
Late-Stage Diagenesis of Illitic Clay Minerals as Seen by Decomposition of X-ray Diffraction Patterns: Contrasted Behaviors of Sedimentary Basins with Different Burial Histories

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Abstract: The smectite-to-illite diagenetic transformation has been documented in 5 different sedimentary basins using X-ray diffraction (XRD). Intermediate reaction products coexisting because of the effect of kinetics on this reaction have been characterized using decomposition of XRD patterns and comparison with calculated patterns. The nature and relative abundances of the various subpopulations of particles are shown to vary as a function of the geothermal gradient and of the age of the sediment. In all sedimentary basins that experienced a low steady geothermal gradient the physico-chemical characteristics (coherent scattering domain size [CSDS], junction probabilities) of intermediate mixed-layered illite-smectites (I-S) are similar. However, both the relative abundance and the crystallinity of the end-member illite increase as a function of the age of the sediment.

In basins that have experienced a higher geothermal gradient, the CSDS of the I-S subpopulation is higher for a given illite content, indicating a slightly different reaction pathway. This difference in the characteristics (peak position and width) of elementary peaks may be used to infer the presence of such a high geothermal gradient when no other data are conclusive. In this case the growth of the illite end-member is favored over the growth of intermediate I-S phases even in young basins. Illitic phases formed from the alteration of kaolin minerals exhibit characteristics similar to the reaction products of the smectite-to-illite diagenetic transformation in the case of a high geothermal gradient. In contrast with what is observed in shale diagenesis, the characteristics of the illitic subpopulations describe a continuum with absolutely no gap in between subpopulations. In sandstone reservoirs, the various subpopulations crystallize simultaneously from a kaolin precursor. As a consequence, no kinship is expected between the various subpopulations.

Key Words: Clay Minerals • Decomposition • Diagenesis • Illite • Illite-Smectite • Mixed Layering • X-ray Powder Diffraction

Clays and Clay Minerals; February 1998 v. 46; no. 1; p. 69-78; DOI: [10.1346/CCMN.1998.0460108](https://doi.org/10.1346/CCMN.1998.0460108)

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