ABIOGENIC HYDROCARBON ACCUMULATIONS IN THE SONGLIAO BASIN, CHINA

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Introduction

Although abiogenic hydrocarbons (HCs) have been discovered in geofluids in sediment-poor mid-ocean ridges, continental rifts and regions associated with ultramafic and peralkaline igneous rocks, hot springs, fractures and boreholes in the Kidd Creek mine in Precambrian shields, and fluid inclusions in mantle and igneous rocks, they have not been considered a significant source for global hydrocarbon reservoirs. The abiogenic HCs generally include (1) HCs preserved in the mantle since the early accretion of the Earth or may have formed by reduction of CO and CO_2 under mantle conditions, and (2) HCs formed by reduction of carbon dioxide, a process thought to occur during magma cooling and more commonly in hydrothermal systems during water-rock interactions, for example involving Fischer-Tropsch reactions and the serpentinization of ultramafic rocks. Suggestions that abiogenic HCs make a significant contribution to economic reservoirs have been difficult to resolve, as there is uncertainty in the carbon isotopic signatures for abiogenic versus thermogenic HCs and economic reservoirs of abiogenic HCs have not been found or recognized.

Results

In this study, we analyzed the carbon, hydrogen, and helium isotopic ratios of gases in the Xujiaweizi area of the Songliao Basin in NE China. Our isotope data show a clear distinction between abiogenic and thermogenic HCs (Fig. 1). The $\delta^{13}C$ and $\delta^{2}H$ values of HCs in the buried volcanoes and clastic bodies overlying volcanics in the basin display characteristic patterns that are indicative of abiogenic rather than bacterial or thermogenic origin. The progressive carbon isotopic depletion trends for the series of C_1-C_4 n-alkanes indicate HC production by kinetically controlled polymerization of methane precursors related to mantle-derived fluid as indicated by helium isotopes. The mixtures of these HCs with biogenic HCs can also be recognized with this multi-isotope approach. The abiogenic HC reservoirs in the Songliao Basin illustrate the presence of a significant abiogenic source of HCs especially in buried volcanoes in rift basins where there exist pathways and traps for abiogenic HC accumulations.

Conclusions

Multi-isotope analyses of gases in the Songliao Basin show the existence of a significant abiogenic source of HCs in this rift basin. Our results suggest that buried volcanoes and clastic reservoirs overlying volcanics in rift basins can be favorable exploration targets for abiogenic HCs.

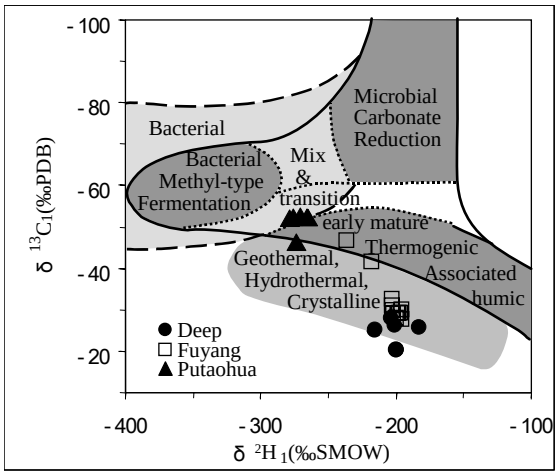

Figure 1. Combination of carbon and hydrogen isotope ratios of methane to characterize the various origins of gas samples from the volcanic reservoirs and clastics overlying volcanics in the deep strata and conglomerate in the Lower Cretaceous Fuyang interval, and sandstone in the Upper Cretaceous Putaohua interval in the Xujiaweizi area of the Songliao basin, China.