Recovery of Rare Earth Elements from Acid Mine Drainage Using Geotextile Tubes Containment and Dewatering Technology

Tom Stephens
TenCate Geosynthetics
Acid Mine Drainage (AMD) occurs when ground water passes thru a layer of sulfide minerals and becomes acidic forming a low pH sulfuric acid solution. This AMD leaches heavy metals into a solution and oxidizes when coming in contact with air. This acidic water drains from the surface and underground mines into the open environment polluting surface water with ochre, which are red, orange or yellow precipitate sediments.
Results of Acid Mine Drainage

1997 USGS Fact Sheet Reported by WVDEP: 484 Streams totaling 4,563 km (2,852 miles)
Results of Acid Mine Drainage

1997 USGS Fact Sheet Reported by WVDEP: 484 Streams totaling 4,563 km (2,852 miles)
Omega Mine AMD Treatment Plant With Geotextile Tube Dewatering and Containment Opened in 2016

Designed and Operated by West Virginia DEP
Omega Mine AMD Treatment Plant With AMD Source Location

Designed and Operated by West Virginia DEP
AMD Treatment Stages

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### AMD Collection Well

**AMD Incoming Flow**

2018 Average of 16 Data Point Measurements of Each Category

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>Al</th>
<th>Ca</th>
<th>Cl</th>
<th>Fe</th>
<th>Mg</th>
<th>Mn</th>
<th>Na</th>
<th>SO₂</th>
<th>Si</th>
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<td></td>
<td>mg/L</td>
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<td>0.013</td>
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</tbody>
</table>

Paul Ziemkiewicz PhD Director - WVU Water Research Institute
First Stage of Treatment

Equalization Tank
pH Adjusted AMD
Solids Precipitate and Sink To Bottom of Clarifier as a Sludge
AMD Sludge Is Pumped Into Pump House Where Polymer Is Injected and Slurry Is Pumped To Geotextile Tube Dewatering Cell
Automated Controls
Omega Mine AMD
Geotextile Tube Dewatering Cell

160’ x 340’ Geotextile Tube Dewatering Cell
Third Geotextile Tube Layer
Added in 2018
System Operated 24/7
365 Days Per Year
Clear Effluent From Treated and Geotextile Tube Dewatered AMD Returned To Native Stream
### Omega Coal Mine Acid Mine Drainage Treatment Plant and Geotube® Dewatering Operation and Efficiency

- **Incoming Flow Rate** — 200 gpm (46 m³/hr)
- **pH Range** — 2.3 to 2.9
- **Lime Adjustment pH** — 6.5 to 7.0
- **Heavy Metals and Sulphate ppm** — 1,985
- **Allowable Discharge Upper Limit ppm** — 3.73
- **General Operating Discharge** — >1.0
- Since opening in 2016, there have been no discharge violations.

**WV DEP Operations Manager – Mark Dickey**
What are Rare Earth Elements And Why Are They Important?

+99% of World Supply Comes From China
What are Rare Earth Elements And Why Are They Important?

+99% of World Supply Comes From China
Extraction of rare earth elements from acid mine drainage precipitates

Paul Ziemienowicz  
WV Water Research Inst., West Virginia University  
Xinyun Liu  
Mechanical Engineering, West Virginia University  
Aaron Nally  
Mining & Minerals Engineering, Virginia Tech

Sampled locations: 140

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### Results of AMD Analysis

#### Estimated REE production CAPP/NAPP

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Sludge cells sampled, this project</td>
<td>76</td>
</tr>
<tr>
<td>Sludge volume (Dry)</td>
<td>482,915 $m^3$</td>
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<tr>
<td>Sludge mass (Dry)</td>
<td>1,062,413 $tons$ D.W.</td>
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<tr>
<td>average TREE grade</td>
<td>663 $g/t$</td>
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<tr>
<td><strong>TREE mass</strong></td>
<td>350 $tons$</td>
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<tr>
<td>REE Basket Price (MREO)</td>
<td>$237.23 /$kg TREE</td>
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<tr>
<td><strong>estimated CV</strong></td>
<td>$79,633,629$</td>
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#### Estimated annual REE production: Appalachian Basin

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Low</th>
<th>High</th>
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<tbody>
<tr>
<td>AMD production</td>
<td>1,503,371 $gpm$</td>
<td>6,626,156 $gpm$</td>
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<tr>
<td>avg. TREE concentration</td>
<td>0.269 $mg/L$</td>
<td>0.269 $mg/L$</td>
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<tr>
<td>Annual TREE production</td>
<td>807 $tons/year$</td>
<td>3,555 $tons/year$</td>
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<tr>
<td>REE Basket Price (MREO)</td>
<td>$237.23 $/kg$</td>
<td>$237.23 $/kg$</td>
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<tr>
<td><strong>Contained TREE value</strong></td>
<td>$191,362,343 $/yr$</td>
<td>$843,435,793 $/yr$</td>
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</tbody>
</table>
Results of AMD Analysis

WVDEP-Omega AMD treatment site
18 Geotubes in cell: Contained value $808,901

Paul Ziemkiewicz PhD Director - WVU Water Research Institute
Conclusion?

- AMD Can Be Effectively Treated and Contained and Dewatered with Geotextile Tube Technology
- Effluent Water From AMD Treatment and Geotextile Tube Dewatering Can Be Discharged Direct Native Streams
- Rare Earth Elements Are Present In High Concentrations in Dewatered AMD Contained in Geotextile Tubes
- Rare Earth Elements Can Be Economically Recovered From Dewatered Ore Retained Inside Geotextile Tubes