AAPG HEDBERG CONFERENCE
"NATURAL GAS GEOCHEMISTRY: RECENT DEVELOPMENTS, APPLICATIONS, AND TECHNOLOGIES"
MAY 9-12, 2011 – BEIJING, CHINA

Geochemical Characteristics and Origins of Coalbed Methane in Hancheng, Ordos Basin

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Hancheng coalbed methane field is the second largest coalbed methane field in commercial development of China. There are 404 wells drilled including 114 producing wells, until 2010, and the gas geological reserve is estimated to exceed 86 billion m^3. However, recently, there are few papers to illustrate gas geochemical characteristics and origins of coalbed methane in Hancheng area. The objective of this paper is to conclude the composition geochemical characteristics of coalbed methane, to discuss the gas sources and analyze factors influence the gas generation.

There are totally 78 samples were collected from the center and south of the study area in this paper due to few wells were drilled in north, including well producing gas samples, coal samples, cores, desorption gas from coal samples and drainage water samples. In order to protect the samples from oxidation during transportion, the gas was preserved in steel cylinders, drainage water samples were preserved in plastic container, and coal samples were enclosed by fresh-keeping film. For this study, many parameters, such as CH_4%, C_2H_6%, CO_2% and $\delta^{13}C$ values of methane, were measured.

From the results of sample measurement, methane is the major composition with carbon dioxide and other hydrocarbon gas occurring in lesser amount for Carboniferous-Permian coalbed methane in Hancheng area. Both methane and ethane $\delta^{13}C$ values are less variable, and their values varied from -42.98 to -32.20‰, -21.62 to -9.75‰, respectively. Unexpectedly, ethane $\delta^{13}C$ values are heavier isotopically than the values of generally occurred with the range of -32.90 to -22.80‰. The $\delta^{13}C_1$ values increase with the depth and Ro values increasing. A positive correlation was established between $\delta^{13}C_1$ values and Ro. Carbon isotope values of methane, ethane and propane of a gas, thermally generated from a Type III source rock ($\delta^{13}C_{kerogen}$= –26.0‰) at a maturity of 1.0 to 1.2Ro%, have been determined with the help of the modeling approach proposed by Berner and Faber (1996). The modelled data show that the $\delta^{13}C$ values of methane and ethane range between –30.60 to –29.90‰, and –26.30 to –25.70‰, respectively. In comparison these calculated values with the values of coalbed methane in the study show that methane $\delta^{13}C$ values are much lighter. In general, there are four possible causes can explain the methane $\delta^{13}C$ values isotopically lighter, including biogenic gas mixing, coalbed methane stable isotope fractionation during desorption – diffusion process, the carbon isotope exchange between methane and carbon dioxide and strong hydrologic conditions. Coalbed methane stable isotope fractionation during desorption – diffusion process are be identified the primary reason for isotopically lighter through many analyses in the study. During uplift, isotope fractionation effect could be produced. Heavy hydrocarbon gas is harder to be desorption from coal matrix than methane, and $^{13}CH_4$ harder than $^{12}CH_4$. It caused $\delta^{13}C_1$ values isotopically lighter in preferential desorption gas and heavier in residue methane.

Empirical compositional and isotopic classifications for discerning different origins of natural gases have been applied to coalbed gases in various basins. Many effective diagrams for identifying the gas source were established. The C1/ (C2 + C3) ratio versus the $\delta^{13}C_1$ values of methane compound is taken into consideration (Fig.1). According to this diagram methane from the investigated Shanxi and Taiyuan coal seams are formed, all by a pure thermogenic source. Consequently, associating with the analysis of compositions geochemical characteristics, it demonstrates that, in origin, coalbed methane is secondary thermal cracking gas with the alteration of isotope fractionation effect during desorption – diffusion process.

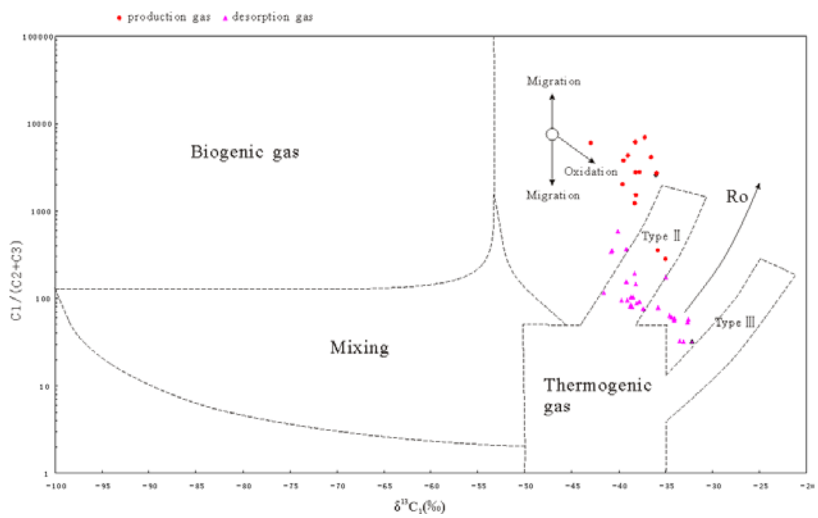

Fig.1 Relationship between C1/ (C2 + C3) ratio and the $\delta^{13}C_1$ values of methane