

New insights on gas storage and transport in shales

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The rapid development of shale gas and liquids has far outpaced our knowledge of how these systems function. Most of the tools and models used on conventional reservoirs are inadequate to characterize tight rocks. Using new methods and techniques, researchers in industry, academia, and government labs have made considerable progress in revealing the underlying processes involved in gas storage and transport.

Although all shales have some inter- and intra-granular mineral porosity, the majority of the gas in mature, carbon-rich shales is stored in porous organic matter. NMR, small angle neutron scattering (SANS), mercury injection capillary pressure (MICP) and gas sorption experiments suggest that shales possess a broad range of pore sizes with an appreciable volume existing in mesopores having diameters of 2 to 50 nm. Unlike conventional reservoirs where pore throats tend to scale with pore size, the connecting pore throats in shales appear to be small (<20 nm). SEM has been extensively used to image pores in shales, but sees only a fraction of the pore network. The Zeiss Helium Ion Microscope has proven to be capable of imaging the nm-scale structures revealing the true nature of gas storage in shales. Local porosity in kerogen can be extremely highly (>30%) and nm-wide conduits for gas migration can be traces over μm distances. These porous networks form late in the oil window, becomes abundant by the onset of the gas window, and remain relatively unaltered in shales at extremely high maturity.

The nm-scaled features, however, are inadequate to explain the observed rates of gas transport in producing wells. Using micro X-ray CT and NMR, we have measured gas transport in whole cores under reservoir conditions. Rapid transport occurs in high permeability features sub-parallel to bedding, followed by slower transport into the rock matrix surrounding these features. The high permeability features are physical micro-cracks within the mineral matrix and at mineral-organic boundaries. It is impossible to prove that such features exist in undisturbed subsurface shales; however, we find a correlation with their presence and well productivity.

The work being presented was conducted by Max Deffenbaugh, John Dunsmuir, Aaron Eberle, Hubert King, Chris Kliewer, Pavel Kortunov, and Michael Sansone.

Use of sulfur isotopes to quantify biological and abiotic processes contributing to sulfur cycling in an AMD treatment system

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Untreated drainages from abandoned coal mines are generally low-pH waters that contain high concentrations of dissolved SO_4^{2-} , Fe, Al, Mn and other elements of environmental concern (e.g., As, Se, Zn, Cd and Ni). In the Illinois Basin this has been a significant and costly problem as extensive mining has been carried out during the last century. Currently, treatment systems of coal-generated AMD include the use of bio-induced stabilization of dissolved SO_4^{2-} and metals in sulfides, as the optimal way for effective, long-term treatment. However as AMD systems evolve, fluctuations in physical (e.g., rain induced-dilution, dynamic AMD flow rates), chemical (e.g., precipitation, sorption, desorption, etc.) and biological processes provoke temporal disequilibria within the system. Therefore, it remains challenging to assess the extent of permanent contaminant sequestration and predict long-term treatment viability.

We present a 1-year study of concentrations and $\delta^{34}\text{S}$ values of sulfur compounds in six field-scale column experiments conducted at the Tab-Simco site to constrain the efficiency of various organic substrates in supporting the bio-reduction processes. Our results show: (1) During warm months months ($T > 10^\circ\text{C}$) high levels in H_2S in the reactors containing limestone and different combinations of *organic amendments indicate the presence of sulfate reducing bacteria (SRB)*. Analysis of initial microbial community and SRB community via the 16S rRNA and *dsrAB* genes, respectively, suggest the presence of *Desulfotomaculum*, *Desulfomicrobium* and *Desulfococcus*. (2) Sulphur cycling is dynamic and strongly influenced by both biological and abiotic processes. (3) Increasing bacterially-mediated sulfate reduction processes are associated with enrichment of 10-15‰ and precipitation of secondary sulfates is associated with depletion of 1-2‰ in $\delta^{34}\text{S}$ in residual SO_4^{2-} . (4) Isotopic mass balance calculations indicate that abiological sequestration was the dominant mechanism during the initial stage of the experiments and the low-temperature months. Our study demonstrates the applicability of the method to assess the rates, progress and environmental fate of pollutants associated with in AMD treatment processes.