Key Innovations in Exploration and Extraction and their Drivers

Findings from the Horizon 2020 Project MIN-Guide

Anders Sand, Luleå University of Technology
Michael Tost, Montanuniversität Leoben
What is MIN-Guide?  
**Facts and Figures**

- Coordination and Support Action (Horizon 2020)
- 3-year project: Feb 2016 - Jan 2019
- Project Coordinator:

  ![Institute for Managing Sustainability WU](image)

- 10 Partners
- 9 countries

![University of Zagreb](image)

![University of Westminster](image)

![University of Aveiro](image)

![National Technical University of Athens](image)

![Instituto Geológico y Minero de España](image)
Innovation-friendly mineral policy

Industry innovation & policy frameworks

Identify EU and EU MS mineral policy frameworks

Legislative framework

Economic and financial instruments

Information provision and awareness

Identify industry innovation challenges and cases

Exploration & Extraction

Mineral and metallurgical processing

Waste management & mine-closure

Identify industry innovation challenges and cases
MIN-Guide activities

Events and information provision

5 Policy Laboratories

1st Policy Lab (WP2)
Vienna, Oct 2016

2nd Policy Lab (WP3)
Leoben, Mar 2017

3rd Policy Lab (WP4)
Luleå, May 2017

4th Policy Lab (WP5)
Athens, Sept 2017

5th Policy Lab (WP6)
Madrid, 2018

3 Annual Conferences (EU-Level)

The Closing Conference ‘The future perspective of minerals production in the circular economy’

The Mid-term Conference: ‘Good practice minerals policy transitioning the minerals production value-chain’

The Opening Conference: ‘European minerals policy: Stock-taking and revealing the governance framework’

Webpage and policy guide

Online Mineral Policy Guide – Currently over 600 entries!

www.min-guide.eu
Key Innovations in Exploration and Extraction and their Drivers

Findings from the Horizon 2020 Project MIN-Guide

Anders Sand, Luleå University of Technology
Michael Tost, Montanuniversität Leoben
WP3 “Innovative exploration and extraction”

- Identification of EU MS mineral policies and legislation relevant to innovation in minerals exploration and extraction
- Identification of catalyzing and inhibiting elements for the implementation of innovative mineral exploration and extractive methods (non-technological as well as technological elements) and, following this, an identification of best practice cases
- Assessment of needs and gaps analysis for aligning future policy developments/directions with inclusion of all relevant stakeholders
- Exploration of the feasibility of innovative mining legislation and legal framework for exploitation of sub-surface and deep sea resources.
The process

Identify key innovation challenges and/or outcomes and investigate if and how they are influenced by policies.

1. Desktop research: "innovation in exploration and mining" (past/current/future)

2. Stakeholder interviews (companies, NGOs, policy makers, academia) to identify key innovations (to cover various categories and past/present/future), their drivers/challenges and key players/countries.

3. Policy impact on these 5-7 innovations (+/-)

4. Interviews with neutral experts regarding the situation in other (key?) member states regarding these policies.

Path 1 feedback loop: Did policies cause key innovations and if so, which?
Deliverables (so far)

ONLINE “Project results” (www.min-guide.eu)
Innovation drivers and challenges

**Exploration**
- Commodity prices are considered the most important driver or challenge for expenditure on exploration itself.
- Geological potential and data is considered the most relevant direct driver for innovation.
- Data availability and innovative ways of data access.
- Suitable mining policy.

**Extraction**
- Costs and productivity.
- Orebody geology (incl. remote, lower grade or more complicated orebodies).
- Legislation (i.e. environmental).
- Health and safety of employees.
Innovation needs

Exploration
Process innovations

• Better geological data, mapping and modelling to increase geological attractiveness
• New exploration technologies
  • New drilling techniques
  • Integrated drilling and analytical technologies
  • Down-hole and cross-hole sensing
• 3D geophysical (seismic, gravimetric, magnetic, electrical and electromagnetic)

Extraction
Process innovations

• Autonomous and automated mining
• Continuous mining, including mechanical cutting or in-situ leaching
• Safer and greener mining
• Applied in more remote operations (deeper underground, deep sea)
Innovations - exploration

- No breakthrough innovations in exploration in the last 20 years
- “Skills of the geologist”
- Field vs. data
Innovations - extraction

<table>
<thead>
<tr>
<th>Extraction innovations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autonomous equipment/operations including-use-of-robotics, smart-sensors and 3D-printing</td>
</tr>
<tr>
<td>Process control &amp; (big) data-management (&quot;real-time-information-and-mass-flows&quot;)</td>
</tr>
<tr>
<td>Continuous processes and automation</td>
</tr>
<tr>
<td>Resource characterisation</td>
</tr>
<tr>
<td>New models for financing of mining</td>
</tr>
<tr>
<td>Lower environmental footprint (ie-biodiversity, ore-recovery, energy and CO2, water, waste)</td>
</tr>
<tr>
<td>New/Alternative mining methods (in-situ leaching, mechanical cutting to replace DLE, etc)</td>
</tr>
<tr>
<td>Digitally enabled worker including remote operation centres, virtual and augmented reality, virtual collaboration</td>
</tr>
<tr>
<td>Transparency and traceability including open-platform databases, blockchain usage</td>
</tr>
<tr>
<td>Surveying methodology and mine design</td>
</tr>
<tr>
<td>Scale-up of production equipment</td>
</tr>
<tr>
<td>Resource characterisation for better structural controls</td>
</tr>
<tr>
<td>Integrated platforms, enterprise ecosystems incl. IT/OT-convergence, asset cybersecurity</td>
</tr>
<tr>
<td>Next generation analytics and decision making including Artificial Intelligence, simulation modelling</td>
</tr>
<tr>
<td>Land use planning governance (site level vs. Cumulative impact at regional level) -- data will allow models/analysis as part of regional development plans</td>
</tr>
<tr>
<td>New business models and customer relations (collaborative business models, customer responsibility)</td>
</tr>
<tr>
<td>Dealing with extreme environments (deep-sea mining, extreme depths, arctic...)</td>
</tr>
<tr>
<td>Various safety innovations including cultural changes</td>
</tr>
<tr>
<td>Better skills base</td>
</tr>
<tr>
<td>Better infrastructure, i.e. electricity and &quot;mine-to-market&quot;</td>
</tr>
</tbody>
</table>

- First two considered key
- NGOs: more innovations needed concerning transparency, land use, environmental management
10 top innovations chosen for case studies

Portable XRF-analyser
Use of portable XRF-analyser for drill core and in-pit analyses for instant geochemical results

PROJECT PERIOD: 1990 - Ongoing | CASE ORIGIN: GERMANY

Summary

Instant results, non-destructive method, large numbers of analyses can be obtained quickly and inexpensively, data can be stored easily, makes time-consuming lab analyses in many cases obsolete.

Description

Portable XRF analysers allow in-situ chemical analyses of soils, rocks, and ores in outcrop, drill core or mine walls (open pit and underground).
Policy and legislation framework

• EU Raw Materials Initiative
• EIP SIP Raw Materials
• National Mineral Strategies (10 MS only)
• Minerals related policy is vertically (EU-MS-regions) and horizontally (Mining – environment – land use planning, etc) dispersed
• Often based on societal challenges
• Strong impact from other policy areas, such as taxation, RDI programmes
Impact of policy on exploration & extraction innovations

• Innovations are mainly driven by business opportunity
• Policy is only playing a secondary role, except for areas where innovation can help with meeting legislative requirements
  • Health and safety (e.g. communication and warning systems in underground mines)
  • Environment (e.g. resource efficiency, energy, water, waste management)
• RMI seen as positive since it made minerals a political priority again
• Horizon 2020 and EITRM programmes seen as positive for e&c innovations
## Policies with an impact on exploration and extraction innovations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of mobile metal ion theory in geochemical exploration</td>
<td>Raw Materials Initiative (RMI)</td>
<td>+&lt;br&gt;EU Natura 2000 (acc. to Directive 92/43/EWG)</td>
<td>-&lt;br&gt;Land Use and Building Act 132/1999 (Finland)</td>
<td>-&lt;br&gt;Mining Act 621/2011 (Finland)</td>
<td>+&lt;br&gt;EU and national environmental policies</td>
<td>+&lt;br&gt;Environmental Impact Assessment Directives 2011/92/EU and 2014/52/EU</td>
</tr>
<tr>
<td>Advanced field work, including better sample processing and analysis techniques, data analysis and processes for environment-friendlier exploration</td>
<td>EU and national environmental policies</td>
<td>+&lt;br&gt;Environmental Impact Assessment Directives 2011/92/EU and 2014/52/EU</td>
<td>+&lt;br&gt;Law on Industrial Licensing 169/2012, 73/2015, 278/2015 (Portugal)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

• Innovation is critical for e&ē in the EU
• RMI, EIP, etc seen as positive – will minerals continue to be a political priority?
• National RDI programmes (Sweden, Finland, Portugal) seen as positive
• Innovation is mainly driven by business opportunity
• Legislation based on societal challenges drives innovation
• RDI, tax, education policies can support innovation
• Mineral policy makers need to be aware of other policy areas and what is going on there (e.g. aviation policies)
Stay with us!

@minguide.eu

@minguideEU

MIN-GUIDE