Needs and Opportunities for R&D within the Critical Minerals

American Midwest Regional Workshop on Critical Minerals Sustainability

Kwame Awuah-Offei (kwamea@mst.edu)
Thomas J. O’Keefe Institute for Sustainable Supply of Strategic Minerals

• Combining existing excellence across the supply chain at Missouri S&T
• Basic and applied research to develop technology, methodologies and tools that facilitate sustainable supply of strategic minerals for United States
• Science-based policy work on strategic minerals
• Workforce development and international capacity building

mining.mst.edu/research/okeefe-institute/
2017 USGS Critical Minerals List

**Energy Minerals**
Li, Co, Ni, Mn

**Electronics**
Ga, As, In, REE

**Solar**
Te, Si

**Wind**
REE, Co, Sc

**Infrastructure**
Cu, Fe, Al, Ag, Au
Raw Materials Supply – REEs, Co, In, Ga

- REEs are mined and processed as a primary target
- Co is a by-product from Ni concentrate and Cu ore processing
- In is primarily a by-product from Zn production (not mining)
- Ga is a primarily by-product from alumina production (not mining)

Data from USGS Mineral Commodity Summaries
### USA Situation of REEs, Co, In, Ga Supply

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Deposits</th>
<th>Mines</th>
<th>Processing</th>
<th>Refining</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>REEs</td>
<td>Yes</td>
<td>One</td>
<td>Limited</td>
<td>None</td>
<td>Limited</td>
</tr>
<tr>
<td>Co</td>
<td>Multi-metal deposits</td>
<td>One</td>
<td>Limited</td>
<td>None</td>
<td>Soon</td>
</tr>
<tr>
<td>In</td>
<td>Some Zn deposits</td>
<td>None</td>
<td>None</td>
<td>No ITO</td>
<td>Limited</td>
</tr>
<tr>
<td>Ga</td>
<td>Some Zn deposits</td>
<td>None</td>
<td>None</td>
<td>High purity Ga, Not GaAs</td>
<td>Limited</td>
</tr>
</tbody>
</table>
Closing Domestic Supply Chain Gaps

- Support mineral exploration to uncover new deposits
- Streamline mine permitting process
- Develop processing and refining infrastructure and innovation
- Facilitate off-take agreements between domestic “mining” and “green energy” companies
- Educate workforce needed for critical minerals supply and green energy transition
- Ensure sustainable extraction and processing
R&D Needs

• Support mineral exploration to uncover new deposits
  – Re-characterize existing core samples for CMs
  – Improve understanding of geologic framework
  – Develop improved ore genesis models
• Innovation in processing and refining
  – Understand deportment of CMs throughout base metal supply chain
  – Develop new flowsheet to treat low grade multi-metal feeds
• Support sustainable extraction and processing
  – Improve understanding of impacts (and risks) of tailings and other waste streams
  – Develop better reclamation techniques to facilitate sustainable post-mining land use
  – Develop technology to improve renewable energy use in mining
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https://criticalminerals.mst.edu/