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Biogeophysics: A tool for monitoring and detecting microbial natural gas accumulation

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Methane is formed by subsurface thermogenic and biogenic processes. Although the contribution of microbial processes in the formation of methane gas accounts for more than 20% of the global natural gas reservoir, microbial contribution to the natural gas accumulation is rarely considered in geophysical exploration. Thus, a laboratory study has been undertaken to investigate the possibility of monitoring and detecting the microbial formation of methane by electrical potential (EP) technique. Methanogenesis is the final step in the decay of organic matter and in most of natural and engineered systems, it occurs after the microbial sulfate reduction. In microbial formation of methane, CO_2 acts as electron acceptor and H_2 as an electron donor. To achieve the preset tasks, a Winogradsky column is used to represent natural water-sediment interface in a controlled laboratory environments, which is similar to sea or marine environment. Five Ag-AgCl electrodes were installed in the column to monitor EP associated with various microbial pathways, particularly sulfate reduction and methanogenesis. EPs were measured twice a day with high internal impedance voltmeter though Ag-AgCl electrodes over the entire period of experiment. Results derived from time-lapse EP measurements and the supportive solid phase and liquid phase analysis of samples collected from the experiment column, and microbiological and geochemical studies confirm that the methanogenesis is accomplished by both acetoclasitc and hydrotropic methanogens. Biogenic gases O_2, CO_2, H_2S, and CH_4 evolved in the column have been monitored by gas analyzer by connecting it to the headspace of the column. These gases are used as an indirect indictors for availability of oxygen and the presence of the dominant microbial activities occurred in time. The completion of sulfate reduction is indirectly inferred from deposition of black precipitates of ferrous sulfide (FeS) on the wall of the Winogradsky column and by depletion of H_2S gas production simultaneously. Distinct EP signals originated from acetoclasitc and hydrotropic methanogenesis suggests that the detection and monitoring of biogenic formation of methane is possible by employing biogeophysical techniques. Additionally, a methodology has been developed to estimate biogeochemical parameters from EP signals associated with microbial sulfate reduction, occurring in natural systems such as sea and ponds. Thus, this study will be helpful in detection and monitoring of methane gas formation associated with natural and engineered systems, and in estimation of biogeochemical parameters altered by microbial processes.

Keywords: Methane gas, Biogeophysics, Electrical Potential, Methanogenesis, Sulfate Reduction