GTK - GEOLOGICAL SURVEY OF FINLAND
GTK STAKEHOLDER SEMINAR
GTK MINTEC
KUOPIO 7.5.2013
Purpose of Metallurgical Testing in a Mine Project

- Produce data for the selection of the process (e.g. grinding, flotation, leaching etc.) and the flowsheet.

- Confirm or give an estimate on the metallurgical results (grades, recoveries)

- Improve ore grade estimation (by pilot or plant tests with gold ores, for instance)

- Produce concentrates for pyro- or hydrometallurgical tests

- Produce basic data for process cost estimation (capital & operating)
Different Processes to be Studied

- Grinding tests

- Mineral processing (beneficiation)
  - Flotation
  - Magnetic separation
  - Gravity separation
  - Dense medium separation
  - Leaching (Heap leaching, Agitation leaching (atmospheric, pressurized))
  - Combination of these

- Hydro-/pyrometallurgical tests for concentrates

- Other tests connected mainly with mineral processing, including
  - Thickening and filtration tests
# Mineral Processing Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Principle</th>
<th>Application</th>
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</thead>
<tbody>
<tr>
<td>Gravity separation</td>
<td>based on differences in density between minerals</td>
<td>gold, coal, wolframite, chromite</td>
</tr>
<tr>
<td>Flotation</td>
<td>based on different surface properties of the minerals</td>
<td>sulphide ores: chalcopyrite, galena, sphalerite</td>
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<td></td>
<td></td>
<td>oxide ores: phosphates, carbonates, silicates</td>
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<tr>
<td></td>
<td></td>
<td>coal</td>
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<td>Magnetic separation</td>
<td>dependent on magnetic properties of the minerals</td>
<td>low intensity separators</td>
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<td></td>
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<td>ferromagnetic minerals: magnetite</td>
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<tr>
<td></td>
<td></td>
<td>high intensity separators</td>
</tr>
<tr>
<td></td>
<td></td>
<td>paramagnetic minerals: hematite</td>
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<tr>
<td>Electrical separation</td>
<td>dependent on electrical conductivity properties of the minerals</td>
<td>fairly limited in some minerals found in heavy sands</td>
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<tr>
<td></td>
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<td>from beach or stream placers</td>
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</tbody>
</table>
Selection of the Test Method Depend on

- Mineralogy of the ore

- Marketability of alternative products (concentrates, hydrometallurgical products)
Scale of Testing

- Laboratory (bench scale)  
  Always required
- Minipilot  
  Optional
- Pilot Plant  
  In most cases required
- Plant tests  
  Sometimes done
Mineralogy

The knowledge of ore mineralogy is essential for planning the metallurgical testwork, e.g. selection of the methods for ore processing.

Preliminary knowledge of ore mineralogy is required already in first stage (conceptual valuation) and in any case before starting the metallurgical testwork.

During the testwork the mineralogical studies of the test products are required for developing the processing method. The need for mineralogical information increases with increasing complexity or difficulty of the ore.
The Tests Required at Different Stages of a Mine Project

- **Conceptual valuation**
  - The tests are not always mandatory. Flowsheets and metallurgical results can be based on assumptions (with "easy" ores at least)
  - Preliminary bench scale tests probably are useful for difficult ores (as judged by the mineralogy)

- **Prefeasibility study**
  - Bench scale testwork is required
  - More than one alternative for processing the ore is possibly studied (e.g. flotation, leaching, combined process)
The Tests Required at Different Stages of a Mine Project

Feasibility study
- All testwork will be finalized in feasibility study
- Bench scale tests together with mineralogical studies are carried out to such an extent that the processing of ore is fixed and the connected difficulties are solved as far as possible.
- Pilot plant (or plant) tests confirm achieved results in a continuous process

Bankable feasibility study
Required Sample Sizes for the Metallurgical Tests

- Representativeness of the sample is essential

- Bench scale: from 50 to 100 kgs

- Minipilot: from 400 to 3000 kgs

- Pilot plant: from 50 to 300 tons

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GTK Mineral Processing (GTK Mintec)
GTK Mintec in Outokumpu

- Leading mineral processing research facility in Europe
- Entire research chain from mineralogical studies to process design
- Focus of the R&D activities are:
  - process development for new orebodies
  - troubleshooting/process development on beneficiation plants
  - as well as
  - solutions for material recycling and soil remediation
- Turnover 5,1 M€ (2012)
  - over 60 % from confidential contract research for clients
  - clients from abroad (50 %)
- Total staff 44 people + Labtium Oy 6 people
GTK Mintec Organization

Administration
• Laboratory Management
• Accounting
• Desk Services
• IT Support

Laboratory Group
• Mineralogy
• Process Research

Pilot Group
• Pilot and Minipilot Research
• Physical Separation

Labtium Oy
• Analysis Services
Research Chain
from Ore Deposit to Mine

GTK can assist in

- Exploration - geochemistry, geophysics, drilling, consultancy
- Chemical analyses - Labtium Oy
- Mineralogical analyses
- Mineral processing
  - bench scale tests
  - mini-pilot tests
  - pilot plant tests
  - plant tests
- Basic engineering participation
Research Topics

- Process development for ores and by-products of industry
- Comminution studies
- Flotation studies and process chemistry
- Biotechnology in processing of minerals and by-products
- Leaching of concentrates and ores
- Environmental studies
- Process water research
- Recycling of materials
- Developments in mineralogical research
Mineralogical Research

- Preparation of microscope specimens
- Heavy liquid separation
- X-RAY diffraction
- Infrared, optical and electron microscopies
- Image analysis (MLA)
- EDS analysis
Occurrence of Gold in Rock and Drill Core Samples

Good understanding of the mineralogy of an ore is required to design or operate a beneficiation process for optimum efficiency.

- Microscope specimens will be prepared (polished sections).
- MLA-studies give information on mineralogy, particle size, liberation, and association of minerals.
- Optical microscope and MLA-instrument will be used to search gold.
- MLA-studies will give:
  - Gold mineralogy
  - Particle size of gold
  - Association of gold
Gold Beneficiation Studies

Gravity separation
- For coarse free gold
- Spirals, tables and centrifugal separators

Flotation
- For free and associated gold
- Flash and fine flotation cells

Leaching
- Heap leaching
- CIL, CIP
- POX and leaching
- Bioleaching
Mineral Processing on Bench Scale

- Comminution and classification
- Flotation
- Hydrometallurgy
- Magnetic separation
- Gravity separation
- Dewatering
Mini Pilot

- First study in a continuous process after bench scale results
- Sample size 400 – 2,000 kg drill cores, ore sample etc.
- Sample pre-crushed to feed size of 3 - 6 mm
- Facility is designed and constructed in a sea container
- Feed capacity 10 - 50 kg/h
Pilot Plant

Processes can easily be adapted to capacity ranges from 0.5 tph up to 5 tph.

Sample sizes typically from 50 to 300 tonnes

Plant automation and process control of a high level, together with automatic sampling systems, ensure the highest quality results.
Pilot Plant
Objectives of Studies

- To conduct testwork for feasibility studies of new ore deposits
- To conduct process development for existing plants
- To develop comminution and benefication methods, and equipment for industry
- To generate process information for plant design
- Bankable feasibility studies
Process Development for New Orebodies

- Process development for feasibility studies and plant design
- Examples
  - CuNi, Cu and Ni ores
  - PGAu ores
  - Au Ores
  - CuMo ores
  - PbZnAg ores
  - Nb ores
  - Iron ores
  - Ilmenite ores
  - Phosphate ores
  - Calcite, Talc ores
  - Chromite ores
  - Kimberlites
Thank You for Your Attention!