



Robot-miners for a new mining future

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A multi-disciplinary team – the ROBOMINERS consortium – is creating a robot-miner for the future exploitation of difficult to access deposits. The approach builds on using robotics-related capacities for the mining sector. In particular, the ROBOMINERS vision foresees the use of a modular and reconfigurable robot in a mining setting where activities are nearly invisible. Mining will be more socio-environmentally viable, thus contributing to a more safe and sustainable supply of mineral raw materials fostered by the EU Raw Materials policies. When compared to current mining methods, the ROBOMINERS approach aims at: no presence of people in the mine, less mining waste produced and mining infrastructure needed, less investment, the possibility to explore currently uneconomic resources and development of new underground small-sized mines.

In the past two years, work focused on studying and designing enabling technologies, robot components and capabilities. The next steps will include integration of different software and hardware components leading to the development of the first robotic prototype (December 2022). Critical aspects of previous studies included 1) biological inspiration, 2) perception and localisation tools, 3) robot's behaviour, navigation and control, 4) actuation methods, 5) modularity, 6) autonomy and resilience, and 7) the selective mining ability, including development of ore perception and specialized production tools. Knowledge and technology transfer from these sub-

fields to the robot-miner concept were possible thanks to collaborative work developed by the different mining and robotics teams in the laboratory and online, even during the COVID-19 times.

At the same time, the vision of a new mining robotic "ecosystem" is being developed: 1) computer models and simulations, 2) data management and visualisation systems, 3) rock mechanical and geotechnical characterisation, 4) analysing ground/rock support methods, bulk transportation methods, backfilling types and mining methods, and 5) sketching upstream and downstream mining industry analogues for the ROBOMINERS concept.

Merging of robotics and geoscientific know-how for the purpose of creating test environments (simulated and real), construction of scale models (actual and virtual), iterative development and testing key robotic functions, together with the creation of a pool of deposits that could become viable targets for future extraction, and economical studies, back up the implementation capacity of the technology.

Thanks to the integration of the previous mentioned aspects, the mining machine will be able to perform autonomous selective ore extraction. The prototype will be tested at targeted areas representatives, including abandoned and/or operating mines, small but high-grade mineral deposits, unexplored/explored non-economic occurrences and ultra-depth, not easily accessible environments. Possible current candidates for testing purposes include mines in Estonia, Slovenia or Belgium. The trials are scheduled for 2023 and will provide a first case for the operability of this new mining machine and concept.

ROBOMINERS aims at delivering a proof of concept for the feasibility of this technology line at Technology Readiness Level 4, being validated in the lab and in the test mine locations. With future-proof improvements to the technology (deriving from roadmapping) it could enable the EU to access mineral raw materials from domestic sources that are otherwise inaccessible or uneconomic.