Unlocking The Hidden Value of Coal Wastes: Critical Minerals Recovery and Extraction

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Critical Minerals & Materials from **Unconventional Resources**

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DOE Office of Fossil Energy & Carbon Management

COMMERCIALIZATION

Technology available for wide-scale market use

DEMONSTRATION

System demonstrated in operational environment

SYSTEM TESTING

PRODUCTION

PROCESSING

PROSPECTING

System performance confirmed at pilot-scale

DEVELOPMENT

Technology component validated/integrated

DISCOVERY

Mission — Develop / rebuild U.S. leadership role in the extraction and processing technologies that support an economic, environmentally benign, and geopolitically sustainable production of domestic rare earth elements and critical minerals and materials for use in clean energy and national defense applications

Minerals Sustainability Division Unconventional & Secondary Resource RD&D





Unconventional & Secondary Resource Materials



IMPORTS / DESTINATIONS

Courtesy of Ed Barry, ANL-FECM

Unique Properties & Benefits of Coal-Based Materials

- Higher Heavy Rare Earth Element (HREE)
 Content in Comparison to Conventional
 Resources (Monazite; Bastnaesite)
- Ease of Extraction
 - AMD Physical Beneficiation Is Not Required; Reduced Processing Costs
 - Lignite REE Are Organically Bound
- <u>Abundant Ash Resources</u>
 - Power Generation Fly Ash
 - Legacy Impoundments
- <u>Waste Remediation</u> Active or Abandoned Mines & Land Reclamation with Generation of REE-CMM



Unconventional Feedstocks — Legacy Coal & Ash Materials

U.S. Legacy Coal Waste — 4 Billion Tons Scattered over 1,000 Sites U.S. Legacy Coal Ash — 2 Billion Tons Scattered over 1,300 Sites

| | Average Concentration in Domestic Coal | Quantities in U.S. Legacy Waste Coal (Rough OME) | Estimated Average Concentration in U.S. Coal Ash | Quantities in U.S. Legacy Coal Ash (Rough OME) | Potential Supply in U.S. Legacy Coal Ash at Current Rates of Consumption |
|----|--|--|--|--|---|
| Nd | 9.5 ppm | 38,000 tons | 86 ppm | 172,000 tons | ~40-year supply (Estimate) |
| Dy | 3.39 ppm | 13,600 tons | 31 ppm | 62,000 tons | ~14-year supply (Estimate) |
| Li | 16 ppm | 64,000 tons | 144 ppm | 288,000 tons | 130-year supply |
| Со | 6.1 ppm | 24,400 tons | 55 ppm | 110,000 tons | 15-year supply |
| Ni | 14 ppm | 56,000 tons | 126 ppm | 252,000 tons | 1.1-year supply |
| Ir | 0.002 ppm | 8 tons | 0.02 ppm | 40 tons | 15 -year supply |
| Pt | 0.035 ppm | 140 tons | 0.3 ppm | 600 tons | 15-year supply |
| Ga | 5.1 ppm | 20,400 tons | 10 ppm | 20,000 tons | 1,100-year supply |
| Ge | 7.2 ppm | 28,800 tons | 65 ppm | 130,000 tons | 3,900-year supply |
| | COALQUAL, Finkelman, Lin, Granite | | | | U.S. Geological Survey, 2022, Mineral Commodity Summaries |

Evan Granite, Recovery of Critical Materials from Abundant Domestic Wastes, Byproducts, and Non-Traditional Sources, 48th International Technical Conference on Clean Energy, Clearwater, Florida, June 19, 2024.

Critical Minerals Processing (2014-2023)



Critical Minerals Processing RDD&D (2025-2035/2050)

PROCESSING

U.S. Domestic Self-Reliance

Support Clean Energy, National Defense & Commodity Product Production Next-Gen Technology Advancements

Process Commercialization

Financing, Site Permitting, Infrastructure Supply Chains / Market-Ready Materials Sales & Profits

Stakeholder Participation / Off-Take Agreements

Existing Markets & Supply Chains New Product Development Alloys, Components, Equipment Manufacturing

Advanced Process / System Development

Technology Transfer & Innovation Circuit / System Optimization & Efficiency Improvements Reduced CAPEX / OPEX – AI & ML – Economic Viability Continuous Operation (1,000 hrs) / Operational Repeatability

Process Feedstock Flexibility / Diversification

Resource Sustainability Additional Co-Recovery (C, Li, HREE, Al, etc.) & Value-Added Saleable Products Interagency Collaboration / Goals



Critical Minerals Processing



Courtesy of NETL REE-CM Website

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Learn more about CMM at DOE <u>energy.gov/criticalmaterials</u>

