Illite-Smectite Alteration and Accompanying Reactions in a Pennsylvanian Underclay Studied by TEM

F. Elsass[1], J. Środoń[2] and M. Robert[1]

[1] Station de Science du Sol INRA, Route de Saint-Cyr, 78000 Versailles, France
[2] Institute of Geological Sciences PAN, Senacka 1, 31-002 Kraków, Poland

Abstract: Pennsylvanian underclay from Illinois is characterized by well-developed mineral zonation: towards the coal bed, marly limestone gradually evolves into carbonate-free clay, chlorite becomes undetectable and illite/smectite changes from ordered and illite-dominated into random and smectite-dominated, with both types present in the middle of the profile. Transmission electron microscopy (TEM) observations of the bulk material imply that disappearance of calcite is due to dissolution. Movement of SiO_2 in the upper part of the profile is evidenced by quartz cementation of clay aggregates; crystallization of kaolinite, by the presence of vermicular aggregates absent from less-altered samples. Illitic material in unaltered (limestone) samples consists of rare, large, Al-rich crystals of mica, interpreted as detrital, and abundant thin crystals of illite/smectite intimately mixed in approximately equal proportions with even thinner crystals of discrete illite. Both are more Mg- and Fe-rich than the large mica crystals and are interpreted as diagenetic, based on their $1M_d$ polytype and the correlation with coal rank. Illitic material of the upper, carbonate-free section of the profile contains the same 3 types of crystals, but in different proportions: illite/smectite crystals dominate and their composition is more smectitic. Two distinct morphologies of the aggregates of crystals with different proportions of the component layers are observed. It explains why 2 different illite/smectites are detectable by X-ray diffraction (XRD) in these samples. The analysis of chemical data suggests that the underclay is a residue after dissolution of all of the calcite and half of the quartz from the original limestone (paleosol and/or telogenetic process). The TEM observations are not decisive regarding the origin of variation within the illitic material. It may result from burial diagenetic illitization of more-smectitic material, similar to the composition preserved in the center of underclay profile, or it may represent telogenetic alteration of illitic clay by acid waters penetrating down from the coal bed. The aggradation model explains the increase in percent K_2O, MgO and illite layers in the uppermost part of the profile. Whichever is the direction of reaction, it proceeds on an aggregate-by-aggregate basis and not fundamental particle-by-particle, and cannot be explained by simple opening or collapse of interlayers.

Key Words: Coal Basin • Diagenesis • HRTEM • Illite/Smectite • Paleosol • Underclay • Weathering

Clays and Clay Minerals; June 1997 v. 45; no. 3; p. 390-403; DOI: 10.1346/CCMN.1997.0450309

Clay Minerals Society (www.clays.org)