ORGANIC GEOCHEMISTRY OF CHINKEH OIL FROM MAXHAMISH FIELD: IMPLICATIONS FOR GARBUTT SHALE RESOURCES IN LIARD BASIN, CANADA

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Introduction

The Lower Cretaceous Chinkeh Formation of the Liard Basin in NE British Columbia and SW Northwest Territories, Canada is an irregular blanket of sandstone of up to 32 meter thick. Located at depths of 1200 to 1700 meters and spanning over 2000 km^2 in the Maxhamish area, the Chinkeh Formation is overlain by 200 to 250 m of black, silty shale and mudstone of the Cretaceous Garbutt Formation and uncomformably overlies sandstone and shale of the Triassic Toad Formation (Leckie *et al*., 1991). Shale intervals from the lower part of the Garbutt Formation were found to be thermally mature with fair to good hydrocarbon generating potential (Leckie, et al., 1991; Ardakani et al., 2017; Ferri et al., 2017). The underlying Toad Formation was also thought to contain potential source rocks. With 8–15% porosity and adjacent to potential source rocks at favourable levels of maturation, the Chinkeh sandstones were proposed as a frontier-type play in the early 1990's. Exploration in the last two decades resulted in discovery of 300 to 400 Bcf natural gas and 400 to 500 million barrels of light oil in place in the Chinkeh strata at Maxhamish field. Despite its relatively small reserve, the Chinkeh oil from Maxhamish has attracted industrial interest regarding its main source rock(s) and its implications for unconventional hydrocarbon potentials of the Garbutt shale. This study presents preliminary geochemical results and interpretations for the Chinkeh oil and its relationship to the Garbutt shale.

Results

Chinkeh oils from Maxhamish field are characterized by high API gravities (39.2–41.4°) and low sulfur contents of ~0.08%, typical of light sweet oil. Their whole oil gas chromatography (GC) traces are dominated by light to medium *n*-alkanes, with aromatic hydrocarbons being minor components. *n*-Alkanes as heavy as C_{30}-C_{35} are apparently present in the oils and C_{20}^{+} hydrocarbons can account for as much as 10% of the GC-amenable hydrocarbons. The Chinkeh oils have a pristane/phytane (Pr/Ph) ratio of 1.5–1.8.

Gas chromatography-mass spectrometry (GC-MS) analyses show that diasteranes dominate over regular steranes on the m/z 217 mass chromatograms of the Chinkeh oils, and their m/z 191 traces are dominated by tricyclic terpanes (Fig. 1). This suggests both a high level of thermal maturity and a clastic (shaly) lithology of their source rock. This is further supported by their Pr/Ph ratio >1 and dibenzothiophene over phenanthrene ratio of 0.19–0.28 from aromatic GC-MS analysis. C_{30} 4-desmethyl steranes are also detected in the oils, indicating a contribution from marine source rocks.

The Chinkeh oils have a $\alpha\alpha\alpha C_{29}$ sterane 20S/(20S+20R) ratio in the range of 0.56–0.64, having reached the equilibrium of the 20R to 20S isomerization. Maturity parameters based on alkyl naphthalenes and phenanthrenes correspond to an estimated vitrinite reflectance of 0.81–1.0% Ro. Therefore, the Chinkeh oil has been likely sourced from a marine shale interval at its peak to late oil generation window.

On average, the oils have a 34:33:33 of C_{27}-C_{28}-C_{29} sterane distribution. This signature relates the oil accumulation best to the Cretaceous Garbutt shale that directly overlies the Chinkeh sandstone, and provides supporting evidence for earlier studies by Leckie et al. (1991), Ardakani et al. (2017) and Ferri et al. (2017), all of which recognized Garbutt shale as an important regional potential source rock. Despite this, the Chinkeh oil has a very different pattern of tri- and penta-cyclic terpane distribution than that of the Garbutt shales in this study, and therefore there seems to be another source for the Chinkeh oil accumulation at Maxhamish field. Whether potential source rocks in the deeper formations such as the Triassic Toad and the Devonian Muskwa have served as secondary sources needs further investigation.

In conclusion, biomarker signatures of crude oils and potential source rock extracts indicate that the Cretaceous Garbutt Formation shale have contributed to the hydrocarbon accumulations in the underling conventional sandstone reservoirs in the Chinkeh Formation at Maxhamish field. This geochemical evidence not only proves that significant hydrocarbon generation occurred in the Garbutt shale, but also implies that the Garbutt shale can be an important liquids-rich unconventional shale hydrocarbon play where the shale interval is thick and oil expulsion has not been efficient.

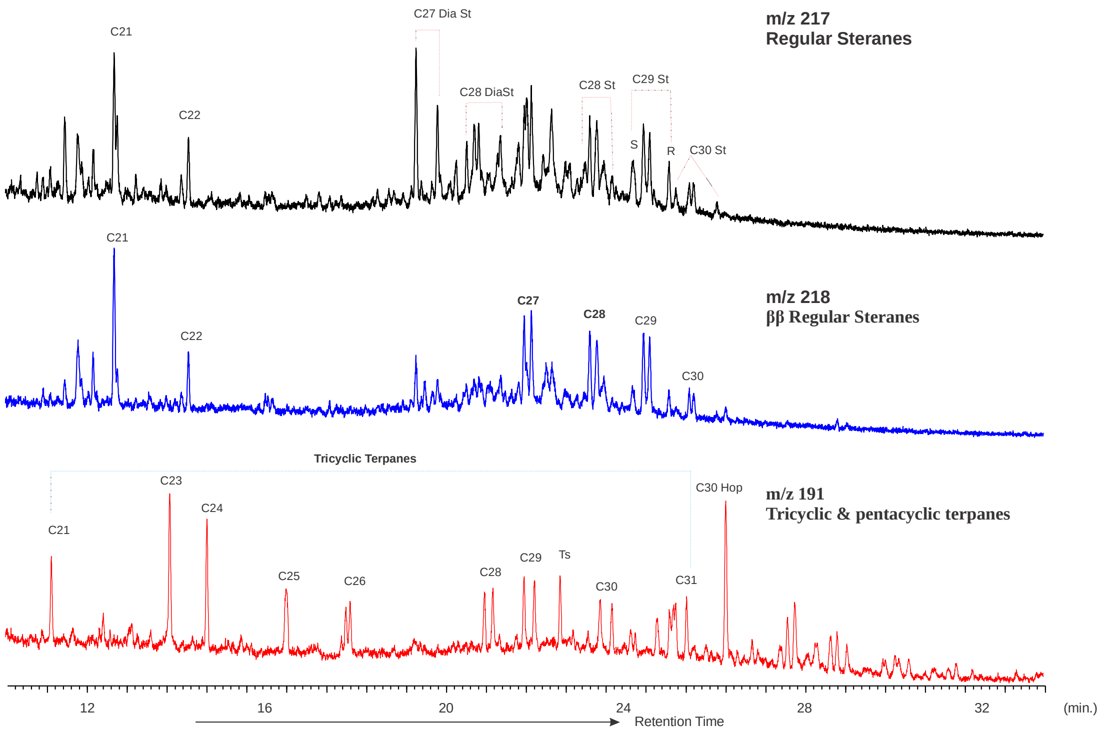

Figure 1 Mass chromatograms of m/z 217, 218 and 191 from GC-MS analysis showing the typical distributions of steranes and terpanes for a light crude oil sample from the Maxhamish field, Liard Basin.

References

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