Rare Earth Elements in Coal Combustion Byproducts of Saskatchewan: a Geochemical, X-ray Adsorption Spectroscopy, and Machine Learning Investigation

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Rare earth elements (REE) are essential for the global transition to clean energy sources owing to their role in high powered magnets used in technologies such as wind turbines and electric vehicles. Therefore, demand for REE is expected to increase in the coming years, however current North American production is not sufficient to meet this anticipated demand. This lack of domestic production could have significant economic and national security implications and negatively impact our ability to meet climate change goals. Recently, there has been increased interest in extracting REE from secondary sources, such as coal combustion byproducts (CCBs) including fly ash and bottom ash, however their potential as a REE source is dependent on the geochemistry of the particles which must be understood before extraction strategies can be developed.

This contribution investigates REE in CCBs from three power plants which burn lignite coal in southern Saskatchewan to ascertain the variables which affect the potential for REE recovery. Total digestions were performed to determine REE abundances, sequential extractions were used to elucidate the dominant REE host phase, and acid leaches were utilized to quantify the leaching potential of the CCBs. These data were then combined with existing geochemical characterizations of CCBs from across North America and subjected to machine learning algorithms and statistical analyses to determine elemental associations and geochemical indicators of REE enrichment. Finally, the molecular binding environment of REE was determined using X-ray adsorption spectroscopy (XAS). This study is the first step in assessing the potential for REE extraction from CCBs from Saskatchewan, while insights from this study can be applied to CCBs in other localities. Identifying new, environmentally friendly sources of REE is crucial in order to meet climate goals and to secure energy independence.