AAPG HEDBERG CONFERENCE
"NATURAL GAS GEOCHEMISTRY: RECENT DEVELOPMENTS, APPLICATIONS, AND TECHNOLOGIES"
MAY 9-12, 2011 – BEIJING, CHINA

Isotopic Fractionation of Methane in Shale as a Predictor of Matrix Deliverability

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Developments in the horizontal drilling and hydraulic fracturing of organic rich shale have lead to an intense, world wide, drive to develop these unconventional resources. Presented here are examples from the Marcellus Shale (Devonian, Appalachian Basin) where the intervals targeted and the techniques used for completion were not materially different. However, the resulting initial production points to important differences in the geology of these wells.

In the study area, the organic rich portion of the Marcellus is roughly 100ft in thickness with TOC values ranging from 2-10%. Although originally oil prone, the high virinite reflectance (~ 2.0% Ro) means that dry thermogenic gas currently is being produced in the study area.

Due to the very low permeability of most shale, the formation could act like a membrane delivering hydrocarbons from the matrix to the wellbore through diffusive processes. As a result, kinetic isotopic fractionation may occur by which the residual hydrocarbons remaining in the matrix would be expected to become enriched in heavier isotope fractions. This phenomenon is most apparent in the headspace gas collected from canned cuttings.

Samples collected from the Marcellus suggest that isotopically heavier gas is associated with the matrix of wells which have higher initial production. The proposed mechanism for this observation is that a matrix with higher deliverability of hydrocarbons will display a greater fractionation of the stable carbon isotope of methane, leading to isotopically heavier gas associated with the residual gas released from cuttings as shown in Figure 1 (Marcellus-3). The Marcellus-1 and Marcellus-2 wells (Figure 1) are interpreted to have a matrix which has lower deliverability of hydrocarbons resulting in less isotopic fractionation as seen from headspace gas released from the associated cuttings. The headspace gas collected from Marcellus-1 and Marcellus-2 is isotopically lighter, correlating to poorer well performance.

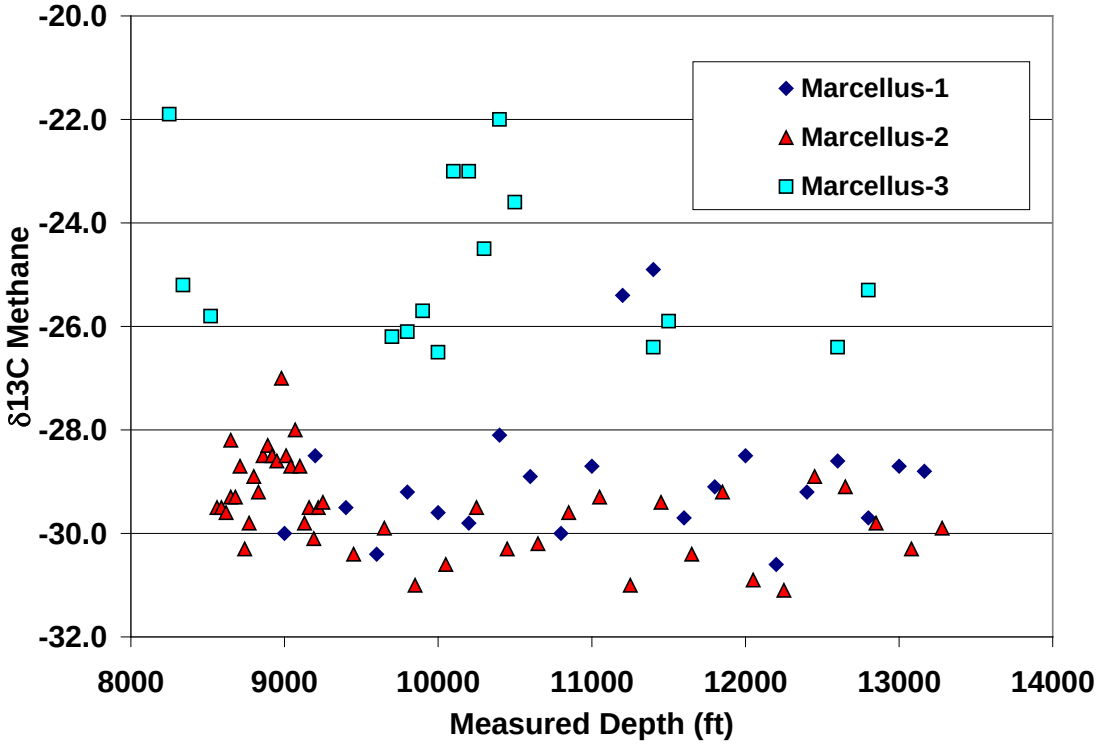

Figure 1. Stable carbon isotope of methane from gas evolved out of cuttings at the surface. The headspace gases from poorer producing wells (Marcellus-1, Marcellus-2) are isotopically lighter than the gas associated from cuttings from the better producing Marcellus-3 well.