TEM textural study of the illite/smectite system evolution in marls from the Basque Cantabrian Basin, Spain: Transition from R0 to R1 diagenetic stages of smectite illitization

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Introduction

A textural study of four marly samples using HRTEM, have been performed to investigate diagenetic evolution of the Upper Cretaceous materials from the Alava Block (Basque Cantabrian Basin). These materials are especially suitable for studies of diagenetic prograde transformations due to the exceptionally thick sequence of sediments (more than 4000 m), homogeneity of lithologies and no major tectonic overprint. The investigations have been focused in the textural and mineral transformations which occur during transition between R0 and R1 diagenetic stages, origin and provenance of the phases. This work complements the XRD and HRTEM previous studies about the evolution of layer-charge characteristics of the expandable component of mixed-layer I/S minerals using the n-alkylammonium method (Arroyo et al., 2006). Conventional XRD methods show for R0 samples smectite (R0 order I/S) coexisting with minor amounts of R1 order I/S, illite, kaolinite and chlorite. R1 samples present R1 order I/S, illite, kaolinite, chlorite and mixed-layer C/S.

Results and Discussion

Specimens have been prepared with L.R. White resin following the procedure of KIM et al. (1995) to avoid complete collapse of smectite-like interlayers in the vacuum. HRTEM images show that marls are composed of large calcite and quartz crystals (≥2μm) with the phyllosilicates distributed randomly throughout the matrix. The absence of discrete smectite, that is the limit between R0 and R1 stages of smectite illitization, is directly related with a microtextural change, characterized by diminution of microporosity, subparallel reorientation of grains and larger phyllosilicate packets. The same clay mineral phases previously identified by XRD studies have been recognized in lattice fringe images. Moreover, HRTEM research has allowed us to distinguish between the various chemical varieties of micas, as illite, muscovite and paragonite. Detrital micas appear in both R0 and R1 samples, presenting most of them evident signs of alteration. Lattice fringe images show in some cases the crystal edges of the altered micas transformed to R1 or R≥3 I/S, indicating a back-reaction process under diagenetic conditions. It can be concluded that ordered mixed-layer illite-smectite can be produced in diagenetic conditions both through prograde reactions from smectite and back-reactions from detrital micas. The simultaneous presence of R0, R1 and R3 I/S at the level of sample is consistent with a process governed by the Ostwald-step-rule, in which the result of the reaction is not a unique stable phase but a mixture of various heterogeneous intermediate metastable phases.

References

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