Geochemical characteristics of the marine/terrestrial shale gas in China

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According to analyses on samples from 53 wells (about 1/8 of current Chinese shale gas wells) of marine facies Wufeng-Longmaxi shale in Sichuan and terrestrial Chang7 shale in Ordos Basin, a geochemical investigation is carried out with the combination of American and Canadian shale gas. The Sichuan shale has TOC of 2.52% and Ro from 2.4% to 3.6%.Its shale gas contains averagely 98.38% CH_4 and is dry gas. It has the shale gas well with the highest CH_4 content in world (99.59%). $\delta^{13}C_1$ is heavy and there is heaviest $\delta^{13}C_1$ (-26.7‰) in the world. $\delta^{13}C_1$, $\delta^{13}C_2$ and $\delta^{13}C_3$ are averaged at -31.3‰, -35.6‰ and -47.2‰, respectively, with $\delta^{13}C_1>\delta^{13}C_2>\delta^{13}C_3$. δ^2H_1 and δ^2H_2 are averaged at -148‰ and -173‰, respectively, with $\delta^2H_1>\delta^2H_2$. Chang 7 shale has TOC of 13.81% and Ro from 0.7% to 1.2%. CH4 accounts for 84.90%, belonging to wet gas. δ13C1, δ13C2 and $\delta^{13}C_3$ are averaged at -48.7‰, -36.4‰ and -31.3‰, respectively, with $\delta^{13}C_1<\delta^{13}C_2<\delta^{13}C_3$. δ^2H_1, δ^2H_2 and δ^2H_3 are averaged at -256‰, -244‰ and -188‰, respectively, with $\delta^2H_1<\delta^2H_2<\delta^2H_3$. The differences of components and isotopes of shales gases in these two basins are due to different maturity. Gases of both basins have low content of CO_2 (<1%). $\delta^{13}C_{CO2}$ of Sichuan varies from 8.9‰ to 9.2‰, indicating of the inorganic origin of cracking of brittle mineral carbonatite under high temperature; $\delta^{13}C_{CO2}$ of Ordos varies from -8.2‰ to -22.7‰, implying the organic origin formed in hydrocarbon generation. R/Ra of both basins ranges from 0.01 to 0.08, indicating of crust origin. Possible causes for carbon isotopic reversal: A.Mixing of alkane gas from the same source but different maturity stage; B.Secondary cracking; C.Special redox reaction with formation water; D. Diffusion; E.High temperature effect which is the main factor. 9 complex charts are compiled based on the gases in Chinese, American and Canadian. The $\delta^{13}C_2$-Wetness plot is in horizontal “S” type evolution. There are two inflection points at Wetness. Inflection point 1.4% is the transition of pyrolysis gas and cracking gas, and inflection point 6% marks the end of oil generation window. In wetness-$\delta^{13}C$ plot, when wetness is 1.6% or even greater, shale gas is dominated by positive carbon isotope series ($\delta^{13}C_1<\delta^{13}C_2<\delta^{13}C_3$); when wetness is less than 1.6%, lots of negative carbon isotope series ($\delta^{13}C_1>\delta^{13}C_2>\delta^{13}C_3$) and partial carbon isotopic reversal appear.