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Stable Hydrogen and Carbon Isotopic Ratios of Coal-Derived and Oil-Associated Gases: A Case Study in the Tarim Basin, NW China

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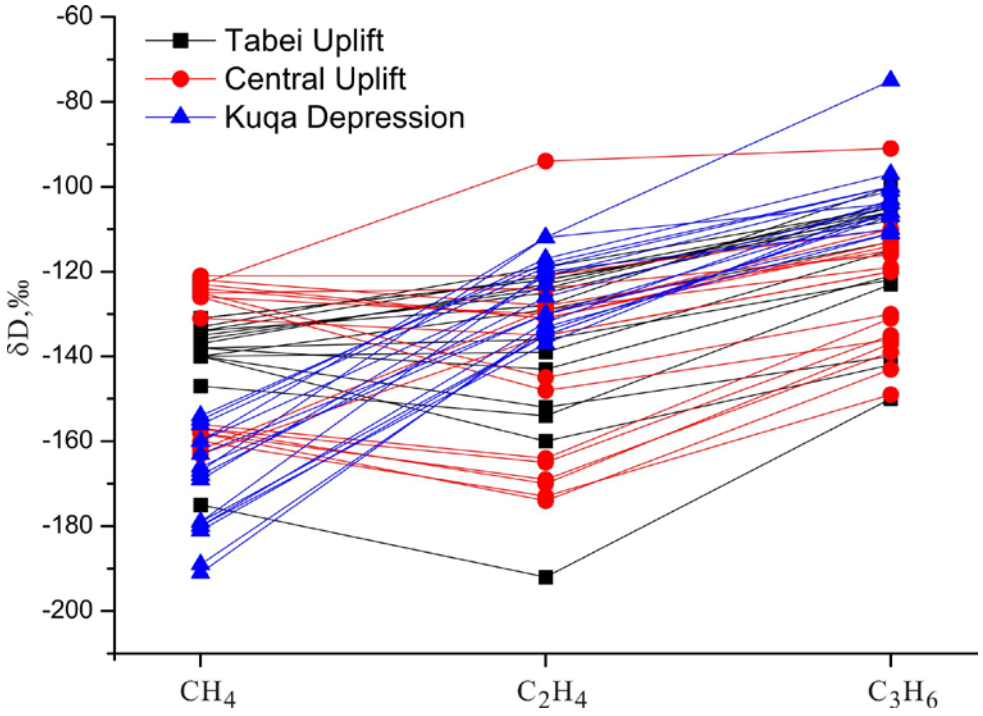
Due to the simple composition of natural gases, stable carbon and hydrogen isotopes have been main tools for geochemists to obtain important genetic information. However, due to the analytical precision, hydrogen isotopic studies on C_2-C_4 hydrocarbons are not as practical as $\delta^{13}C$ in the past several decades. Recent advances in the capability of measuring δD values of individual compounds in complex mixtures have made such analyses more accessible and powerful for use in petroleum and natural gas research. Specific case studies here illustrate the characteristics of stable hydrogen isotopes of coal-derived and oil-associated gases and its use in discrimination of gas origin.

The Tarim basin is located in northwest China with an area of 560,000 km^2. The basin is filled with 16 km sedimentary rocks from Sinian to Quaternary and consists of three uplifts (North uplift, Central uplift and South uplift) and four depressions (Kuqa depression, North depression, Southwest depression and Southeast depression). Main reservoir rocks include Ordovician, Carboniferous and Tertiary rocks and potential source rocks consist of high-overmature Cambrian-Lower Ordovician marine source rocks, middle-high mature Carboniferous-Permian transitional facies source rocks and low-middle mature Triassic-Jurassic terrestrial source rocks. The first two are widespread in the platform basin and are dominant source rocks of the marine oil/gas, while the last one is mainly developed in the forward basin such as Kuqa depression and characterized by type III organic matters. Gas samples are from forward basin, Central Uplift and Tabei Uplift.

According to the geological settings and stable carbon isotopes, especially the $\delta^{13}C_{C2H6}$, gases from the forward basin are determined to be coal-derived gases sourced from the Triassic-Jurassic terrestrial source rocks, while gases from the Central Uplift and Tabei Uplift are oil-associated gases. In contrast to the carbon isotope, stable hydrogen isotope has no distinct difference between coal-derived and oil-associated gases (Figure 1). Coal-derived gases in the forward basin have δD_1 of -154‰ ~ -191‰, δD_2 of -112‰ ~ -137‰, δD_3 of -75‰ ~ -111‰, and oil-associated gases in the Central Uplift and Tabei Uplift have δD_1 of -121‰ ~ -175‰, δD_2

of -94‰ ~ -192‰, δD_3 of -91‰ ~ -150‰. Similar to previous studies, natural gases become more enriched in D with increasing molecular mass ($\delta D_1 < \delta D_2 < \delta D_3$), especially for the coal-derived gases in the forward basin. However, oil-associated gases from the Central Uplift and Tabei Uplift show partial hydrogen isotopic reversal (mainly $\delta D_1 > \delta D_2 < \delta D_3$) among the C_1-C_3 alkanes. A typical partial carbon isotopic reversal ($\delta^{13}C_1 > \delta^{13}C_2 < \delta^{13}C_3$) is also found in the oil-associated gases from the Tabei Uplift, while gases in the Central Uplift generally have normal carbon isotopic distribution pattern ($\delta^{13}C_1 < \delta^{13}C_2 < \delta^{13}C_3$). Combined with geological settings and other geochemical index, it is concluded that oil-associated gases in the Tabei Uplift is a result of mixing, and stable hydrogen isotopes of hydrocarbon gases are controlled by both thermal mature and deposition environment.



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