Exploring Geophysical Properties of Sn-Cu-Pb-Zn Deposits at Depth Using ROBOMINERS' Mid-Perception Capability

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ABOUT ROBOMINERS

ROBOMINERS is a 48-months H2020 project that started on 1 June 2019. The main goals are to:

➔ Develop a **bio-inspired, modular and reconfigurable robot-miner for small and difficult to access deposits**. The aim is to create a prototype robot that is capable of **mining underground, underwater in a flooded environment,** and can be delivered in modules to the deposit via a large diameter borehole drilled from the surface to the mineral deposit.

➔ To deliver a proof of concept for the feasibility of this technology line at Technology Readiness Level (TRL) 3 to 5. The technology could **enable the EU to access mineral raw materials from domestic sources that are otherwise inaccessible or uneconomic**.

TARGET

With this project comes the need of a new approach to mining design and strategy. The targeted mines can be divided into **4 scenarios**:

- Abandoned mines, non-economic parts of operating mines
- Small deposit, non-economic, minimum surface footprint
- Hazardous or not accessible environments
- Ultra deep deposit

In our research we focused on mineral deposit that are small or difficult to access and abandoned mines/non –economic parts of operating mines. In particular **Sn-Cu-Pb-Zn hydrothermal vein type deposit and MVT type deposit**.

Those type of deposits are known for being **extremely variable in the shape and distribution of the ore, mineralogy and texture.** Moreover also the structural framework play an important role on the distribution of the ore. [1][2]

CHARACTERISTICS OF THE ROBOT-MINER

Vision 2030	Vision 2050
The robot is composed of different connected modules, each with a specific function (e.g. drilling, analysis, exploration,..)	Robot modules are sent underground via a borehole
Using specific sensing devices, they detect the ore	The robot is autonomous
Using ad-hoc production devices, they produce slurry that is pumped out	They self-assemble to form a fully functional robot
Bio-inspired locomotion with legs and Archimedes screws	They can re-configure on-the-job

Technical specification

0.5-1 ton	0.8-1 m Ø	20-30 kW	hydraulic	tethered

MID-RANGE PERCEPTION SENSORS

Solid state sensors

Default sensor considered:
bio-mechanical perception, T, pH, P, vibration, electric-conductivity

Mid-range sensors for the perception of the environment

Geophysical methods considered: ERT/IP, ultrasound scanning;
Spectroscopic methods considered: THz imagery, reflectance-fluorescence spectroscopy.

Advanced Mineralogical Segment

In-stream elemental and molecular analysis:
LIBS spectrometer, XRF, optical UV-VIR-NIR techniques.

As the targeted environment will be (mostly) flooded, we need to consider the impact of the water/fluid on the measurement. **THz spectroscopy** frequencies are highly absorbed by water [3] and therefore it cannot be applied in completely flooded environment. THz spectroscopy can be used for the screening of the wall in case it is covered in drilling mud, where regular multispectral camera might not work.

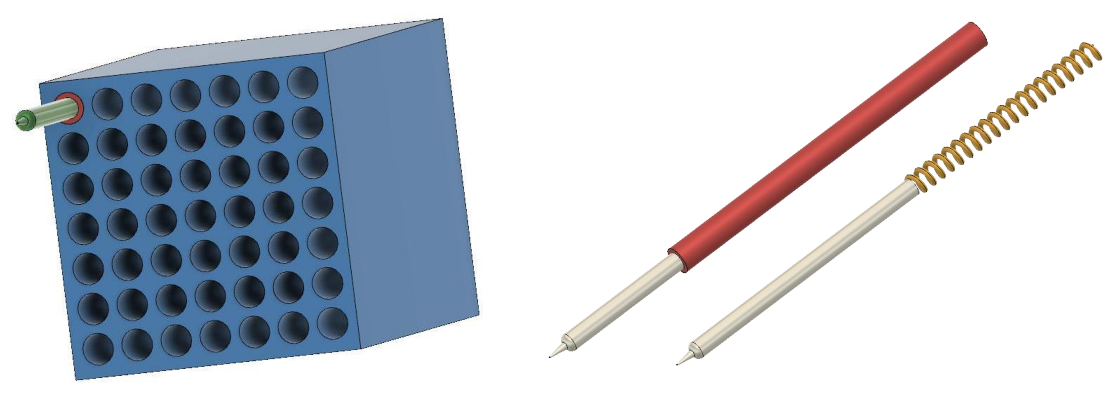


Fig.1 Concept for electrode plate and electrode with "pogo pins" for a complete adherence to the rock wall

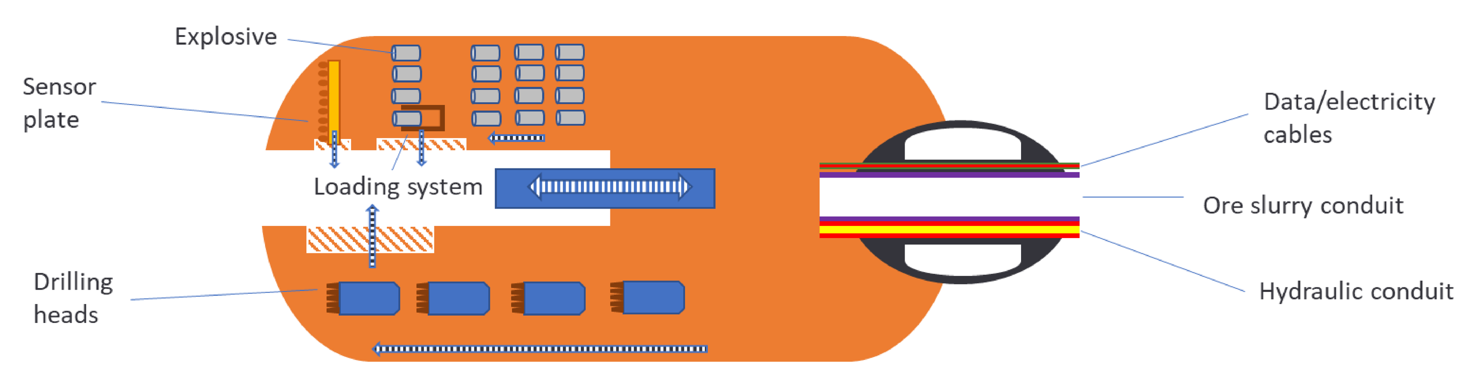
Based on the existing general model of the deposit, the robot-miner will start its excavation path towards the ore. In order to be as efficient as possible, a more refined model is needed for the advance directional drilling (cm to m ahead) to identify a continuation direction of an ore body. Conventional **DC resistivity and IP methods** for geophysical exploration are well reported in the literature, however, in the framework of ROBOMINERS we wants to develop a new approach for DC resistivity and IP that use the deposit itself as a probe for the diffusion of the signal.

A concept for an electrode plate is currently under development (Fig.1). This plate will be placed in the first modules and it will be controlled by a mechanical arm that will position it on the front wall. The current will be then injected, and the electrodes positioned on the plaque will receive the response of the portion investigated. More electrodes will be placed on the body of the robot in order to collect the response also from the lateral walls (Fig.2).

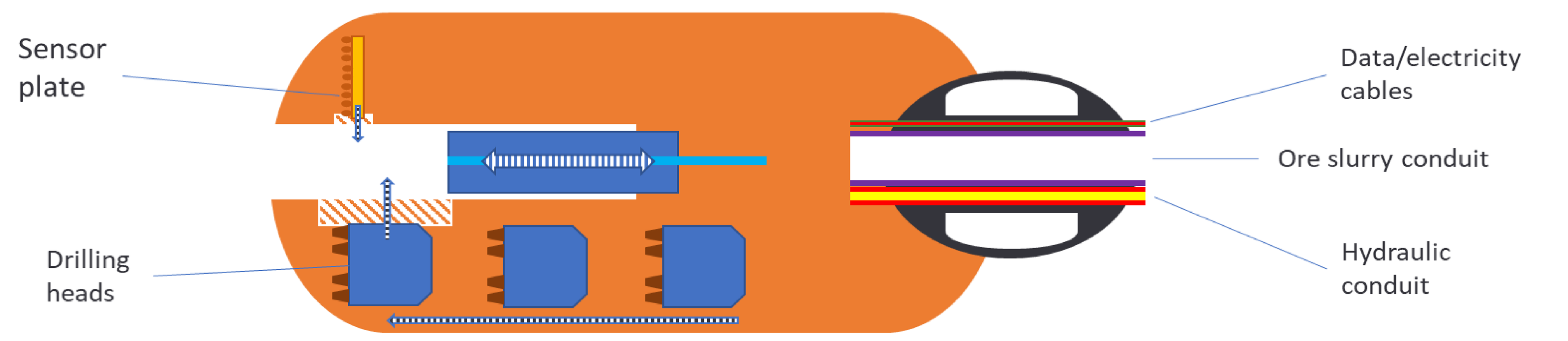
THE ROBOT-EXPLORER

The sensor plate will be positioned in the first module, responsible also for the drilling. In this way the investigation (non continuous) of the mine's wall can take place during the interval for the changing of the drilling head. We present here the concept with two production methods that have been selected:

Drilling and blasting



High pressure water cutting



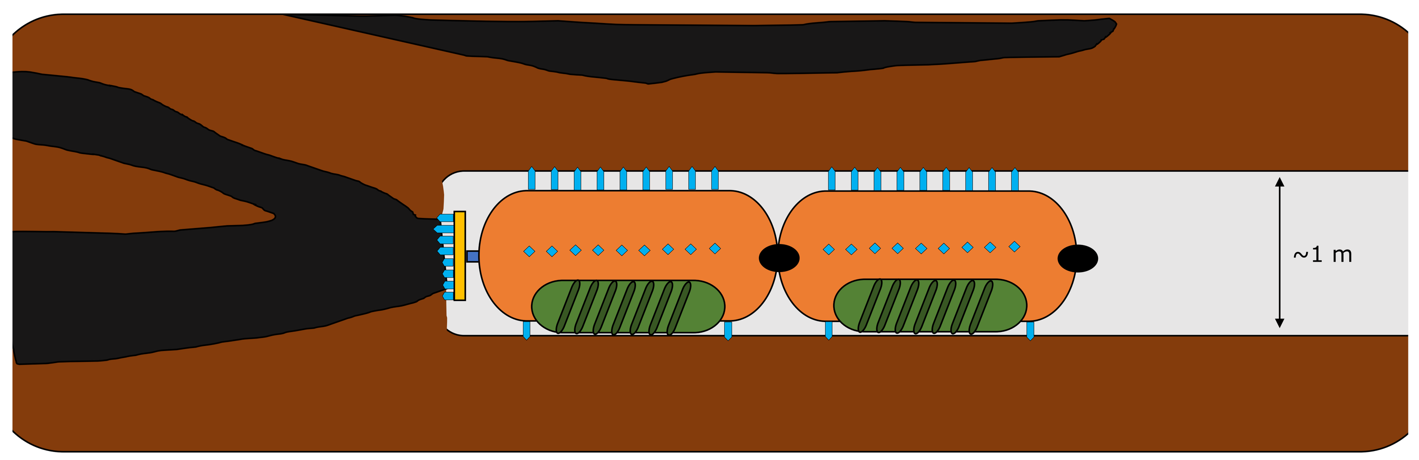


Fig.2 Representation of the electrode plaque in action. The current is injected through the plaque and the electrode on the plaque and on the robot's body receive the response.

MVT deposits are epigenetic, stratabound, carbonate-hosted bodies composed mostly of sphalerite, galena, iron oxides and carbonates, and they are one of the major source for Pb and Zn, with accessories As, Cu, Co, Ni, Cd, Ag, In, Ge, Ga, Sb, Bi, As, Mo, Sn, and Au [4-5]. Those deposit are characterized by the presence of separate and variable bodies that can be interconnected [5]. The accessory minerals (CRMs) combined with the irregular shape makes MVT deposit the perfect target for ROBOMINERS.

As the geometry is particularly irregular, a clear mapping of the ore for the autonomous operation of the robot is needed. Thanks to the clear contrast in conductivity and resistivity between sulphides and carbonates, electrical methods could be considered an optimal, and economic in terms of equipment, solution for short-distance directions and exploration.

During the ROBOMINERS project we will move towards a solution for the autonomous data collection and interpretation of the data in real-time.

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