Investigating the Effect of Organic Sulphur Compounds on Oil Generation in Bakken Formation in Saskatchewan*

Titi Aderoju[1] and Stephen L. Bend[1]

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[1]University of Regina, Regina, SK, Canada (aderojut@uregina.ca)

Abstract

This paper presents the preliminary results from an on-going study of the Madison-Bakken petroleum system of the Williston Basin, particularly with respect to oil-source correlations and Bakken source potential. This study seeks to examine and identify areas of anomalous (i.e., early) generation.

Through the application of petroleum geochemistry, this project aims to improve the present understanding of the Bakken petroleum system within the northern part of the Williston Basin, with a specific focus on southern Saskatchewan. More specifically, this study aims to examine oil-source relationships through the application of gas chromatography-mass spectrometry (i.e. biomarker analysis) and an examination of organic sulphur compounds within oils and source extracts, with the aim of determining the possible role of sulphur in the early generation of oil within potential sources conventionally considered 'immature'.

Previous studies have characterized the lower and upper Bakken Formation to be organic rich, typically with total organic carbon contents in excess of 10wt%, and generally recognised as immature/marginally mature in the Canadian portion of Williston Basin based on Rock-Eval Tmax and vitrinite reflectance data (%VR). Source characterisation of the Bakken Formation shows that Bakken Formation is also typically composed of mainly Type II kerogen with 'pockets' of Type I. It has been suggested that some occurrences of Type II kerogen also contain the highest amount of organic sulphur.

Investigation of Bakken extracts in this study clearly show that the Bakken Formation contain substantial amount of elemental sulphur, with variations within the upper and lower Bakken across the basin. Extractable organic matter was separated using column chromatography into saturate and aromatic hydrocarbon fractions, and the distribution of the various organic sulphur compounds was compared in the aromatic fraction of immature sediments using gas chromatography-mass spectrometry. The variations in sulphur compounds have been mapped, although the search for organic sulphur compounds amenable to the early generation of oil is at present on going.

Introduction

The Williston Basin is a prolific petroleum provenance that contains a number of petroleum systems (Dow, 1974; Williams, 1974). All of the known systems have been extensively studied, typically defined using the genetic relationships between pooled oils and oil-source characteristics (e.g. Osadetz et al., 1992). It is also generally regarded that the oils present within the Canadian portion of the Williston Basin have migrated from long distance sources elsewhere within the basin (Osadetz et al., 1992; Li et al., 1998).

Through the application of petroleum geochemistry, this study aims to test our present understanding of the Bakken petroleum system within the northern part of the Williston Basin, with a specific focus on southern Saskatchewan. More specifically, this study aims to quantify total sulphur and organic sulphur, with the aim of determining the possible presence of organic sulphur and its influence of C-S bond scission in the early generation of oil within potential sources conventionally considered ‘immature’.

Experimental

High-resolution sampling was conducted by obtaining up to 20 samples per well within the Bakken Formation in Saskatchewan (Figure 1). Core samples were cleaned and weathered surfaces were removed before sample preparation. The evaluation of hydrocarbon potential and thermal maturity was achieved using Rock-Eval pyrolysis. Source extraction was also carried out using soxhlet extraction and the extract fraction subsequently fractionated using liquid column chromatography into saturate, aromatic and NSO fractions. Further analysis was done using gas chromatography and gas chromatographic-mass spectrometry to investigate sulphur compounds in aromatic fraction and biomarker compounds, which are useful thermal maturity indicators for further calibration with Rock-Eval Tmax. The amount of sulphur was also examined using LECO Elemental Analyzer.

Results and Discussion

Previous studies (e.g. Osadetz and Snowdon, 1995) have characterized the Lower and Upper Bakken Formation to be organic rich, typically with total organic carbon contents in excess of 10wt%, and generally as immature/marginally mature within the Canadian portion of the Williston Basin based on Rock-Eval Tmax and vitrinite reflectance data (%VR) (Stasiuk, 1994; Osadetz & Snowdon, 1995). Source characterisation of the Bakken Formation shows that the Bakken Formation is also typically composed of mainly Type II kerogen with 'pockets' of Type I (Stasiuk, 1994; Wrolson, personal communication).

Variations in the levels of sulphur detected for the Upper and Lower Bakken within the same stratigraphic interval suggests that the presence of sulphur may be dependent on source input or depositional environment. Variation in extract composition is also in agreement with variation in the proportion of hydrocarbon and NSO compounds in the analyzed samples.

High levels of sulphur can be highly significant, because it has been suggested, throu

- ., 1989).

Type II-S kerogens are recognized as capable of generating hydrocarbons at relatively low levels of thermal maturity due to the lower bond dissociation energy of the C-S bond (ΔH°=65). In this study, the total sulphur was compared for Bakken samples, with the aim of establishing any correlation with conventional maturity parameters and determining the possible role of organic sulphur in the early generation of oil within potential sources that are conventionally considered 'immature'.

Conclusions

Investigation of Bakken extracts in this study clearly shows that the lower and upper Bakken Formation contain substantial amount of elemental sulphur prior to before subsequent GC and GCMS analysis, during source rock extraction. These variations in sulphur content have been mapped, although the search for organic sulphur compounds amenable to the early generation of oil remains plausible, further studies is required.

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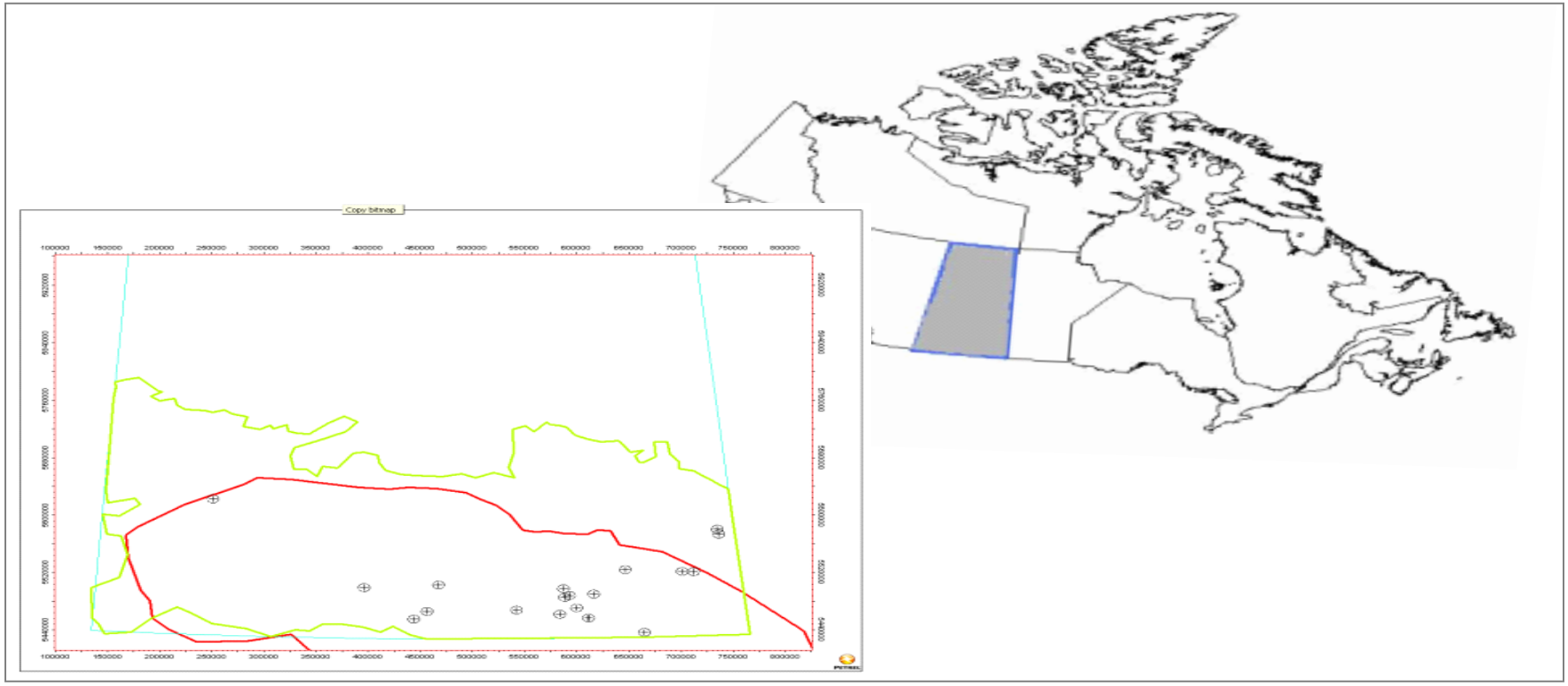

Figure 1. Map showing the study area (bounded in green), Williston Basin (bounded in red) and the well sampling locations within southern Saskatchewan.