

Geochemical characterization and assessment of migration or mixing of Upper and Middle Devonian produced waters following horizontal drilling and hydraulic fracturing

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Directional drilling and hydraulic fracturing of organic-rich shales are increasingly used for hydrocarbon production (gas, natural gas liquids, and oil) in the USA and throughout the world. The generation of large quantities of brine from these wells has implications for wastewater treatment in areas with limited access to disposal into injection wells, and requires knowledge of temporal and spatial variations in order to optimize treatment, safe storage and potential resource recovery. Produced waters from hydraulically fractured Marcellus gas wells in Pennsylvania, USA show a trend of increasing strontium concentration and isotopic composition over several years [1, 2]. Mixing relationships indicate a shift within the first week from an injected fluid signature to one dominated by formation waters held in pores, fractures or water-soluble components of the Marcellus shale.

At a southwestern Pennsylvania test site [3], the ⁸⁷Sr/⁸⁶Sr ratio of produced water from conventional gas wells 900-1200 m above the Marcellus shale showed no evidence of Marcellus fluid migration up to 15 months after hydraulic fracturing. In addition, analysis of local spring waters demonstrated that Sr isotopes can be a highly sensitive indicator for Marcellus brine incursions into local ground water aquifers, and that the ⁸⁷Sr/⁸⁶Sr ratio is significantly more sensitive to brine incursions than shifts in concentrations of fluid constituents such as sodium, barium, bromine and radium. Once a baseline is established, the ⁸⁷Sr/⁸⁶Sr ratio of well waters can be used as a long-term natural monitor of stratigraphic isolation of Marcellus fluids from overlying units.

[1] Chapman *et al* (2012) *ES&T* **46**, 3545-3553 [2] Capo *et al* (2013) *Int. J. Coal Geol.* DOI: 10.1016/j.coal.2013.12.010. [3] Hammack *et al* (2013) *SPE* 10.2118/165720-MS.