CHARACTERIZING SOURCE ROCK INTERVALS IN THE SUBSURFACE: AN EXAMPLE FROM OFFSHORE NOVA SCOTIA

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One of the major risks present when entering any underexplored basin is the presence of viable source rocks. In the case of offshore Nova Scotia (as well as larger portions of the north and central Atlantic conjugate margins) this may be considered the highest risk to the success of hydrocarbon exploration efforts. In order to derisk source rock presence, identify potential productive intervals, and properly characterize their depositional environments, detailed stratigraphic and seismic interpretation and organic geochemical analyses were performed on 8 oil selected oils from the Sable Island area.

The geologic evidence compiled from seismic mapping and facies analysis led us to hypothesize the presence of marine source rock facies in the subsurface of Nova Scotia at both Lower and Upper Jurassic levels. We have come to this hypothesis because:

1. Interpretation of seismic data indicates possible carbonate buildups on basement and/or evaporite-cored highs outboard of the modern shelf edge within interpreted lower/middle Jurassic intervals. Marine conditions in deeper-water settings may also provide the depositional environment for source rock deposition within classical north-central Atlantic lower Jurassic intervals associated with source rock (e.g., Sinemurian through Toarcian).
2. High amplitude reflections consistent with the possible occurrence of organic rich mudrocks were identified at both lower and upper Jurassic levels. These reflectors were mapped and observed to blanket the region with amplitude increase and reflector splitting downdip.
3. Decollement of lower and middle Jurassic sediments on high amplitude reflectors provides geomechanical evidence for ductile facies at an interpreted lower Jurassic level. This could be interpreted as the presence of muddy or shaly lithologies occurring at that depth.

Comprehensive organic geochemical analyses were also undertaken to better link oils to source rocks. Eight oil samples from the Sable Island area were analyzed. We interpret the presence of two source rocks having contributed to the hydrocarbon volumes in our sample set. One source rock deposited in the mid to late Jurassic and likely relates to the oil window component of the samples as well as the upper Jurassic reflectors interpreted in seismic. The second source rock may be early Jurassic in age and likely relates to the diamondoid component of the oil fraction.

Organic Geochemical Analyses also provide evidence for Jurassic age source rocks in Nova Scotia. Eight oil samples from the Sable Island area were analyzed. A summary of results includes: 1. Maturity indicators: Diamondoid concentrations (QDA) indicate a wide range of oil cracking has occurred in these oil samples. Low biomarker concentrations together with high diamondoid concentrations suggest that the predominant component of these oils is post-mature, though mixing of a post mature and an oil-window source is also evident. Biomarker maturity analyses indicate that: a) the oil window portion of the biomarkers is below peak oil window maturity, but that b) a higher maturity fluid exists within the oil samples. 2. Source Rock age indicators: All biomarker analyses of age-related components indicate that the most likely age for the oil window fraction of the biomarkers is of Jurassic (probably upper Jurassic) age. We interpret the relatively high diamondoid fraction to be older, but cannot categorically determine the age of that older fraction without direct correlation with source

rocks. 3. Environment of source rock deposition: Biomarker/oil window component: All samples except for sample 8 are mostly terrestrial in biomarker composition, which is to be expected as all samples were recovered from the Sable Island delta complex. Compound specific isotope analysis of biomarkers (CSIA-B) of sample 8 is also indicative of deposition within a stratified water column, while other samples appear to have been deposited within a more mixed water column (Figure 1a). Diamondoid source correlations: The cracked high-diamondoid portion of sample 8 appears to be an end-member of one deep source component; whereas the other seven samples show affinities to a different deep high-diamondoid source (or source facies) with some intermediates as possible mixtures of the two. Distribution patterns of large diamondoid molecules (QEDA) include evidence for interaction with a stratified or evaporative setting. Isotope ratios of diamondoids determined by CSIA of diamondoids (CSIA-D) again show a different isotope ratio for Sample 8 compared to some of the other and evidence of mixtures of both deep source types (Figure 1b). The composite of this evidence would most likely place the diamondoid fraction of sample 8 within the Triassic or early Jurassic, and is further evidence for a second older source rock.

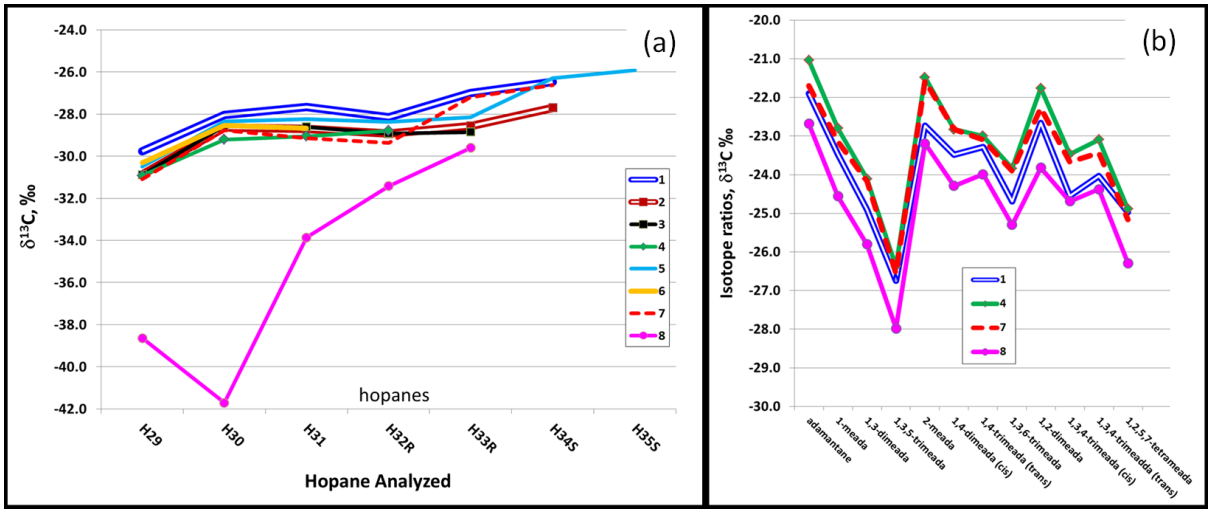

Figure 1. *(a) Isotope values of hopanes by CSIA-B extend to nearly -42 ‰ for Sample 8 suggesting the depositional environment of the oil-window portion of this oil consisted of a stable stratified water with a euxinic bottom layer, compared to an anoxic (still light isotope values to < -30 ‰) for the other samples, that also correlate with each other. (b) CSIA-D shows isotopically lightest diamondoids in Sample 8, and excellent correlation with heavier diamondoids for Samples 4 and 7 and a possible mixture for Sample 1, which supports a two-source scenario for the post-mature contribution to these oils.*