

Emplacement Modes of Rare Earth Element Occurrences in Illinois Basin (USA) Coal Seams: are Coal Swamps like Countertop Water Filters?

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Coal seam, coal mine wastes, and coal combustion residuals (CCR) have long been considered a potential source of rare earth elements (REEs) and other critical minerals (CM), one in which interest has recently increased due to the demands of the high technology, national security, and the energy transition. Recent studies and sampling campaigns in the Illinois Basin, located in the North American midcontinent, have made two major findings about REE occurrence in the coal field: (1) REEs generally occur in low concentrations in the coal itself but are (2) comparatively enriched in the coal underburden and overburden. This finding is true for most basinwide coal seams except the lower-Pennsylvanian Colchester coal seam, which shows near parity in REE concentration between the coal and the overburden rock and is also generally enriched when compared to crustal REE abundance.

This study addresses the occurrence of REE in Illinois Basin coals in general, and the Colchester coal in particular. Two hypotheses for REE emplacement are considered: (1) that REE are captured in the coal swamp itself, by adsorption or geochemical means (the “water filter hypothesis”); or (2) that REE deposition is controlled by sedimentary process moving very fine-grained clays and other minerals through the coal swamp environment. Geochemical analysis shows systematic differences between the Colchester and other coal seams, with the Colchester coal and accompanying strata showing mean total REE levels of $\approx 300\text{--}400\text{ppm}$ vs. most basin-wide coal seams hovering near mean crustal abundance in the $\approx 150\text{--}250\text{ppm}$ range. Analysis further suggests that the coal swamp environment does not take an active role in controlling REE disposition, with total REE concentration strongly anticorrelated with total carbon content (Figure 1). These results suggest that the coal swamp environment is incidental to the deposition of REE in their surrounding strata and has only marginal impact on REE fate and transport.

