Tobias C. Kampmann
Luleå University of Technology

Sustainability Assessment:
Data concerns of geoscientists

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation
Structure of this talk

• Part 1: LCA for European copper mining. Experience and issues with LCI data collection.
  - SUPRIM LCI case studies
  - System description and boundaries
  - Data sources and collection approach
  - Issues along the way

• Part 2: Geological uniqueness of ore deposits and implications for LCA results.
  - Every mine exhibits a unique and complex geology
  - Geological character steers the entire mining process, incl. environmental flows
  - Simplifications (e.g. ”black box” thinking) will result in questionable LCA results and interpretations
Part 1: Experience and issues with LCI data collection

Two case studies:

Aitik, Sweden (Boliden Mineral)

Cobre las Cruces, Spain (First Quantum Minerals)

Source: Boliden Mineral AB

Source: Cobre las Cruces S.A.

Supported by:

www.suprim.eitrawmaterials.eu
Two case studies:

- Aitik, Sweden
- Cobre las Cruces, Spain
Approach:

Product (functional unit): 1 kg copper cathode

Cradle-to-gate approach
Aitik process: System boundary

Aitik mine

- Drilling, charging and blasting
- Conveying and ore storage
- Ore crushing
- Deposition of waste rock

Aitik concentrator

- Milling
- Floation
- Deposition of the tailings

410 km railway transport

Rönnskär smelter

- Roasting
- Flash smelting
- Electric smelting
- Conversion
- Water treatment
- Sulphur dioxide and sulphuric acid production
- Anode casting
- Copper refinement

Product: Copper cathode

Source: Boliden Mineral AB

Mixing at smelter: Issues with traceability...

Supported by:
www.suprim.eitrawmaterials.eu
Cobre las Cruces process

Source: Cobre las Cruces S.A.
Cobre las Cruces process: System boundary

Source: Cobre las Cruces S.A.

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

www.suprim.eitrawmaterials.eu
## Input data: Source categories

### Aitik case study:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Data available in environmental report (year 2015) for Aitik or in similar data compilations provided by the environmental division.</td>
</tr>
<tr>
<td>2</td>
<td>Data available in environmental report (year 2015) for the Rönnskär smelter or in similar data compilations provided by the environmental division.</td>
</tr>
<tr>
<td>3</td>
<td>Energy audit (year 2015) for the Rönnskär smelter or directly provided by staff</td>
</tr>
<tr>
<td>4</td>
<td>Data provided by Boliden Commercial, which forms part of the Boliden Mineral concern.</td>
</tr>
<tr>
<td>5</td>
<td>Average data estimated on Bibliography or recorded assumptions.</td>
</tr>
</tbody>
</table>

### Cobre las Cruces case study:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Data provided by Environment Department of CLC. Specific data based on measures.</td>
</tr>
<tr>
<td>2</td>
<td>Data provided by Environment Department of CLC. Specific data estimated by specific calculations.</td>
</tr>
<tr>
<td>3</td>
<td>Average data estimated on Bibliography or recorded assumptions.</td>
</tr>
</tbody>
</table>
Approach to data collection

• One contact person in each company to provide data

• Aitik data collected by LTU and GU; Cobre las Cruces data collected by Tecnalia

• Iterative refinement of the datasets in discussions between data collectors/LCA experts and mining companies

• Discussions between the two case studies to have a common data structure
Impact assessment

Contribution of the different elements of the system to the environmental impacts of copper production in the Aitik case study. Abbreviations: M&C = Mine and concentrator.

Supported by:
www.suprim.eitrawmaterials.eu
Issues along the way

Dust: Peripheral measurement stations, no source data (machines, blasting etc.)

Source: Boliden Mineral AB

Supported by:

www.suprim.eitrawmaterials.eu
Issues along the way

Lack of reliable upstream data

Example Blasting

• LCI data on explosive production may be hard to retrieve from the supplier
• Background datasets from LCIA software are too general and not representative for the specific case

• Our solution: Sensitivity analysis incl. different scenarios

Aitik case: 500 ton explosives / week

Source: Boliden Mineral AB

www.suprim.eitrawmaterials.eu
Issues along the way

Complex data collection within the mining companies

- Data collection may involve many departments (or sites) and staff resources
- Collection will take more time and working hours than initially estimated
- Full commitment from all involved partners incl. management is necessary
- Helpful to set up clear communication guidelines and structure early in the project
Part 2: Geological uniqueness of ore deposits and implications for LCA results

Exploration is the basis for any mineral discovery and subsequent mining activity
Economic ore deposits are formed by exceptional processes enriching metals in rocks.

### Part 2: Geological uniqueness of ore deposits and implications for LCA results

<table>
<thead>
<tr>
<th>Metal</th>
<th>Concentration in the crust</th>
<th>Grade in ores</th>
<th>Enrichment factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe (iron)</td>
<td>4 %</td>
<td>50 %</td>
<td>10</td>
</tr>
<tr>
<td>Al (aluminium)</td>
<td>8 %</td>
<td>30 %</td>
<td>3-4</td>
</tr>
<tr>
<td>Cu (copper)</td>
<td>28 ppm</td>
<td>0.6 %</td>
<td>200</td>
</tr>
<tr>
<td>Nd (neodymium)</td>
<td>27 ppm</td>
<td>1 %</td>
<td>300</td>
</tr>
<tr>
<td>Au (gold)</td>
<td>1.5 ppb</td>
<td>6 ppm</td>
<td>4 000</td>
</tr>
<tr>
<td>Pt (platinum)</td>
<td>0.5 ppb</td>
<td>5 ppm</td>
<td>10 000</td>
</tr>
</tbody>
</table>
Exploration and geological data

- Exploration success rates are very low
- Typically <<1% of projects will lead to mine development (Bell, 2012)
- Exploration projects are relatively high-risk financial investments

- Why is this? Lack of robust subsurface data...
- Conclusion: We have to take what we find and where we find it, and we are lucky if we find anything...
- We don’t have enough new discoveries to meet expected future demand (Schodde, 2017).
Aitik, Sweden: 1 200 Mton @ 0.2 % Cu

Cobre las Cruces, Spain: 6 Mton @ 5.0 % Cu

Add complexity…
…and provide the more detailed geological perspective
Aitik, Sweden: 1 200 Mton @ 0.2 % Cu

Porphyry Copper deposit

www.suprim.eitrawmaterials.eu
Cobre las Cruces, Spain:
6 Mton @ 5.0 % Cu

Volcanogenic massive sulphide deposit
Comparing three base metal deposits

**Deposit 1:**
Gold in arsenopyrite

- Similar grade and tonnage
- Process optimized for base metals (Zn, Pb, Cu)
- Process needs to be changed to avoid gold going to waste

**Deposit 2:**
Gold in silicates

**Deposit 3:**
Gold in pyrite

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation.
Comparing three base metal deposits

- Same type of ore deposit (volcanogenic massive sulphide)
- Similar mineralogy
- Similar gold grades
- Different gold textures

Requires different approaches in the mineral processing of these ores, with implications on environmental footprint and sustainability.

Mining and mineral processing needs to be adjusted for each individual deposit, even at similar grades and tonnages.
Complex differences in geology lead to differences in mining, mineral processing, metallurgy etc., with implications for environmental footprint. Makes "black box" comparisons very difficult.
Conclusions

- LCI data collection faced issues with background data, data structure, traceability and communication between industry and practitioners.

- With low exploration success rates it is not possible to pick and choose where to place a mining operation, e.g. based on sustainability considerations. Big difference to other industrial sectors?

- Geology steers where in the world a mine is situated and the mining process.

- Complexities in the geology of an ore deposit may have a large impact on the sustainability assessment of the mine.

- Close consultation between LCA practitioners and experts in geology and mining is recommended when conducting LCA in mining.