Biogenic methane cycling in a laboratory model of an abandoned bituminous coal mine

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The use of abandoned mine methane (AMM) has been proposed as a means to decrease mine CH_4 emissions and provide a local energy source. Recent studies conducted on coal mine microbial communties have found populations of aerobic methanotrophs [1] and anaerobic microorganisms including methanogens [2], both of which may effect AMM. To determine microbe-methane interactions in an abandoned bituminous coal mine, we monitored a sealed 1 m long coal column for one year after inoculating with aerobic and anaerobic microorganisms from Bowen Basin, Australia coal mines. The column contained 5.8 kg of bituminous coal (Rv_{max} = 1.3%) and water that matched the natural geochemistry, including low nutrients.

After the column was flushed with N_2 and the microbial community became established, methane production occurred at rate of approximately 0.11 nmol CH_4 / gram of coal per day. In the column, methanogens closely related to *Methanolobus sp*. likely used an acetoclastic or methylotrophic pathway to produce methane. However, throughout the experiment aerobic methylotrophs were also dominant in the community. When an small oxygen leak occurred after 14 weeks, methane was consumed at a rate of 0.86 mmol CH_4 per day. At 25 weeks the column was flushed again with N_2 and resealed; after a lag, methane production resumed at rate of 0.05 nmol CH_4 / gram of coal per day.

This experiment suggests that during the transition from aerobic to anaerobic conditions net methane production is very slow, with an estimated time of approx. 1000 years to produce 1 m^3 CH_4 / tonne of coal. As such, AMM projects should expect to only produce from the remnant methane in the mine, rather than rely on microbial methane production from bituminous coal.

[1] Pytlak, Stępniewska, Kuźniar, Szafranek-Nakonieczna, Wolińska & Banach (2014), *Geomicrobiology Journal* **31**, 737-747. [2] Beckmann, Krüger, Engelen, Gorbushina & Heibert (2011), *Geomicrobiology Journal* **28**, 347-358.