Evaluation of Kinetic Models for the Smectite to Illite Transformation

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Abstract: Three different models have been reported previously to describe the kinetics of the transformation of smectite to illite (Pytte 1982; Velde and Vasseur 1992; Huang et al. 1993). In order to evaluate the general utility of these models to calculate the timing and extent of this transformation, each model was applied to four different geologic settings (Denver Basin, Gulf Coast, the Salton Sea Geothermal System, and Paris Basin) in which the ages, geothermal gradients and potassium ion activities vary markedly. The model results are compared to the measured percentages of illite in illite/smectite (I/S) and the K/Ar ages of I/S (if available) to test the utility of a given model to a particular basin.

Although individual models can be applied to study this transformation within a specific setting, none of these models was successful in simulating the transformation for all four basins. The Salton Sea was simulated best using the model by Huang et al. (1993), which incorporated an increased geothermal gradient during the last 20,000 years. These results indicate that a large fraction of illite formed due to this increased geothermal gradient, and underscores that temperature is a dominant kinetic factor in forming illite. The Denver Basin was simulated well by the models of Velde and Vasseur (1992) and Pytte (1982). The Gulf Coast was simulated very well by the model of Huang et al. (1993) using a term that terminates the transformation at 75% illite. For the Paris Basin, the results are mixed. The models can be refined by comparing the calculated and measured ages of illite such as the K/Ar ages of I/S to understand the thermal history of a particular basin. The calculated ages of illitization derived from these refined models can be used to indicate the time at which source rocks became thermally mature to form oil and gas.

Key Words: Illite • Kinetics • Models • Smectite

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