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Expandability of anchizonal illite and chlorite: Significance for crystallinity development in the transition from diagenesis to metamorphism

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ABSTRACT

In mixed-layer illite/smectite containing >80% illite, the presence of an expandable component and changes in its abundance are difficult or impossible to detect with the X-ray diffraction (XRD) method using conventional polar interstratification compounds, e.g., solvation with ethylene glycol. Although high-grade diagenetic and very low-grade metamorphic (VLGM) samples do not expand in response to ethylene glycol treatment, the illite crystallinity (IC) improves significantly with increasing diagenetic/metamorphic grade. Improvement of IC in anchizonal to epizonal samples previously was thought to be related primarily to increase in crystallite thickness and decrease in the number of stacking faults. The present study reexamines the contribution of expandable components to IC in shale and slate samples from the Gaspé Peninsula for both the <2 μm and <0.1 μm size fractions in the high-grade diagenetic and VLGM zone. As tools, we have used XRD patterns and high-resolution transmission electron microscopy (HRTEM) lattice-fringe images of samples treated with *n*-alkylammonium cations. These studies reveal the presence of expandable components including R1- and R3-ordered structures and "expandable illite." Expandable 2:1 clay minerals decrease in abundance with increasing metamorphic grade. The improvement of IC with grade is due to the decrease in expandable layers and also to the decrease in the number of lattice defects and an increase in crystallite size. Stacking faults may be the main source of lattice distortion only when phyllosilicates consist of thick non-expandable layer silicates.

During late diagenesis, the chlorites become ordered and are stabilized. They are the dominant phyllosilicate minerals present together with illites in the illite-chlorite facies of the anchizone. Lattice fringe images and XRD patterns document the presence of a short-range, corrensite-like R1 ordered phase and thick chlorite packets.