[PS]Unraveling Complex Oil Mixtures in the Williston Basin*

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Abstract

Oil mixtures can be encountered in both tight shale and conventional reservoirs. Knowing the components of oil mixtures can improve exploration prospect selection. However, oil mixtures may be difficult to recognize by classical geochemical analysis. Once recognized they may be even more difficult to disentangle and to determine the component sources. We tested new high-resolution geochemical technologies for correlation in the Williston Basin. With its multiple stacked source rocks, the Williston is a prime proving ground for identifying oil sources and mixtures, and if successful, a venue for application with high yield potential for exploration.

The new applied technologies begin with quantitative diamondoid analysis to identify black oil-cracked oil or condensate mixtures. In spite of the occurrence of as many as a dozen possible source rocks in the basin, individual components can be distinguished and correlated by using compound specific isotope analysis of diamondoids (CSIA-D) and biomarkers (CSIA-B), and by the very latest advance in correlation, quantitative extended diamondoid analysis (QEDA). The parallel use of diamondoid and biomarker correlation methods facilitates correlation of both black oil and cracked oil sources and de-convolution of their mixtures.

Unraveling Complex Oil Mixtures in the Williston Basin

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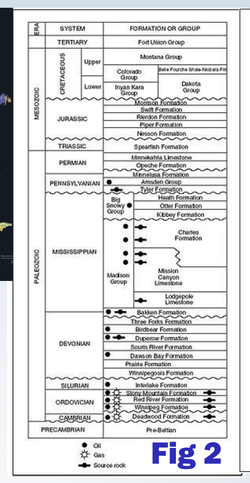
DIAMONDOID PARAMETERS FOR CORRELATION

- **Correlate black oil, cracked oil/white oil, severely biodegraded oil/seep oil, source rocks, tight shale/gas & oil shale**
- **Unravel mixed oil components**
- **Indispensible for cracked-oil correlation**
- **Determine gas sources**

1. CORRELATION EXAMPLE: WILLISTON BASIN

This diversity of source rocks, the occurrence of cracked oil and the often-encountered oil mixtures make oil-oil correlation by conventional methods difficult. We tested the source-related diamondoid technologies to see how many different source fingerprints and oil-mixtures we could identify from among a set of oil samples taken from the basin.



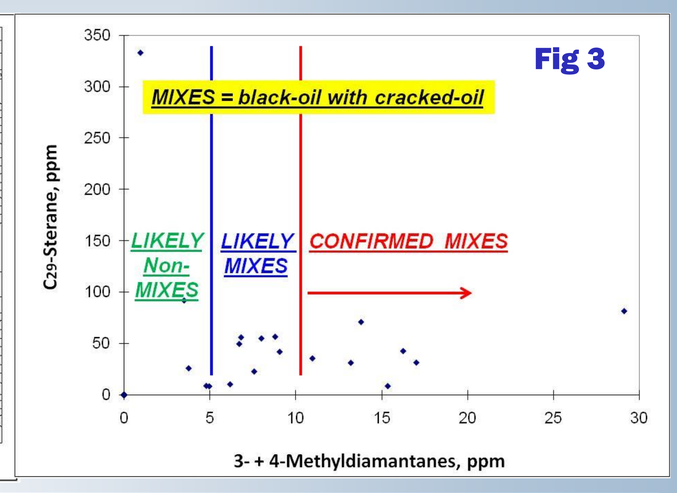
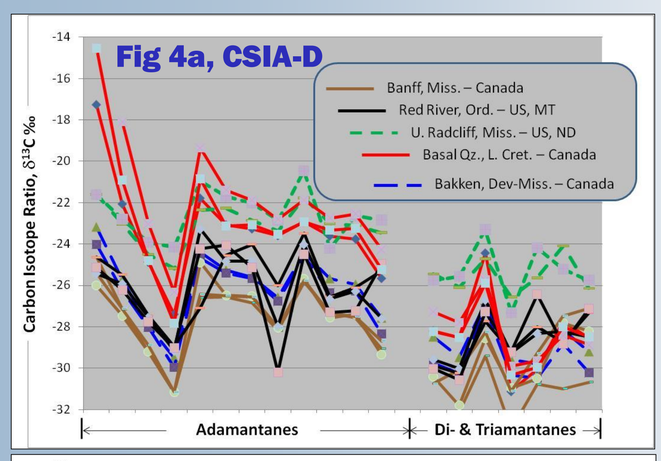
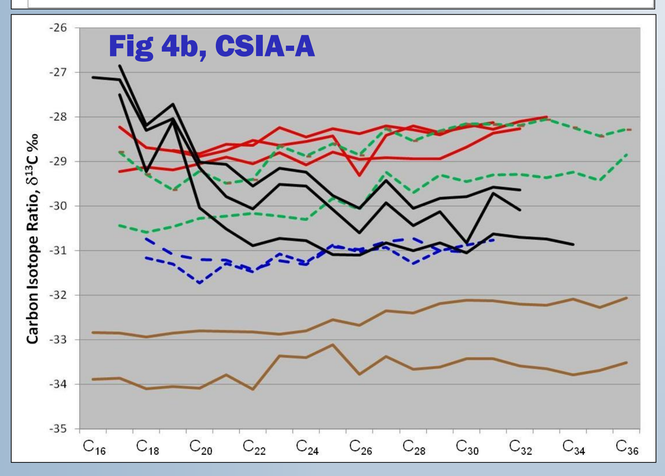


Figure 1. The Williston Basin is a frontier for oil and gas production from tight shale.
Figure 2. Twelve proven and potential source rock formations have been identified in the Williston Basin.
Figure 3. Quantitative diamondoid analysis (QDA) revealed that many of the oil samples were mixtures of cracked oil and black oil.

Panel 1

Compound Specific Isotope Analysis of Diamondoids (CSIA-D) is used for correlation of all oil types.

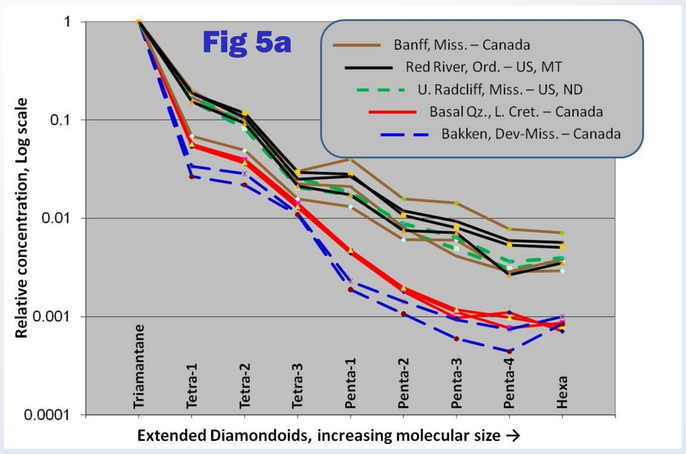


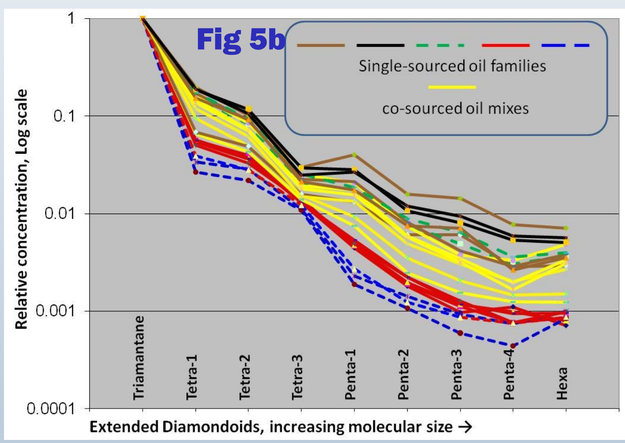


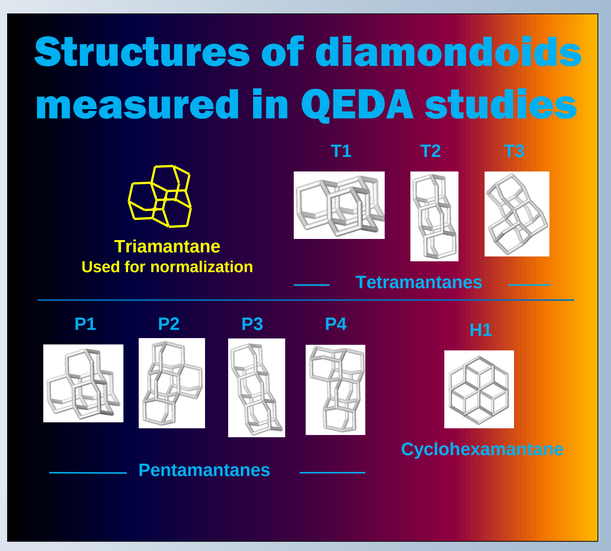
In the Williston Basin oil set five end member source families were identified as indicated in the five listed reservoirs, respectively (Fig 4a). Bakken and Basel Quartz are distinguished very well by CSIA-D, while Bakken and Red River are not. CSIA of alkanes (CSIA-A, Fig 4b) helps to further confirm the source types.

Panel 2

Quantitative Extended Diamondoid Analysis (QEDA) is a correlation method complimentary to CSIA-D.







Figures 5a & b show concentrations of extended diamondoids in the oil measured by GC-MS and normalized to that of triamantane. QEDA clearly distinguishes Bakken and Red River oils (Fig 5a), better than CSIA-D. Bakken and Basel Quartz oils also show clearly different patterns. Radcliff and Red River are distinguished better by CSIA-D. The yellow traces (Fig 5b) plot data from oil samples that may be mixtures.

Panel 3