Minerals Policy Guidance for Europe

Innovative Exploration and Extraction

Deliverable 3.1

Policy and legislation framework for innovative exploration and extraction

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The innovations and policies described are based on the authors' best knowledge, but there is no guarantee that all relevant innovations and policies have been considered.

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1. Background and objectives

MIN-GUIDE: a brief introduction

The Horizon 2020-funded MIN-GUIDE project aims to support the secure and sustainable supply of minerals in Europe through the development of a major new online repository outlining guidance and the latest in good practice for minerals policy decision makers. The project's key objectives are (1) to provide guidance for EU and EU Member States minerals policy, (2) to facilitate minerals policy decision making through knowledge co-production for transferability of best practice minerals policy, and (3) to foster community and network building for the co-management of an innovation-catalysing minerals policy framework. MIN-GUIDE will profile relevant policy in Europe, identifying innovation-friendly good practice through quantitative indicators, qualitative analysis of country-specific framework conditions, and the compilation of minerals statistics and reporting systems. These insights will form the basis for the project's key output, an online Minerals Policy Guide (referred to in this document as 'the Policy Guide').

The project is split across 8 work packages (WPs) (see Table 1 below). The content-rich work packages are WPs 2-6: WP2 will produce a comprehensive and well-structured knowledge repository of EU level and EU Member States' mineral policies and governance frameworks; WPs 3-5 will identify, benchmark, and elaborate good practice on policy innovation capacity according to the different activities along the whole mining value chain (permitting, exploration, extraction, cross-border exploitation, processing, waste management, recycling, remediation and mine closure); and WP6 will review the mineral data base and recommend standardisation and systematic reporting requirements for EU Member States.

Common approach	WP1	Minerals policy guide development and conceptual basis
Core content	WP2	Stock-taking of EU and EU MS mineral policy and legislation
	WP3	Innovative exploration and extraction
	WP4	Innovative processing
	WP5	Innovative waste management and mine closure
	WP6	Raw materials knowledge and information base
Cross-cutting management and engagement	WP7	Stakeholder management, communication and dissemination
	WP8	Project management

Table 1: The MIN-GUIDE work packages

What is expected of this work package?

It is the aim of WP3 "Innovative exploration and extraction" to investigate how exploration and extraction innovations are taken up in different EU Member States, and how this is supported or inhibited by national and European policies.

The work of WP3 will be split into 4 tasks:

- **Identification of EU MS mineral policies relevant to innovation in minerals exploration and extraction (based on findings provided by WP2) *(elaborated in this report)*.**
- Identification of catalysing and inhibiting elements for the implementation of mineral exploration and extraction innovations (non-technological as well as technological elements) and, following this, an identification of best practice cases ***(see D3.2 report).***
- Assessment of needs and gaps analysis for aligning future policy developments/directions with inclusion of all relevant stakeholders.
- Exploration of the feasibility of an innovative legal framework for exploitation of sub-surface and deep sea resources.

The process

As described in the D3.2 report "Innovation evaluation criteria and best case practices in exploration and extraction, Version 1" (Tost, 2016), a challenge driven approach was chosen for this work package.

In summary and to set this report in context, we followed a four step process:

1. Desktop research *(see report D3.2)*
2. Stakeholder interviews and questionnaire *(see report D3.2)*
3. Analysis of policy impact on innovations *(scope of this report)*
4. Second round of interviews for the 10 innovation cases chosen for further study and the situation in other EU MS *(scope of this report and D3.4)*

For the analysis we used again results of interviews and the questionnaire (see annex). We asked respondents to assess 1) whether public policies have an impact on the innovations they mentioned, 2) which impact (positive, neutral, negative) these policies have, and 3) the nature of the impact on innovation.

This deliverable

The remainder of this report:

1. Summarizes the key innovations in exploration and extraction as a result of the work in D3.2
2. Links these innovations to public policy mentioned as relevant and describes their impact

Terminology and definitions

WP 3 follows the MIN-GUIDE Common Approach as described in D1.1. This is especially relevant for the innovation categories as described in D3.2 and the innovation case studies.

Within MIN-GUIDE a value chain oriented approach is pursued.

Hartmann describes **Exploration** as the first step in this value chain which includes all processes related to finding ores (commercially viable concentrations of minerals) for the purpose of extraction at a later stage. Exploration processes include **prospecting**, the search for ore, and **exploration**, the definition of the extent and value of ore, itself. Prospecting can include direct (physical, geological) and indirect (geophysical, geochemical) methods, it can involve desktop work (use of maps, literature, the study of old mines), aerial methods (aerial photography, airborne geophysics, satellite) and surface methods (ground geophysics, geology) and involves spotting anomalies, analysis and evaluation of samples and data. Exploration determines as accurately as possible the size and value of a mineral deposit, using techniques similar but more refined than those used in prospecting. It involves sampling (drilling, excavation) and testing, estimation of tonnage and grade of a mineral deposit (reserve estimation) and a thorough feasibility study to determine the potential of developing the deposit into a producing mine, with the outcome of the study being a decision to abandon or develop the deposit.

Extraction involves the **development**, the opening up of an ore deposit for production, and **exploitation**, the large scale production of ore in a mine. Development can include the acquisition of mining rights (if not done as part of exploration), environmental and social impact assessments, technology assessments and permitting, the construction of access roads, transport systems, surface plants. facilities and other infrastructure and the excavation of the deposit, either by stripping overburden (the earth or rock covering the deposit) or excavating openings from the surface (shafts, declines) to access more deeply buries deposits in preparation for underground mining. Exploitation is the actual recovery of mineral from the earth in quantity. The mining method selected for exploitation is based on the characteristics of the deposit and limits imposed by safety, technology and economics. Mining methods fall in two broad categories: surface and underground. Surface mining includes mechanical excavation such as open pit and open cast and aqueous excavation such as placer and solution mining. Underground mining is usually classified into three classes of methods, including unsupported (room and pillar, sublevel stoping), supported (cut and fill, stull stoping) and caving (longwall, block caving). The production cycle is normally grouped in two functions: rock breakage (drilling and blasting) and materials handling (loading and haulage), with certain auxiliary operations (roof support, ventilation, power supply, pumping, maintenance, lighting, communications, delivery of supplies, etc.) supporting these. (Hartmann, 2002: 7ff)

2. Innovation cases in exploration and extraction from D 3.2

Exploration innovations

As described in detail in report D3.2, for exploration, the following innovations were mentioned by experts. They are once again listed below in descending order, with the most often mentioned innovations listed first.

Exploration innovations
New geo-models, i.e. 3D modelling using multiple geological, geophysical and geochemical datasets
Airborne geophysical methods
Use of commercially available drones and other small aircraft in surveying tenure or high precision mapping
In-situ analysis using portable XRF analysers
In-situ analysis using multispectral core logging
Trace-element lithogeochemical & mineral systems mapping
Use of MMI (mobile metal ion) theory in geochemical exploration
Advanced field work, including better sample processing and analysis techniques, data analysis and processes for environment-friendlier exploration
Advanced geological and geophysical data processing and interpretation, e.g. SOM (self-organising maps) method, prospectivity analysis
Advanced surficial geochemical and biogeochemical methods based on weak and selective leaching
Mobile GIS/GNSS applications and improved field mapping workflows, plus availability of cloud-based server storage
Deep drilling technologies, including accurate down-hole surveying and directional drilling, downhole geophysical and structural analysis (but NOT yet including downhole chemical analyses)
Deep penetrating geophysical technologies, in particular magneto-tellurics and electromagnetics (including SQUID development)
New drilling technologies, e.g. horizontal drilling
Improved online access to existing exploration and geological data
All geological data (incl. from private exploration activities) becomes publicly available
New, faster technology in exploration to scan larger areas
Overarching mining code (incl. streamlined permitting processes, access to land for mining)
Development of innovative near-mine and deep exploration technologies
Multi-layered information and integrated geological, geochemical and geophysical services and products
Integration of ancillary data to 3D models (e.g., remote sensing, geochemical, geophysical, and spectral data, etc.) adds an essential, holistic, multidisciplinary approach that further enhances the process.
Methods to facilitate finding of new mineral deposits on the continent and at and below the sea-bed. Better understand ore genesis and direct exploration at deeper(down to 150-4000 meters), unexploited levels of the bedrock

Table 2: Exploration innovations

Extraction innovations

For extraction, the innovations shown in table 3 below were brought up.

Extraction innovations [1]
Autonomous equipment/operations including use of robotics, smart sensors and 3D printing
Process control & big data management („real time information and mass flows“)
Continuous processes and automation
Resource characterisation
New models for financing of mining
Lower environmental footprint (ie biodiversity, higher ore recovery, energy and CO2, water, waste)
New /Alternative mining methods (in-situ -/ bio -/ leaching, mechanical cutting to replace DLB, etc)
Digitally enabled worker including remote operation centres, virtual and augmented reality, virtual collaboration
Transparency and traceability including open platform databases, block chain usage
Surveying methodology and mine design
Scale up of production equipment
Resource characterisation for better structural control
Integrated platforms, enterprise ecosystems incl. IT/OT convergence, asset cybersecurity
Next generation analytics and decision making including Artificial Intelligence, simulation modelling
Land use planning policies (site level vs. Cumulative impact at regional level) - data will allow models/analysis as part of regional development plans
New business models and customer relations (collaborative business models, customer responsibility)
Dealing with extreme environments (deep sea mining, extreme depths, arctic…)
Various safety innovations including cultural change
Better skills base
Better infrastructure, i.e. electricity and “mine to market”
Electronic detonators in blasting
Renewable sources of energy
Electrification of haul trucks
Flexible (i.e. train-less) haulage

Table 3: Extraction innovations

[1] The innovations listed in tables 2 and 3 above are listed with short titles only and not explained in detail, thus requiring basic technical understanding of exploration and extraction processes.

3. Identification of public policies relevant to the innovation cases

MIN-GUIDE reports D4.1 and D2.2 describe the overall raw materials policy situation in the EU, which is of cause also relevant for exploration and extraction, as follows:

The EU has adopted a Raw Materials Initiative (RMI) (Raw Materials Initiative, 2008) pointing out the critical importance of raw materials for its economy. Internal market access to raw materials, security of supply from abroad and resource management aspects are key issues discussed within this document. More importantly, however, the initiative constitutes an important recognition of the importance of the European raw material producers, including mining and metallurgical industries, for the European economy. This has later been followed by additional policies and policy-related documents, such as the Strategic Implementation Plan on Raw Materials and the National Minerals Policy Indicators (EIP SIP Raw Materials, Part I, 2013; National Minerals Policy Indicators – Framework conditions for the sustainable supply of raw materials in the EU, 2014) (Sand, 2016).

The RMI recommended the design of National Mineral Strategies, but it was not obligatory to adopt such strategies at the national level. In total, 10 EU Member States have designed National Mineral Strategies to better accommodate the EU minerals policy framework objectives with particular raw materials needs and specific circumstances of their national economies (Endl, 2016).

In addition, the following statements are also relevant:

Minerals Policy relevant to exploration, extraction, processing and waste management, and mine closure is dispersed vertically between the EU, Member States, the sub-national level, and horizontally between different policy sectors, such as permitting, land use planning, environmental policy, etc. (Endl, 2016).

As D 4.1 states, the main impact of these public policies can be derived from broader societal challenges, for instance related to resource efficiency, permitting aspects, emissions, handling of hazardous materials and wastes, as well as health, safety and risk management aspects. Public policies within these categories typically, but not always, impose various restrictions on the industrial operations (e.g. regulations on emission levels).

Other factors strongly influencing particularly the mining industry include national levels of taxation, land use legislation including compensation to landowners, both national and EU funding schemes for research projects, RDI programmes, and coordination and support actions, government-controlled public acceptance promotion campaigns, etc. (Sand, 2016).

Concerning exploration and extraction specifically, we asked experts, as part of the process described in D3.2, which policies they see as relevant for innovation overall and specifically for the innovations described above.

Generally, they see innovation in exploration and extraction **mainly driven by business opportunity**, e.g. to find new deposits, improve productivity or decrease costs. Public **policy is only playing a secondary role** - except for areas where innovation can help with meeting legislative requirements. This is especially the case for health and safety (e.g. communication and warning systems in underground mines) or concerning the environment (e.g. resource efficiency, energy, water, waste management).

They see the RMI and the related National Mineral Strategies as positive since they made minerals and their supply a political priority once again. Regarding innovation, the RDI opportunities in Horizon 2020 and the EIP Raw Materials were mentioned as positive examples supporting innovation. Box 1 describes national examples supporting innovation in mining from Sweden, Portugal and Finland.

Between 2013 and 2016 VINNOVA, the Swedish Energy Agency, ran an initiative called "The Strategic innovation programme for the Swedish Mining and Metal producing Industry", STRIM (STRIM, 2013).

The aim of the initiative in strategic areas of innovation was to encourage international competitiveness and sustainable solutions to global societal challenges.

The programme included seven areas:

- Innovative deep exploration – improvement of drilling technology and exploration methods to expand the availability of domestic mineral raw materials
- Mining - strengthening of the Swedish mining sector's competitiveness through more efficient technology and environmentally friendly, safe processes
- Enrichment – increase in resource efficiency and energy efficiency
- Reuse and foundries – minimizing environmental impact and maximizing the financial results through the effective utilization of waste and scrap
- Recycling and environmental performance – minimizing the overall footprint of mining
- Attractive workplaces – minimization of personnel underground through new technology for the extraction
- Equality in mining – breaking gender patterns as well as ore.

In Portugal, based on their National Mineral Strategy (National Strategy for Mineral Resources), a new "Portuguese Cluster of Mineral Resources" was formed in 2016. The cluster consists of companies and associations, government, academia and research organisations and aims to

- promote knowledge creation and sustainable economic value for mineral resources, boosting the export capacity and the added value.
- deepen knowledge of the economic potential of resources, promoting RDI, improving productive investment conditions and access to markets, as well as increase skills (technical, technological, management) and stimulate, overall, inter-institutional, and, in particular, inter-company cooperation.

Amongst other objectives, the cluster wants to increase raw materials related RDI spending in Portugal by 5% in 2020, compared to current levels. For example - in the context of this report - this will include actions on the use of innovative exploration technologies to further improve knowledge of Portugal's mineral potential (onshore and offshore) or new financing models for extraction using blended EU structural fund and private bank funding. (Peres, 2016)

Another example is Finland's Green Mining project. Between 2011 and 2016, Tekes - the Finish Funding Agency for Innovation - funded 107 projects worth 116 M € focusing on innovations to make Finish mining more sustainable, i.e. reduce the environmental footprint and improve the social impact. Results achieved during the programme have been put to good use in the activities of the Finish Network for Sustainable Mining, among others.

Box 1: Examples of national programmes supporting RDI in mining

The tables 4 and 5 below show examples of policies linked to exploration and extraction and their perceived impact (+= driving innovation, 0= neutral, -= hindering innovation) on innovation. The tables show the policy links as mentioned in the questionnaires and interviews, referring both to generic policies that are relevant across all MS, as well as to specific country examples.

Innovation	Examples of public policies	Impact
New geo-models, i.e. 3D modelling using multiple geological, geophysical and geochemical datasets	General Data Protection Regulation (Regulation (EU) 2016/679)	0
	Finish Open Data Programme	+
	Raw Materials Initiative (RMI)	+
	Horizon 2020 projects related to raw materials	+
	National research policies and grants	+
	National tax policies	+/-[2]
Airborne geophysical methods	EU Aviation Strategy	+[3]
	National research policies and grants	+
	National tax policies	+/-
	EU Habitats Directive 92/43/EWG	+
Use of commercially available drones and other small aircraft in surveying tenure or high precision mapping	EU planned standards for drones	+
	Aviation law – LFG, BGBl. I Nr. 80/2016 (Austria)	-
	Irish Aviation Authority (Small Unmanned Aircraft (Drones) and Rockets) Order, 2015	+
	Aviation Act (864/2014), Sections 9, 57 and 70 (Finland)	-
In-situ analysis using portable XRF analysers	Raw Materials Initiative (RMI)	+
	Radiation Act 1069/1983 (Finland)	+
	National research policies and grants	+

[2] In the case of generic policies, their impact depends on the MS and can range from + to -.
[3] Seen as an innovation driver regarding "open skies" in the EU, which should help commercial providers of such services

	Policies concerning national Geological Surveys: mandate & funding	+/-
	Waste Framework Directive 2008/98/EC	+
	Water Resources Act 1991 (United Kingdom)	+
	National mining policies	+/-
In-situ analysis using multispectral core logging	Raw Materials Initiative (RMI)	+
	National research policies and grants	+
	Policies concerning national Geological Surveys: mandate & funding	+/-
	Waste Framework Directive 2008/98/EC	+
	Water Resources Act 1991 (United Kingdom)	+
	National mining policies	+/-
Use of mobile metal ion theory in geochemical exploration	Raw Materials Initiative (RMI)	+
	EU Natura 2000 (acc. to Directive 92/43/EWG)	-
	Land Use and Building Act 132/1999 (Finland)	-
	Mining Act 621/2011 (Finland)	+
Advanced field work, including better sample processing and analysis techniques, data analysis and processes for environment-friendlier exploration	EU and national environmental policies	+
	Environmental Impact Assessment Directives 2011/92/EU and 2014/52/EU	+
	Law on Industrial Licensing 169/2012, 73/2015, 278/2015 (Portugal)	+
Advanced geological and geophysical data processing and interpretation, e.g. SOM (self-organising maps) method, prospectivity analysis	General Data Protection Regulation (Regulation (EU) 2016/679)	0
	Finish Open Data Programme	+
	Policies concerning national Geological Surveys: mandate & funding	+/-
	National research policies and grants	+
	EU and national environmental policies	+
	National mining policies	+/-

Deep drilling technologies, including accurate down-hole surveying and directional drilling, downhole geophysical and structural analysis (but NOT downhole chemical analyses)	Raw Materials Initiative (RMI)	+
	National research policies and grants	+
	National tax policies	+/-
	National land use/ access policies	+/-
Deep penetrating geophysical technologies, in particular magneto-tellurics and electromagnetics (including SQUID development)	Raw Materials Initiative (RMI)	+
	National research policies and grants	+
	National tax policies	+/-
New drilling technologies	Raw Materials Initiative (RMI)	+
	National research policies and grants	+
	National tax policies	+/-
	National land use/ access policies	+/-

Table 4: Examples of policies/legislation related to exploration innovations

Innovation	Examples of public policies	Impact
Autonomous equipment/ operations including use of robotics, smart sensors and 3D printing	Raw Materials Initiative (RMI)	+
	National research policies and grants	+
	EU and national environmental policies (i.e. concerning EIAs such as Directives 2011/92/EU and 2014/52/EU)	+
	National mineral policies	+/-
	EU and national Health & Safety policies, e.g. Directive Concerning Minimum Requirements for Improving the Safety and Health Protection of Workers in the Extractive Industries 1992/91/EC Council Directive on the Minimum Requirements for Improving the Safety and Health Protection of Workers in Surface and Underground Mineral Extracting Industries 1992/104/EEC	+
	National tax policies	+/-
	National education policies	+/-

Process control & (big) data management („real time information and mass flows“)	National research policies and grants	+
Continuous processes and automation	EU and national health & safety policies National tax policies EU and national environmental policies	+ +/- +
Financing of mining	Raw Materials Initiative (RMI)	-
Lower environmental footprint (ie biodiversity, ore recovery, energy and CO2, water, waste)	Raw Materials Initiative (RMI) EU and national environmental policies EU Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading	+ + +/-
New /Alternative mining methods (in-situ leaching, mechanical cutting to replace DLB, etc.)	Raw Materials Initiative (RMI) National research policies and grants EU and national environmental policies National mining policies National education policies	+ + + +/- +/-
Scale up of equipment	Raw Materials Initiative (RMI)	+
Land use planning governance (site level vs. Cumulative impact at regional level) - data will allow models/analysis as part of regional development plans	EU and national land use planning policies Austrian Mineral Resources Plan Croatian Spatial Development Strategy	+/- + +/-
New business models and customer relations (collaborative business models, customer responsibility)	Upcoming EU regulation on conflict minerals	+
Dealing with extreme environments (underwater mining, extreme depths…)	EU and national health & safety policies EU and national environmental policies International trade agreements	+ + -[4]
Electrification of haul trucks	EU Energy efficiency directive 2012/27/EU EU Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading	+ +

Table 5: Examples of policies/legislation related to extraction innovations

[4] A lack of minimum standards for this topic was mentioned as an issue

4. Conclusions

Innovation in this part of the mining value chain will continue to play a critical role for the mining industry in the EU, given the challenges described in D3.2 ranging from finding new deep underground orebodies, extracting small and complex orebodies economically, to doing so in densely populated areas, with strong land use competition and fulfilling rigorous requirements for environmental and nature protection.

In this context, the current European framework conditions (RMI, EIP, etc.) and their related national raw materials strategies are generally positively recognised by interviewed experts. However, they also raised concerns that this might change again with the current economic conditions, i.e. lower growth in China and the connected lower demand for raw materials is leading to lower raw material prices and less competition for supplies, making raw materials security and policy once again a lower political priority.

Generally, most of the respondents to this project questioned the influence of public policy on innovation in exploration and extraction. They see it mainly as driven by business opportunity, e.g. to find new deposits, improve productivity or decrease costs - with policy only playing a secondary role.

Where it does play a role however is through legislation facilitating innovation. This is mainly the case for societal challenges, i.e. environmental issues such as resource and energy efficiency, GHG and other air emissions, water use, waste management, land use management or health and safety.

Indirectly, RDI related policies, tax (incentive) and education policies can also influence innovation in this part of the value chain.

One important aspect that came out of this work is also that decision makers in the public and private sector in the EU, MS and at sub-national levels need to be aware of the innovations taking place in exploration and extraction and their links to various other public policy sectors. They should play an active role in shaping them in such a way that they consider relevant mining aspects.

Examples of such policies currently being shaped and having an impact on innovation in exploration and extraction are aviation policies regulating the use of drones, data policies regulating data transparency, privacy and security and education and labour policies potentially impacting automation.

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6. Annex

List of Abbreviations

DLB	Drilling, Loading, Blasting
EIA	Environmental Impact Assessment
EIP	European Innovation Partnership
ETS	Emission Trading System in the European Union (EU ETS)
EU	European Union
GHG	Greenhouse Gases
GIS	Geographic information system
GNSS	Global navigation satellite system
IT/OT	Information technology/ Operational technology
MMI	Mobile metal ion
MS	Member states (of the EU)
RDI	Research, development and innovation
RMI	Raw Materials Initiative
SIP	Strategic implementation plan
SQUID	Superconducting quantum interference device
SOM	Self-organising maps
XRF	X-Ray Fluorescence

WP3 Questionnaire

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MIN guide

MIN-GUIDE is a Horizon 2020 project that aims to establish a **coherent and innovation friendly minerals policy framework in Europe** by developing a Minerals Policy Guide and engaging diverse stakeholders in the mineral sector and related areas. For further information please visit:

www.min-guide.eu

For the purposes of the MIN-GUIDE project, we propose an understanding of innovation based on the OECD Oslo Manual definition:

"An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." OECD and Eurostat (2005, p. 146)
In lay terms, **we interpret an innovation to be the novel application of something** (e.g., a **product, tool, software, process, technique, method or concept**).
This questionnaire looks at **exploration and mining**, with exploration including all processes that lead to the discovery of new mineral deposits and mining including all processes involved in the extraction of materials from the earth. It excludes all processing of these materials and the handling of waste materials, which this project will look at at a later stage.

Not included in the scope of MIN-GUIDE are energy minerals incl. coal and oil& gas.

Please select for which area you would like to fill in the questionnaire:

☐ Exploration ☐ Mining ☐ Both

Name:
Organisation:
Country:

Please let us know if you want to get regular updates from the MIN-GUIDE project

☐ Yes ☐ No

Exploration

E1 Please rank the top 5 innovations in exploration that either took place in the last 10 years, are currently being implemented or will, in your opinion, take place in the next 5-10 years.	
	List of innovations *(please choose from the drop down list (and add as needed), starting with the most important)*
Innovation 1	
Innovation 2	
Innovation 3	
Innovation 4	
Innovation 5	
If you chose "Other", please describe:	

E2 For the top 3 of these innovations, please name the institution (company, research organisation, government agency, etc), person and/or country, who you think played/plays a leading role in implementing this innovation first.			
	Institution	**Person**	**Country**
Innovation 1			
Innovation 2			
Innovation 3			

E3 Please choose up to 3 key drivers leading to this innovation.				
	Driver 1	Driver 2	Driver 3	**If you chose "Other", please describe:**
Innovation 1				
Innovation 2				
Innovation 3				

E4 Please describe the impact of these innovations, i.e. what is the difference to before and why you consider this to be a top 3 innovation.	
Innovation 1	
Innovation 2	
Innovation 3	

E5 Please list up to 5 key policies/legislations directly or indirectly influencing this innovation, their impact (+/0/-) and the aspects relevant to this innovation.			
Innovation 1	**Name of policy:**	**Impact:**	**Aspects:**
Innovation 2	**Name of policy:**	**Impact:**	**Aspects:**
Innovation 3	**Name of policy:**	**Impact:**	**Aspects:**

E6 Does this innovation also have a significant impact on other parts of the mining value chain? Please select and describe the impact.					
					Description of impact:
Innovation 1	☐ Mining	☐ Processing	☐ Waste management	☐ Manufacturing	
Innovation 2	☐ Mining	☐ Processing	☐ Waste management	☐ Manufacturing	
Innovation 3	☐ Mining	☐ Processing	☐ Waste management	☐ Manufacturing	

E7 Moving away from the above described examples, can you generally think of policies/legislations that drove/ are driving innovation in exploration?			
Name of policy:	Owner:	Impact:	Relevant aspects:

E8 Please rank the top 5 member states of the EU that you think should be most concerned about the above mentioned innovations and policies.	
Country 1:	
Country 2:	
Country 3:	
Country 4:	
Country 5:	

Mining

M1 Please rank the top 5 innovations in exploration that either took place in the last 10 years, are currently being implemented or will, in your opinion, take place in the next 5-10 years.	
	List of innovations *(please choose from the drop down list (and add as needed), starting with the most important)*
Innovation 1	
Innovation 2	
Innovation 3	
Innovation 4	
Innovation 5	
If you chose "Other", please describe:	

M2 For the top 3 of these innovations, please name the institution (company, research organisation, government agency, etc), person and/or country, who you think played/plays a leading role in implementing this innovation first.			
	Institution	**Person**	**Country**
Innovation 1			
Innovation 2			
Innovation 3			

M3 Please choose up to 3 key drivers leading to this innovation.				
	Driver 1	Driver 2	Driver 3	**If you chose "Other", please describe:**
Innovation 1				
Innovation 2				
Innovation 3				

M4 Please describe the impact of these innovations, i.e. what is the difference to before and why you consider this to be a top 3 innovation.	
Innovation 1	
Innovation 2	
Innovation 3	

M5 Please list up to 5 key policies/legislations directly or indirectly influencing this innovation, their impact (+/0/-) and the aspects relevant to this innovation.			
Innovation 1	Name of policy:	Impact:	Aspects:
Innovation 2	Name of policy:	Impact:	Aspects:
Innovation 3	Name of policy:	Impact:	Aspects:

M7 Moving away from the above described examples, can you generally think of policies/legislations that drove/ are driving innovation in exploration?			
Name of policy:	Owner:	Impact:	Relevant aspects:

M8 Please rank the top 5 member states of the EU that you think should be most concerned about the above mentioned innovations and policies.	
Country 1:	
Country 2:	
Country 3:	
Country 4:	
Country 5:	