

Geochemical Evaluation Insights on Origin and Thermal Evolution in Type-IIS Source Rock

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Abstract

Source rock assessment, comprising evaluation of kerogen type, richness, and thermal maturity, is an important step in hydrocarbon exploration. Sulfur-enriched marine source rock (Type-IIS) exhibits different thermal maturity patterns from normal Type-II source rock, since sulfur incorporation into the source rock affects the kinetics of oil and gas generation. Conclusions cannot be drawn on the characteristics and thermal maturity of the Type-IIS using thermal evolution models of Type-II source rock. Evaluation of Type-IIS kerogen source rock must be performed on multiple liquid and rock parameters in order to confidently assess the origin and characteristics of this type of source rock. This study provides insight into the gas characteristics and thermal maturity evolution of hydrocarbon gases hosted in excellent Type-IIS kerogen-dominated source rock deposits. Additionally, it assesses the abundance of hydrogen sulfide gas (H_2S) and its relationship to associated hydrocarbon gases. Carbon isotope ratios were measured for individual hydrocarbon compounds from methane (C_1) to pentane (C_5) for 67 gas samples, alongside standard pyrolysis analysis on 47 core samples from source rocks of the same interval. Carbon isotope and gas molar concentration reveal the likely presence of thermogenic and microbial gas mixture. Carbon isotope data from ethane to n-pentane ($\delta^{13}\text{C}_{2-5}$) were plotted against Tmax and HI data to assess the effect of thermal maturity on carbon isotope values. The results reveal a strong positive correlation between Tmax and the carbon isotope of the gases, indicating a constant increase in isotopic values with maturity. This is supported by the inverse correlation between HI and the carbon isotope, where gas coming from a lower HI rock has higher carbon isotope value. Observed negative correlation of H_2S concentration with the carbon isotope of the methane ($\delta^{13}\text{C}_1$) is likely to indicate that the H_2S generation happened during early diagenesis or at lower thermal maturity. Additional geochemical analyses are needed to further assess the different sulfur species with thermal maturity of the source rock. This study gives insights on the evolution pattern of Type-IIS source rock, guiding future hydrocarbon development on this type of source rock.