inorganic carbon in groundwater suggested that the methane was derived from both thermogenic and biogenic processes. Archaeal 16S rRNA gene analysis revealed the dominance of $H_2$-utilizing methanogens in the groundwater. Furthermore, the high potential of methane production by $H_2$-utilizing methanogens was demonstrated in enrichments using groundwater amended with $H_2$ and $CO_2$. Bacterial 16S rRNA gene analysis showed fermentative bacteria inhabited the deep aquifer. Anaerobic incubations using groundwater amended with organic substrates and methanogen inhibitor suggested a high potential of $H_2$ and $CO_2$ generation by fermentative bacteria. To confirm whether or not methane is produced by a syntrophic consortium of $H_2$-producing fermentative bacteria and $H_2$-utilizing methanogens, anaerobic incubations using the groundwater amended with organic substrates were performed. Consequently, $H_2$ accumulation and rapid methane production were observed in these enrichments incubated at 55$^o$C and 65$^o$C. Thus, the results suggested that past and ongoing syntrophic biodegradation of organic compounds by $H_2$-producing fermentative bacteria and $H_2$-utilizing methanogens contributes to the significant methane reserves in the deep aquifer associated with the accretionary prism in Southwest Japan.

We are currently conducting research to develop the $CH_4$ and $H_2$ production system using the groundwater and the microbial community associated with the accretionary prism in Southwest Japan. In this paper, we describe the potential and future plan of the bioenergy production system.

Keywords: accretionary prism, subterranean microbial community, methanogen, fermentative bacteria, bioenergy