Carbon Isotope Composition as an Indicator to Assess Oil-Cracking and Reforming Gas Contribution to Shale Resource Plays

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Since the large amount of hydrocarbon generated during oil window and condensate window (corresponding vitrinite reflectance of 0.7-1.5%) is expelled from shale, and water from dehydration processes of clay mineral occupies the pore system to a large extent, residual hydrocarbon potential from oil cracking and the unconventional generation mechanism (organic matter water reforming and consequent Fischer-Tropsch-like reactions[1]) make a major contribution to shale gas plays. Due to the high uncertainty of burial history and expulsion efficiency, it is rather difficult to make a straightforward estimation of the present original gas in place (OGIP) with high confidence.

On the other hand, carbon isotope composition is an important indicator for obtaining accurate contributions of gas from different origins, provided that the isotopic composition of these gases can be well distinguished. We investigated the isotope fractionation kinetics of the above reactions and revealed the profound pattern of isotopic composition of the mixing of gas from different origins; an example using carbon isotopes of methane and ethane is illustrated in Figure 1.

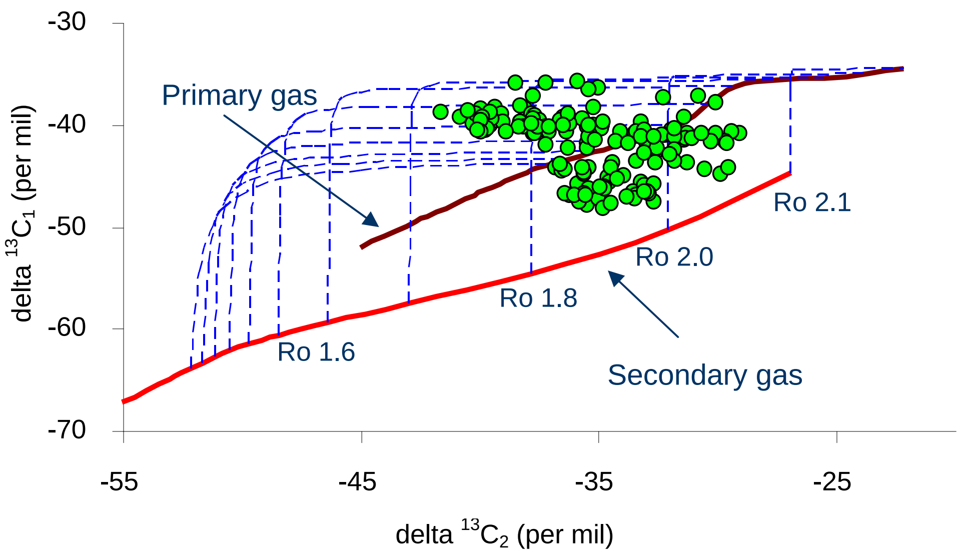

Figure 1: *Determining the contribution of primary gas (from kerogen) and secondary gas (from oil-cracking) in shale using methane and ethane isotope compositions. Solid lines: isotope composition of gases from a Type II kerogen and from oil cracking. Dots: gas sample (data from GeoMark). Dashed line: mixing line with given maturity and different mixing ratio.*

The quantitative analysis on the data of both shale gas productivity and the contribution of different gas sources indicates that shale gas reserves has positive correlation to the contribution of gases from secondary cracking and from organic water-reforming with consequent Fischer-Tropsch-like reactions. Based on this correlation, we established a well-tested method to predict OGIP and productivity, as shown in Figure 2. This well correlation also indicates the beneficial geological conditions for shale gas reserves: 1) high residual hydrocarbon or low residual water after fluid expulsion from the shale; 2) sufficient burial depth and temperature for water-reforming of organic matter.

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[1] Tang, Y. and Xia X., Kinetics and Mechanism of shale Gas Formation: A Quantitative Interpretation of Gas Isotope "Rollover" for Shale Gas Formation, abstract of this conference.

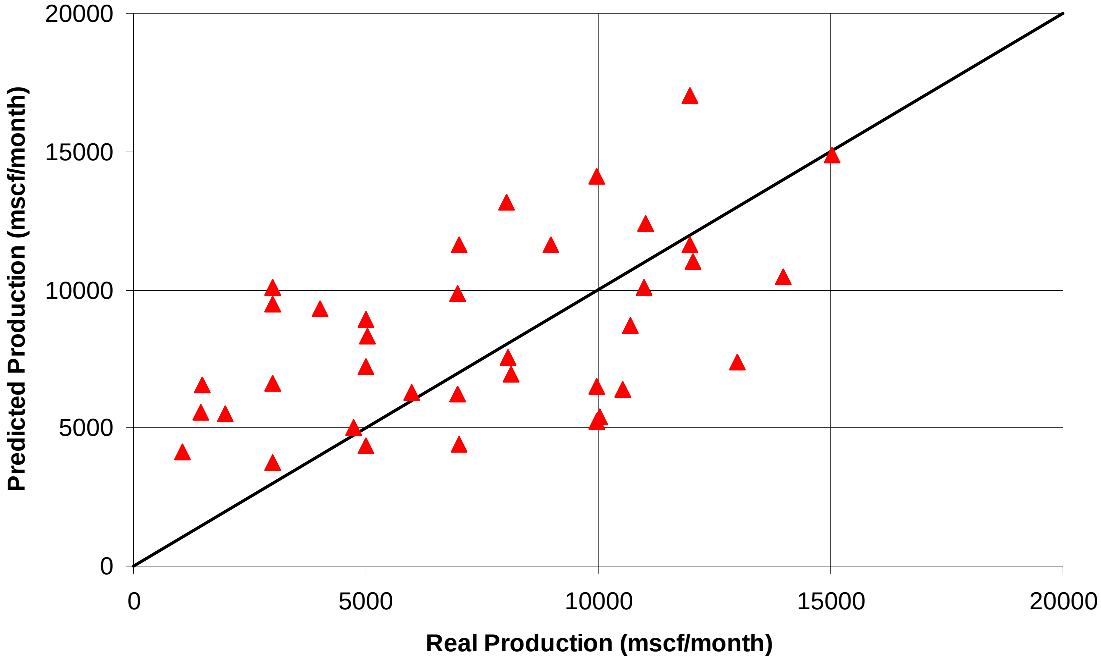

Figure 2: *Comparison between real and predicted production. The prediction is based on the empirical relation between production and the contribution of gas from oil-cracking and Fischer-Tropsh-like reaction.*