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Geochemical Evaluation of Unconventional Materials in the Southern Appalachian Basin for Sustainable Critical Minerals Recovery

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The Department of Energy's CORE-CM Program seeks to identify domestic sources of non-fuel carbon ore, rare earth elements (REE), and other critical minerals (CM), with a focus on unconventional and secondary sources of these materials. The long-term aim of the Program is to establish critical mineral extraction plants and supply chains in the United States that support manufacturing, national defense, and green energy technologies to reduce dependence on international supply chains and to provide jobs and healthier environments to support local communities.

This study targets unconventional and sustainable materials located within, and proximal to, the Southern Appalachian Basin, encompassing much of Alabama and parts of Tennessee and Georgia. To date, a total of 300 samples of coal-associated sediments and waste materials as well as lignite, organic shale, clay, and sandstone have been collected and characterized for chemistry and mineralogy using multiple analytical techniques. Of these materials, ponded coal ash samples collected across 10 CCP management facilities located in Alabama and Georgia had the highest total REE (REE_T) and REE+Y+Sc (REE+) concentrations, with average concentrations of 349.1 ppm and 442.2 ppm, respectively. The highest average lithium concentrations were measured in coal processing waste (224.6 ppm) and coal underclay (217.4 ppm) samples, but coal ash also had comparable average lithium concentrations (202.4 ppm).

Micro-XRF mapping of REEs and other elements has been conducted on the most promising samples to better inform potential extraction strategies. This work indicates that REE in coal ash are primarily associated with phosphate minerals and organic matter, rather than glass. Phosphate phases are also the dominant host of REEs in coal underclay and processing wastes, while REEs in clays are associated with Ca, P, and Zr and likely also with clay adsorption sites.

Utilizing wastes as CM supply chain feedstocks has clear advantages compared to conventional mining of in-situ raw materials. Beneficial reuse of coal wastes would remove these potentially hazardous materials from the environment and has the additional benefit of presenting fewer associated permitting and regulatory issues. The challenge of developing sustainable CM extraction technologies will be a primary goal of the second phase of this study.