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Geochemical Characterization of a Gas Condensate Accumulation: A Case Study from the Middle East

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Summary

In this study, fluid samples collected from a Cretaceous interval in a Middle East field were characterized. The collected geochemistry data consisted of gas composition, carbon isotopes of hydrocarbon gases by isotope ratio–mass spectrometry (IRMS), and molecular composition of liquid samples by high-resolution gas chromatography (HRGC) and gas chromatography-mass spectrometry (GCMS). The sample set included mud gas, bottomhole, and oil samples collected during circulation at two different depths, as well as separator samples. The various sample types allowed the comparison of fluid compositions collected through different sampling procedures. The results enabled the definition of gas origin, hydrocarbon thermal maturity, and source rock type to support a comprehensive understanding of the gas condensate target accumulation. Reservoir continuity was also assessed using gas and oil geochemical fingerprinting, and the results reveal the presence of a lower-maturity gas that seems to reside in unconnected pores and is only accessible via crushing of the rock by the drill bit. HRGC data suggest connectivity between the lower and upper zones of the target reservoir.

Method / Workflow

The investigated sample set consisted of mud gas samples collected from a 1,500-m thick Cretaceous reservoir interval. The section covers three different units, identified as A, B, and C in Fig. 1 (the displayed stratigraphic column is a schematic, not an accurate representation of the actual sequence). Unit B, an Early Cretaceous tight carbonate, is the main target reservoir, and it is further divided into Lower B and Upper B. Additionally, liquid and gas were flashed from bottomhole samples collected from Upper Unit B, and two pressurized surface samples (separator liquid) were also acquired from Lower Unit B. All mud gas samples were analyzed for gas composition including hydrocarbon compounds from C_1 to C_{6+} and inorganic species CO_2, CO, O_2/Ar, and N_2, while a subset of samples/components were selected for carbon isotopes analysis. The oil samples were fingerprinted by HRGC and GCMS analysis. Quantified components included polyaromatic hydrocarbons and diamondoids.

Results, Observations, Conclusions

The results indicate the presence of a gas of primarily thermogenic origin, sourced by a type II kerogen, with distinctive carbon isotope fingerprints for units B and C (see Fig. 1), showing increasing thermal maturity with depth; while C_1-C_5 gas isotopes do not differ significantly from Upper B mud gas samples. Estimated vitrinite reflectance equivalent (VRE) based on C_2 vs. C_3 carbon isotopes varies in the range 0.9% to 1.8%.

Based on compositional analysis, most samples show characteristics of associated gas, cogenetic to oil/volatile oil and condensate. In contrast, based on isotopic composition of C_2 vs. C_3, the gas is inferred to be associated with volatile oil/condensate up to dry gas or gas from oil cracking. Also, some of the samples show very high concentration of C_2+ components, suggesting

residual oil association, based on wetness and balance values (Haworth et al., 1985). In general, molecular ratios (such as wetness, balance, character, and C_1/C_1+C_2) appear affected by the sampling mechanism and possibly fluid phase behavior, while isotope data do not seem to be impacted. A high thermal maturity fluid is also supported by the concentration diamondoids.
The results suggest that the composition of the Upper B gas corresponds to an earlier, lower-maturity charge that is not a flowing phase, whereas a more mature gas dissolved in the liquid phase, below the gas-oil contact, is produced and released by the formation during pumps off and tripping operations. The result of HRGC fingerprinting further indicate the Lower and Upper B reservoirs correspond to a single hydraulic unit.

References

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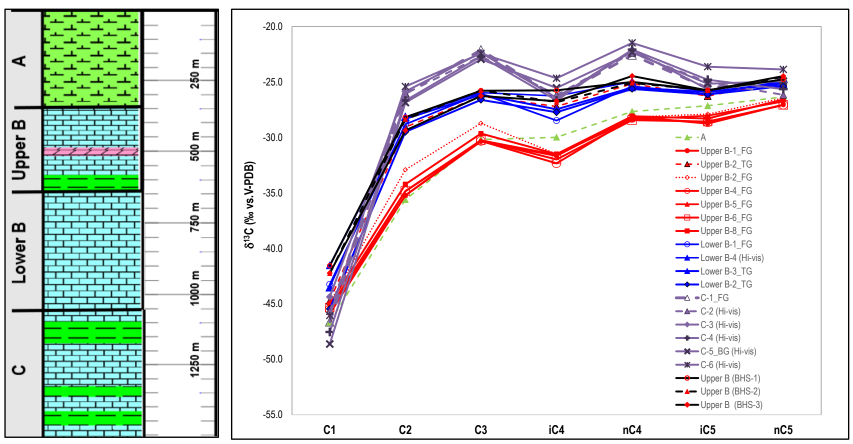

Figure 1: Profiles of $\delta^{13}C$ of C_1-C_5 of all investigated mud gas samples from units A, Lower and Upper B, and C (the stratigraphic column is schematic, not an accurate representation of the reservoir).

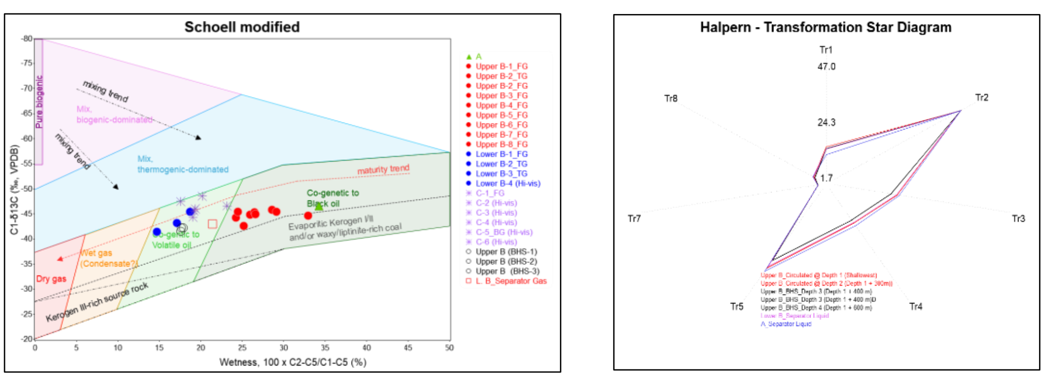

Figure 2: **Left:** Modified Schoell plot showing gas type classification based on $\delta^{13}C$ of methane vs. wetness (modified after Schoell et al., 1983). **Right:** Halpern plot based on C_7 components for the investigated oil samples (after Halpern et al., 1995).