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Effects of Biodegradation on the Carbon Isotopic Compositions of Shallow Gas in
Xinglongtai Field of the Bohai Bay Basin, Eastern China

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To study the geochemical characteristics of gaseous hydrocarbons of the natural gases in the Xinglongtai field of Liaohe Depression, the Bohai Bay Basin, twenty five gas samples were collected and analyzed. The results present here an example of gas biodegradation. The main component of natural gas is methane, in the range of 96.4% to 99.8%. There are only small amounts of ethane and heavier wet hydrocarbon components in the gas, with C_1/C_{1-5} ratios ranging from 0.945 to 0.999 and $C_1/(C_2+C_3)$ ratios ranging from 21 to 831. The carbon isotopic compositions of methane range from -52.4 to -42.4‰, with an average of -45.9‰. The carbon isotopic compositions of ethane, propane, iso-butane and normal butane display significant variability, ranging from -34.8 to -17.4‰, -22 to -7‰, -28.9 to -25.2‰, and -24 to -17.4‰, respectively. Compared with the regular gas, the carbon isotopic compositions of ethane don't change or enriches in ^{13}C slightly (Fig.1). The carbon isotopic compositions of propane and normal butane are generally more enriched in ^{13}C than that of iso-butane (Fig.1). As a consequence, the order of carbon isotopic composition is partially reverse, they are $\delta^{13}C_1 < \delta^{13}C_2 < \delta^{13}C_3 > \delta^{13}C_4$. Propane seems to be selectively attacked during the initial stage of microbial alteration, with abnormally lower content compared to that of butane as well as anomalously heavy carbon isotope.

This study reveals that biodegradation of natural gas can lead to drier gas compositions; the carbon isotopic values of propane and normal butane are preferentially changed by microorganisms; normal butane and pentane are easier attacked by biodegradation than iso-butane and iso-pentane; the carbon isotopic compositions of methane have not been changed basically by biodegradation and those of ethane for some samples are slightly attacked.

As to four gas samples, light hydrocarbon compositions display evidence for microbial alteration. The sequence of hexane isomers vary obviously with high content of 2,3-DMC₄, which indicate that they have been in the fourth level of extensively bacterial alteration. It confirms that the abnormal gas components, carbon isotopic compositions and light hydrocarbons of natural gases of the Xinglongtai Field are the result of biodegradation.

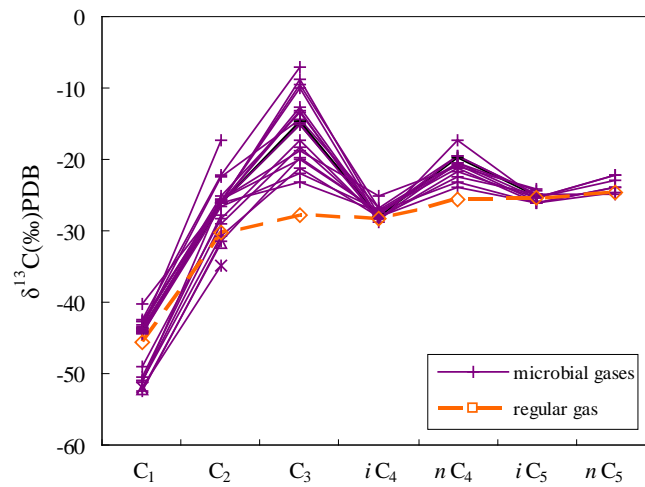


Fig.1 Compound-specific carbon isotopic composition of gas samples in Xinglongtai field displaying enrichment in ^{13}C of $\delta^{13}\text{C}$ values of propane and normal butane as a result of biodegradation and that of a hypothetical regular gas for comparison purpose

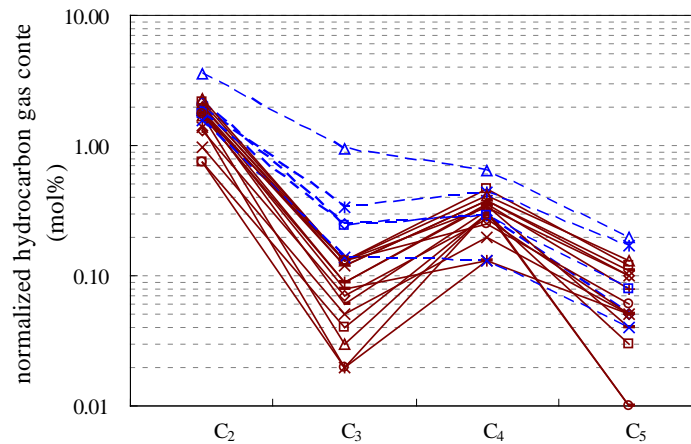


Fig.2 Components of wet gases in the Xinglongtai field: the solid line indicating the extensively altered gases whose propane contents are lower compared with that of butane; the dotted line displaying the less extensively altered gases with unapparent decrease of propane content.