EGU General Assembly 2022

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The ROBOMINERS mineralogical sensors: spectrometer prototypes for autonomous in-stream, in-slurry geochemical diagnostics.

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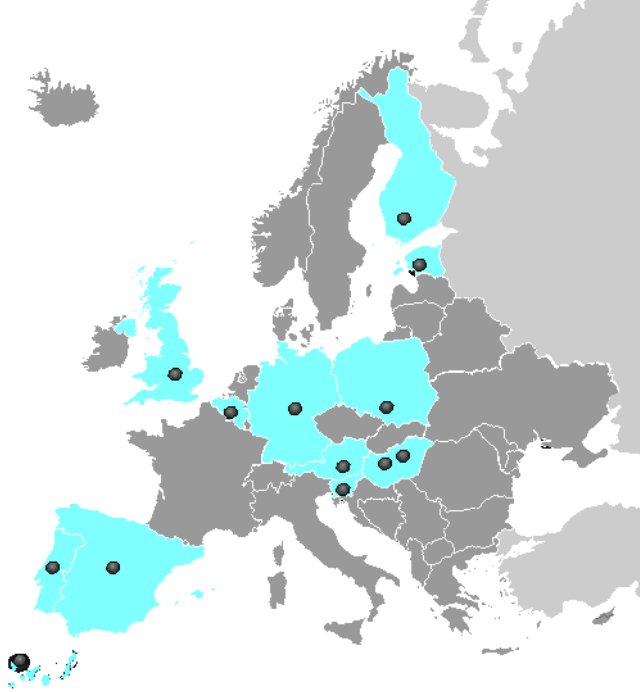
ROBOMINERS

museum

125 years since 1896 Geological Survey of Belgium

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 820971.

ROBOMINERS



2019-2023 H2020 project :

robot miner prototype following a bio-inspired design, capable of operating, navigating and performing selective mining in a flooded underground environment

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

Objective :

TRL 3-4-5

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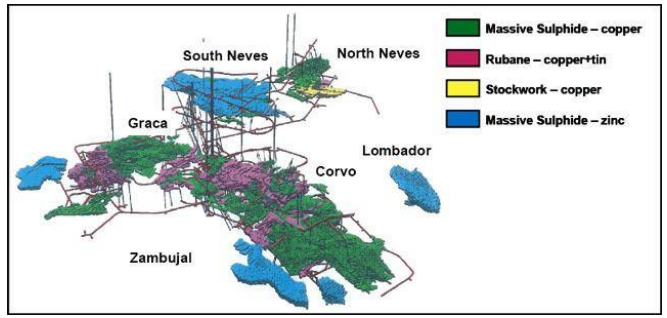
Targets

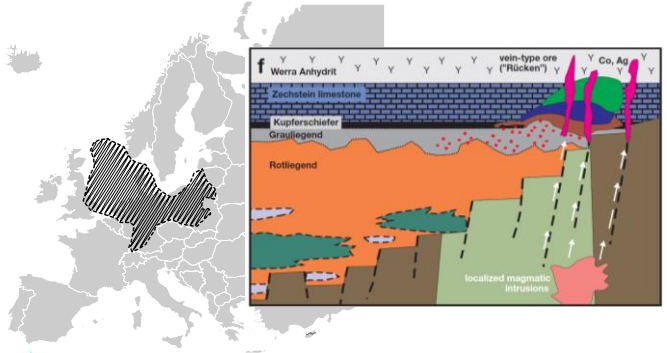
Operating and abandoned mines
with known remaining unfeasible resources



From Lundin Mining, Neves-Corvo Zinc Expansion Study 2017

No need for full recommissioning or dewatering of the mine.

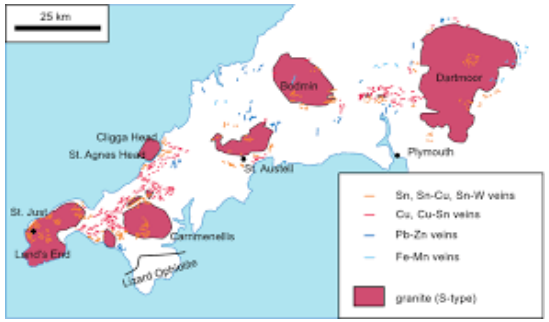
Ultra-depth deposits



Extension and proposed metallogenic model for the Kupferschiefer ores with two late epigenetic stages being responsible for the economic orebodies. From Borg et al 2012

No need for development of any mine infrastructure and even very small deposits can be mined.

Small but high-grade mineral deposits



Hydrothermal deposit in Cronwall. From Neukirchen and Ries (2020)

A large diameter borehole will be drilled from the surface to the deep-seated deposit.

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Mining robot?

Julius robot – Innok Robotics

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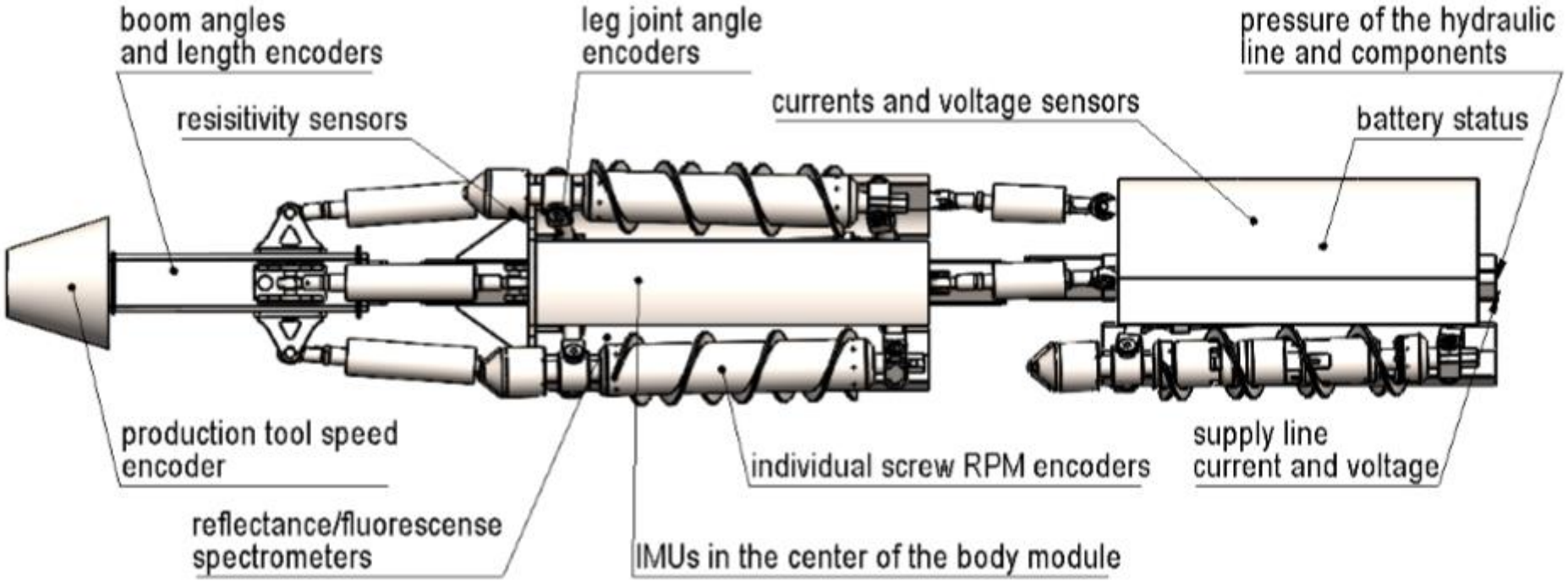
The RM1 prototype : mining capacity (leader Tampere univerisity, Finland)



0.5-1 ton	0.8-1 m Ø	hydraulic	tethered

- Articulated screw propulsion with four screw units
- High traction

- Reliability and survivability
- Modular
  Independent robotic modules
  2 modules = 1 miner

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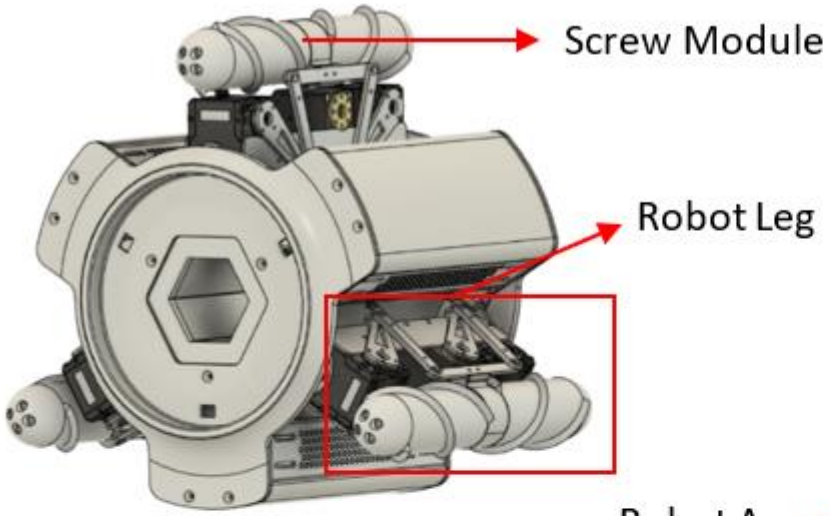
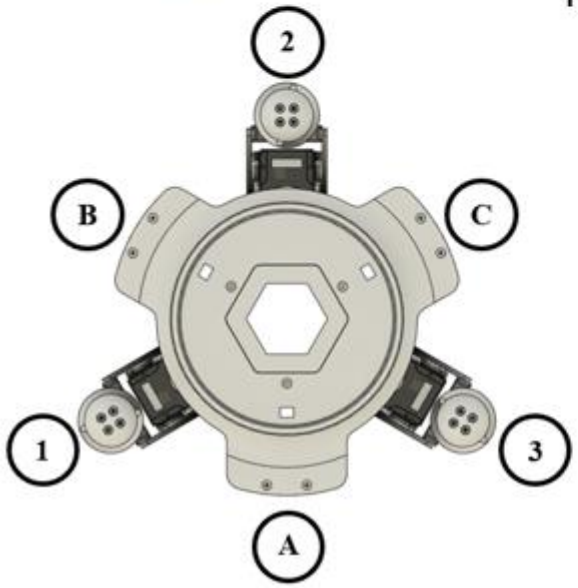
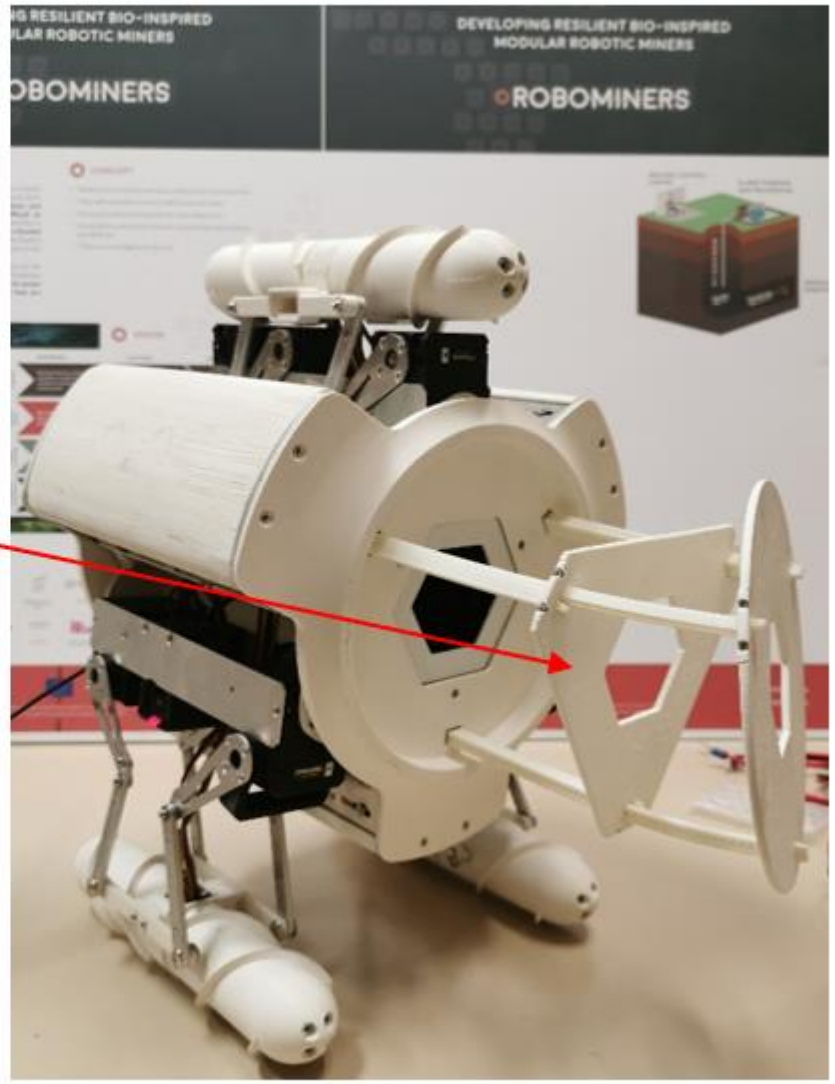
The RM2 prototype : Reconfigurability (Leader : UPM Madrid)



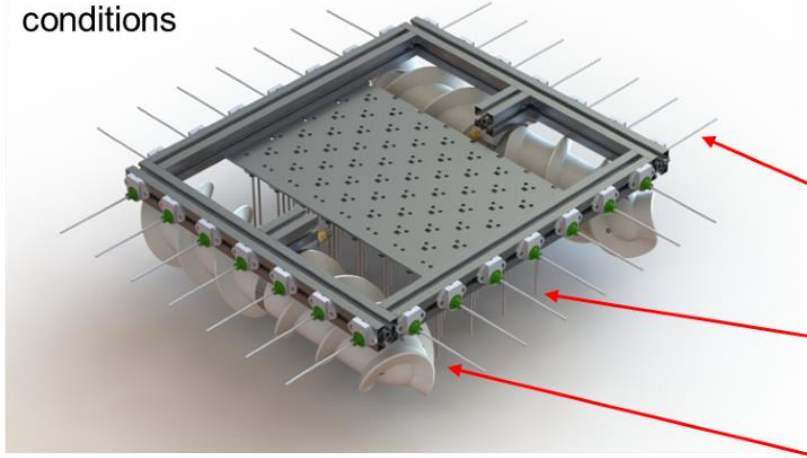


Robot Arm

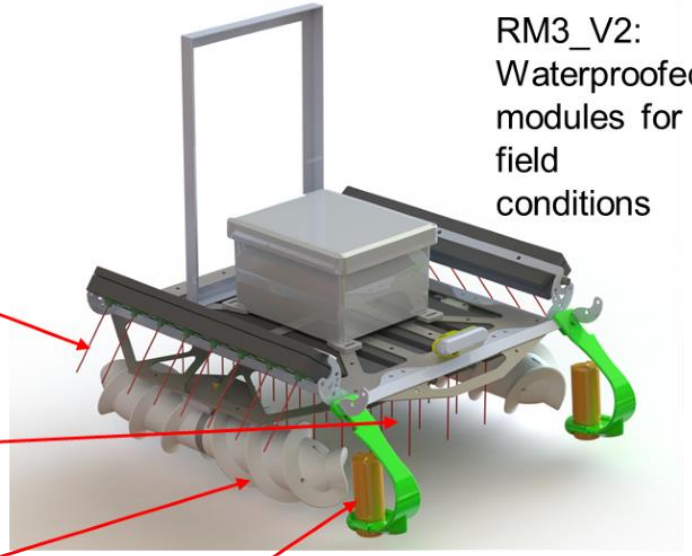


The RM3 prototype : localisation and mapping (leader : Taltech, Tallinn)

RM3_V1:
For testing in lab conditions



RM3_V2:
Waterproofed modules for field conditions

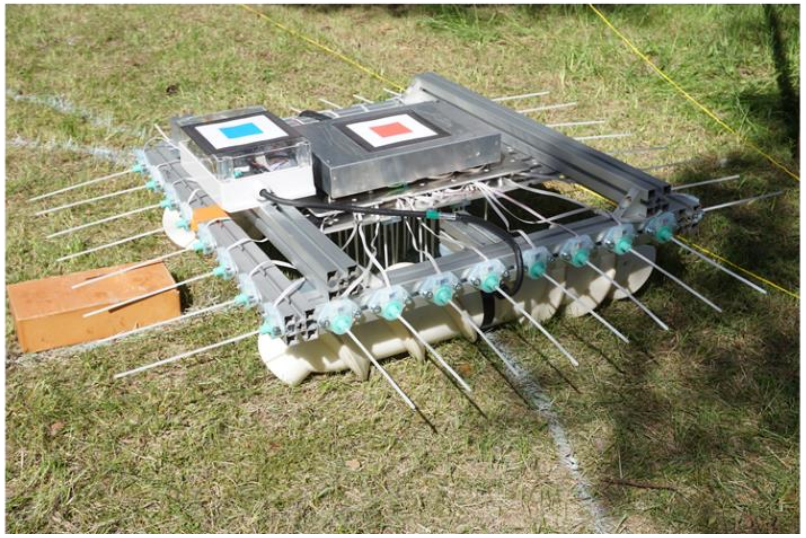


side whiskers

bottom whiskers

screw modules

color spectrometry sensors



Miner geological sensing abilities

- **Clear water, rock face visible** (free air gallery, use of inflatable packers, washing with clear water)
- Drilling with no fluild, low pressure
- **Good ore/host rock contrast**
- Regular wall surface (easily scannable with contact instrument
- **Mined rock easily transported** via belt system

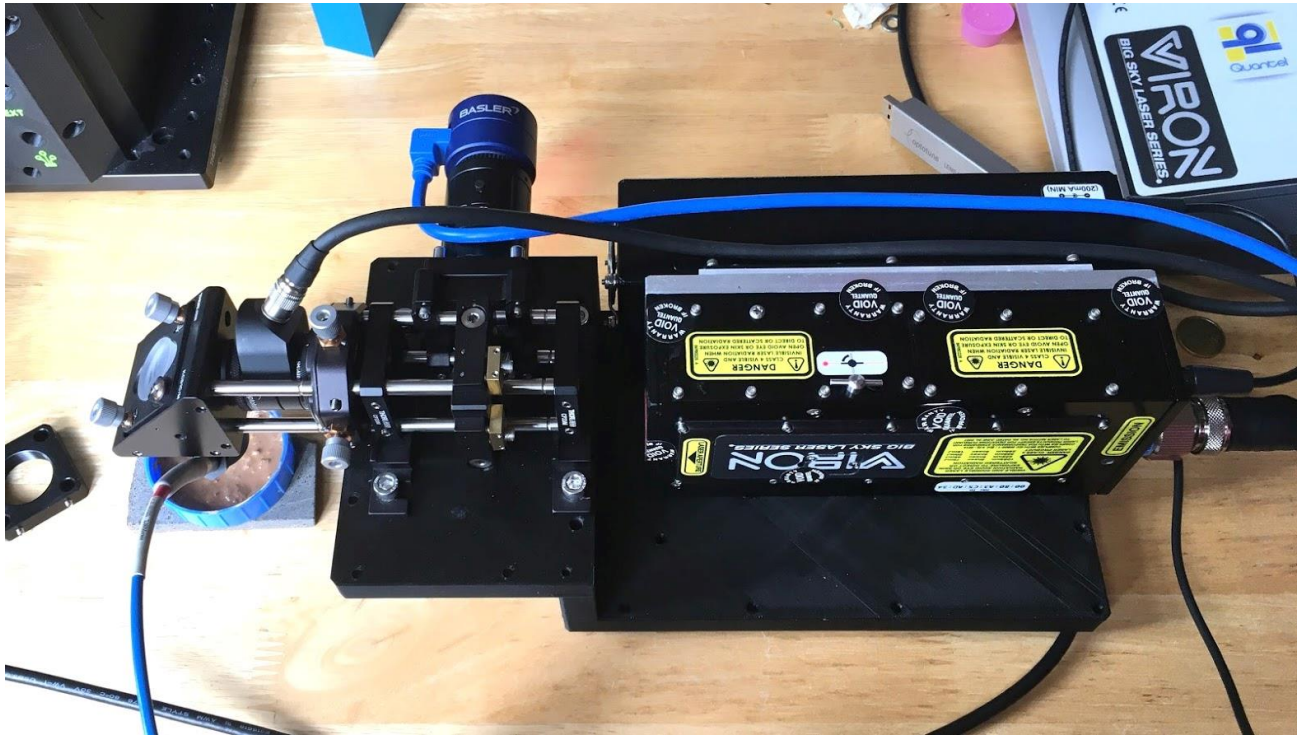
- **opaque medium** (slurry or heavy dust) directly in contact with he miner surface
- physical access to the rock surface difficult
- **Complex ore** (always mixed, trace elements,…)
- transport pipe with opaque, thick material
- **High pressure, debris and abrasive material**
- **Complex slurry** (additives, settling effect)

- Miner "Geosteering" using logging-while-drilling -> derived from petroleum industry
- "Digestive mineralogy" : in-stream real-time mined material characterization. -> bio-inspiration
- Data fusion with localization sensors (ex: "whiskers") and production tool sensors (ex: torque sensor)

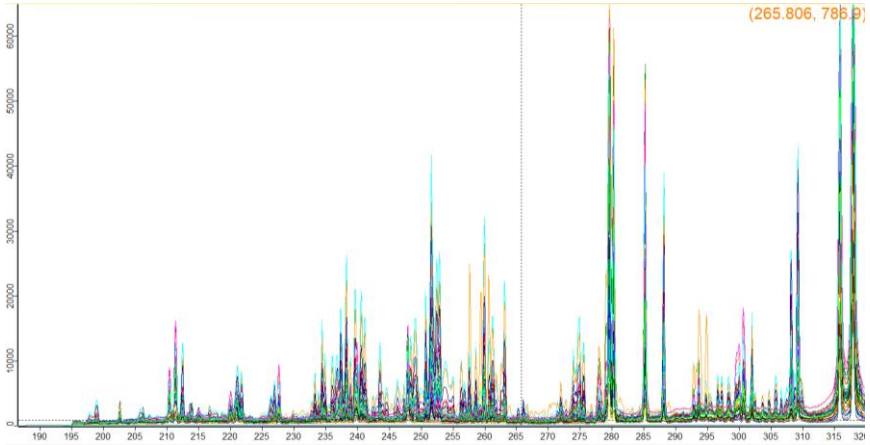
Slurry LIBS spectrometer

- TRL-3 to TRL-4 demonstration of minerals analytics and perception abilities reproducing the Miner's expected working conditions.
- Analog simulations on slurries **+ analog simulations of geophysical perception scenarios**

->Inspired by N. Khajehzadeh,et al. 2017



Slurry LIBS spectrometer scale model



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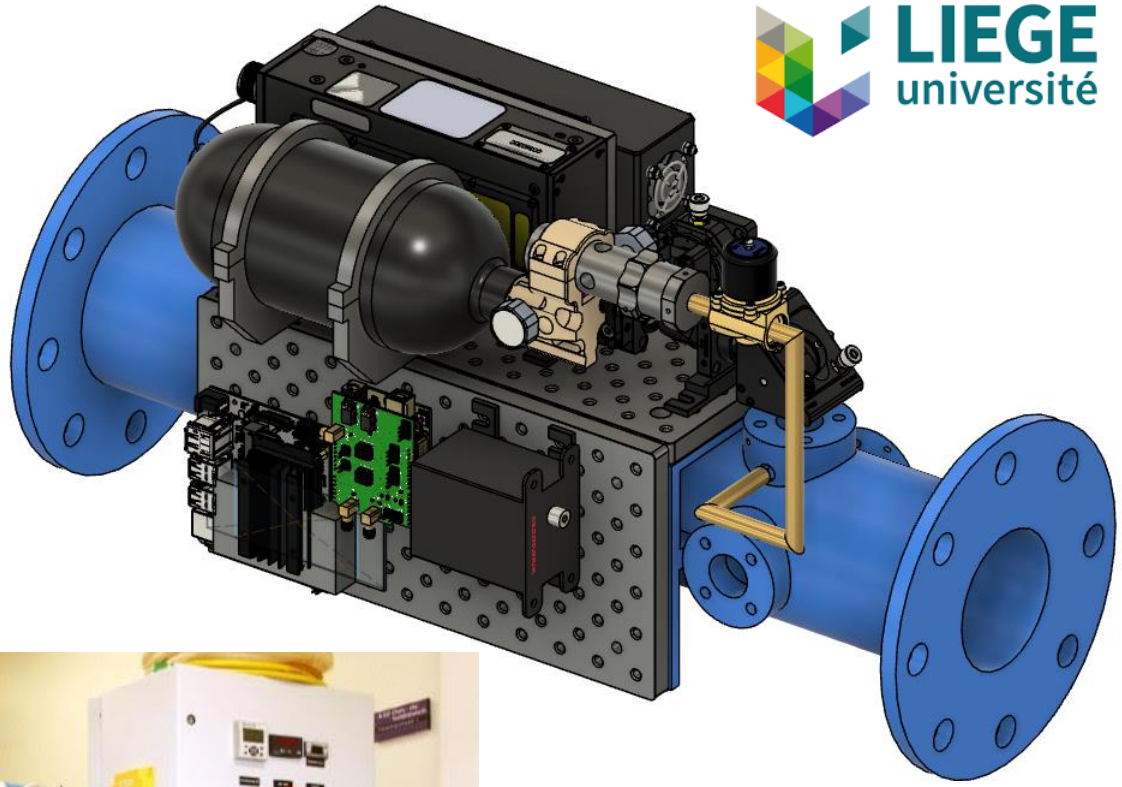
Mineralogical segment prototype
Static tests @ kutec
-> inox tube 10mm thickness
-> sapphire-stainless steel viewports ok
(25bar pressure rated)

-> modular (optical tables bolted on pipe):

- LIBS
- UV fluorescence
- VIS-SWIR reflectance (400-2500nm)

- 24V input (will be converted to 48V)
- 250W peak power, 10W mean

Control :
High-level : Olimex 64bits linux SBC
Low-level (timings) :
custom board and µcontroller)



K-UTEC
SALT TECHNOLOGIES

For more insights check: www.robominers.eu

Thank you for your attention!

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