

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

Evan J. Granite, Elliot Roth, Mary Anne Alvin

United States Department of Energy

National Energy Technology Laboratory

PO Box 10940

Pittsburgh, PA 15236-0940

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.

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

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.

Tran X. Phuoc, Ping Wang, Dustin McIntyre, "Discovering the Feasibility of Using the Radiation Forces for
Recovering Rare Earth Elements from Coal Power Plant By-Products", Advanced Powder Technology, 26
(1465-1472), 2015.

Clinton W Noack, Jinesh C Jain, John Stegmeier, J Alexandra Hakala, Athanasios K Karamalidis, "Rare Earth
Element Geochemistry Of Outcrop And Core Samples From The Marcellus Shale", Geochemical
Transactions (16:6) 2015.

James Hower, Evan Granite, David Mayfield, Ari Lewis, Robert Finkelman, "Notes on Contributions to the
Science of Rare Earth Element Enrichment in Coal and Coal Combustion By-Products", Minerals, accepted
March 2016.