

Kinetics for Oil and Gas Composition in Source Rocks: Implications for Unconventional Petroleum Systems

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Abstract

From previous studies, it was demonstrated that kerogen is first decomposed into asphaltenic compounds and a first source of hydrocarbons is observed. At the same time, most of the asphaltenic compounds undergo secondary and contribute for a second source of hydrocarbons. These heavy compounds produce a solid residue and resin compounds, the cracking of which generates third source of hydrocarbons. It is worth noting that the generated asphaltenes are less unstable than the kerogen they originated from. This means that they decompose very rapidly within source rock or during the migration pathway if expelled with hydrocarbons.

After the oil window, the residual mature kerogen (kerogen 2) and the prechar undergo secondary reaction to generate a very dry gas with minor contribution of ethane. We demonstrated that on contrast to oil generation which is organic matter source dependent, the late gas potential is the same whatever the kerogen type with an average potential of 60 – 80 mg/g C. This late gas is always dry with more than 95% of methane. Moreover, this experimental study shows that the same amount of late gas is generated either from an immature kerogen than from a mature kerogen. This means that it is possible to anticipate from immature samples both the volume and gas composition in maturity higher than 1.2 Ro.

After the oil window, compounds which were not expelled undergo secondary cracking reactions to generate gas in maturity higher than 1.2% for Ro. It is observed that in geological conditions, polar compounds such as asphaltenes and resins are first degraded together with a major part of the aromatics leading to a residual fluid enriched in saturates with more than 70% at the end of the oil window. In order to better constrain kinetics of the saturates, specific experiments of thermal cracking were carried out on a pure C14+ saturated fraction. Then, we developed a full compositional kinetic schema for describing the secondary cracking of the polar compounds, saturated and aromatic hydrocarbons. Results show that this heavy fraction is still stable up to Ro at 1.7 and then are converted into light hydrocarbons and wet gas. The light saturated fraction (C5-C14) remains stable up to Ro at 2.5. This means that liquid is largely present within the gas window and dominant gas fraction can be observed only for Ro higher than 2.5.

When this compositional model is coupled to that for primary cracking and late gas generation, it is possible to predict fluid composition after the oil window and during the gas window up to Ro = 3.0. This kinetic model was applied with success to predict the chemical composition of the produced oils in an unconventional petroleum system with wells at different source rocks maturity.