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Modification of Hydrocarbon Fluid Distribution in the Montney Tight-Gas Fairway by the Secondary Migration of Methane

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Summary

The trend in commodity prices over the last few years has prompted a shift in industry focus in the Montney Formation away from dry gas areas and toward prolific hydrocarbon liquids-rich portions of the tight-gas fairway. In the Montney, like most other tight-gas and shale-gas plays, thermal maturity is the first-order control on the the richness of natural gas expressed, for example, by condensate-gas ratio (CGR). The rush to hydrocarbon liquids has thus resulted in industry activity focused on shallower and lower thermal maturity portions of the Montney tight-gas fairway where the production results have led to notable success, but also to some unexpected outcomes.

In many areas of the wet gas window, CGR ratios are found to be highly variable and do not conform solely to the trend of regional thermal maturity. Here we show that a significant second-order control on CGR is the secondary migration of methane. Methane migration is focused along distinct linear or curvilinear pathways controlled by stratigraphic trends with superior matrix permeability and likely also structural trends with enhanced fracture permeability (Wood and Sanei, 2016). Indigenous hydrocarbon fluids are modified along these pathways by natural processes of methane enrichment including phase separation and segrative migration during the last ~60 million years of basin uplift, removal of overburden and depressurization. Geological complexity that influences the secondary migration of methane thus also finds expression in the surprizing intricacy of Montney CGR maps.

To help decipher complex CGR distributions, we developed a simple method to identify secondary methane migration trends from the analysis of routinely collected gas composition data (Wood and Sanei, 2016). Previous work shows that the iC_4/nC_4 ratio of natural gas can a reliable indicator of thermal maturity, whereas the dryness ratio can be be influenced by hydrocarbon migration as well as maturity. For a shale-gas basin with no significant modification by migrated hydrocarbons such as the Barnett Shale, a cross-plot of gas dryness ratio (normalized methane content) versus iC_4/nC_4 ratio (Fig. 1) shows a coherent distribution with a normal trend at low maturity and a reversed trend at high maturity (Zumberge et al., 2012). A comparable Montney cross-plot (Fig. 2) shows a more complex distribution. A portion of the data (black dots) matches the normal maturity trend of the Barnett Shale. Many data points, however, lie to the left of the normal maturity trend. These data points (coloured dots) have an ‘excess methane’ signature, indicating that the maturity-controlled distribution of hydrocarbon fluids is modified by methane introduced during secondary migration (Wood and Sanei, 2016). Recognition of ‘excess methane’ signatures allows secondary migration trends to be mapped and helps bring greater clarity to otherwise confounding CGR distributions.

Acknowledgements

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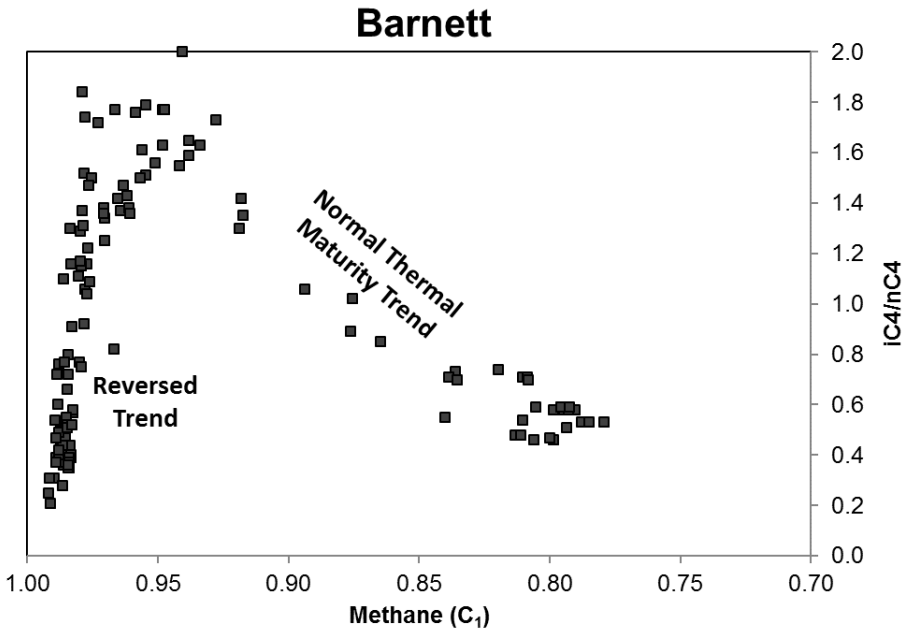

Figure 1 - Cross-plot of normalized methane (C_1) content versus iC_4/nC_4 ratio of natural gas samples from 131 wells in the Barnett Shale, Texas showing normal and reversed thermal maturity trends. A reversed iC_4/nC_4 trend at high thermal maturity is thought to result from the cracking of wet gas in an essentially closed system. Data from Zumberge et al., 2012.

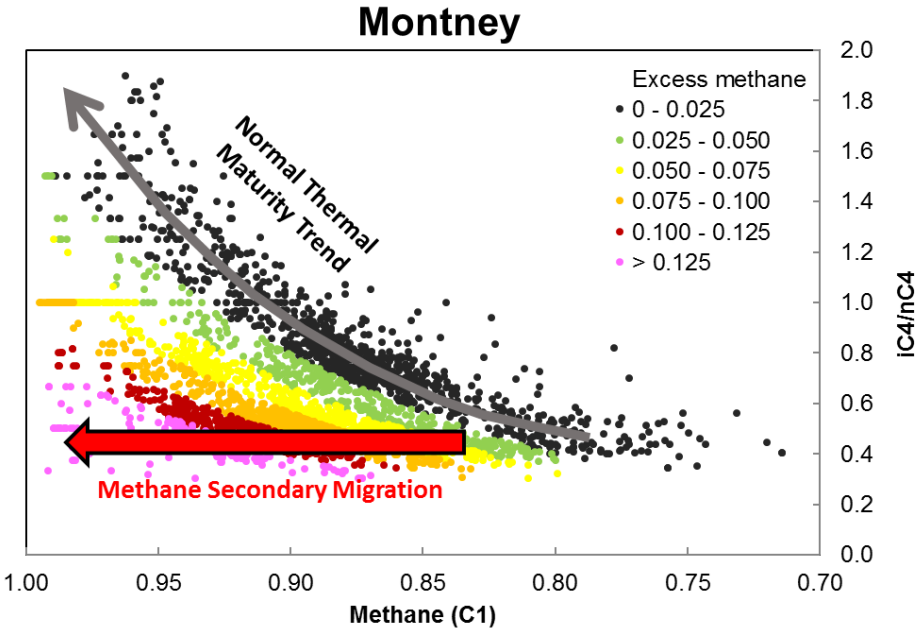

Figure 2 - Cross-plot of normalized methane (C_1) content versus iC_4/nC_4 ratio for natural gas samples from 1,907 wells in the Montney Formation of Alberta and B.C. showing normal thermal maturity trend modified by secondary migration of methane. Data points are colour-coded by 'excess methane' defined as the amount of methane greater than the normal thermal maturity trend (black dots) at comparable iC_4/nC_4 ratio. A reversed trend at high maturity is not evident and suggests siltstones of the Montney comprise a more open and permeable system than shales in the Barnett. Modified from Wood and Sanei, 2016.

References

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