Preferred Orientation of Phyllosilicates in Gulf Coast Mudstones and Relation to the Smectite-Illite Transition

Ho Nei-Che, Donald R. Peacor and Ben A. van der Pluijm

Department of Geological Sciences, The University of Michigan, 2534 C.C. Little Building, Ann Arbor, Michigan 48109-1063, USA

Abstract: Development of preferred orientations of illite-smectite (I-S) has been studied using X-ray diffraction (XRD) texture goniometry to produce pole figures for clay minerals of a suite of 16 mudstone samples from a core from the Gulf Coast. Samples represent a compaction-loading environment in which the smectite-to-illite (S-I) transition occurs. In five shallow, pre-transition samples, there is no significant preferred orientation for smectite rich I-S. Development of preferred orientation of I-S, although weak, was first detected at depths slightly less than that of the S-I transition. The degree of preferred orientation, which is always bedding-parallel, increases rather abruptly, but continuously, over a narrow interval corresponding to the onset of the S-I transition, then continues to strengthen only slightly with increasing depth. The degree of post-transition preferred orientation is also dependent on lithology, where the preferred orientation is less well-defined for quartz-rich samples.

Previously obtained transmission electron microscope (TEM) data define textures consistent with the change in orientation over many crystallites. The smectite in pre-transition rocks consists largely of anastomosing, “ wavy ” layers with variable orientation and whose mean orientation is parallel to bedding, but which deviate continuously from that orientation. This results in broad, poorly defined peaks in pole figures. Post-transition illite, by contrast, consists of thin, straight packets, with most individual crystallites being parallel or nearly parallel to bedding. This results in pole figures with sharply defined maxima. By analogy with development of slaty cleavage in response to tectonic stress during metamorphism, the S-I transition is marked by dissolution of smectite and neocrystallization of illite or I-S locally within the continuous “ megacrystals ” of smectite. The transition is inferred to have some component of mechanical rotation of coherent illite crystals within a pliant matrix of smectite. The data suggest that change in orientation and coalescence of clay packets plays an important role in the formation of the hydraulic seal required for over-pressure generation.

Key Words: Gulf Coast • Phyllosilicates • Preferred Orientation • Smectite-Illite Transition

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