Development of a Cost-Effective Extraction Process for the Recovery of Heavy and Critical Rare Earth Elements from the Clays and Shales Associated with Coal

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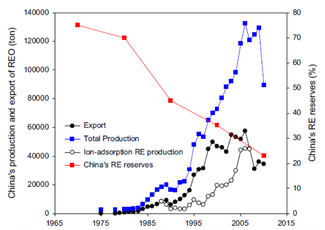
Abstract

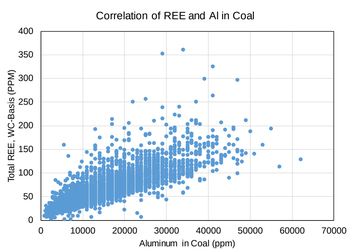
The primary objective of the proposed project is to investigate and develop a novel process technology that can extract and concentrate rare earth elements (REE) from coal refuse material, namely shales and clays using novel leaching and solution purification technologies.

Motivation



Rare Earth production in China (Yan et al., 2013)

- Production forecasts indicate reductions in Chinese REEs due to declining reserve base.
- Around 80% of the world's HREE production comes from Chinese Ion-adsorption clays

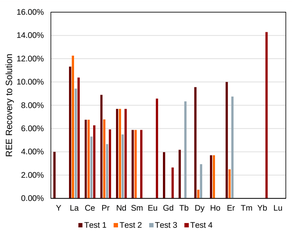


Relationship between REE and aluminum in Eastern US coals (Bryan, 2016)

- Strong correlation between REEs and Al in coal may indicate an association with kaolinite clay

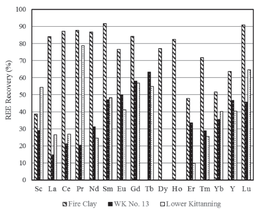
Background Data

1) Typical IX Leaching



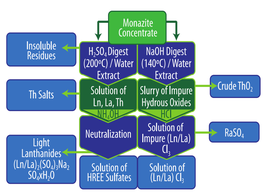
Ammonium Sulfate leaching of coal pond fines

2) Mild Acid Leaching



REE recovery values from acid leaching tests (Honaker et al., 2017)

3) REM Cracking

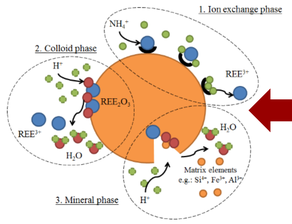


Flowsheet for processing monazite

1) ***Coal refuse typically responds poorly to IX leaching.***
2) ***Some researcher can obtain >70% REE recovery at moderate conditions.***
3) ***REM'S typical require concentrated acid at high temperature to achieve full extraction.***

What is being leached?

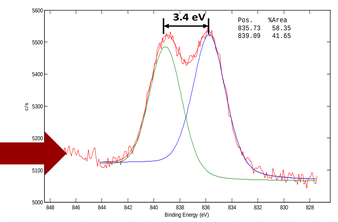
Theoretical Basis



Possible modes of REE speciation (Vobenkaul et al., 2015)

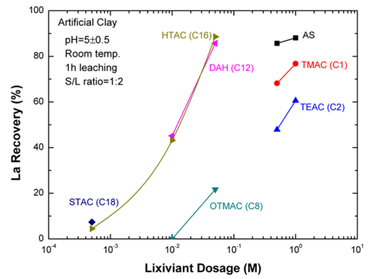
Literature surveys show that a third REE phase, the *colloidal phase*, can be formed in alkaline environments.

Preliminary XPS data also suggests that La(OH)3 is the predominant species on artificially-prepared clay.



XPS spectrum of a La3+ ion adsorbed kaolinite.

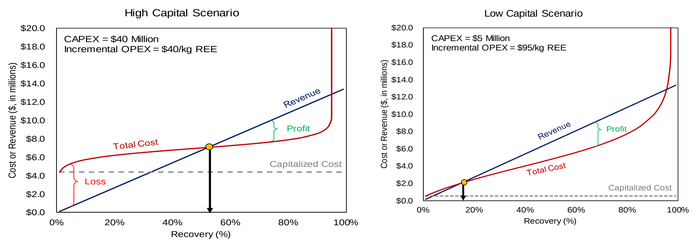
Preliminary Leaching Data



Leaching results for synthetic clay samples spiked with La

Leaching tests from a prior project showed that novel lixiviants can achieve similar overall REE recovery to that of ammonium sulfate (AS) at a fraction of the dosage.

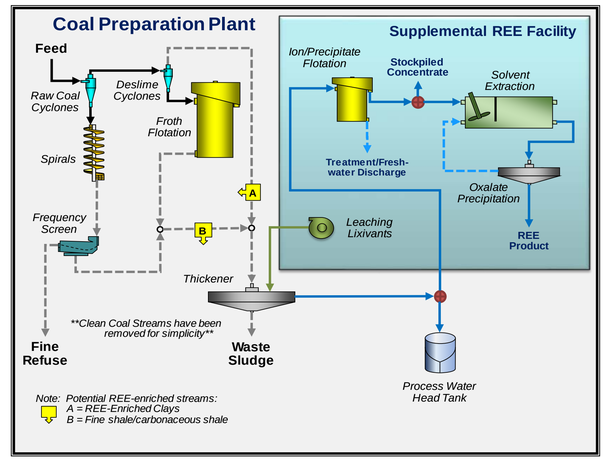
Economic Considerations



Two production scenarios based on hypothetical cost models.

- Given REE price volatility, a high operating cost is more tolerable than a high capital cost.
- Low capital cost will also permit favorable economics at lower process recovery values

Flowsheet Integration



Notional process flowsheet, integrated with existing fine coal process circuit

Design Approach

- Utilize existing process circuitry as much as possible
- Minimize capital costs

Future Objectives

Sample Characterization

- Confirm the presences of colloidal REEs in clays and shales within the US coal measures.

Process Development

- Develop novel lixiviants uniquely tailored to extract heavy and critical REEs from coal resources

Flowsheet Design

- Demonstrate technical and economic feasibility by integrated with existing process circuitry.

Acknowledgement

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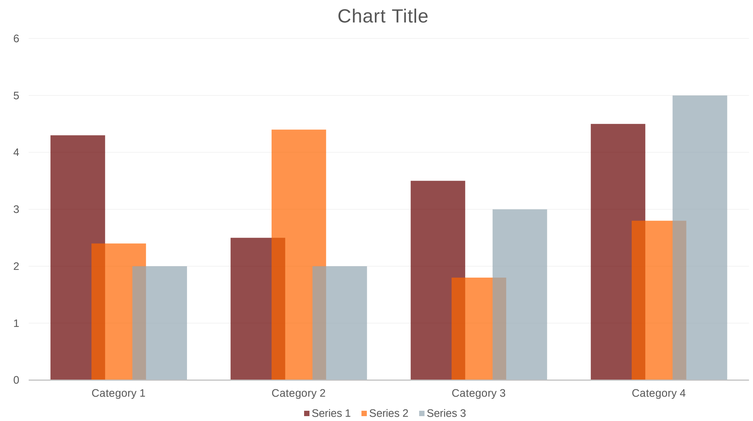
- Type your answer / solution here
- Write hypothesis before you begin the experiment
- This should be your best educated guess based on your research



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Most coals respond poorly to ammonium sulfate leaching

Describe this step in your experiment

Materials (quantities list)	Quantity (be specific)
Item	Amount
Item	Amount
Item	Amount
Item	Amount
Item	Amount
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