Cation exchange as a control on coal mine drainage geochemistry in the Appalachian region, eastern USA

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Over 170,000 km^2 of the eastern USA Appalachian region is underlain by coal, and its extraction has resulted in >5,000 km of metal- and pH-impaired streams. Coal mine drainage (CMD) in Pennsylvania alone ranges from pH 2.7 with 0 mg/l alkalinity to pH 7.3 with 510 mg/l alkalinity [1]. Two types of underground coal mining produce characteristically different CMD. Up-dip mining (increasing elevation as mining progresses) permits gravity drainage and typically produces low pH CMD due to low retention times and high Eh environments conducive to sulfide oxidation. Down-dip mining results in minepools that act as confined aquifers once pumping ceases. Over years to decades, these minepools typically evolve from low pH to circumneutral with alkalinity because of the flushing of acid weathering products, carbonate dissolution, and sulfate reduction [2].

Alkalinity concentrations in these minepools vary widely and the controlling factors are poorly understood. One possible explanation for high alkalinity is the cation exchange of Ca^{2+} and Mg^{2+} with Na^+ on clays shifting the equilibrium of the system to enhance carbonate dissolution. This is suggested by a positive correlation between Na^+ concentration and alkalinity in CMD [1]. Preliminary experiments suggest that when shale from units adjacent to the Pittsburgh Coal are added to limestone and low pH CMD, up to 60% more alkalinity is generated than with limestone alone. Ongoing experiments with well characterized clays and Pittsburgh Coal overburden and underclay are addressing the magnitude and mechanism of cation exchange enhanced alkalinity generation. Understanding cation exchange controls on minepool geochemistry will help predict minepool evolution and could lead to novel mine drainage treatment technologies.

[1] Cravotta (2008), *Applied Geochem.* 23, 166-202; [2] Perry (2001), *Geochem. Expl. Env. Anal.* 1, 61-70.