Isotope Systematics of High Maturity Shale Gases in the WCSB Compared to Other North Amercan Shale Gases

B.J.Tilley*, University of Alberta, Edmonton, Alberta, Canada
btilley@ualberta.ca
and
K. Muehlenbachs, University of Alberta, Edmonton, Alberta, Canada

Summary

Stable isotope geochemistry of shale gas has proven to be useful for exploration and development. Here we compare the isotope ratios of shale gases from the WCSB to other known basins in North America. We find that they all can be described by one self-consistent continuum of isotope relationships and trends.

Abstract

Stable isotope geochemistry is now recognized as a tool for shale gas exploration. Its utility however depends on an understanding of the isotope systematics for the particular region of interest as well as for shale gas maturation in general. Isotope data for Barnett and Fayetteville shale gas (Zumberge et al., in press), fractured reservoirs and shale gas in the Appalachians (Burruss and Laughrey, 2010; Baldassare, 2011, Molgat et al., 2011) and fractured reservoirs and shale gas in the WCSB (Tilley et al., 2011 and unpublished data) provide a framework within which mature shale gases can be evaluated and better understood in terms of their general evolution. Compilation, review and re-interpretation of these data show that shale gases can be classified into three distinct maturation stages that have unique and distinctive carbon and hydrogen isotopic relationships and trends. Identifying the maturation stage of a gas can lead to a better understanding of the processes that have occurred and may help predict the ultimate productivity of a shale gas play.

The three maturation stages of shale gas are defined here as pre-rollover, rollover and post-rollover. Gases in the pre-rollover stage are isotopically normal (δ^{13}C1< δ^{13}C2< δ^{13}C3) unless mixing of gases from different sources has occurred. In the rollover stage, δ^{13}C ethane and δ^{13}C propane become progressively more negative as δ^{13}C methane becomes less negative. However, ethane and methane are reversed (δ^{13}C2 < ^{13}C1) only towards the most mature portion of the rollover stage. Gases from the Barnett Shale in Texas and the Triassic Montney-Doig Phosphate formations in eastern British Columbia are characteristic of the pre-rollover and rollover maturation stages. In the Appalachians, where Marcellus shale gases are generally at the transition between the rollover and post-rollover stages, isotope ratios must be compared to a background range of Marcellus shale gas maturities in order to assign a maturity stage. Correct assignment of maturity stage could be of importance because the rollover stage may represent the peak of high productivity shale gas whereas the post-rollover stage may represent a decline in productivity (Burruss and Laughrey, 2011). At the beginning of the post rollover stage, δ^{13}C1> δ^{13}C2> δ^{13}C3, but as δ^{13}C ethane and δ^{13}C propane become increasingly less negative at varying rates, ethane and propane may or may not be reversed with respect to each other at the highest maturities. δD of methane in gases of the post-rollover stage generally stays constant or becomes more negative with increasing maturity. The post rollover stage is represented by shale gas in the Horn River Basin of British Columbia, Permian and Triassic fractured reservoirs in the Foothills of the WCSB, Utica shale gas in both Quebec and Pennsylvania, Ordovician fractured reservoirs in New York State, and the most mature Fayetteville shale gas.

References

Baldassare, F., 2011, The origin of some natural gases in Permian through Devonian age systems in the Appalachian basin and the relationship to incidents of stray gas migration: Proceedings of the Technical Workshops for Hydraulic Fracturing Study: Chemical and Analytical Methods, EPA 600/R-11/066 May 20111, www.epa.gov

Burruss, R. C., Laughrey, C. D., 2010. Carbon and hydrogen isotopic reversals in deep basin gas: Evidence for limits to the stablility of hydrocarbons. Organic Geochemistry **41**, 1285-1296.

Burruss, R. C., Laughrey, C. D., 2011. Isotope reversals and rollovers: The last gasp of shale gas? Abstract: AAPG Hedberg conference, May 9-12, 2011, Beijing, China.

Molgat, M., Chatellier, J-Y., Rioux, R., Holmes, K., Goodall, C. and Smith, R. 2011, Best practices and applied organic geochemistry to address a surface casing vent flow, example from Talisman 2011 remediation work in Quebec: http://www.forumschiste.com/uploads/images/Poster-QOGA-2011.pdf

Tilley, B.J., McLellan, S., Hiebert, S., Quartero, B.. Veilleux, B., Muehlenbachs, K., 2011. Gas isotope reversals in fractured gas reservoirs of the western Canadian Foothills: Mature shale gases in disguise. American Association of Petroleum Geologists Bulletin **95**, 1399-1422

Zumberge, J., Ferworn, K., Brown, S., in press. Isotopic reversal (‘rollover’) in shale gases produced from the Mississippian Barnett and Fayetteville formations: Marine and Petroleum Geology (2011), doi:10.1016/j.marpetgeo.2011.06.009