

ROBOMINERS

RESILIENT BIO-INSPIRED MODULAR ROBOTIC MINERS

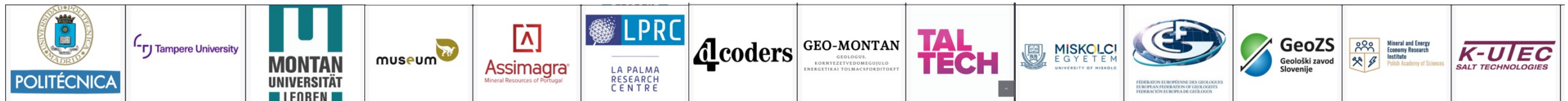
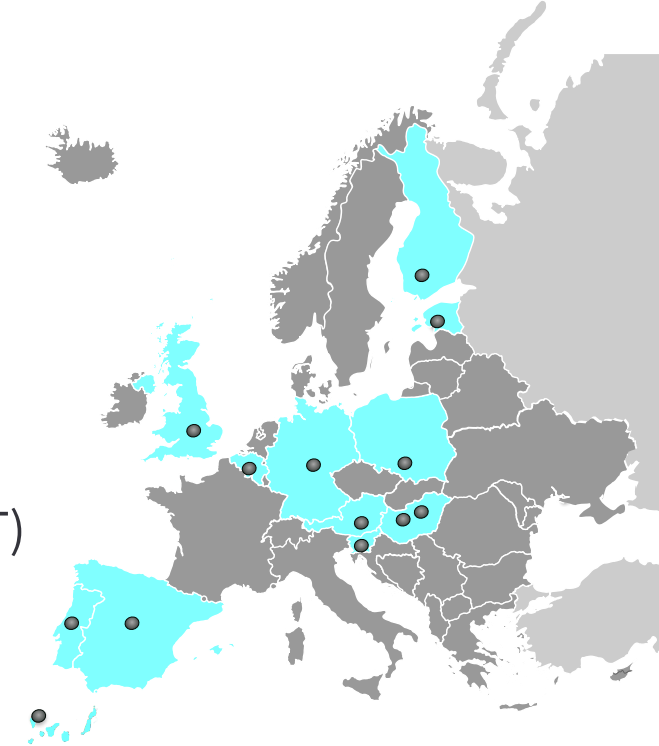
Claudio Rossi





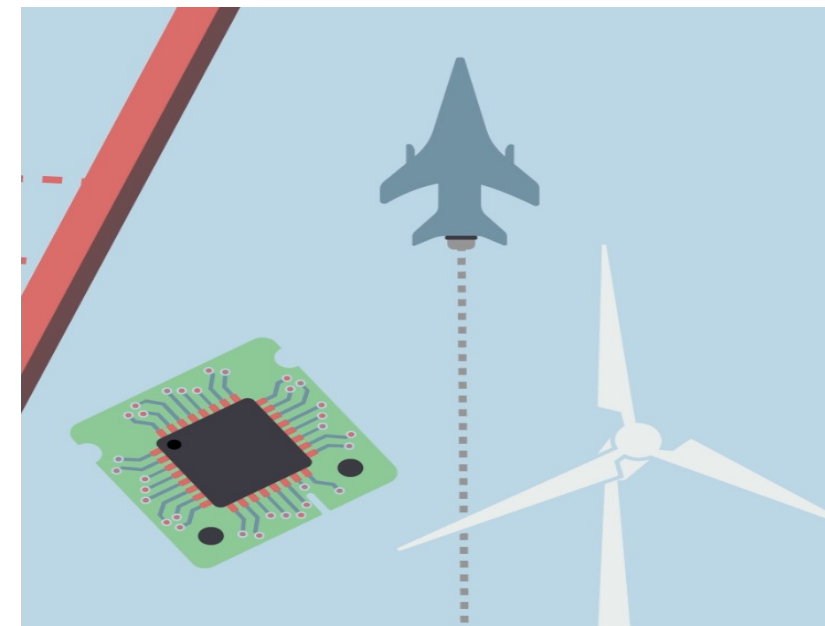
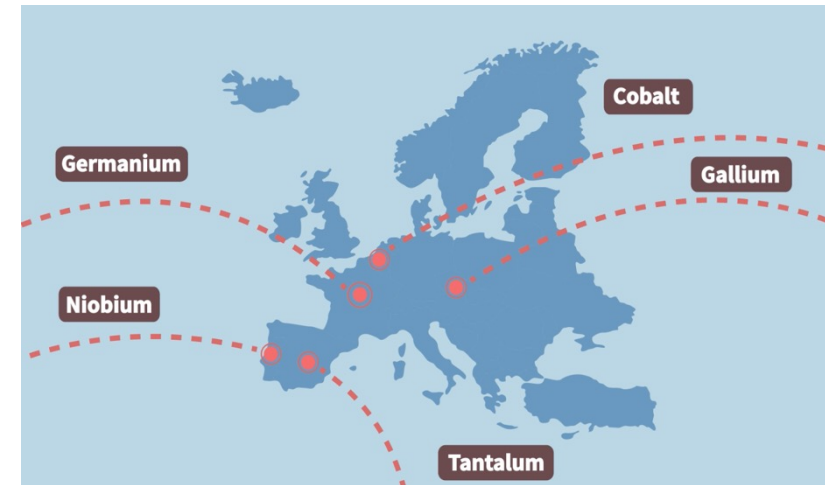
PROJECT' S QUICK FACTS

- *Project duration:* 54 months
- Project total cost/ EU contribution : 7,4 M€
- Coordinating entity: Universidad Politécnica de Madrid, Spain
- 14 partners (+18 LTPs), 11 European countries
 - Geo-scientific SMEs (LPRC, GEOM, KUTEC, RCI)
 - Academics covering both mining (UNIM, MUL) and robotics (UPM, TALL, TUT)
 - Non-governmental (ASSIM, EFG)
 - Governmental (GeoZS, RBINS, IGSMIE)
- Project web site: www.robominers.eu



INTRO

- The European Union is **largely dependent** on raw material imports
 - Minerals & metals in particular
 - Above 50% as a general average and up to 100% for a range of critical commodities.
- There is a **growing concern** towards the continuous and affordable supply of raw materials for industry and the need of finding new pathways for **domestic supply**
- **ROBOMINERS** presents a **solution** for reopening many of Europe's abandoned underground mines, without the need for a full recommissioning and in particular without the need for dewatering the mine.





- *Call Topic: “**New solutions for sustainable production of raw materials**”*
(SC5-09-2018-2019, RIA)

From the call’s text:



*...need for **very innovative and sustainable** raw materials production solutions (...) to **bring the next 'digital generation' to the raw materials field.***

ROBOMINERS high-tech vision aims at having a **transformational effect** on the mining industry: **mining as a high-tech industry**

ROBOMINERS also aims at tackling **sustainability**, as well as **social** and **environmental** issues



TARGETED MINES

- **Old abandoned mines.** Reopening Europe's abandoned underground mines, **without the need for a full recommissioning** and in particular **without the need for dewatering the mine.**
- **Small but high grade mineral deposits.** The proposed technology does not require the development of any mine infrastructure and even **very small deposits** can be mined.
- **Ultra depth.** Under this application scenario a large diameter borehole will be drilled from the surface to the **deep-seated** deposit.



Cornwall mineralised belt and ruins of the abandoned Botallack Mine, operating from the 1500s to 1895



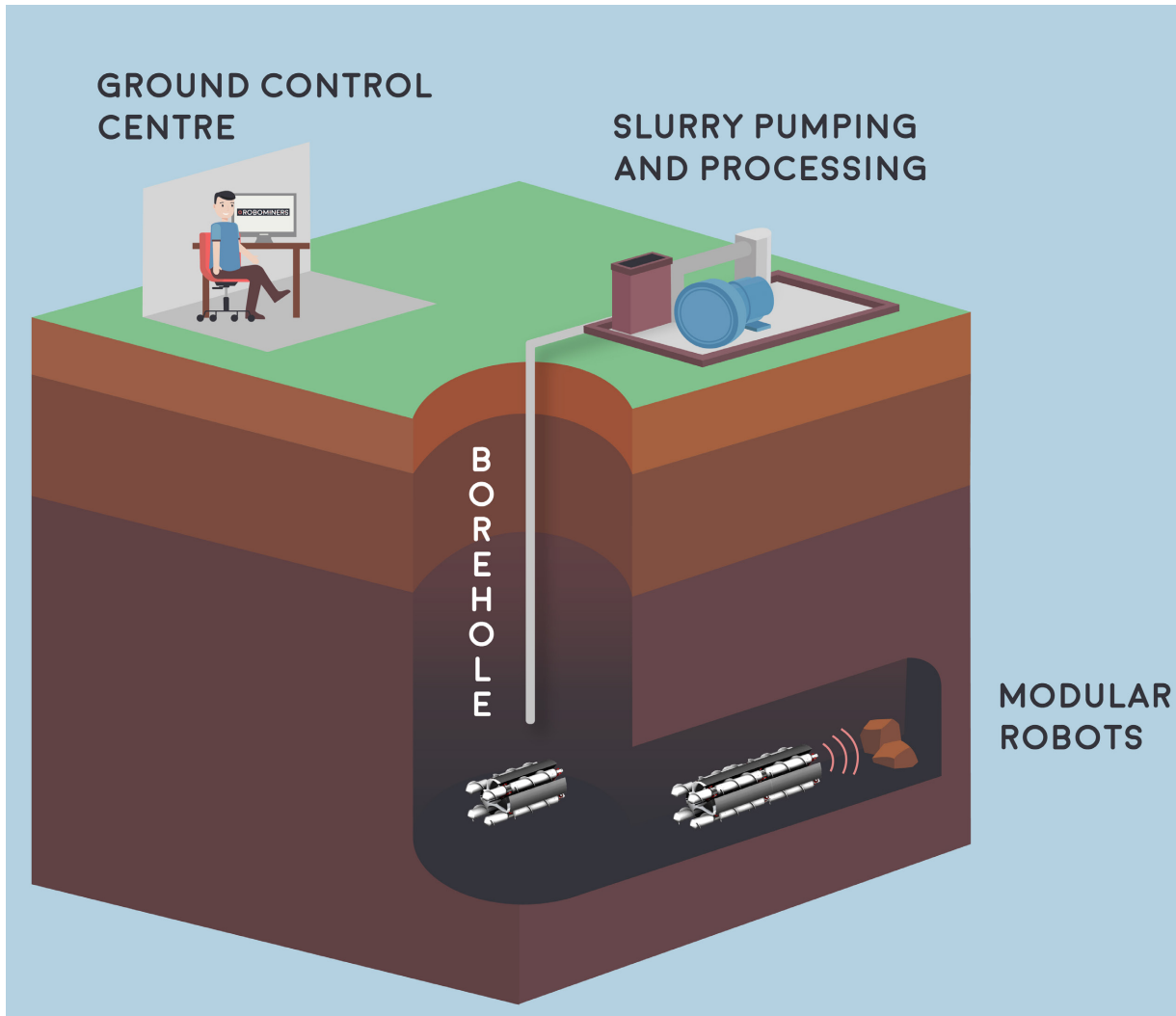
Kupferschiefer: thickness of **30 to 60 centimetres** and maximum **2 metres** Depth up to **1,580 metres***



Locations of the enrichments of rare earth elements in Europe.



CONCEPT



1. Robot parts (**modules**) are sent underground via a borehole
2. They **self-assemble** to form a fully functional robot
3. Using **specialised sensing devices**, they detect ore
4. Using **ad-hoc production tools**, they produce **slurry** that is pumped out
5. They can **re-configure** on-the-job



SPECIFIC OBJECTIVES



Construct a fully functional **modular robot miner prototype** capable of performing **selective mining**



Validate all **key functions** of the robot-miner to a level of TRL-4 (**lab**).



Design a **mining ecosystem** of expected future upstream/downstream raw materials processes via simulations, modelling and prototyping

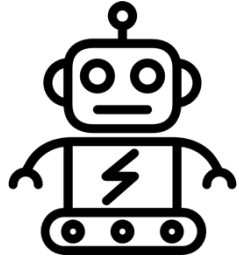


Study future research challenges on

- scalability, resilience, re-configurability, self-repair, collective behavior, operation in harsh environments,
- selective mining,
- production methods, as well as for the
- necessary converging technologies on an overall mining ecosystem level.

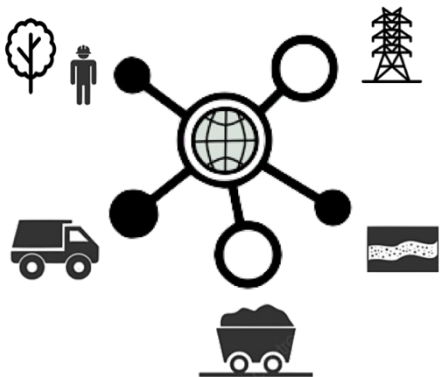
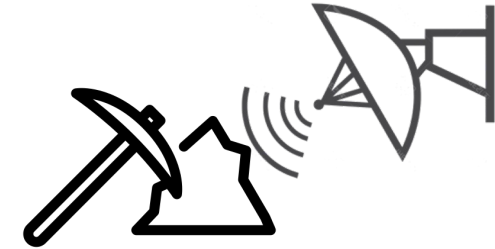


WORK TOPICS



ROBOTICS

SELECTIVE MINING

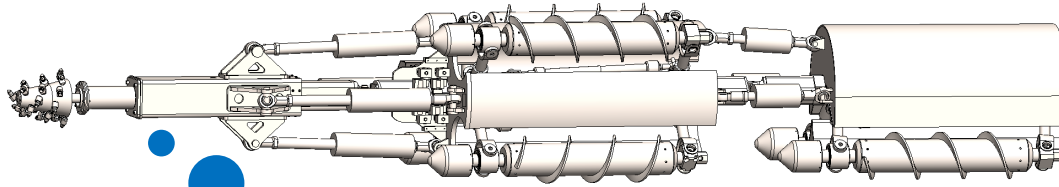


MINING ECOSYSTEM



WORK TOPICS: THE MINER

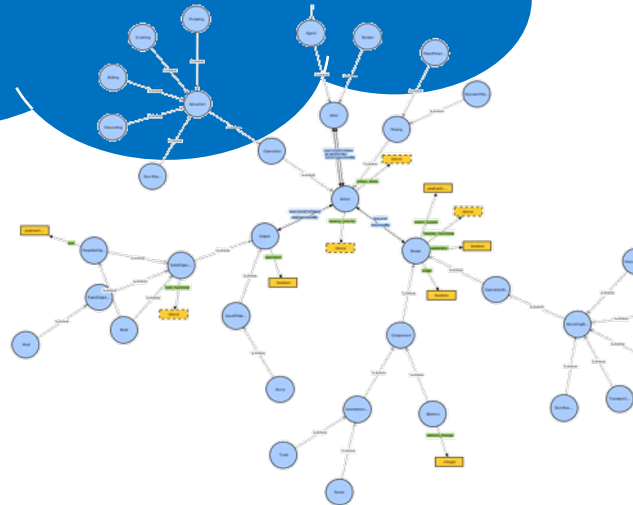
ROBOTICS



- Locomotion in different means
 - Autonomy and navigation
 - Self-assembly and reconfiguration
- Self-awareness



- Which is my mission?
- Which functionalities does it need?
- Which capabilities do I have?
- How can I change my configuration and/or objectives to fulfil my mission ?



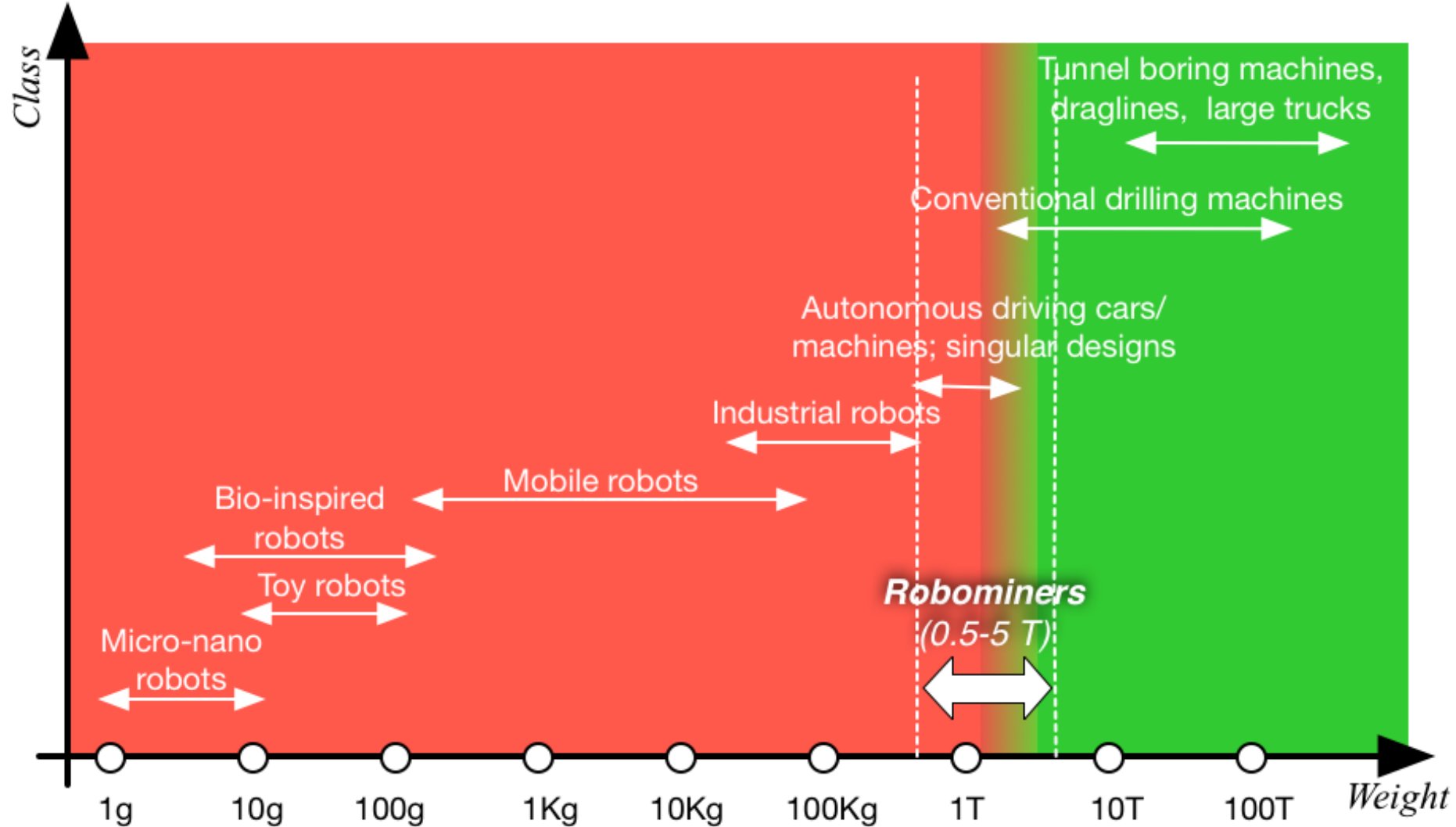
```
Initialization OK
New WARN status received, checking metrics
Capability app_attach.cap_extract underachieved,
  searching for alternatives
No alternative object found in Capability category
Searching for alternatives in other categories
Component app_attach.rm2_sim AVAILABLE
REQUIRES app_attach.rm2_attachable to be equivalent
Creating new morphism from relation in other category

New Configuration requested: [app_attach.rm2_sim,
  app_attach.rm2_attachable] of type ROS 2 NODE
-----Reconfiguration successful-----
Executing attach action
Action succeeded!
-----RESUMING TO MINING TASK-----
```



WORK TOPICS::THE MINER

- **Big robot, small mining machine**



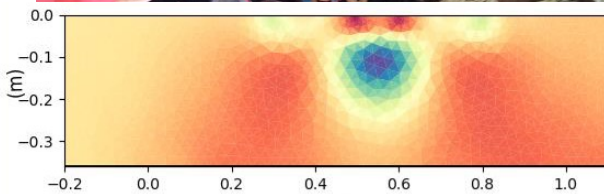


WORK TOPICS::SELECTIVE MINING

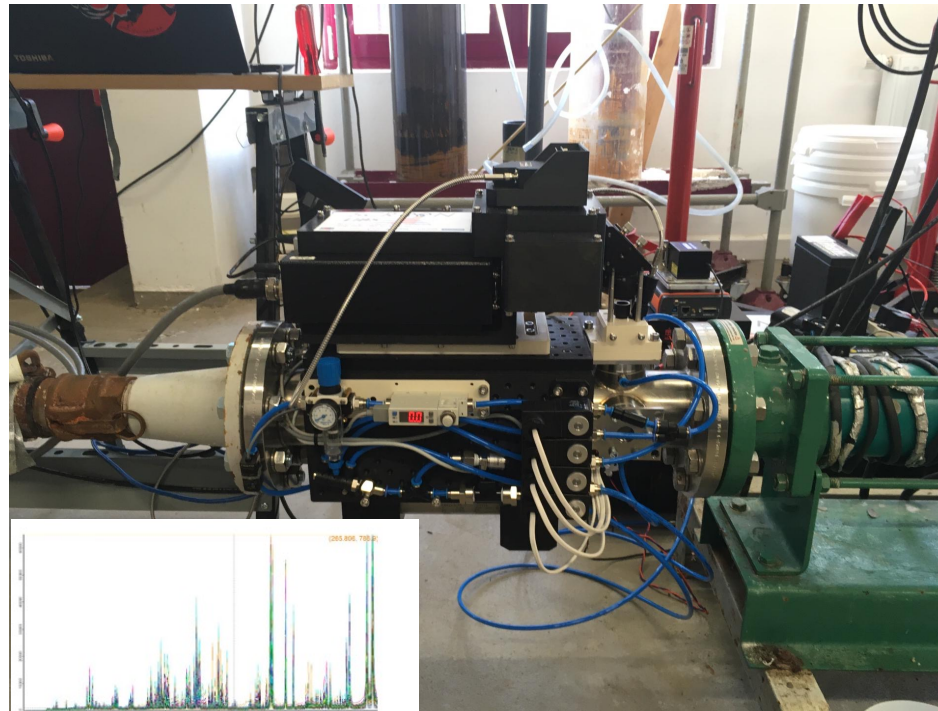
SELECTIVE MINING

- Perception devices (sensors)
- Production tools

Mid-range geophysical sensors



Mineralogical sensors and in-stream elemental and molecular analysis



Ad-hoc production tools

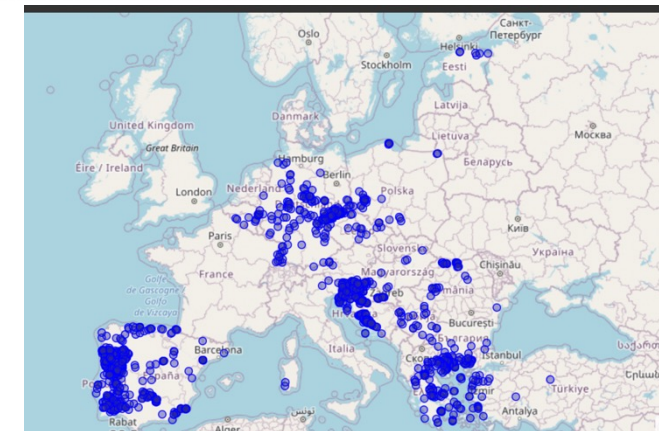
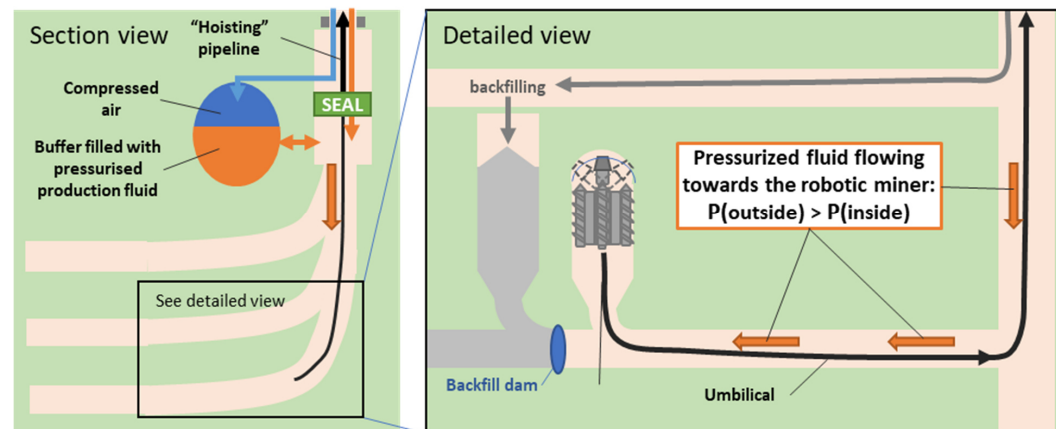
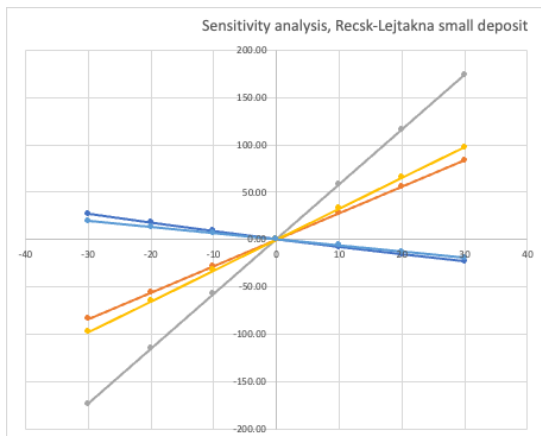
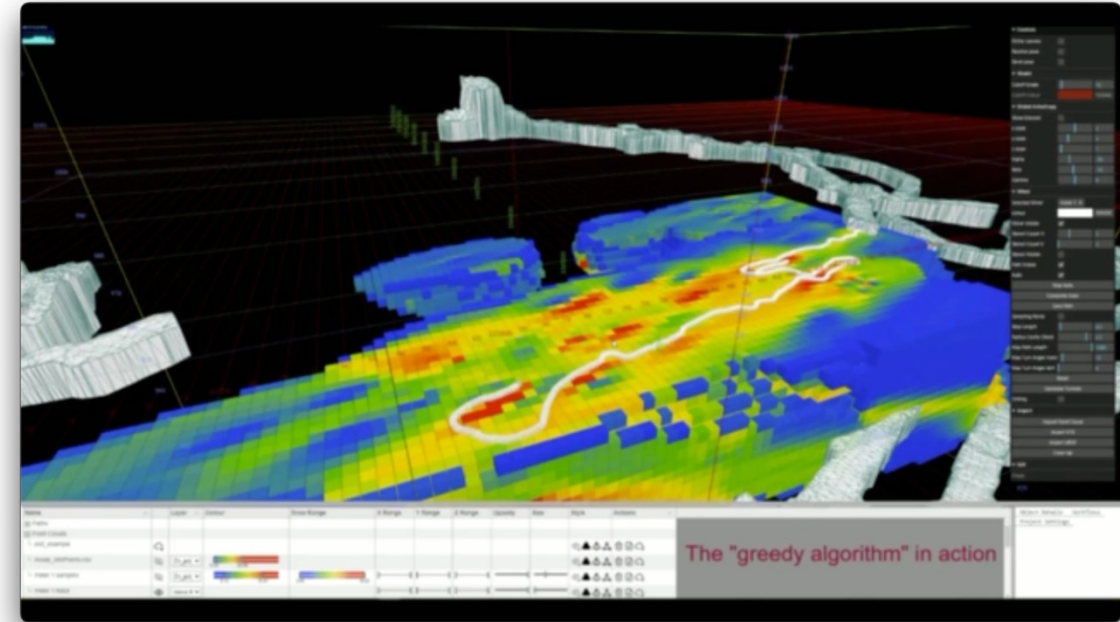




WORK TOPICS::ECOSYSTEM

MINING ECOSYSTEM

- Mining ecosystem
- Mine design and mining strategy
- Geological modeling / data management
- Micro-Macro economic studies
- Inventory of relevant deposits



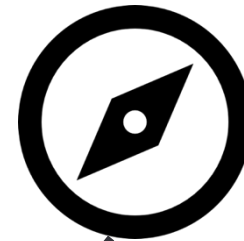


IMPACT

Potential to be adapted to **extra-terrestrial** environments and ocean bottom



Open **new exploitation scenarios** for Europe's domestic mineral resources



Increasing **domestic supply of raw materials**, especially for Critical Raw Materials



Supporting the transformation of mining into a **high-tech digital industry**



ROBO MINERS

Enabling **small-scale** and **artisanal mining**



Environmental benefits: no dewatering needs, no humans in the mine, less waste, reduction of groundworks on surface





**ROBO
MINERS**

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THANK YOU !



www.robominers.eu



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