Real-Time Mining: Turning Geo-Data into Mining Intelligence

CIM Conference, 09.05.2018

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 641989
Structure

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- Real-Time Mining Project Overview
- Specific Developments in WPs
  - Material Characterization
  - Model Updating
  - Visualization
- Summary & Outlook
Mining a geologically complex orebody

- Highly complex geology
- Critical accessment
- Geological uncertainty

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Mining a geologically complex orebody

Input

- Critical assessment
- Highly complex geology
- Geological uncertainty

Output

- Strict customer specifications
- Continuous, reliable feed
- Good quality product

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Mining a geologically complex orebody

Complex Mineral Extraction Process

Input

• Critical assessment
• Highly complex geology
  ➔ Geological uncertainty

Output

• Strict customer specifications
• Continuous, reliable feed
• Good quality product
Requirements for a resource-effective extraction

Ore body with high variability and uncertainty

Variability of grades

Homogeneous product

Effective Grade Control

Taking into account geological structure and customers requirements

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Availability of online data:

- Material Characteristics (grade, texture, petro-physical properties)
- Machine Performance (Actual cutting energy, break down behavior)
- Online positioning and material tracking (GPS, UPS)
Usage of online data to improve GC process

Recovery can be significantly increased by changing mineral resource/reserve management from a ‘batch-type’ to a near-continuous model-based controlled activity utilizing online data.
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XGraphic – Company Profile

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Research focus in the RTM approach

Non-destructive methods for material characterization

Live updating of resource/grade control models

Big Data Management and Visualization

Real-Time decision support in operations management

Decision support in:
- Block classification
- Block delineation
- Short-term schedule and blending
- Logistics and stockpile management

Sensor Image

Classification

Block grade and mineral content

3.7% Cu
4.7% Zn

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Process and information flow in an underground mining cycle

Step 1: Blast hole drilling

Drill Hole

Classification
Scheduling

Grade Control
Block Model

Dispatching
Logistics

Control
decision
points

Sensors for material characterization
Sensors for machine performance
Sensors for geo-referencing (positioning and material tracking)
Process and information flow in an underground mining cycle

Step 2: Ore Handling

Drill Hole
Core Sample
Ore zone
Muck-pile
LHD
Ore-pass
Ore Transfer
BIN
Crusher
Step 2: Ore Handling Control decision points
Selective Loading Scheduling
Sensors for material characterization
Sensors for machine performance
Sensors for geo-referencing (positioning and material tracking)

Step 1: Ore Handling

Control decision points
Selective Loading Scheduling
Sensors for material characterization
Sensors for machine performance
Sensors for geo-referencing (positioning and material tracking)

Dispatching
BIN A B C
Crusher

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### Options for sensor deployment in a mining cycle

<table>
<thead>
<tr>
<th>Cycle position</th>
<th>Sensor location</th>
<th>Sensor Type</th>
<th>Information</th>
<th>Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre extraction</strong></td>
<td>MWD (Monitoring while drilling blast holes)</td>
<td>Machine performance</td>
<td>hardness, grindability</td>
<td>3D point data</td>
</tr>
<tr>
<td></td>
<td>Down-hole logs</td>
<td>Material properties</td>
<td>Textures, mineralogy, geochemistry</td>
<td>3D point data</td>
</tr>
<tr>
<td></td>
<td>Chip- and Channel Sampling</td>
<td>Material properties</td>
<td>typically geochemistry</td>
<td>3D point data</td>
</tr>
<tr>
<td></td>
<td>Production face</td>
<td>Material properties</td>
<td>property maps</td>
<td>Images or 3D geometries</td>
</tr>
<tr>
<td><strong>During extraction</strong></td>
<td>Rock cutting</td>
<td>Machine performance</td>
<td>Specific energy usage, hardness</td>
<td>3D point data</td>
</tr>
<tr>
<td></td>
<td>Supply chain</td>
<td>Material tracking</td>
<td>material flow</td>
<td>3D point data</td>
</tr>
<tr>
<td><strong>Post extraction</strong></td>
<td>Pre crusher</td>
<td>Material properties</td>
<td>size distribution, textures, mineralogy, geochemistry</td>
<td>time series</td>
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<td>time series</td>
</tr>
</tbody>
</table>
Developments in sensors for material characterization

- Imaging techniques will be deployed to define target domains for point analysis.

**Mine face (static)**
- Imaging
  - Optical
  - Thermal
  - Hyperspectral

**Drill core (Static)**
- Imager
- LIBS

**Muckpile (Static)**
- Imager
- XRF
- (LIBS)

**Dynamic**
- Conveyor belt
- LHD
- Imager
- XRF
- LIBS is excluded

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Developments in data assimilation for model updating

True but unknown deposit

Sensor Measurements

Production Monitoring

Closing the Feed – Back - Loop

Exploration Data Set

Sampling

Difference

Sequential Updating

Model Based Prediction

Decisions e.g. Mine Planning

Estimated Deposit Model + Uncertainty

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Developments in data integration and visualization

- Mine layout with operating points
- 3D visualization of the geological surfaces
- 3D visualisation of the grade-control model
- 2D View of the schematic process flow
- Machine and equipment positions
- Sensor measurements
- Long term planning
- Short term planning
- Optimizer scenario comparison
- Editor for optimization parameter
- Face view screen

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Public demonstration: “Reiche Zeche” Research Mine Freiberg, Germany RTM-Conference
Summary: Moving towards a closed loop of resource management

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Outlook: VR/AR @ XGraphic

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Thank you and „Glückauf“

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