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Acetate-oxidation activities in the deep subseafloor biosphere associated with coalbeds off the Shimokita Peninsula

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The IODP Expedition 337 was the first riser-drilling expedition dedicated to subseafloor microbiology using the drilling vessel Chikyu. During Expedition 337, we penetrated a 2466 m deep sedimentary sequence at Site C0020A with a series of coal layers at 2000 m bellow the seafloor (mbsf) off the Shimokita Peninsula, Japan. One of the primary scientific objectives of Expedition 337 was to understand ecological roles of subseafloor microbial activity in biogeochemical carbon cycles associated with the deeply buried coalbeds in the ocean. It has been hypothesized that immature coalbeds (i.e., lignite) release substantial dissolved organic compounds such as volatile fatty acids or hydrocarbons during the burial alternation process, which compounds may play important roles for supporting microbial population and activity in the deep sedimentary habitat. Alternatively, it is also conceivable that deep subseafloor microbial activities may contribute to the hydrocarbon reservoir system.

To examine those hypotheses, we measured methanogenic and acetate-oxidation activities by radiotracer incubation experiments using 2 cm^3 of the innermost sediment core samples that were supplemented with ^{14}C-labelled substrate ([2-^{14}C]-acetate) immediately after core recovery. Activities of aceticlastic methanogenesis were observed in the sediment above the coalbed layers (>1990 mbsf), ranging from 0.2 to 4 pmol cm^{-3} d^{-1}. The highest activity was observed in a coalbed horizon at 1990 mbsf; however, no aceticlastic methanogenesis activities were observed below the 2 km-deep coalbeds. Activities of acetate oxidation to CO_2 were measured by $^{14}CO_2$ production rate from [2-^{14}C]-acetate. Interestingly, the acetate-oxidation activities were observed in sediments above the coalbeds, which values were generally higher than those of methanogenesis with the maximum value of 150 pmol cm^{-3} d^{-1} at 1800 mbsf. The rates gradually decreased with increasing depth from 1800 mbsf and reached bellow the detection limit in 2 km-deep coalbeds. The occurrence of relatively high acetate oxidation at around 1800 mbsf above the coalbeds indicates the presence of available electron acceptors (e.g., glauconitic iron oxides) in the deep sedimentary habitat.