

Unlocking the Potential of Gas Isotope Geochemistry: Exploring its Applications to the Unconventional Duvernay Fm. of the Western Canada Sedimentary Basin

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The Duvernay Formation in the Western Canada Sedimentary Basin (WCSB) is a prolific source rock, particularly in the ultra-low permeability, self-sourced, mudstone unconventional reservoir within the Kaybob area (Fig. 1a). Regional carbon isotope analyses of hydrocarbons from the Duvernay Fm. indicate their generation near the peak of the “oil window” (González Arismendi et al., 2023). In here, we implemented geochemical tools to determine the natural gas reaction systems and the source of the gases. Accordingly, the isotopic composition of gas individual hydrocarbon components ($\delta^{13}\text{C}_n$) are plotted versus the inverse of the carbon number ($1/n$) of that component and is based on the premise that the magnitude of isotopic partitioning between kerogen and the respective gas moieties is determined by molecular mass as well as temperature (Chung et al., 1988). While a traditional “open” vs. “closed” classification system applies broadly to the Duvernay Fm., a detailed interpretation of the isotope data from 112 samples leads to a more refined classification of gases from the Duvernay as “unaltered,” “altered,” or “mixed” (González Arismendi et al., 2023). Regionally, there is spatial variations between the western and eastern facies within the Formation, suggesting facies interconnectivity influenced by reef-related migration paths toward the Nisku Formation in the south, potentially identifying mixing of gases. This classification provides insights into the distribution of liquid fractions in unaltered gas samples (Fig. 1b).

We add new data and expand on a recent research in the Kaybob field, where we compared production data and static modeled reservoir properties to isotope data of 25 wells. The results led to the proposed classification scheme and furthermore, suggested potential applications to better understanding of variations in well production (González Arismendi et al., 2023)(Fig. 1). Carbon isotope fingerprints correlate with key production variables such as condensate gas ratio, cumulative condensate, and cumulative gas. Gas isotope variations not only discriminate “unaltered”, “altered” vs. “mixed systems”, but also contribute to the refinement of the thermal maturity model in the KD field. The results underline the potential of this isotopic analysis approach as a pragmatic tool for production forecasting and field optimization in unconventional low permeability reservoirs.

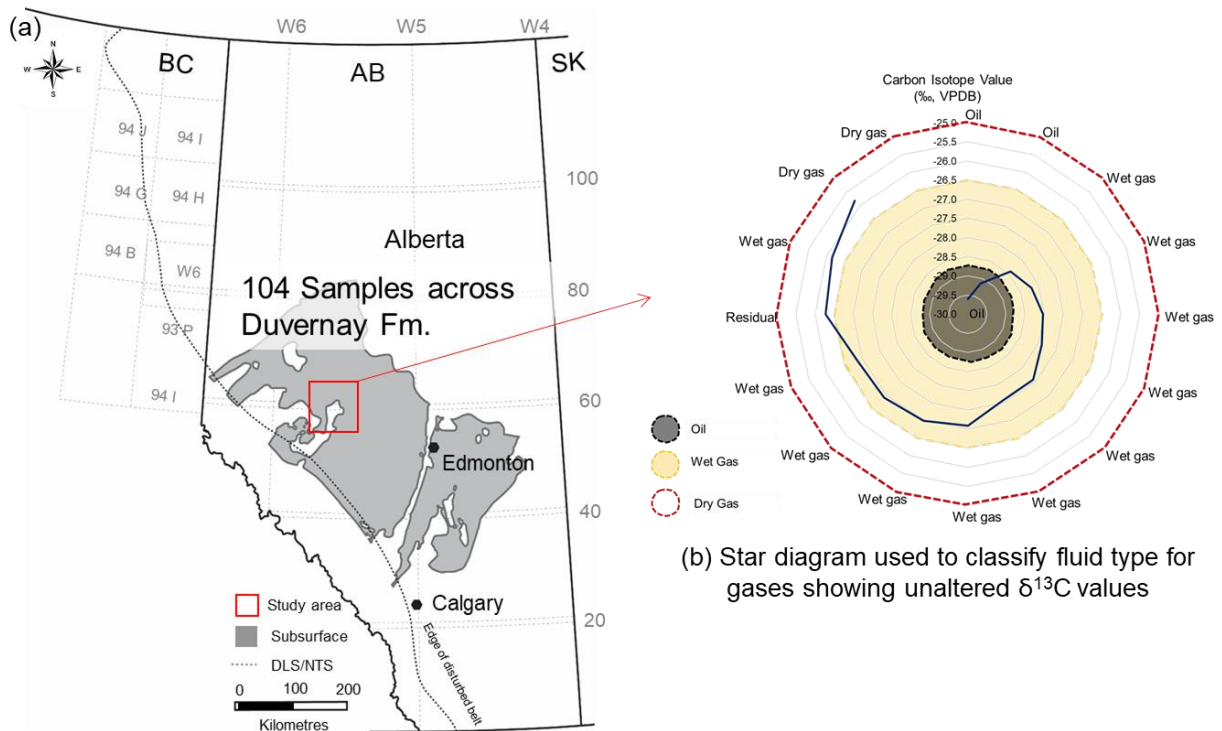


Figure 1. (a) Map of Alberta showing the subsurface of the Duvernay Formation and (b) star diagram presenting wetness classification for unaltered gas samples. The red square represents the Kaybob field for which a detailed study of 25 samples were combined with 104 archived data in the area. This led to a new classification system based on natural gas carbon isotopic compositions as mixed, altered and unaltered, by implementing such classification, we were able to better predict fluid distribution. (b) The unaltered produced hydrocarbons can be further subdivided as to fluid type based on carbon isotope values of pentane as shown in (b) by the star diagram.

References

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