ANALYSIS OF ABNORMAL CARBON ISOTOPIC COMPOSITION OF NATURAL GAS IN THE DONGPU SAG, EAST CHINA

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Introduction

The isotopic ratios (C and H in particular) is significant, which has been considered as sensitive tracers for natural gases and hydrocarbon because their isotopic characters contain important information on their generation, migration, and accumulation processes.

In recent years, The author observed a type of abnormal gas which indicates by abnormally heavy carbon isotope ratios in the process of systematically summarizing the genetic type and reservoir forming mechanism of natural gas in the Dongpu sag, east China. The carbon isotope characteristics of heavy hydrocarbons (ethane and propane) are mainly affected by organic precursors, and the humic type is rich in 13C compared with the sapropelic organic matter(Dai, 1993, 2011). Besides, Secondary processes, including thermal alteration, accumulation process (diffusion(Krooss, 1988), migration(Prinzhofer and Huc, 1995) and gas mixing(Burruss and Laughrey, 2010)), microbe-prompted degradation(Pallasser, 2000) and thermochemical sulfate reduction(TSR)(Cai et al., 2005; Liu et al., 2013) could increase carbon isotope values.

This paper comprehensively analyzes the natural gas chemical components, carbon hydrogen and noble gas isotope ratios along with gold tube pyrolytic simulation experiment, geologic setting and previous research results, so as to investigate the gas genetic type and factors controlling abnormal carbon isotope ratios of the heavy alkanes. The analysis above could enhance understanding of hydrocarbon accumulation of Dongpu sag and offer a theoretical basis for further gas exploration and development.

Result

The data set reveals that abnormal stable carbon isotope ratios vary within the following ranges: δ13C(CH4) from -36.9‰ to -24.9‰ with an average of -32.3‰, δ13C2(C2H6) from -20.1‰ to -11.4‰ with an average of -16.2‰, δ13C3(C3H8) from -19.0‰ to -16.0‰ with an average of -17.2‰. The isotope ratios of δ2H-C1(CH4), δ13C-CO2, 3He/4He and 40Ar/36Ar range from -168‰ to -149‰, -16.5‰ and -5.9‰, 1.91×10^-8 to 2.53×10^-7 and 691 to 3270. And the dryness coefficients (C1/C1.5) vary from 0.95 to 0.99, which are typical dry gases. The CO2 content of well wengu2 reaches 30.6%. However, the isotope values of natural gases in the entire Dongpu sag vary within a wide range: δ13C1(CH4) from -48.3‰ to -24.9‰ with an average of -35.8‰, δ13C2(C2H6) from -35.8‰ to -11.4‰ with an average of -25.4‰, δ13C3(C3H8) from -32.6‰ to -15.7‰ with an average of -24.7‰. What is more, in the entire Dongpu Depression, the isotope values of δ2H-C1(CH4), δ13C-CO2, 3He/4He and 40Ar/36Ar range from -253‰ to -149‰, -25.5‰ and -2.4‰, 1.48×10^-8 to 1.12×10^-6 and 279 to 3270, respectively. Obviously, the abnormal stable carbon isotope ratios of ethane and propane are anomalously enriched in 13C, and other parameters also show anomalies. Besides, The δ13C values of this type of gases exhibit a positive sequence carbon isotope pattern (δ13C1 < δ13C2 < δ13C3) apart from the well He3 in the southwest depression and well Liu9-6 in Liuzhuang area.
The well He3 and well Liu9-6 exhibit a partial reversal sequence ($\delta^{13}C_2 > \delta^{13}C_3$). Gold tube pyrolytic simulation experiments demonstrate that stable carbon isotope ratios of ethane and propane display enrichment of $^{13}C$ with EasyRo($\%$). When EasyRo is 2.5%, the stable carbon isotope ratios of ethane can reach -10$\%$ for type III organic matter. Source rock samples used for experiment are collected from Paleogene formation and coal with vitrinite reflectances of 0.5%. A variety of indicators and parameters can be comprehensively investigate the genetic type of this natural gas.

**Conclusion**

Which causes the abnormal carbon isotope ratios of heavy alkanes

This abnormal carbon isotope ratios of heavy alkanes of natural gas vary greatly across the Dongpu sag, in which $\delta^{13}C_2(C_2H_6)$ ranges from -20.1$\%$ to -11.4$\%$, $\delta^{13}C_3(C_3H_8)$ from -19.0$\%$ to -16.0$\%$. And this type of gases are typical dry gases. The cause of anomaly carbon isotope ratios of heavy carbon in the Dongpu sag are slightly different. Anomalies of wells in Liuzhuang area and well He3 in the southwest sag are due to thermal alteration, but the former are located in the uplift and are caused by Paleogene magmatic thermal event, the latter is located in the deep sag belt and is mainly due to the highly deep of burial of C-P source rocks. Baking effect of volcanic rocks widely developed in the upper part of the Paleogene plays a key role of the thermal alteration in Liuzhuang area. The carbon isotopic anomaly of natural gas in well Wengu2 is maybe due to the mixing of organic gas and inorganic gas. Diffusion, migration, microbe-prompted degradation and thermochemical sulfate reduction (TSR) are ruled out. Partial carbon isotope reversal wells may be caused by the mixing of deep coal-type gases which transport to the shallow and the oil-type gases of Paleogene.

**References**


Pallasser, R. J., 2000, Recognising biodegradation in gas/oil accumulations through the $\delta^{13}C$ compositions of gas components: Organic Geochemistry, v. 31, p. 1363-1373.