A Model for Fibrous Illite Nucleation and Growth in Sandstones

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We have developed a model for the formation of fibrous illite in sandstones based on the kinetics of crystal nucleation and growth which, in turn, are controlled by temperature and supersaturation state. Nucleation occurs on pore walls and micaceous materials are considered to be favorable substrates. Reactants include kaolinite and, optionally, K-feldspar. Particle dimensions are tracked through geologic time as are K-Ar dates and δ^{18}O values. The model is integrated with Touchstone's compaction, quartz cementation, microporosity, and permeability models.

We tested the model on quartzose Jurassic sandstones from offshore Norway and on lithic Miocene sandstones from offshore southeast Asia. Maximum sample temperatures from basin modeling range from 108-172 °C and 154-173 °C, respectively. We assumed Al and K mass balance on the thin section scale with kaolinite and K-feldspar reactants and that the saturation state is controlled by equilibrium with these phases and quartz. The model generally matched measured illite, kaolinite, and K-feldspar abundances in both datasets using identical model parameters other than the temperature histories and the compositions and textures of the host sandstones.

Predicted illite K-Ar dates for the Norway samples are within the published range of ~30-60 Ma for samples in the region with comparable maximum temperatures. Although no illite particle size data are available from the analyzed samples, modeled crystallite thicknesses are comparable to published values of ~40-120 Å from Jurassic North Sea samples with similar temperature histories.
Predicted illite K-Ar dates for the southeast Asia dataset trend with the measured values of 7-14 Ma but are 2-4 m.y. too young. The model results, however, are comparable to the measurements if it is assumed that minor detrital contaminants are present in the analyzed samples. Calculated δ^{18}O values are within 1 of the measured values assuming a constant water value of 4 δ^{18}O SMOW.

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