

Controls on Rare Earth Elements in Abandoned Coal Mine Drainage in the Appalachian Basin, Eastern USA

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To determine coal mine drainage rare earth element (REE) sources and strategic enrichment processes, REE concentrations were measured in abandoned mine discharges and in mine drainage treatment system precipitates within the coal-producing regions of the Appalachian Basin, eastern USA. Water chemistry and REE were determined from 18 separate mine discharges, and compared to different types of treatment precipitates from an additional 21 sites throughout the region. The waters ranged from acidic mine drainage (AMD) to net alkaline mine drainage (NAMD) with a wide range of pH (2.9 to 6.6) and dissolved ion concentrations. Precipitate chemistry is additionally influenced by treatment methods and ranges from relatively pure metal oxy-hydroxides to Ca/Mg-dominated (“lime”) solids.

The REE patterns of most discharges, normalized to the North American Shale Composite (NASC), displayed a characteristic enrichment in the middle REE (MREE), with greater depletion in the light REE than in the heavy REE. Discharges from the Appalachian Basin also show a wide range (factor of 10⁴) in total REE concentrations. There is no clear correlation of REE abundance with water chemistry characteristics. The likely lithologic units that interacted with the mine water (Paleozoic shales and coals) have REE patterns similar in shape and magnitude to NASC [1], and distinct from the mine water. While REE patterns of coal pyrite [2] are somewhat similar to those of mine drainage, average $\Sigma\text{REE}/\text{S}$ in the pyrite is ~10x lower, suggesting non-conservative behavior of S and/or additional REE sources.

Mine drainage treatment precipitates have REE patterns that reflect those of the discharges, with Fe oxy-hydroxide MREE values 0.3–3.3x NASC, and lime slurry MREE 0.2–8.5x NASC. Ongoing work focuses on the factors controlling discharge REE abundances and identifying precipitation processes that could concentrate strategic REE from solution.

[1] Schatzel & Stewart (2003) *Int. J. Coal Geol.* 54, 223-251; [2] Wolfe *et al.* (2016) *Chem. Geol.* doi:10.1016/j.chemgeo. 2016.02.015.