Groundwater extraction for coalbed methane production: Influence on the subsurface geochemical environment

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Biogenic gas generated via methanogenesis is adsorbed onto organic matter in coals and organic-rich shales, and held in place by hydrostatic pressure. Therefore, groundwater must be removed before gas is released from the formation. In the Powder River Basin (PRB) in southeastern Montana and northeastern Wyoming, 7.4 billion barrels of groundwater has been extracted since 2000 to produce microbial coalbed methane (CBM), which in some cases has led to major declines in the water table. The disposal or reuse of this CBM-produced water is a major challenge due to its high Na concentration. Recently, thousands of CBM wells in the PRB have been shut-in and little new drilling has occurred, possibly leading to a rebound in water levels. This study uses a multi-tracer approach to investigate the influence of groundwater pumping and recovery on subsurface geochemical conditions, specifically water, solute and energy sources, and subsequent microbial activity in PRB coals.

PRB coal waters are typically within the methanogenic zone, where other electron acceptors, such as sulfate and ferric iron, have been depleted. High-SO_4 (>2.8 mM) coal waters are typically only found near the coal subcrop. As groundwater is extracted for CBM production, sulfate-bearing waters may be drawn into the coalbeds from upgradient coals or overlying siliciclastic aquifers, as seen in local monitoring well data, corresponding to slight decreases in water table elevations. The introduction of SO_4 may stimulate sulfate-reducing bacteria while inhibiting methanogens, recorded by increasing $\delta^{34}S$ results.

Sr isotopes can provide a unique fingerprint of solute sources and water flowpaths in the PRB, as the coals exhibit more radiogenic $^{87}Sr/^{86}Sr$ than adjacent siliciclastic sediments [1]. Interestingly, the shallowest, SO_4-bearing waters generally exhibit the lowest values of $^{87}Sr/^{86}Sr$. Therefore, increased inputs of shallow groundwater to coalbeds due to pumping should be recorded by declines in $^{87}Sr/^{86}Sr$. Boron isotopes also offer the potential for identifying external water inputs to coalbeds.

[1] Frost, *et al* 2002, *Geology* **30**, 923–926