Mine waste and site characterisation research at the University of Miskolc, Hungary

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Faculty of Earth Sciences and Engineering, University of Miskolc, Hungary
The only one institution in Hungary for higher education in:
- Mining engineering
- Petroleum engineering
- Mineral processing
- Hydrogeological engineering
- Geo-environmental engineering and risk assessment

Engineering Solutions for a Sustainable Planet
Relevant research projects

- Primary rock geochemistry and AMD effects in the abandoned mines of carbonate-hosted sulphide mineralization in Rudabánya (NE Hungary) and Asturias (Northern Spain)
- ARD characterisation of siderite-hosted base metal deposit Rudabánya
- Kinetic testing and mineralogical characteristics of sulphide mine wastes from the Oruro deposit (Bolivia)
- TAILSAFE: Sustainable Improvement in Safety of Tailings Facilities
- PEREBar: Long-term Performance of Permeable Reactive Barriers used for the Remediation of Contaminated Groundwater
- InSUPeRB: Innovative solutions in using permeable reactive barriers
Primary rock geochemistry and AMD effects in the abandoned mines of carbonate-hosted sulphide mineralization in Rudabánya and Asturias

- Spanish-Hungarian Bilateral research 2010 - 2011
- Partners: University of Miskolc, Universidad de Oviedo
- Sites: Rudabánya, Hungary - Asturias, Spain
- To develop geochemical and hydrogeological models of the basins where the abandoned mine operations are located
- To study the possibility to avoid the pollution associated to acidic mine effluents and acidic mine waste heap leachates.
- To design a new exploration model to know the economic suitability of these ore deposits
ARD-screening of site rocks from the Rudabánya base metal mineralization (NE-Hungary)

• Check the acid generating potential of 7 sulphide-rich site rock type samples

• Hosting carbonate minerals have significant iron-content

• Check the applicability of the currently formulating European standard on acid generation behaviour to slow-reacting carbonates and especially to iron-bearing carbonate phases.
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>description</th>
<th>CO$_3$-C (from ISO 10693)</th>
<th>CO$_3$-C from XRPD</th>
<th>Total S % (ISO 351)</th>
<th>Pyrite S %</th>
<th>Sulphide S %</th>
<th>Sulphate S %</th>
</tr>
</thead>
<tbody>
<tr>
<td>81216001</td>
<td>Mine waste sample. Intensively cemented breccia of the oxidized sparry iron ore. (goethite 9%).</td>
<td>0.10</td>
<td>7.58</td>
<td>2.23</td>
<td>1.83</td>
<td>1.83</td>
<td>0.4</td>
</tr>
<tr>
<td>81216004</td>
<td>Gray, slaty, brecciated clay-marl. Zn-Pb sample from the contact zone</td>
<td>7.93</td>
<td>11.94</td>
<td>5.92</td>
<td>2</td>
<td>5.47</td>
<td>0.45</td>
</tr>
<tr>
<td>81216010</td>
<td>Dolomitic pyrite-rich sparry iron ore close to contact zone with the marl</td>
<td>5.26</td>
<td>10.71</td>
<td>6.1</td>
<td>6.1</td>
<td>6.1</td>
<td>0</td>
</tr>
<tr>
<td>81216011</td>
<td>Dolomite-rich sparry iron ore with vein-fillings of fahlore and pyrite</td>
<td>6.21</td>
<td>8.33</td>
<td>2.81</td>
<td>2.14</td>
<td>2.81</td>
<td>0</td>
</tr>
<tr>
<td>81216024</td>
<td>Pyrite-rich sparry iron ore</td>
<td>3.34</td>
<td>4.61</td>
<td>13.21</td>
<td>13.06</td>
<td>13.06</td>
<td>0.15</td>
</tr>
<tr>
<td>81216025</td>
<td>Massive pyrite accummulation in the sparry iron ore</td>
<td>1.58</td>
<td>2.99</td>
<td>30.83</td>
<td>29.72</td>
<td>29.72</td>
<td>1.11</td>
</tr>
<tr>
<td>81216026</td>
<td>Sample from the „baritic spare edges” with significant barite and pyrite content</td>
<td>0.05</td>
<td>1.17</td>
<td>15.38</td>
<td>6.09</td>
<td>8.45</td>
<td>6.93</td>
</tr>
</tbody>
</table>
### Mineral Composition of the Samples

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>81216001</th>
<th>81216011</th>
<th>81216010</th>
<th>81216024</th>
<th>81216004</th>
<th>81216025</th>
<th>81216026</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mg-siderite</td>
<td>66</td>
<td>2</td>
<td>8</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>dolomite</td>
<td>4</td>
<td>74</td>
<td>52</td>
<td>36</td>
<td>26</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>dolomite Fe-rich</td>
<td>2</td>
<td>15</td>
<td>19</td>
<td>27</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesite</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>calcite</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>cerussite</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>covellite</td>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>pyrite</td>
<td>8</td>
<td>3</td>
<td>14</td>
<td>30</td>
<td>5</td>
<td>66</td>
<td>11</td>
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<tr>
<td>sphalerite</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
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<tr>
<td>tetrahedrite</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>galena</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>gypsum</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>0</td>
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<tr>
<td>anhydrite</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>barite</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Static test results

Net Neutralisation Potential (t CaCO3/1000 t)

-1000 -800 -600 -400 -200 0 200 400 600

NAG pH

0 1 2 3 4 5 6 7 8 9

NNP=0

Uncertain

Non Acid Generating

NAGpH=4.5

Potentially Acid Generating

NPR=1

NPR=3

NAGpH=4.5

NPR

0.01 0.1 1 10
Kinetic testing and mineralogical characterization of sulphide mine wastes from the Oruro deposit (Bolivia) in cooperation with Kjeoy Research and Education Centre, Norway

- **Mineralogical analysis**
  - X-ray diffraction (Rietweld),
  - SEM + EPMA

- **Geochemical testing (from kinetic test)**
  - pH, Eh, TDS
  - Conductivity, salinity, temperature
  - Anion and cation content

- **Sequential extraction**
### Mineral composition of the samples (XRPD)

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Jalpha-01</th>
<th>Playa Irroco-01</th>
<th>Itos jig tailing-01</th>
<th>Itos jig tailing-02</th>
<th>Itos Granza-01</th>
<th>Itos Granza-02</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz</td>
<td>59 %</td>
<td>45 %</td>
<td>61 %</td>
<td>59 %</td>
<td>62 %</td>
<td>70 %</td>
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<tr>
<td>Illite</td>
<td>21 %</td>
<td>14 %</td>
<td>25 %</td>
<td>25 %</td>
<td>25 %</td>
<td>19 %</td>
</tr>
<tr>
<td>Pyrite</td>
<td>1 %</td>
<td>11 %</td>
<td>6 %</td>
<td>6 %</td>
<td>2 %</td>
<td>1 %</td>
</tr>
<tr>
<td>Dravite</td>
<td>-</td>
<td>4 %</td>
<td>2 %</td>
<td>4 %</td>
<td>5 %</td>
<td>3 %</td>
</tr>
<tr>
<td>Jarosite</td>
<td>7 %</td>
<td>-</td>
<td>1 %</td>
<td>1 %</td>
<td>2 %</td>
<td>2 %</td>
</tr>
<tr>
<td>Alunite</td>
<td>1 %</td>
<td>-</td>
<td>1 %</td>
<td>1 %</td>
<td>-</td>
<td>1 %</td>
</tr>
<tr>
<td>Magnesioxcopiapite</td>
<td>-</td>
<td>11 %</td>
<td>-</td>
<td>1 %</td>
<td>2 %</td>
<td>3 %</td>
</tr>
<tr>
<td>Gypsum</td>
<td>3 %</td>
<td>6 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kaolinite</td>
<td>3 %</td>
<td>-</td>
<td>1 %</td>
<td>2 %</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Pyrite alteration

Jig 1

Granza 1

Granza 2

Jig 2
Modelling

- Sulphate release
- Calculated pyrite oxidation
- Estimation of oxidation time span

<table>
<thead>
<tr>
<th>Sample</th>
<th>Pyrite content * g pyrite / kg sample</th>
<th>Pyrite oxidation rate g pyrite / kg sample / year</th>
<th>Year **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Itos jig tailing-01</td>
<td>60</td>
<td>1.56</td>
<td>38</td>
</tr>
<tr>
<td>Itos jig tailing-02</td>
<td>50</td>
<td>5.95</td>
<td>8</td>
</tr>
<tr>
<td>Itos Granza-01</td>
<td>20</td>
<td>1.35</td>
<td>15</td>
</tr>
<tr>
<td>Itos Granza-02</td>
<td>20</td>
<td>5.72</td>
<td>4</td>
</tr>
</tbody>
</table>

* Based on XRD
** Ideal case
TAILSAFE: Sustainable Improvement in Safety of Tailings Facilities

- EU FP5 project of 10 institutions from 6 countries
- A State-of-the-Art Report, Risks and Reliability and Intervention Actions for Risk Reduction
- Design and Authorisation Procedures for Proposed Tailings Facilities
- Water Management and the Use of Thickened Tailings
- Pilot-scale Hydraulic Transport Test System and Pilot-Scale Slurry Thickener
- Closure and Restoration Plans, Intervention and Remedial Actions and Legislation, Authorisation, Management, Monitoring and Inspection Practices
- Non-Destructive and Minimally Intrusive Methods for the Investigation and Monitoring of Tailings Impoundments
- Catalogue of Site Characterisation Criteria
- An online risk reduction tool implemented on an ASP server and hosted at http://www.tailsafe.net/
PEREBAR Long-term Performance of Permeable Reactive Barriers used for the Remediation of Contaminated Groundwater

- EU FP5 project of 8 institutions from 4 countries
- Selection and characterization of suitable matrix material
- Characterization of the relevant attenuation processes
- Development of contaminant-binding chemical compounds
- Accelerated testing methods to assess the long-term performance of the attenuation mechanisms.
- Development of a scheme to predict long-term behavior of PRB’s
- Evaluation of the influence of site characteristics.
- Monitoring of existing and new field applications
- Field tests: Test Apparatus for Accelerated Testing of Permeable Reactive Material at the former uranium mine tailings at Pécs, Hungary

http://www.perebar.bam.de/
InSUPeRB
Innovative solutions in using permeable reactive barriers

Bilateral research with the Umea University, Sweden

To lay the technical foundations of an innovative, passive remediation system, which is considerable cheaper and offers faster solutions than the traditional PRB-s.
I. Module: Reactive material development

- Investigation of reactive material
- Preparation of reactive material
- Evaluation of natural, high humin-acid containing material
- Production of reactive pack

II. Module: Hydraulic compatibility

- Laboratory permeability testing
- Hydraulic modeling and design parameters
- Transport modeling

- Technical, physical, chemical and hydrodynamic set of prerequisites of the Reactive pack
- Technical idea for reactive pack facilitation and reclaiming
- Designing the modular framework for PRB
- Technical designing and documentation

III. Module: Technical designs

IV. Module: Utilization

- Testing of exhausted reactive pack
- Processing of exhausted reactive pack
- Investigation of utilization alternatives
- Selection of utilization option