

**MICROBIAL COALBED METHANE IN THE ILLINOIS BASIN:
SUBSTRATE COMPETITION AMONG GENETIC PATHWAYS**

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Over the last two decades coalbed methane (CBM) has become an important source of natural gas in North America where coal basins with both thermogenic and biogenic gas proved to be productive on an economic scale. Biogenic methane accounts for >99% of hydrocarbon gases in coals of the eastern part of the Illinois Basin. Our geochemical and isotopic characterization of gases and waters from Indiana coal seams suggest recent (<10ky) microbial CBM generation via CO₂-reduction (Strapoć et al., 2006).

As an alternative to microbial CO₂ reduction leading to CBM generation, microbiological experiments on the enriched microbial biota from Indiana anoxic coalbed waters suggest a two-step substrate-competitive methanogenic pathway consisting of (i) microbial acetogenesis and (ii) acetoclastic methanogenesis. Gibbs free energies calculated for *in situ* conditions of Indiana coal beds show that CO₂ reduction and the alternative sequence of acetogenesis and acetoclastic methanogenesis can all co-exist and compete for required substrates H₂ and CO₂ (HCO₃⁻), leading to isotopically similar CBM. Nonetheless, CO₂-reduction seems to tolerate lower concentrations of required substrates (Fig. 1). We extracted DNA and developed a phylogenetic tree for Indiana coal-biodegrading microbial consortia. The most abundant member of methanogenic Archaea found in coalbed waters and in enrichment cultures is H₂/CO₂-utilizing *Methanocorpusculum parvum* (Zellner et al., 1989), previously found in diverse methanogenic environments, including marine and terrestrial sediments and wastewaters. Characterizing the speciation of sedimentary microbial communities can help track the fate of buried fossil organic matter as macromolecules are partly converted to CO₂, H₂, and CH₃COOH, and subsequently to economically important CH₄.

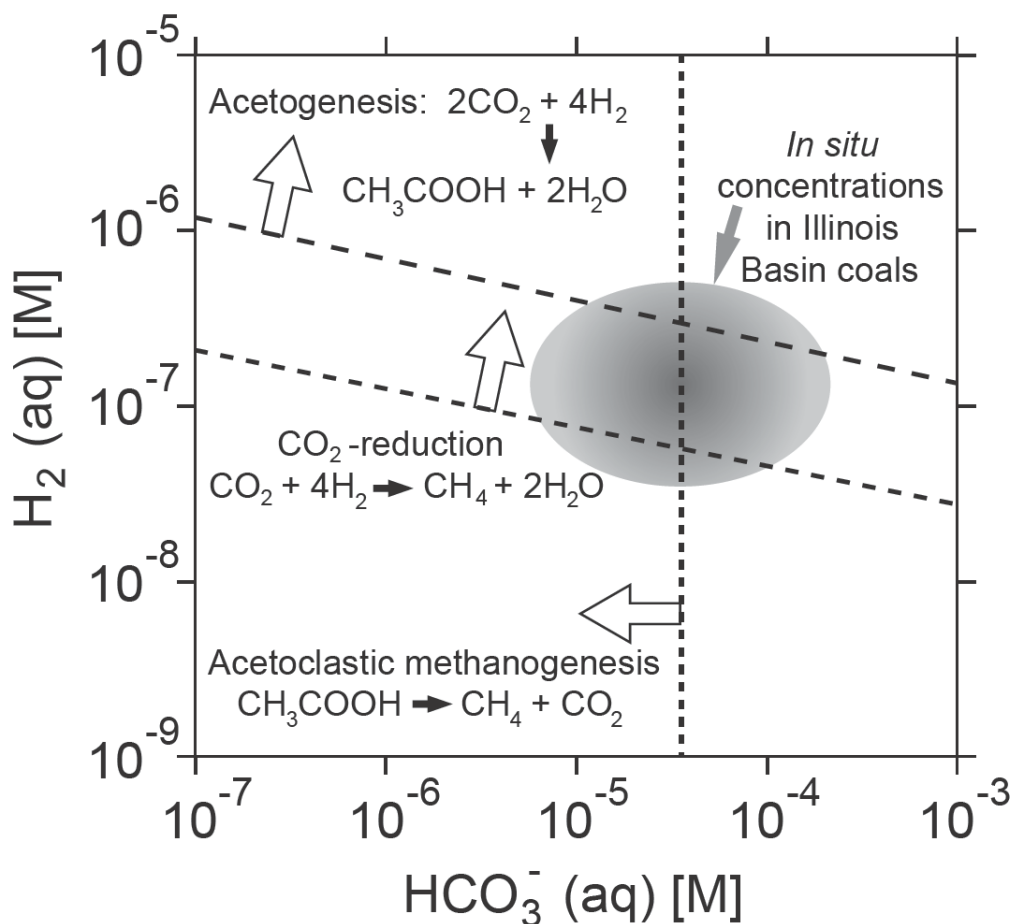


Figure 1. Lines indicate energetic sustainability thresholds for three microbial reactions that are relevant for *in situ* coalbed methane (CBM) generation at shallow depths. Each line represents a -15kJ/mole product boundary considered to be the energetic minimum to sustain microbial life. Acetoclastic methanogenesis depends on acetogenesis as a prerequisite to provide acetate. The CO_2 reduction pathway may be predominantly responsible for CBM generation when dissolved hydrogen, $\text{H}_2(\text{aq})$, is limited. Concentration of $\text{CH}_4(\text{aq})$ was $1.4 \cdot 10^{-2}\text{M}$ and estimated acetate concentration was 10^{-6}M . After Hinrichs et al. (2006).

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