ROBOMINERS

ROBOMINERS

Resilient Bio-inspired Modular Robotic Miners

Claudio Rossi

UNEXMI final conference, Brussels, Sept. 26th, 2019

UNEXMIN project has received funding from the European Union's Horizon H2020 research and innovation programme under grant agreement No 690008

ROBOMINERS project has received funding from the European Union's Horizon H2020 research and innovation programme under grant agreement No °820971

The Centre for Automation and Robotics

Universidad Politécnica de Madrid

POLITÉCNICA

Automation and Robotics division (AKA DISAM)

The Spanish National Research Council

CSIC

Industrial Automation Institute (IAI)

CAR

CENTRE FOR AUTOMATION AND ROBOTICS

Est. 2009

Inert unnecessarily complex organization here

aslab

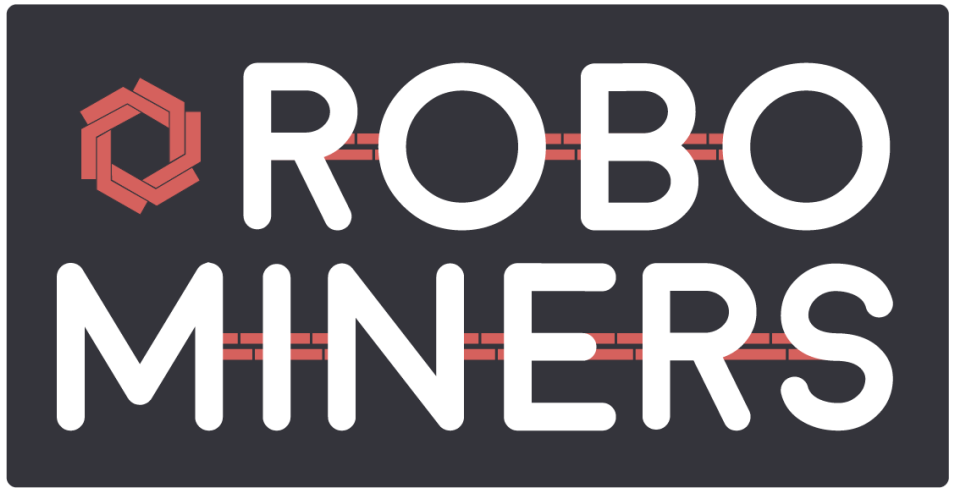
bio-inspired systems lab

CAR

CENTRE FOR AUTOMATION AND ROBOTICS

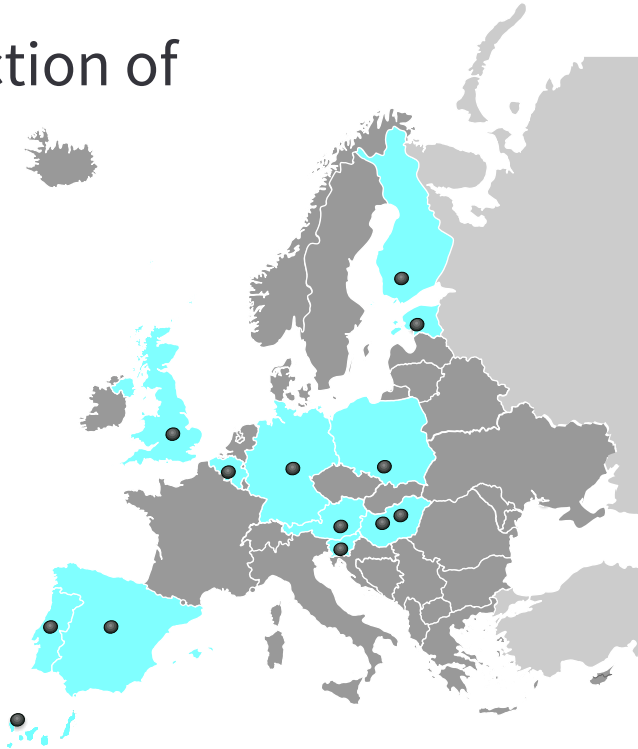
Staff: 140 (approx)

- 30 permanent researchers
- ≈ 90 researchers: PhD candidates, PostDocs and Visitants
- 10 technical assistants and 10 admin assistants


ROBO
MINERS

Project's quick facts

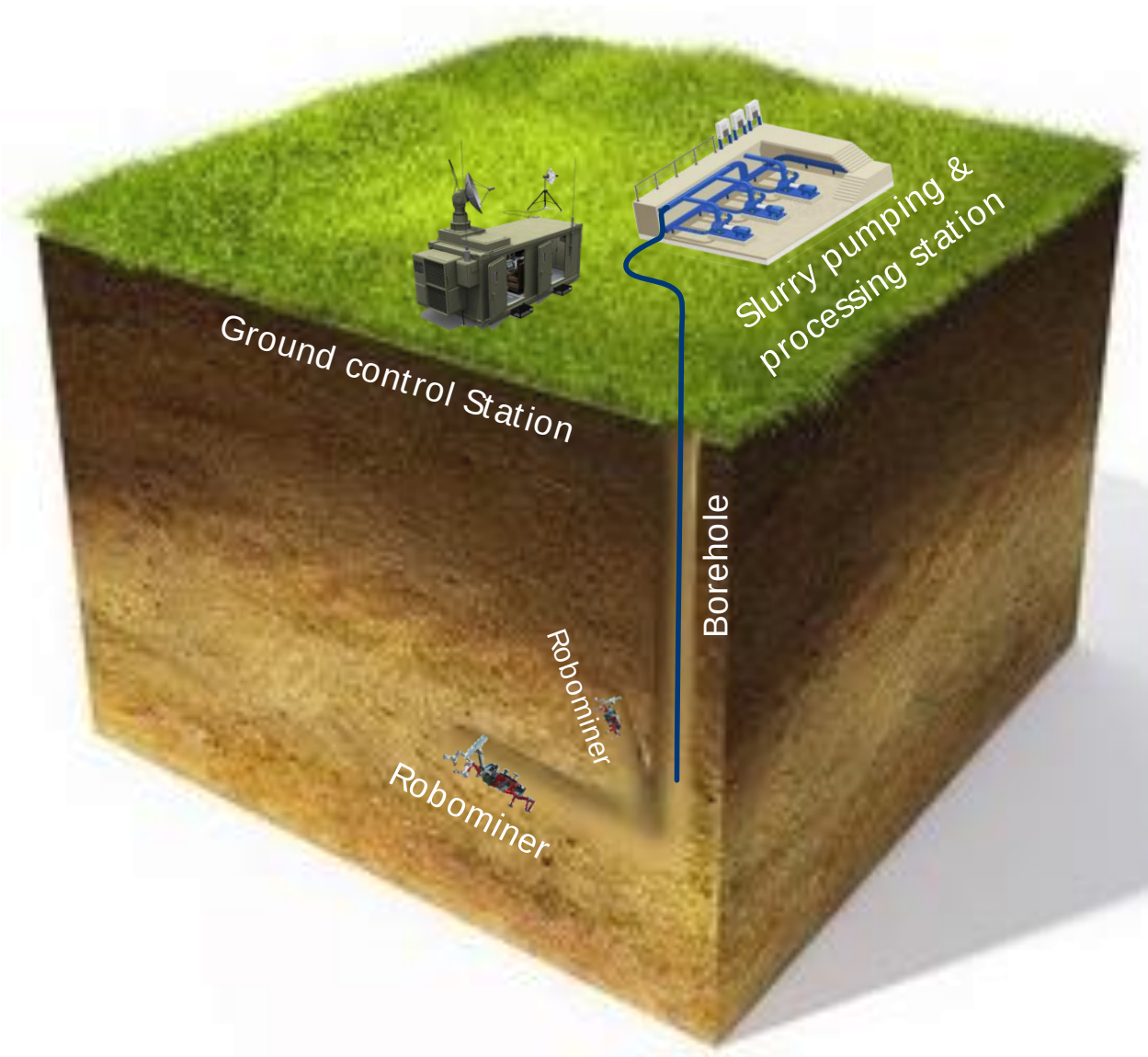
- *Call Topic:* SC5-09-2018-2019 "New solutions for sustainable production of raw materials" (RIA)
- *Project duration:* 48 months
- Project total cost/ EU contribution : 7,4 M€
- Coordinating entity: Universidad Politécnica de Madrid
- Country: Spain
- Project web site: *www.robominers.eu*
- 14 partners, 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)



Objective

- To develop a **bio-inspired**, **modular** and **reconfigurable** robot-miner
- For **small** and **difficult to access** deposits
- Equipped with **selective mining** perception and mining tools
- That can be **delivered in modules** to the deposit via a large diameter borehole
- Mining underground, underwater in a flooded environment.

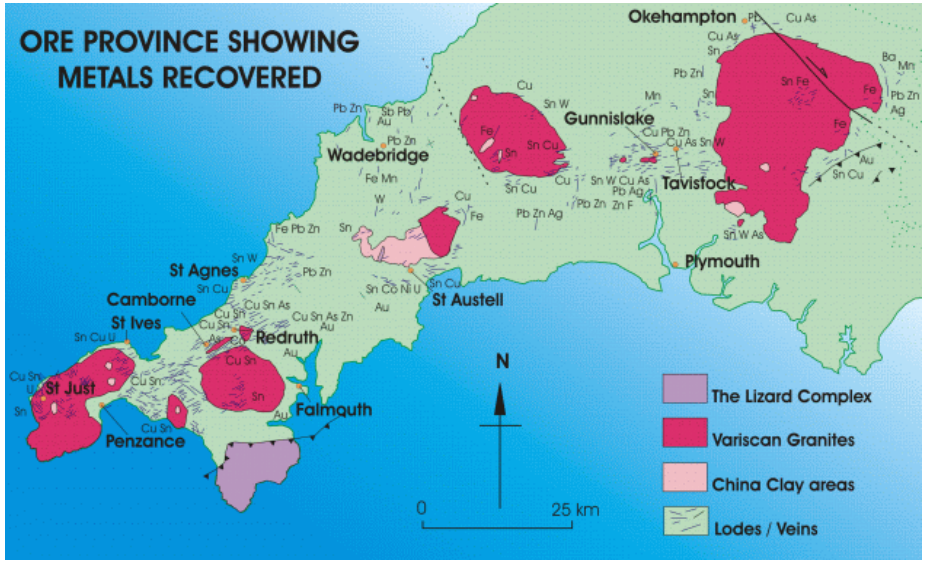
Concept



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

Targeted mines

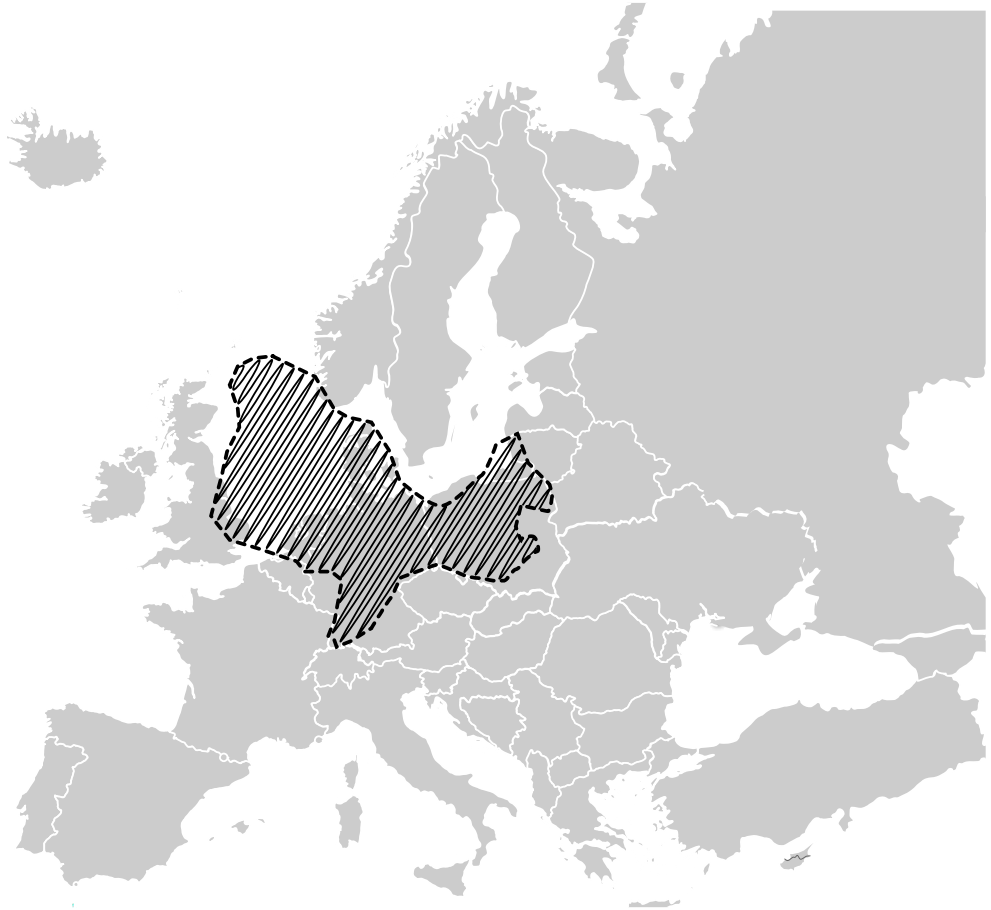
- **Abandoned mines.** ROBOMINERS presents a solution for reopening many of Europe's abandoned underground mines, **without the need for a full recommissioning and in particular without the need for dewatering the mine**.



Left: Metals mined from the Cornwall mineralised belt. Right: Ruins of the abandoned Botallack Mine in Cornwall. Operating from the 1500s to 1895, Botallack was once one of the greatest copper and tin mines in England

Targeted mines

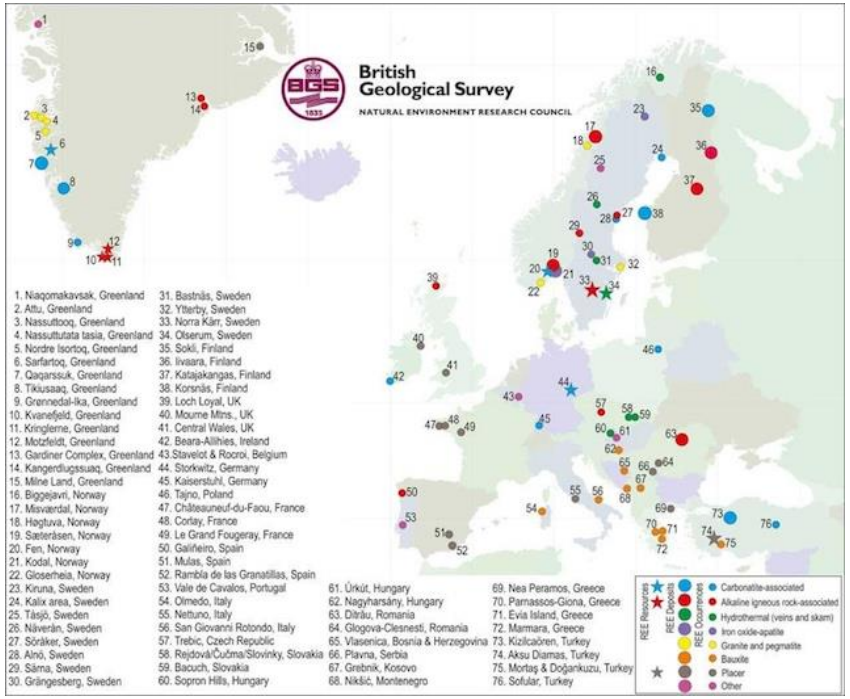
- **Ultra depth.** *Under this application scenario a large diameter borehole will be drilled from the surface to the deep-seated deposit.*



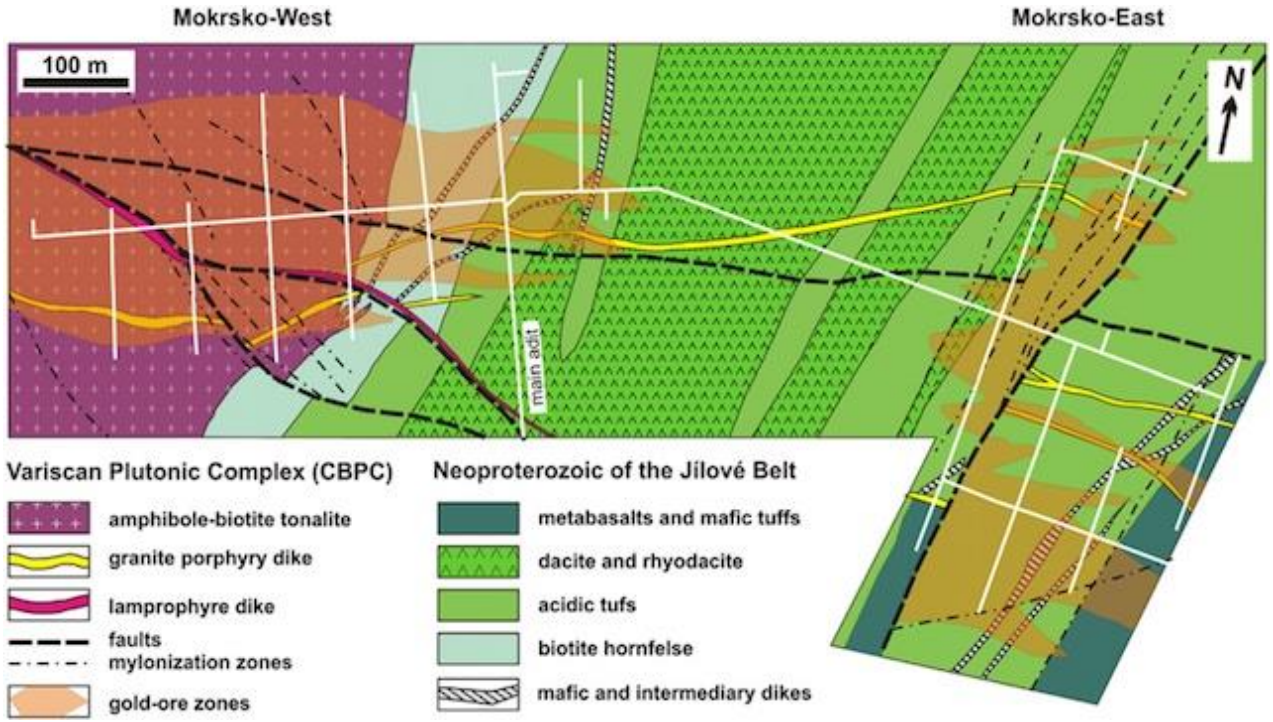
Extension of the Kupferschiefer Formation

Targeted mines

- **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.*



Locations of the enrichments of rare earth elements in Europe.



Geological map of the Mokrsko-West and Mokrsko-East deposits (horizontal section at ca. 300 m a.s.l.)

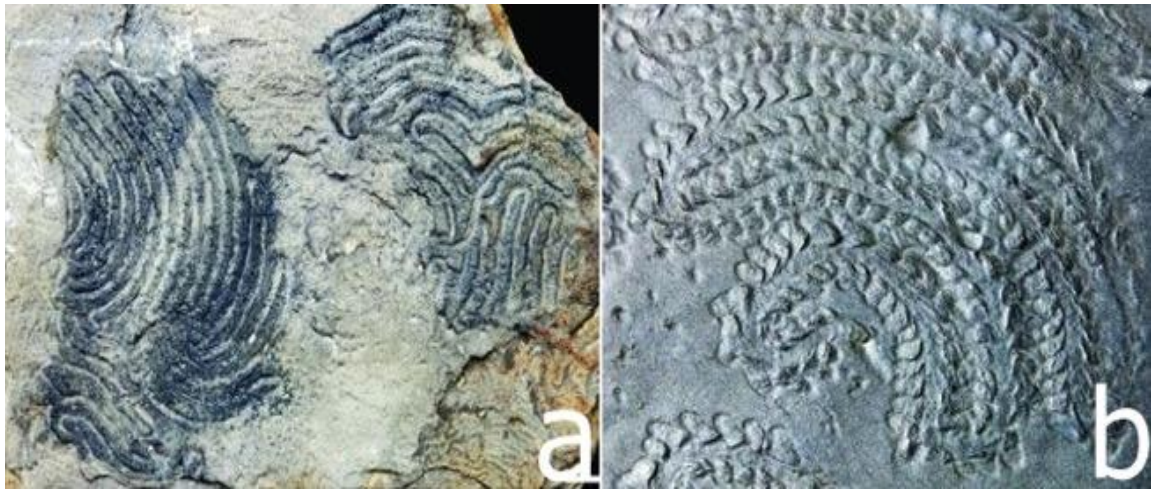
Specific objectives

- 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.
- Design a mining ecosystem of expected future upstream/downstream raw materials processes via simulations, modelling and virtual prototyping
- Use the prototypes to study and advance 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.

The miner

- **Bio-inspired**, **modular** and **reconfigurable**

Inspired on insects and burrowing animals



2D and 3D feeding patterns as shown by trace fossils.

The miner

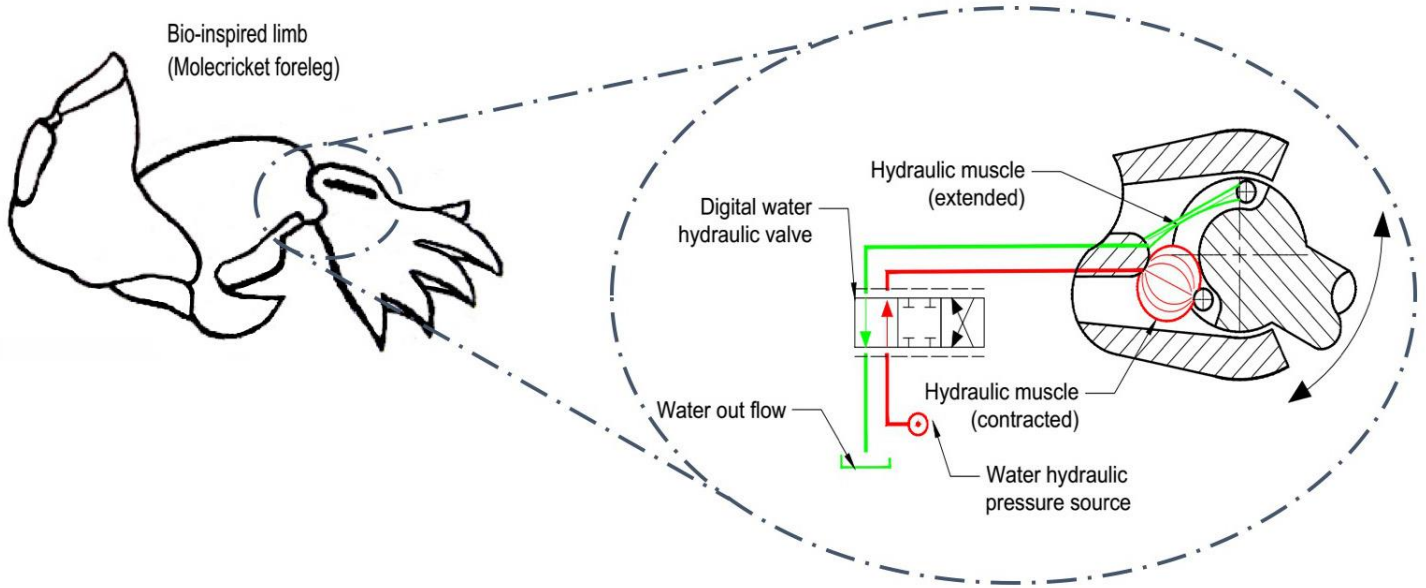
- **Bio-inspired**, **modular** and **reconfigurable**

The miner

- **Bio-inspired**, **modular** and **reconfigurable**

Tech specs:

- 0.5-1 ton
- 20-30 kW
- Hydraulic
- Tethered



COTS artificial muscles

The miner

- **Bio-inspired**, **modular** and **reconfigurable**

Modular robotic platform.

Each leg is a completely autonomous robot, equipped with CPU, batteries and comms.

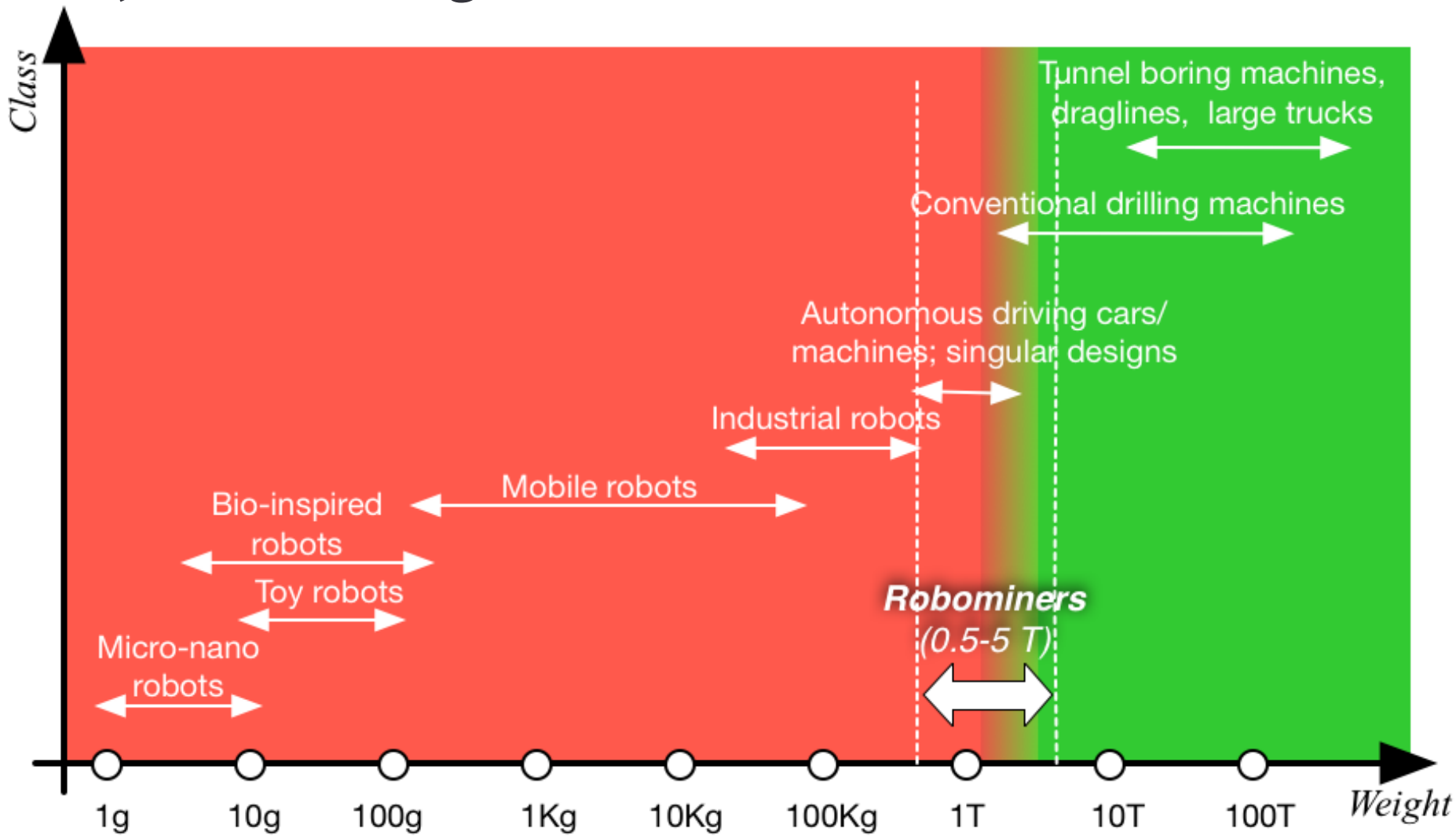
The end-effector is changeable.

Used to validate the concepts that are being discussed in Robominers.

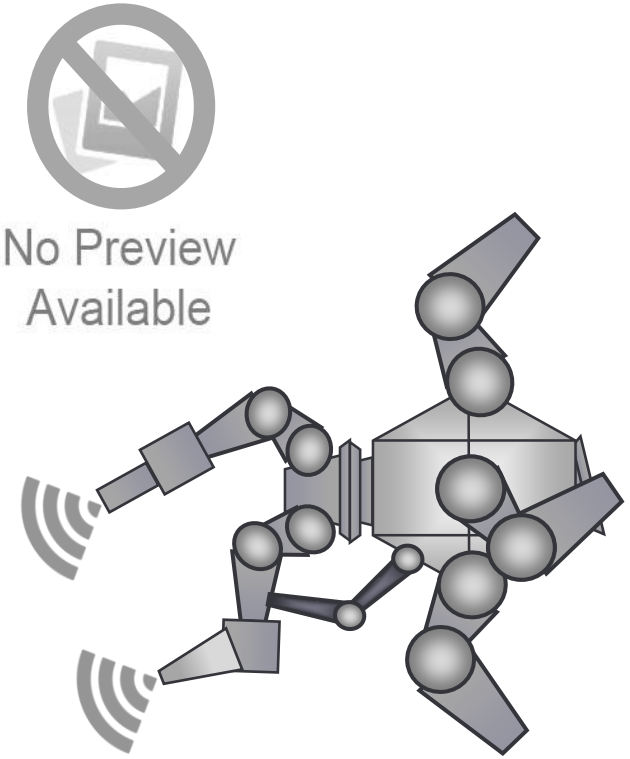
(Source: M. Hernando, UPM)

The miner

- **Big robot, small mining machine**



Selective mining/1: sensing



Instrumentation strategies for **in-stream** elemental analysis:

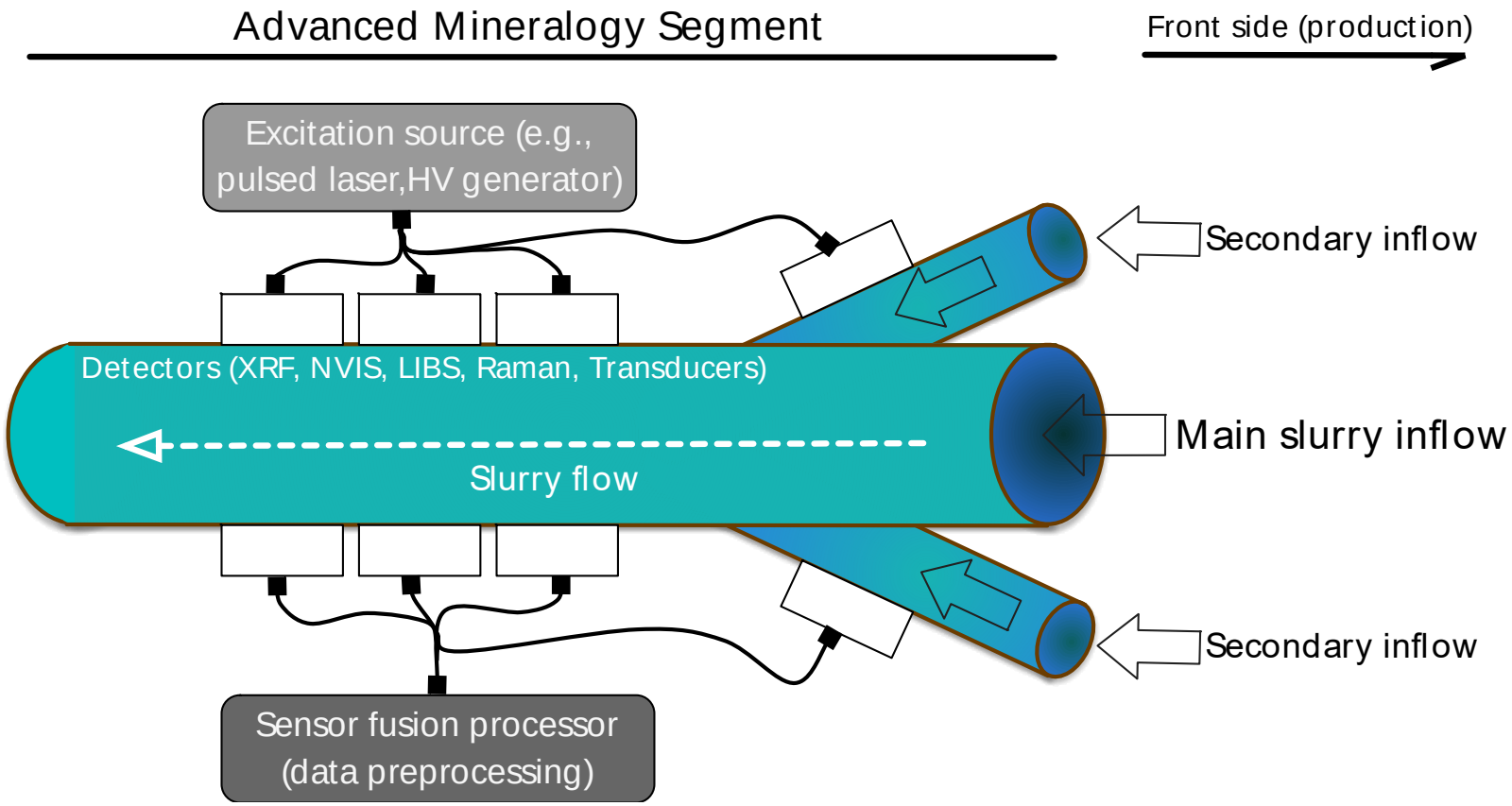
- high sensitivity solid state XRF spectrometer / LIBS spectrometer and Gamma-Ray spectrometer.

Instrumentation strategies for **in-stream** molecular analysis:

- Optical UV-VIR-NIR techniques, including Resonance UV Raman spectroscopy, time resolved VIS Raman spectroscopy, NIR absorption spectroscopy and LINF spectroscopy.

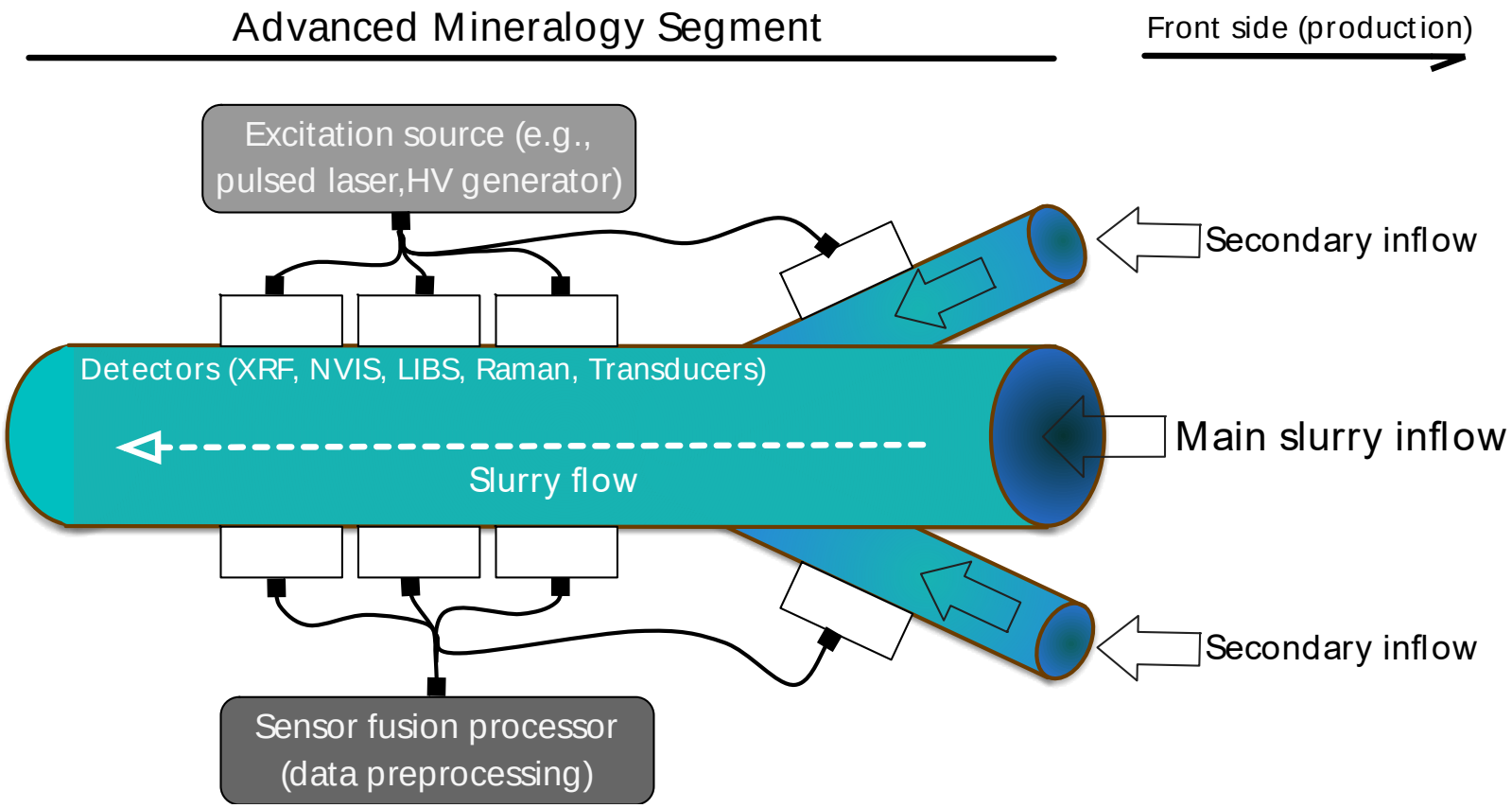
Selective mining/1: sensing

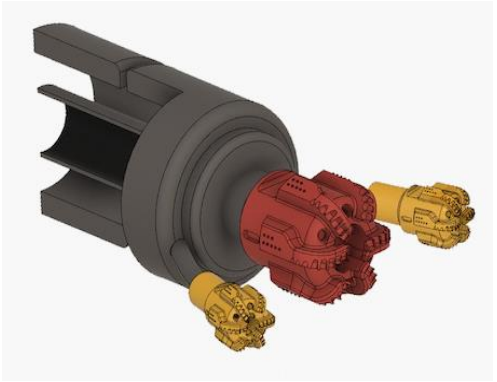
- **“Digestive” mineralogy**



Selective mining/1: sensing

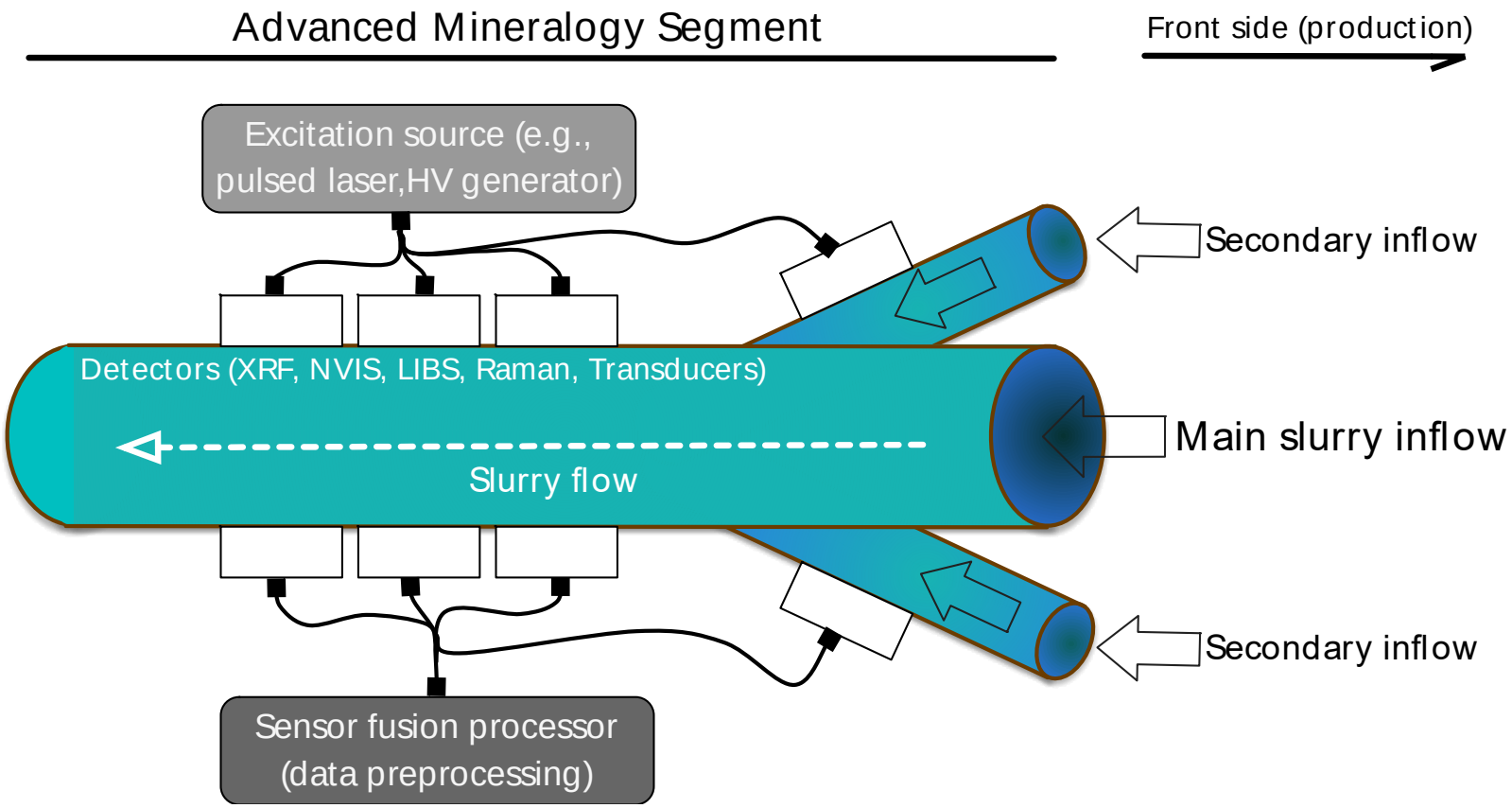
- **“Digestive” mineralogy**



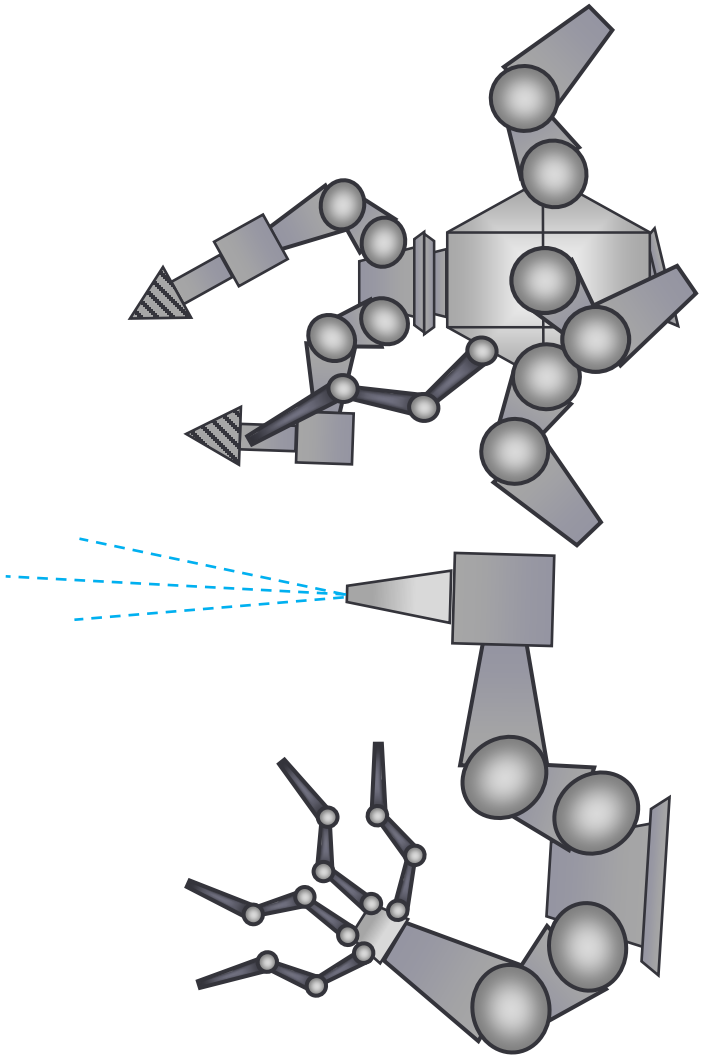


Selective mining/1: sensing

- **“Digestive” mineralogy**



Selective mining/2: production



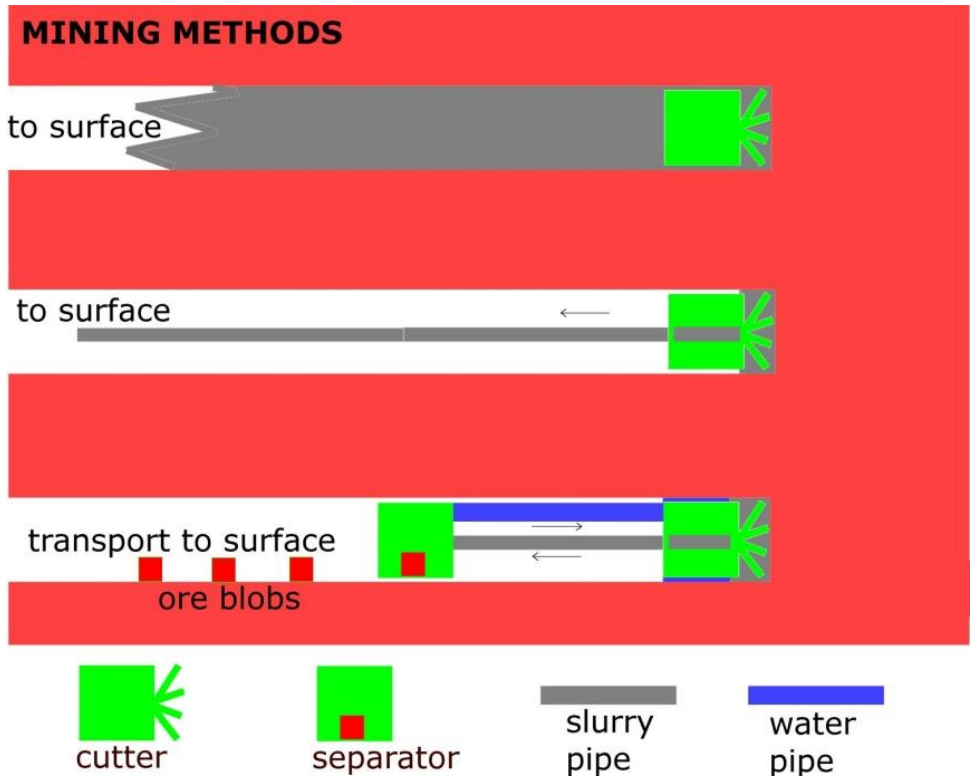
Production tools

- Tricone drill bit
- Hydrodemolition
- Cavitation
- Micro-blasting?

No Preview Available

Mining ecosystem

- Need of a **new approach to mining strategy and mine design**
- Studying and simulating the various systems components in future mining scenarios
- Creating a **simulated environment for the entire mining operation,** considering
  - drilling methods
  - mineral exploration
  - minerals processing and transport options
  - power supply scenarios
  - mine design and mine geometry
- Micro and macroeconomics studies



Simple SIMIO simulation, by RCI

Vision


ROBOMINERS
2030 vision
2050 vison
ROBOTICS
Demonstrator for modularity, self-assembly, perception and navigation, resilience in extreme underground environments
First industrial pilot, tethered, semi-autonomous operation
Full autonomy, self-reconfigurability, self-awareness collective robotics.
SELECTIVE MINING
New mineral perception, detection and classification, as well as new production tools, demonstrated to TRL 4/5
First industrial pilot application
Autonomous mining
MINING ECOSYSTEM
Study of a mining ecosystem of downstream and upstream processes, Identify research challenges for logistics, environment, mineral processing, borehole drilling technology, dredging & pumping
First industrial application in a "small deposit scenario" or "abandoned mine scenario" with on-site minerals processing and paste refilling
Industrial applications in "ultra-depth" scenarios
Small mines deliver a considerable share of the EU's critical minerals production
SUSTAINABILITY ASSESSMENT
Financial viability assessment, sustainability, environmental and ethical considerations
esearch roadmap for development of supporting technologies
Simplified permitting procedures for small-scale mining
upporting policy and legal framework for small-scale mining.
New innovation ecosystem: SMEs and entrepreneurs are working towards further miniaturisation and versatility

Thank you !