Stable Carbon Isotope Reversal Does Not Correlate to Production in the Marcellus Shale*

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Abstract

Do trends in stable carbon isotopes correlate to production in shale gas plays? It has long been noted that the stable carbon isotopes of hydrocarbons such as methane, ethane, and propane tend to become isotopically heavier with higher thermal maturity. Recently, workers have encountered a reversal in this trend in several horizontal plays such as the Barnett Shale of west Texas and the Haynesville Shale in Louisiana. In these areas, the stable carbon isotopes of ethane and propane become isotopically lighter with depth, a reversal of the normal trend. While this trend could be interpreted as mixing of gases with different origin and maturity, the low permeability of these formations makes this unlikely. Although the mechanism of this reversal presently remains unclear, there is an association between the presence of this isotopic anomaly and increased production in some horizontal plays.

Using isotopes to predict areas of higher production was evaluated in the Marcellus Shale in western Pennsylvania. The results of this work indicate that stable carbon isotopes go through the same reversal process as in other plays, but the trends are the same in both areas of good and poor production. Rather than acting as a signal for higher production volumes, the reversal in isotopic trend is probably indicative of maturity and the stratigraphic horizon of this reversal is likely due to the occurrence of better seals within shale members seen throughout the Hamilton Formation. Therefore, better production in the Marcellus Shale seems to be more closely related to traditional matrix parameters like porosity and permeability than trends in stable carbon isotopes.

Selected References


Website

http://www.censusfinder.com/derived/mappa.htm_txt_mappasmall.gif
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Outline

Isotopic Rollover
- Barnett/Fayetteville
- Marcellus

Integrating Isotopic Rollover into Petroleum Systems Analysis
Isotopic Rollover Examples

**δC¹³ Ethane**

Isotopic Rollover or Reversal

Normal Maturity Trend

- **Barnett (Zumberge et al., 2012)**
- **Fayetteville (Zumberge et al, 2012)**

**C₂⁺ %**
Correlation of Rollover to Production

Better production associated with rollover

Rollover wells that under perform are associated with variations in completion and lateral length

Zumberge et al., 2012
Rollover occurs at high maturity with a good seal

Agrees with observations from Tilley et al., 2011
Marcellus Stratigraphy

- Tully (Limestone)
- Hamilton (Shale)
- Low TOC Marcellus (Shale)
- Cherry Valley (Limestone)
- High TOC Marcellus (Shale)
- Onondaga (Limestone)

Seal/Frac Barrier

Source/Reservoir

1000 ft
Isotopic rollover does not discriminate between poorer and better producers

Similar lateral lengths and completions
Permitting Activity

Marcellus Shale Drilling Permits

- Permit Year:
  - 2012 (882 through 3/10)
  - 2011 (1337 permits)
  - 2010 (1249 permits)
  - 2009 (1997 permits)
  - 2008 (528 permits)
  - 2007 (122 permits)

- Marcellus extent
  - Includes non-economic areas
  - Based on Pennsylvania Department of Environmental Protection permit activity reports

MARCELLUS CENTER
FOR OUTREACH AND RESEARCH
www.marcellus.psu.edu
Permitting Activity
Drilling Activity

Marcellus Shale Wells

Year Drilled
- 2012 (337 through 3/16)
- 2011 (1926 wells)
- 2010 (1395 wells)
- 2009 (685 wells)
- 2008 (219 wells)
- 2007 (60 wells)

Marcellus extent
Includes non-economic areas
Based on Pennsylvania Department of Environmental Protection (DEP) Data reports
Marcellus Shale Thickness

Marcellus Shale thickness is an MCOR interpretation based on multiple data sources.
Present Depth of Burial

Depth of Marcellus Shale Base
- 2000 - 3000 ft
- 3000 - 4000 ft
- 4000 - 5000 ft
- 5000 - 6000 ft
- 6000 - 7000 ft
- 7000 - 8000 ft
- 8000 - 9000 ft
- > 9000 ft

Wet/Dry Gas Boundary
Marcellus Shale Extent (includes non-economic areas)

Marcellus location modified from USGS Marcellus Shale Assessment Unit. Onondaga depth modified from Wrightstone, 2009.
Example of Structure from Poorer Producer

- Marcellus
- Cherry Valley
- Onondaga

Well Path
Example of Structure from Poorer Producer
Example of Production from Better Producer
Large increase in matrix permeability is related to improvement in production
Key risk factor in the petroleum system should be addressed by looking at permeability and porosity.
Isotopic rollover does not discriminate between poorer and better production in the Marcellus study area

- Only addresses seal and maturity

Using the petroleum systems method helps identify the key risk elements

- A great seal does not overcome poor matrix properties

Otherwise, we regress to drilling the bumps (or the high TOCs)
Acknowledgements

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Marcellus development team

- Adam Majeski
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- Kristin Walker
- Jessica LaMarro
Figure 11. Comparison of %Ro values calculated for wells along Appalachian cross section EE' (Rowan and others, 2004a, b) with isolines derived from dispersed vitrinite data (Repetski and others, 2002, 2005; Weary and others, 2000, 2001).
Milici et al., 2006
after de Witt, 1975 and Harper 1999