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Kinetic Isotopic Fractionation Modeling Integrated into A 3-D Basin Model: A Case Study From Mamm Creek Field, Piceance Basin, Colorado

Geoffrey S. Ellis[1], Paul G. Lillis[1], Stephen P. Cumella[2], Ira Pasternak[3], Yongchun Tang[4]

[1]U.S. Geological Survey, Denver, CO USA
[2]Bill Barrett Corp., Denver, CO USA
[3]EnCana Oil and Gas (USA) Inc, Denver, CO USA
[4]Power, Environmental, and Energy Research Institute, Covina, CA USA

The Mamm Creek field is one of the largest gas fields in the Piceance Basin, Colorado, with estimated reserves of more than one trillion cubic feet (Lillis *et al.*, 2008). Gas production is predominately from low porosity/permeability sandstones of the Williams Fork Formation of the Upper Cretaceous Mesaverde Group. The primary source of the gas is generally thought to be the Cameo coal zone within the lower part of the formation, with possible contributions from minor intraformational organic-rich units. The basin-centered gas model is commonly used to explain this gas accumulation, whereby overpressuring results from abundant gas-prone source rocks in close proximity to very low permeability, highly discontinuous sandstone reservoirs. Gas was generated at a faster rate than gas was lost from the system, and the overpressured gas charged the sandstones to irreducible water saturations. This caused vertical natural fractures that allowed gas to migrate upward, forming a

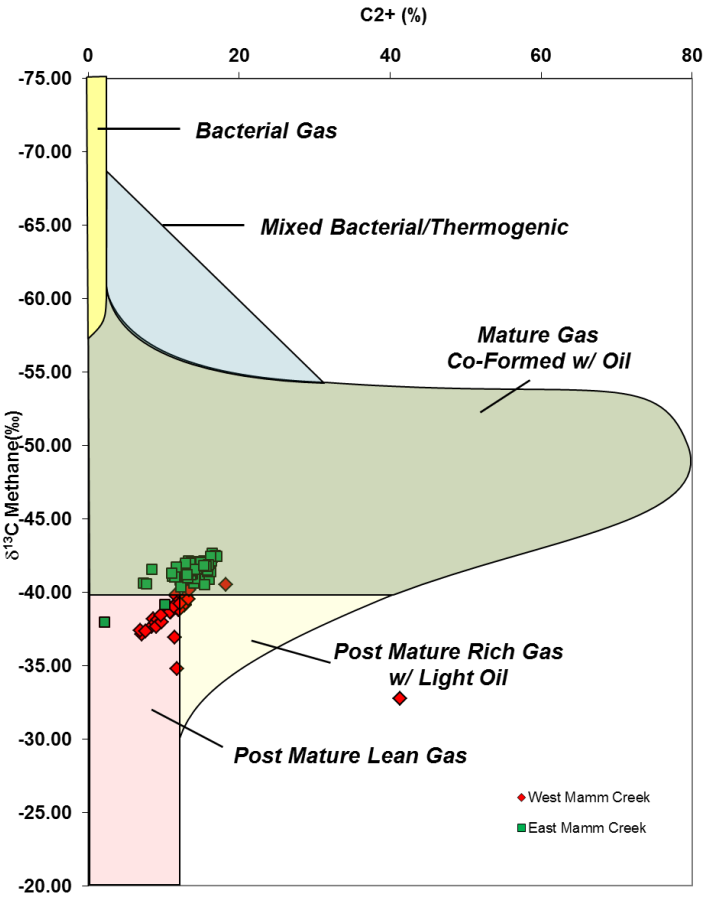

Figure 1: Cross plot of gas wetness (C_{2+}) and stable carbon isotopic composition of methane ($\delta^{13}C_1$) shows a geochemical difference between eastern and western portions of Mamm Creek field.

significant gas column. However, spatial variability in the molecular and isotopic composition of the produced gases indicates the possibility of a more complex history of gas genesis. Specifically, gases produced from the western portion of Mamm Creek field are isotopically heavier ($\delta^{13}C$) and drier than those in the eastern part of the field (Figure 1).

Gas compositional and isotopic data from field samples were combined with other geologic information from the field into a three-dimensional model using the Trinity* software package (Zetaware, Inc.). Additionally, source-specific kinetic isotope fractionation parameters were determined based on sealed-tube pyrolysis experiments, then were extrapolated to the natural time-temperature conditions of the Piceance Basin using the GOR Isotopes* software package (GeoIsoChem, Inc.). Integration of the kinetic model results with geologic and geochemical data provides new insights into the sources of the gas, the timing of gas generation, migration pathways, and reservoir compartmentalization. In particular, the model results indicate that the observed trends in the gas geochemistry cannot be explained by a single Cameo coal source for the gases. Moreover, the model predicts that in the western section of the field, Cameo coal-sourced gases may be mixed with a secondary, isotopically lighter source, most likely from the underlying Upper Cretaceous Mancos Shale that contains predominately type II kerogen (Johnson and Rice, 1990).

Combining the kinetic isotope fractionation model with published burial history data for the Piceance Basin (Yurewicz *et al.*, 2008) allows us to estimate that primary gas generation occurred from approximately 45 to 10 Ma (Figure 2). Moreover, spatial variations in the gas geochemistry throughout the field indicate reservoir compartmentalization, the existence of which helps in determining migration pathways and timing of localized gas emplacement.

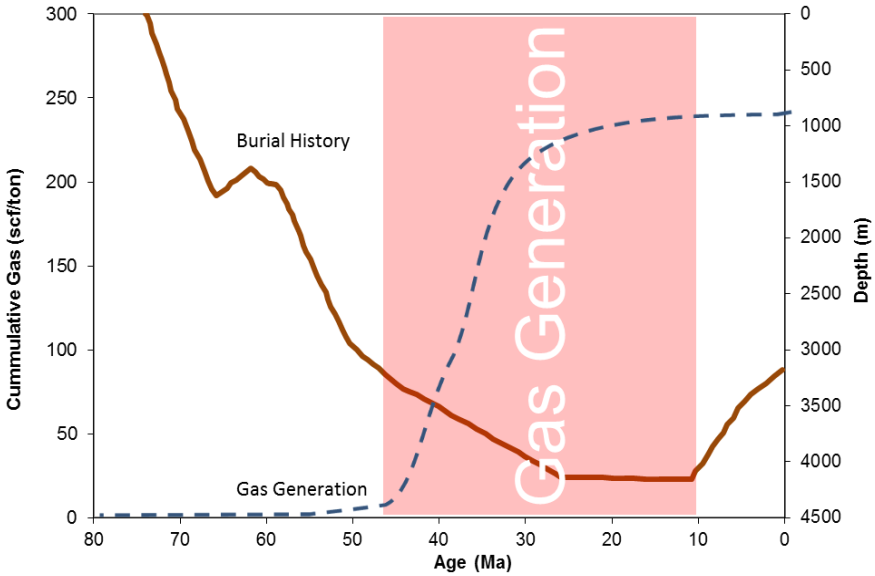

Figure 2: Model results indicate maximum gas generation from the Cameo coal occurred from approximately 45 to 10 Ma (broken line). Burial history curve (solid line) is from Yurewicz *et al.* (2008).

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Overall, the integration of a source-specific kinetic isotope fractionation model with local geologic and geochemical data in a three-dimensional framework provides a powerful tool for improved understanding of the generation and accumulation of natural gas in Mamm Creek field.

References

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