**Recovery of Rare Earth Elements from Coal Byproducts using Battelle’s Acid Digestion Process**

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**Rare Earth Elements (REE) Background**

<table>
<thead>
<tr>
<th>Elements</th>
<th>Uses</th>
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</thead>
<tbody>
<tr>
<td>Light Rare Earths</td>
<td>Sc, La, Ce, Pr, Nd, Sm, Eu, Gd</td>
</tr>
<tr>
<td>Heavy Rare Earths</td>
<td>Tb, Dy, Ho, Er, Tm, Yb, Lu, Y</td>
</tr>
<tr>
<td>Batteries, Alloys, Motors, Electronics, Guidance Systems, Communication Systems, Catalysts</td>
<td></td>
</tr>
</tbody>
</table>

**Sampling and Analysis**

**Country** | **2014 Production, tons** | **2015 Production, tons** |
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>United States</td>
<td>5,400</td>
<td>4,100</td>
</tr>
<tr>
<td>Australia</td>
<td>8,000</td>
<td>10,000</td>
</tr>
<tr>
<td>China</td>
<td>105,000</td>
<td>105,000</td>
</tr>
<tr>
<td>Rest of the World</td>
<td>4,600</td>
<td>4,900</td>
</tr>
<tr>
<td>Total</td>
<td>123,000</td>
<td>124,000</td>
</tr>
</tbody>
</table>

Data from USGS Mineral Commodity Summaries 2016

Locations where Coal REE Concentration exceeds 700 ppm

J.M. Ekmann, Rare Earth Elements in Coal Deposits – a Prospectivity Analysis, 26 Nov 2012.

**Project Objectives**

Demonstrate feasibility of Battelle’s closed-loop Acid Digestion Process to extract and concentrate REEs
- Target >2 wt% REE in concentrate

**Technical Approach**

- Makeup acid
- Leach
- Concentration
- Rare earth oxides
- Commercial separation and purification processes
- Acid recovery

**Feasibility Study**

Techno-Economic Assessment to establish path to profitable operation

**Process Design And Next Steps**

Integrated bench scale system design for potential phase 2

**Demonstrated Results**

- Leaching Efficiency by Element
- 518 ppm REE
- Start >90%
- Recovery of Acid

**Acknowledgements**

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