

Characterization and Recovery of Rare Earths from Coal and By-Products

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Coal is a precious resource, both in the United States and around the world. The United States has a 250-year supply of coal, and generates between 30 - 40% of its electricity through coal combustion. Approximately 1 Gt of coal has been mined annually in the US, although the 2015 total will likely be closer to 900 Mt (<http://www.eia.gov/coal/production/quarterly/>). Most of the coal is burned for power generation, but substantial quantities are also employed in the manufacture of steel, chemicals, and activated carbons. Coal has a positive impact upon many industries, including mining, power, rail transportation, manufacturing, chemical, steel, activated carbon, and fuels. Everything that is in the earth's crust is also present within coal to some extent, and the challenge is always to utilize abundant domestic coal in clean and environmentally friendly manners. In the case of the rare earths, these valuable and extraordinarily useful elements are present within the abundant coal and coal by-products produced domestically and world-wide. These materials include the coals, as well as the combustion by-products such as ashes, coal preparation wastes, gasification slags, and mining by-products. All of these materials can be viewed as potential sources of rare earth elements. Most of the common inorganic lanthanide compounds, such as the phosphates found in coal, have very high melting, boiling, and thermal decomposition temperatures, allowing them to concentrate in combustion and gasification by-products. Furthermore, rare earths have been found in interesting concentrations in the strata above and below certain coal seams.

The National Energy Technology Laboratory (NETL) recently initiated research for the determination and recovery of rare earths from abundant domestic coal by-products. The NETL Rare Earth EDX Database (<https://edx.netl.doe.gov/ree/>) is a resource for rare earth information as related to coal and by-products. Many other research organizations have also initiated efforts for the determination and recovery of rare earths from unconventional sources such as coal by-products.

Much of the recent research on coal utilization in the United States has focused upon the capture of pollutants such as acid gases, particulates, and mercury, and the greenhouse gas carbon dioxide. The possible recovery of rare earth and other critical elements from abundant coal and by-products is an exciting new research area, representing a dramatic paradigm shift for coal. Additional data is needed on the rare earth contents of coals and by-products in order to determine the most promising potential feed materials for extraction processes. Future work will focus on characterization of coals and by-products, and separation/partitioning methods for rare earth recovery.

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Recent Publications

Tran X. Phuoc, Ping Wang, Dustin McIntyre, "Detection of Rare Earth Elements in Powder River Basin Sub-Bituminous Coal Ash Using Laser-Induced Breakdown Spectroscopy (LIBS)", *Fuel*, Volume 163 (129-132), 2016.

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