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Clay minerals as geo-thermometer: A comparative study based on high spatial resolution analyses of illite and chlorite in Gulf Coast sandstones (Texas, U.S.A.)

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Abstract

Phyllosilicates are among the most important stable minerals within the Earth's crust. Their use as geo-thermometer bears great potential for application to the thermal history of rocks within the stability range of layered silicates and was tested here.

A high-resolution analytical technique combining focused ion beam (FIB) milling and analytical electron microscopy (AEM) analysis has been applied to a series of sandstone core samples from the Gulf Coast (Texas, U.S.A.). The nanoscale compositional variations of K-deficient mica and chlorite flakes show that rim compositions are the most likely to approach equilibrium compositions, whereas core compositions may be relict, especially for illite-like phases. These rim analyses were used to test existing empirical or thermodynamically formulated thermo(baro)meters against maximum temperatures, which are perfectly constrained for the selected samples as they were measured in situ during drilling (100–230 °C and 300–1200 bars). The results show that most of the empirical models overestimate the temperature, while thermodynamic models yields reasonable estimates for diagenetic to anchizonal conditions, especially if the Fe^{3+} content is taken into account. This study clearly shows that phyllosilicates thermometry is reliable when combined with an analytical technique giving access to the fine-scale compositional variations that may represent local equilibration, whereas using micrometric compositional analysis precludes trustworthy application of such thermometers.

Keywords: Illite, chlorite, zonation, thermometry, diagenesis, Gulf Coast