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Activity and electron donor-utility of sulfate-reducing bacteria in a groundwater of Tono uranium deposit area

Yuki Murakami[1], Teruki Iwatsuki[1], Kevin Mandernack[1], Takeshi Naganuma[2]

[1] JNC TGC, [2] School of Biosphere Sci., Hiroshima Univ.

Dissimilatory microbial sulfate reduction is an important metabolic process in many reduced environments, such as marine sediments, anaerobic sludge, and contaminated aquifers of deep subsurface environments. This process is mediated by sulfate-reducing bacteria (SRB). In subsurface environments, SRB are distributed in diverse lithologic conditions, such as granite, basalt, and sedimentary rocks. There are some reports about activities of SRB in sedimentary rocks with lignite layers. Low-molecular-weight organic acids such as acetate, propionate, and butyrate are fermentatively produced in these layers and in turn may serve as carbon sources for SRB. SRB may also respire by using humic acids in lignite as a carbon source. However, little is known about the role and type of low-molecular-weight organic acids produced from the degradation of lignite. Measurements of SRB activity and their nutritional limitations in subsurface environments are important for understanding sulfate reduction and the overall sulfur cycle in these environments. We measured abundance of total and viable microbial cells in groundwaters collected at various depths and lithologies. Laboratory groundwater incubation experiments were also maed to assess the overall SRB activity and the specific electron donors utilized by SRB.

Groundwater samples were collected in the TOno area from four different depths with two boreholes, MSB-2 and MSB-4. Total microbial cell numbers in the groundwater samples varied from ~104 to 105 cells ml-1. Viable cell numbers varied from ~102 to 105 cells ml-1 and differed depending on the dyes. The highest viability to total cell counts was observed in groundwater from 95.5 m depth, in the intact granite zone of borehole MSB-4. The lowest viability to total cell counts was observed in groundwater from 132 m depth of borehole MSB-2. THis depth corresponds to sedimentary rocks, in the lowest part of the Toki-Lignite layer. If a high ratio of viable cells reflects overall high microbial activity in the groundwater, then microbial activity in groundwaters from the intact granite and the Upper part of the Toki-Lignite layer appear to be highest.

Microbial utilization of different carbon electron donors showed variations with depth. Microbial sulfate-reducing community at 79 m depth of the Upper part of Toki-Lignite layer used lactate, pyruvate, and ethanol for their growth, on the other hand, the community at 132 m depth of Lower part of Toki-Lignite layer used humic acid, but not lactate or ethanol. All nine of the added organic substrates were utilized with incubations of groundwater collected from the granite. Numerous studies have shown that all SRB preferentially degrade certain organic acids and cannot degrade others. For example, Group I SRB include Desulfovibrio or Desulforhopalus which use of lactate. These SRB's might be dominant in the Upper part of the Toki-Lignite layer. Furthermore, the granite environment may have a more diverse SRB community that utilize several different electron donors.

Rates of sulfate reduction in the groundwater samples showed the range from 3.0 x 10-1 to 9.5 x 10-1 μmol ml-1 day-1. With a lignite-extract solution added, the rate of sulfate reduction increased and ranged from 9.8 x 10-1 to 4.6 μmol ml-1 day-1. The highest rate of sulfate reduction was observed at 95.5 m in the intact granite layer just below the sedimentary rocks. This depth also corresponded with the highest cell viability. Sulfide concentration measured at this depth was also highest. Therefore, in situ SRB activity may also be highest at this depth. SRB activity may be controlled by the concentration of sulfate and/or the avilability of organic substrates in situ condition.