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CLAY MINERAL PROVENANCE, CLIMATE AND TECTONIC RELATIONSHIPS AS ILLUSTRATED BY THE EARLY TERTIARY OF THE POWDER RIVER BASIN, WYOMING, USA.

J. THOREZ[1], D. BOSSIROY[1], R.M. FLORES[2] and J.N. WEAVER[2]

A detailed XRD analysis of the raw material and of the less than 2 μm clay fraction was undertaken on borehole and outcrop samples of the early Tertiary coal-bearing sequences of the Powder River Basin, Wyoming. Outcrop samples from Cambrian to Cretaceous rocks were also collected along the basin margin specifically to determine their potential rock-source relationship to the investigated Tertiary sequences. The 1900-ft thick borehole and related early Tertiary intervals consist of alternating and thick deposits of conglomerates, sandstones, siltstones, mudstones, shales, coal and paleosols. These deposits in the borehole and associated intervals reveal a transition from alluvial fans along the basin margin (conglomerates, sandstones, siltstones, paleosols) to alluvial plain and raised peat bogs basinward (sandstones, siltstones, shales, coals and paleosols).
The XRD analysis of the raw material was specifically devoted to the quantitative evaluation of quartz, feldspars and total clay content throughout the investigated intervals. The XRD analyses of the less than 2 μm fraction (prepared as oriented aggregates with specific post-treatments that include cationic (Li+, K+) and hydrazine saturation and acid attack permit a clear discrimination between "mimetic" clay minerals (smectites, illite-smectite mixed layers, kaolinites, illites or micas, and other mixed layers). In addition these analyses support a hallmark for the genesis of some clay minerals (i.e. in situ pedogenically neoformed beidellite versus inherited volcanogenic montmorillonite).
Qualitative and quantitative trends in both the whole-rock and clay fraction show that the clay minerals are integrated into a system of superposed coarsening-upward and fining-upward megasequences. The clay minerals in these megasequences clearly reflect, before their deposition in the Powder River Basin, tectonic reactivation of the source area which induced reworking of fresh and weathered Cambrian through Cretaceous rocks.

Paleosols associated with coal-bearing intervals of these megasequences are marked by the occurrence of well-crystallized neoformed kaolinite superposed on the inherited disordered kaolinite. Vertisols are characterized by pedogenic neoformed beidellite or illite-beidellite mixed layers, which are XRD discriminated either from in situ ash falls, and from reworked Cretaceous volcanogenic montmorillonite, or from inherited illite-montmorillonite mixed layer developed after the open illite of the Cambrian rocks. As also shown by their internal and stratigraphic position, vertisols developed under permanently alternating wet-dry conditions. Moreover in these vertisols the vertical amount of swelling in either the beidellite or illite-beidellite mixed layers yields local micropaleoclimatic trends sequentially evolving from dry to alternating dry and wet and finally wetter conditions. On the other hand, the contrasted trends shown by intensity ratios of the basal (001) reflections of: inherited Cretaceous montmorillonite / total illite-mica; total kaolinite / illite-mica; total illite / kaolinite + montmorillonite, coincide with syn-sedimentary events such as the onset and development of the tectonic reactivation of exposed source area consisting of Cambrian to Cretaceous rocks.

This study emphasizes the results of the methodology applied here in clay mineralogy. When utilizing routine XRD for the study of the less than 2 μm fraction (i.e. by referring only to the three "classic "tests": air dried, glycolated and heated states), the clay minerals of these early Tertiary sequences appears rather uniform and restricted to a minimum of four species or groups (illite, smectite, kaolinite, undetermined mixed layers) apart from some changes in their relative abundance. Thus, post-treatments applied to the clay mineral assemblages before XRD analysis reveal a large set of clay components including different smectites and kaolinites, and sensitive changes in provenance, composition, relative abundance and sequential distribution under the control of source area, tectonics and (micro)climate.

[1] Clay Geology Laboratory, Liège, Belgium.
[2] Coal Branch, U.S. Geological Survey, Denver, USA.