

GEOLOGICAL CONTROLS ON FLUID PROPERTY HETEROGENEITIES OF THE GROSOMT BITUMEN

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Introduction

The Grosmont carbonate bitumen deposit of northern Alberta contains an estimated 64.5 billion cubic metres of heavy bitumen (5- to 10-degree API gravity), representing about one-sixth of the total hydrocarbon accumulation in the area (Alberta Energy and Utilities Board, 2010). Characterization of reservoir properties of the Grosmont Formation is compounded by the highly heterogeneous nature of both the rock and fluid properties. In addition, the highly viscous nature of the bitumen makes it difficult to recover a representative fluid sample from the carbonate using mechanical extraction (e.g. centrifugation) methods. Severe compositional alteration, as is often observed in analyses of Grosmont bitumen, completely destroys the steranes and hopanes and limits their application for geochemical characterization. Therefore, oil-source correlation relies on molecular markers, such as the aromatic steroid hydrocarbons and aromatic seco-hopanes, which display strong resistance to biodegradation.

Results

In a case study of the Grosmont Formation carbonates, laterally extensive and significant shale barriers (shale breaks) aids the identification of three units of the Upper Grosmont Formation (UGM1, UGM2 and UGM3). The bitumen in the Grosmont Formation has a high viscosity, ranging from 1.6 to 10 million centipoises (at 20 degrees centigrade), and generally displays values of 5 to 10 degree API gravity. The hydrocarbon analysis of the bitumen indicates severe alteration has impacted the steranes and hopanes, showing degradation of PM6–PM10 according to the Peters and Moldowan (1993) scale of biodegradation. Molecular parameters based on the abundance of C₂₇ 18 α (H)-22,29,30-trisnorneohopane (Ts) relative to C₂₇ 17 α (H)-22,29,30-trisnorhopane (Tm) (i.e. Ts/(Ts+Tm) and the steroid aromatization parameter (mono-aromatic steroids versus tri-aromatic steroids) display strong resistance to biodegradation. The depth profiles of the molecular parameters (Fig. 1) are remarkably uniform within the UGM2 and UGM3 units, and the trends also appear uninterrupted by the presence of the shale break. A similar observation is seen amongst the quantitative data obtained for the biodegradation-resistant C₂₄ tetracyclic terpane and Ts. Thus, molecular ratios and concentration data suggest the oils in UGM2 and UGM3 are genetically related.

In contrast, the behaviour of compounds that are sensitive to biodegradation under the severe conditions experienced by the Grosmont bitumen exhibit changes within the reservoir units which show very different distributions between UGM2 and UGM3. The concentration data for the C₂₃ tricyclic terpane and C₃₀ $\alpha\beta$ hopane (Fig. 1) indicate that the biodegradation behaviour is specific to the reservoir units UGM2 and UGM3. In addition, further evidence of different biodegradation systematics between the reservoir units is recorded in the distribution of hopanes versus 25-norhopanes. In UGM3, the C₃₀–C₃₅ hopanes have been completely destroyed, with no evidence for the presence of 25-norhopanes. Although, the pentacyclic triterpene distribution of UGM2 bears some resemblance to the distributions in UGM3, with the predominance of C₂₉ $\alpha\beta$ hopane and lack of C₃₀–C₃₅ hopanes, there is a strong contribution

of 25-norhopanes represented by the complete carbon number distribution of C₂₈–C₃₄ 25-norhopanes.

The molecular evidence indicates there are very different degradation systematics operating within the UGM2 and UGM3 reservoir units, implying that the laterally extensive shales within the Grosmont Formation represent barriers to vertical fluid communication and have contributed to the establishment of unique biodegradation processes in the individual reservoir compartments, most likely with unique environmental conditions above and below the shale.

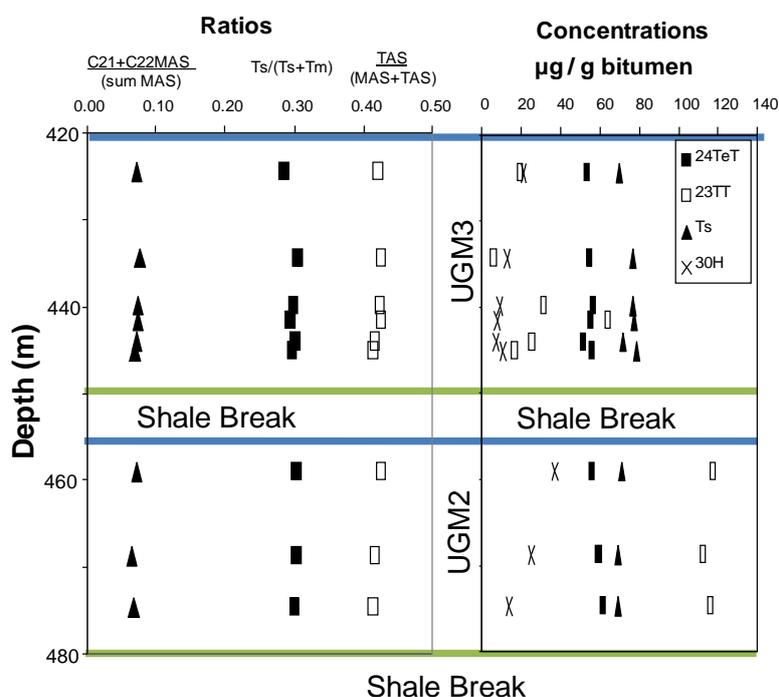


Figure 1. Molecular maturity parameters and molecular concentration ($\mu\text{g/g}$ bitumen) data versus depth (m) for the Upper Grosmont units 2 (UGM2) and 3 (UGM3).

Conclusions

Whereas bioreactive compounds are observed to be impacted by biodegradation, bioresistant compounds such as the mono-aromatic steroids possess unique distributions that can be used to recognize source information even in these severely biodegraded oils. The compositions appear remarkably uniform across significant shale barriers, suggesting that the reservoirs were charged above and below the shales with a uniform oil composition. The shales often compartmentalize the reservoirs such that biodegradation systematics may differ above and below the shales, leading to differences in hydrocarbon composition and reservoir fluid heterogeneities on both lateral and vertical scales.

References

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