Kinetic Evaluation of the Reactivity and Heterogeneities of the Silurian Source Rock

Pan Luo, Guido Port, Lifang Zhou, Qathami Salman
Saudi Aramco

9.29.2020 - 10.1.2020 – AAPG Annual Convention and Exhibition 2020, Online/Virtual

Abstract

Source-rock kinetics, describing the rate of the conversion of kerogen to petroleum under thermal stress, is an essential characteristic beyond quantity, quality and thermal maturity of organic matter for a source rock. The kinetic parameters, activation energy (Ea) and frequency factor (A), are used as a critical input in basin modeling to quantify the timing and extent of kerogen transformation to hydrocarbon fluids. A Green River Shale standard and a series of Silurian Hot Shale samples with lower thermal maturities (T_{max} ~420 °C) from two wells were pyrolyzed with multiple heating rates in an open system. Bulk kinetic parameters were calculated using a discrete Ea distribution with a common A. The obtained kinetic parameters were deployed in an in-house developed maturation simulator and compared against a standard maturity model (EASY%Ro). Results match those obtained using a commercial simulator. The parameters were then extrapolated in a geological heating rate (1 °C/Ma) to examine the cautions in implementing a kinetic model in basin modeling and to investigate heterogeneities of the Silurian source rock from kinetics points of view. The kinetics study shows that the pairs of Ea and A values, compensating for each other, are strongly affected by the heating rates used in pyrolysis experiments and parameter calculation. The compensation effect results in multiple combinations of Ea and A that satisfy the laboratory transformation, but predicted temperatures and timing deviate appreciably at geological situations. The error induced by the commonly used heating rates (1-50 °C/min) may be as large as 7 °C and 9 °C, respectively, for Green River Shale and the Silurian Hot Shale, at 50% kerogen transformation. It is therefore impossible to compare the reactiveness of kerogens by direct comparison of their Ea and A values. As a consequence, implementing

default kinetic parameters in basin modeling without considering the applied laboratory techniques is not advisable. The kinetic parameters for the Silurian Hot Shale provides a dataset to evaluate vertical and lateral variations of organic matter in the source rock. The predicted temperatures at 50% kerogen conversion, based on the kinetic parameters for different units of a source rock, differ by as much as 20 °C. This variation introduces an uncertainty of 20 Ma in timing of hydrocarbon generation within the thermal history of 1 °C/Ma. Such differences show that considerable errors can be induced into basin modeling by assuming only one set of kinetic parameters from a single sample assumed to represent a heterogeneous source rock, or when applying default kerogen kinetics in modeling software. Measured kinetic parameters for each organofacies and sub-facies are therefore needed to capture the heterogeneities of a source rock, which will improve the prediction of basin modeling and resource assessment.