The causes behind oil quality differences in Little Bow and Long Coulee oil fields, southern Alberta

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Introduction

Lower Cretaceous Mannville Group reservoirs contain oils of variable quality, both among locally adjacent fields and within reservoirs of the same oil field. For example, oils from the Little Bow field exhibit a range in API gravity, while oil from the Long Coulee fields does not. There are several processes that can affect the quality of oil during migration or after accumulation. Processes such as gas de-asphalting, water-washing and biodegradation can alter the quality of oil. Biodegradation of oil is the most significant process to affect oil quality in southern Alberta.

Biodegradation is a process where n-alkanes and other hydrocarbon compounds are removed sequentially from oil due to microbial attack. Theoretically a light gravity crude can be degraded to a medium or heavy gravity crude, due to the preferential removal of gases (C_1-C_4), and gasoline range (C_5-C_8) compounds. API gravity will decrease, sulfur content will increase and there will be an enrichment in non-hydrocarbon NSO compounds and asphaltenes, as biodegradation becomes more severe.

Methods

Thirty-one oils were collected from Lower Cretaceous Mannville producing reservoirs from the Little Bow and Long Coulee oil fields in southern Alberta (Townships 14-18 and Ranges 18-24, west of the fourth meridian). Gross composition, gasoline range (C_5-C_8), C_{15}+ saturated hydrocarbon (GC and GC-MS), and sulfur analyses were completed for each oil.

Results and Discussion

Gross composition analyses for Little Bow oils show elevated resin and asphaltene contents (> 20%), and high sulfur contents (> 2%), in association with variable API gravity (14 to 27°). Gasoline range analyses do not suggest significant biodegradation of most Little Bow oils. However, isoprenoid to n-alkane ratios vary considerably, for example phytane/nC_{18} ratios range from 0.4 to 1.5 (Figure 1) suggesting biodegradation to various extents has occurred. The saturate fraction gas chromatograms show the presence an elevated baseline (Figure 2) which can be interpreted as an indicator of extensive biodegradation. Based on this evidence it is suggested that two pulses of oil have accumulated in Little Bow reservoirs. An initial pulse that was subsequently biodegraded, followed by a second pulse that masks the original extent of biodegradation. The extent of biodegradation of oil from Little Bow increases along channel trends with the most degraded oils in the southern portion of the field and the least degraded oils occurring towards the north.

Oils from Long Coulee have low sulfur contents (< 1.0 wt.%) and API gravity averaging 34 ± 2°. Abundant n-alkanes are observed in the gasoline and saturated hydrocarbon fractions and the saturate fraction gas chromatographs do not indicate elevated baseline. There is very little variation in the isoprenoid to n-alkane ratios for Long Coulee oils (Figure 1). Cody (1993) documented H_2S and CO_2 anomalies in the Long Coulee field, which was attributed to biodegradation of the oil in the Long Coulee field. The geochemical evidence does not support biodegradation of Long Coulee oil and therefore biodegradation of oil due to bacterial sulphate reduction is not the source of the H_2S and CO_2 anomaly.

Conclusions

Biodegradation is a process that adversely affects the quality of oil from Little Bow oil field. Two pulses of oil have accumulated in the Little Bow field, an initial pulse that was subsequently biodegraded, followed by a second pulse of oil. Oil at the Long Coulee field does not appear to be biodegraded.

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