REE-cycling

Rare Earth Element and Critical Material Recovery from AMD

Eliza Siefert – WVWRI

2.15.24 WVWRI Seminar Series

West Virginia University
WEST VIRGINIA
WATER RESEARCH INSTITUTE

Intros

- Eliza Siefert
  - Critical Materials Water Researcher, WVWRI.
  - Parkersburg, WV native.
  - BS, Environmental Microbiology, WVU.
  - Worked for WVWRI since 2021.
  - Support data analysis, laboratory, and field needs for Waters and Critical Materials projects.

Image Source: Mel Shafer, WVWRI

Other entities involved

- Government Agencies
  - Department of Energy (DOE)
  - Department of Defense (DOD)
  - WV Department of Environmental Protection (WVDEP)
- Academic/Research Partners
  - Virginia Tech (VT)
  - Montana Bureau of Mines and Geology (MBMG)
- Industry Partners
  - Rockwell Automation
  - Solmax Geosynthetics
  - Montana Resources

AMD and REE

- Acid mine drainage (AMD)
  - Pyrite oxidizes to form sulfuric acid.
  - Leached heavy metals.

- There are over 12,000 miles of streams and rivers affected by AMD in the United States.
  - 2,500 stream mi impacted by AMD in WV (WVDEP).

Image Source: Eliza Siefert, WVWRI

AMD and REE

- 17 elements considered rare earth elements (REE).
- Currently, most of world's REE are mined in China.
- WVWRI found that REEs exist in raw coal AMD across 140 separate sites.
  - Cobalt and Nickel found to be in a 1:1 ratio with REE in AMD.

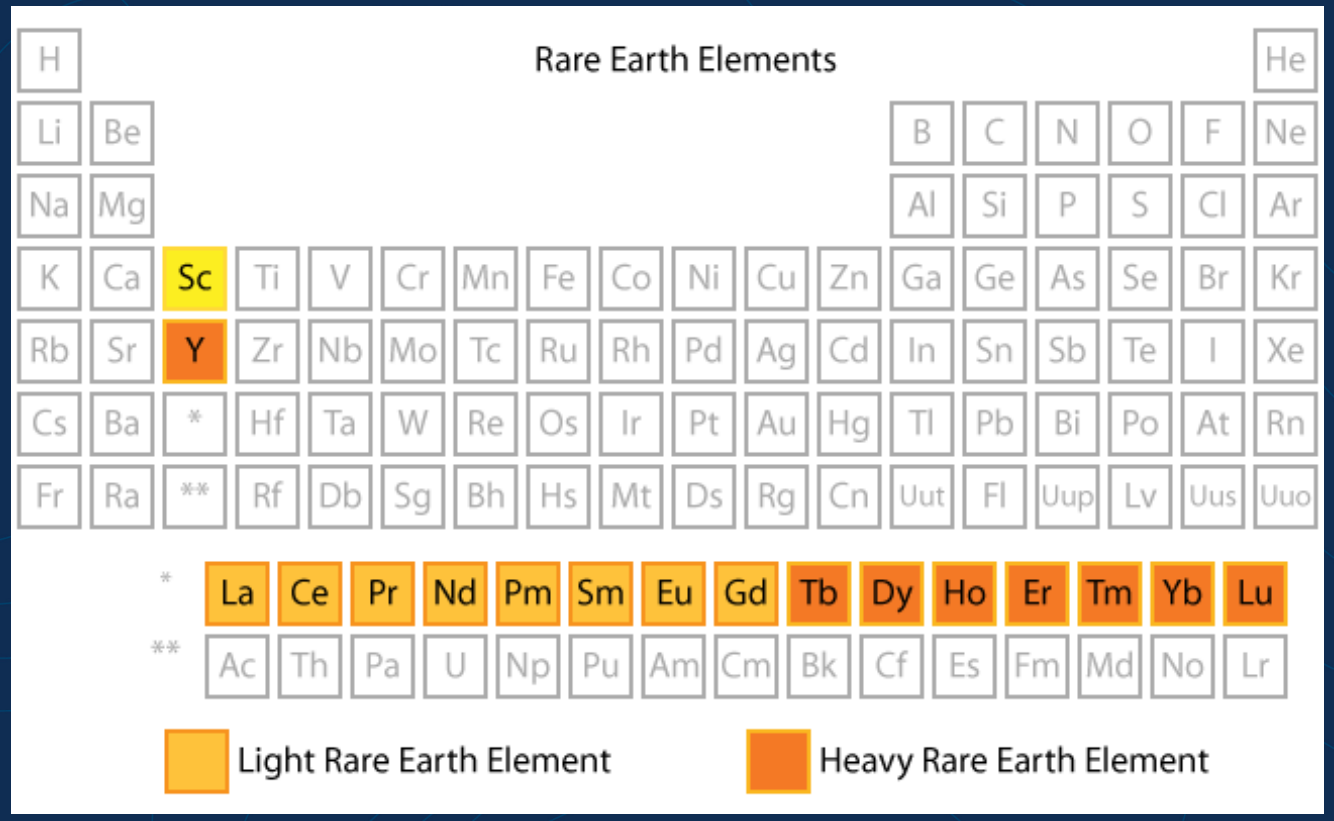

Image Source: sciencenotes.org

Timeline of WVWRI REE

2015

DOE release FOA to find REE in unconventional sources

2017

WVWRI develop two-stage AMD treatment to generate REE feedstock

2018-2020

Bench top pilot system design and testing

2020-Present

REE recovery pilot plant in Mt Storm, WV

- 500 gpm AMD treatment plant; with WVDEP

Evaluation of additional sources

Two Step AMD Treatment

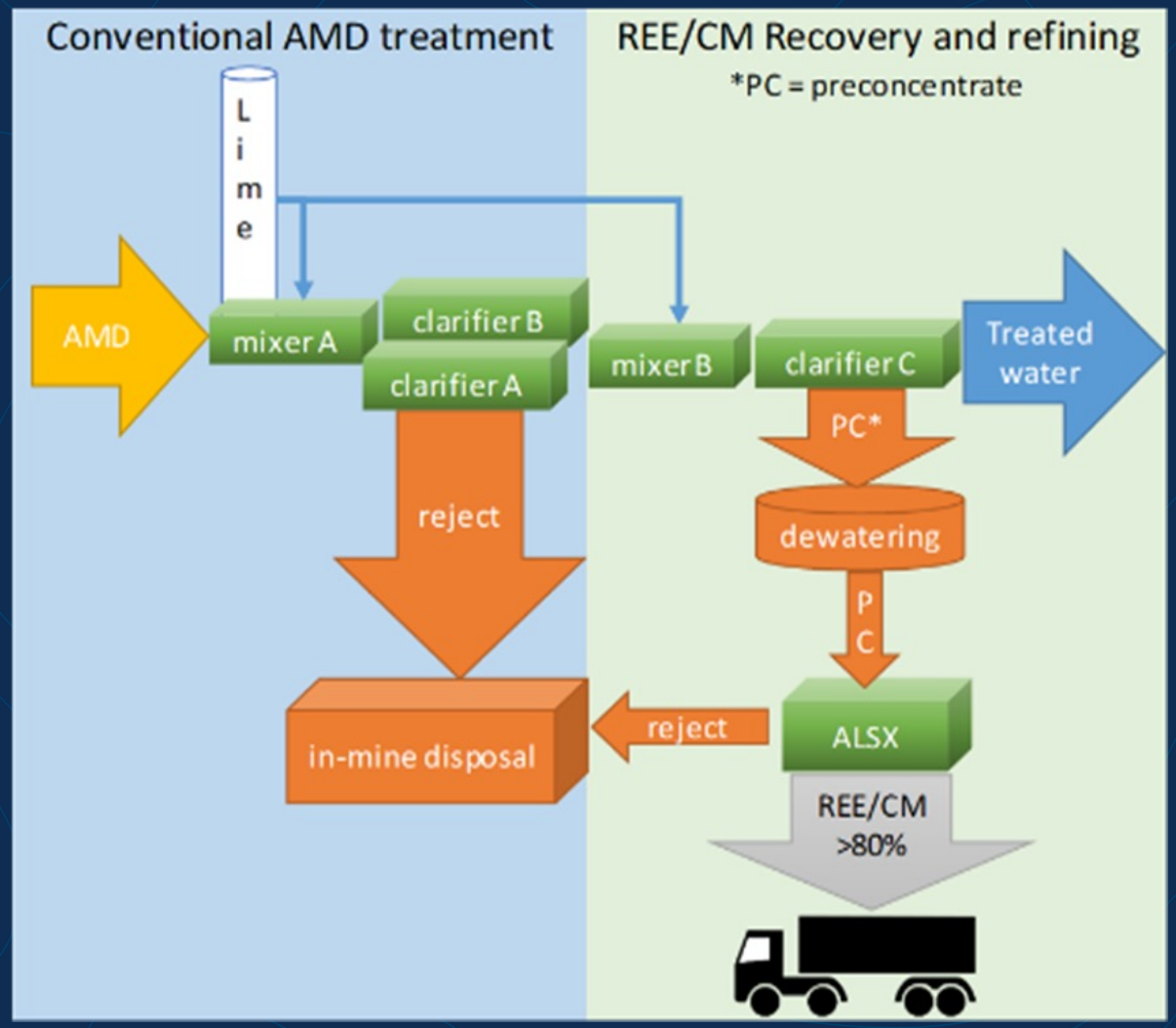

Image Source: WVWRI

- Roughly 1-ton traditional AMD sludge will turn to ½ ton AMD sludge.
  - Other ½ ton is REE feedstock (preconcentrate) for further processing.
- The REE preconcentrate undergoes elemental separation via pH adjustments.

Two Fates of HPC, Same Product

- PC can be processed as a slurry or as a solid.
  - Pump to Geotubes and passively dewatered for storage/transport.
- PC undergoes acid leaching then solvent extraction.
  - Concentrates REEs at each step.
- Solvent is then acid stripped of REEs.
- Gets purified to LREO and HREO.

Image Sources: Nate DePriest, WVWRI

MREO Production – Mt Storm, WV

- Automated system capable of being remotely monitored.
- LREO and HREO currently produced at >90% purity.
- Ability to produce 1.71 t MREO/yr with 500 gpm inflow.

Image Sources: David Hoffman, WVWRI

Current and Future State of Technology

- Final report in DOE review and will be publicly available once review is complete.
- Central Refinery – REE enriched preconcentrate transported to central processing facility.
- Restore AMD impacted watersheds while recovering REE/CM.
    - Utilize money generated to cover plant O+M.

WVWRI REE Program Goals

- Incentivize AMD treatment.
  - Encourage more operators and landowners to treat.
  - Restore watersheds and streams.
- Provide cost savings to reduce operation and maintenance (O&M) costs.
- Create additional jobs for economies dependent on coal.
- Develop an independent Rare Earth Supply Chain in the United States.

Image Source: Caitlin Glascock, WVWRI

REE-covery:
Frequently Asked Questions

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Who gets the benefit of REE recovery from AMD?

- Those who treat get the AMD, get the $$$.
- WV Legislature - HB 4003

Be it enacted by the Legislature of West Virginia:

ARTICLE 2. ABANDONED MINE LANDS AND RECLAMATION ACT.

§22-2-10. Ownership of Substances Derived from Treatment of Acid Mine Drainage.

Treatment of acid mine drainage reduces its environmental harm by reducing metal and acid pollution of receiving streams. Treatment also produces materials that may contain valuable concentrations of rare earth elements and critical materials. Various parties may elect or be compelled to treat acid mine drainage. In order to encourage the treatment of acid mine drainage, the State of West Virginia determines that all chemical compounds, elements, and other materials of value derived from the byproducts of acid mine drainage treatment may, at the discretion of the treating party, be used by the treating party or its designee for its commercial benefit. This condition applies regardless of land or other mineral ownership claims.

The Department of Environmental Protection may promulgate such emergency, interpretive, legislative, and procedural rules as the secretary deems to be useful or necessary to carry out the purpose of this article and to implement the intent of the Legislature.

Image Source: WV Legislature

Is REE recovery environmentally beneficial? Yes

- Goal is clean streams and rivers.
- Process is environmentally benign.
- Upstream process (pre-concentrate production) is the same as conventional AMD treatment.
- Downstream process (REE recovery from pre-concentrate) does not generate hazardous byproducts.
- Only offsite discharge is water treated to NPDES compliance.

Will REE recovery promote additional mining?

- REE is recovered from AMD during treatment.
- REE recovery offsets operation and maintenance (O&M) costs.
- Incentivizes AMD treatment at abandoned mines.
  - cost savings, restoring streams, developing supply chain.
- Main byproduct is clean water.


Image Source: Rachel Spirnak, WVWRI

Looking Forward...

- Identify additional AMD sources for treatment and REE recovery.
- BIL funding for restoring AML sites.
- Watershed-scale restoration.
- REE supply chain.

Image Source: Caitlin Glascock, WVWRI

Questions?

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