



SUSTAINABLE DEVELOPMENT IN MINING  
"ASAREL-MEDET" JSC - THE BULGARIAN  
MINING REPRESENTATIVE IN INTERNATIONAL  
RESEARCH PROJECTS AGEMERA  
PROJECT - CRITICAL RAW MATERIALS

Preliminary Communication  
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**Abstract:** *Asarel-Medet JSC Mining and Processing Complex is the first, biggest and leading Bulgarian company for open pit mining and processing of copper and other types of ores. Asarel-Medet JSC is the only Bulgarian company that participates in the international research project AGEMERA to study the potential of Europe regarding critical raw materials for the green transition. The supply of European critical raw materials (CRMs) does not currently meet the European demand. This gap is predicted to increase, making Europe even more dependent on outside suppliers. AGEMERA is a project to help tackle this strategic problem by studying several CRM sites in Finland, Poland, Spain, the Balkans, and Zambia in different deposit types. To check the potential of the porphyry systems in Europe as a source of CRMs, the Asarel porphyry-Cu deposit was selected as a test site. Here we present preliminary geochemical and mineral chemistry data for hydrothermal ore and alteration minerals in Asarel that reveal the potential of the deposit to source some CRMs as by-products. Further studies will combine the geochemical data with innovative geophysical methods for an improved deposit model and provide enhanced knowledge about effective exploration techniques for CRMs.*

**Key words:** AGEMERA, CRITICAL RAW MATERIALS, PORPHYRY SYSTEMS

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## INTRODUCTION

Asarel-Medet JSC Mining and Processing Complex is the first, largest and leading Bulgarian mining company for open pit mining and processing of copper and other ores.

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It is located 11 km northwest of the town of Panagyurishte and 90 km east of the capital, Sofia. Asarel-Medet JSC is a joint-stock company the core activity of which is open pit mining and processing of copper and other ores, biochemical copper recovery and any engineering and trade activities associated with it. The company has been awarded with dozens of national and international prizes in the field of investment, innovation, environmental protection, management, corporate culture, occupational health and safety and corporate social responsibility. The national industry award for innovations bestowed to the company in 2021 for the successful implementation of the X-mine international project under the Horizon Europe program was among these acknowledgements. Currently, the company is facing another challenge in the innovations area and green transition technological revolution in mining: the AGEMERA project. Asarel-Medet JSC is the only Bulgarian company which is involved in AGEMERA international research project aimed at exploring the potential of Critical Raw Materials in Europe. The company integrates its resources, expertise, innovation power and new technologies with entities from 10 European countries: Finland, Germany, Netherlands, Croatia, Estonia, Hungary, Spain, Bosnia and Herzegovina, Poland and Bulgaria. The consortium includes universities, scientific institutions, technological companies and mining companies and its coordinator is the University of Oulu in Finland. Apart from Asarel-Medet JSC, the Geological Institute at the Bulgarian Academy of Science also takes part in the project representing Bulgaria.

The global demand for critical raw materials is expanding rapidly due to the transition to environmentally friendlier technologies, electric power generation and the endeavor towards a more digitalized world. Mobilizing Europe's internal critical raw material potential is a crucial prerequisite for enabling the European Union (EU) to be more resilient and develop its strategic autonomy. The Old Continent has a long tradition of mining and recovering strategic base metals (such as Cu, Zn and Pb), but a more humble experience in critical raw materials mining. This is partly due to the fact that plenty of them were not considered valuable at an earlier stage. However, Europe has a significant potential for critical raw material mining in various ore regions. Remedying the raw material supply bottlenecks in the near future is of utmost importance for achieving a strategic autonomy of the supply chains of the European industries. The latter is particularly indispensable for critical raw materials which play an essential role in the transition to a low-carbon and digital economy. In a number of cases, the same raw materials are required by multiple technologies and sectors which are crucial to the clean energy transition and therefore they are effectively competing with each other.

AGEMERA's goal is to develop and test innovative and non-invasive geophysical exploration methods to develop a more detailed map of the critical raw materials in Europe, including cobalt, bauxite, lithium, vanadium, niobium, tantalum, etc. The new geophysical exploration technologies have been planned to cover a total area of over 4,700 square km in six European countries: Poland, Germany, Finland, Bulgaria, Spain, Bosnia and Herzegovina and in one African country, Zambia. The three-year research and development project aims at resolving some of the most topical issues of European critical raw materials supply. Its main objective is to enhance the geological understanding of the explored ore regions, improve their genetic models and acquire

information about the critical raw materials as the main ore products or by-products. The project will also be focused on raising the public awareness of the critical raw material crucial role in both the green transition and the EU's strategic autonomy and sustainability.

Exploration targeting of the mineral associations, sampling, modelling and geophysical field testing have been scheduled for various study sites in order to ensure a variety of locations and mineralized systems. The pre-selected areas are located in Bosnia and Herzegovina, Bulgaria, Finland, Poland, Spain and Zambia. The targets are orogenic gold, karst bauxites, epithermal massive sulfides, porphyry Cu-Au-Mo systems, stratabound Cu-Ag and sediment-hosted stratiform Cu. The deposits to be explored are located in the Peräpohja schist belt (Finland), Iberian pyrite belt (Spain), Kupferschiefer district (Poland), Panagyurishte and Rosen districts (Bulgaria), Jajce and Posušje regions (Bosnia and Herzegovina) and the Zambian copper belt (Zambia).

The deposits of a porphyry type are the principal source for copper and molybdenum mining and may contain economic grades of Au, Ag and platinum group elements (PGE). A number of strategic and high-tech elements such as Re, W, Bi, In, Te and Se may reach economic concentration and be recovered as by-products. The Asarel copper-porphyry deposit was selected as a test site in order to explore the potential of the porphyry systems in Europe as a critical raw materials source. This paper presents preliminary geochemical and mineral chemical data of the hydrothermal mineralization and metasomatic altered minerals in the deposit. It will form the basis for their further integration with agile exploration methods and better geological modeling of the deposit.

## REGIONAL LOCATION AND GEOLOGICAL SETTING OF THE ASAREL COPPER-PORPHYRY DEPOSIT

Most of the world's magmatic-hydrothermal porphyry Cu ( $\pm$ Au $\pm$ Mo) and epithermal Au $\pm$ Ag $\pm$ Cu deposits of economic importance are genetically associated with magmatic arcs [10 and references therein]. In Southeast Europe, the Late Cretaceous Apuseni-Banat-Tymok-Srednogorie Belt (ABTS) represents the westernmost arc in the Alpine-Himalayan orogenic system associated with the Neotethys subduction [8,11]. This magmatic arc stretches on more than 1,000 km starting from the Apuseni mountains in Romania, passing through Serbia and Bulgaria and reaching the Black Sea and then Iran.

The Bulgarian part of the ABTS belt is known as the Srednogorie zone which is an 80 to 100-kilometer-wide east-west oriented tectonic-magmatic unit located between the Balkan zone in the north and the Rhodope massif in the south. The most strongly mineralized segment of the Central Srednogorie, also called Panagyurishte ore region [8], consists of a northwest-southeast trending alignment of porphyry and epithermal Cu–Au deposits located at 60 to 90 km east of Sofia. The basement of the Central Middle Srednogorie dates back to the Variscan period. It is composed of metamorphic rocks (mainly gneisses, gneiss-schists and amphibolites) with Paleozoic and older protoliths and a high-grade metamorphic imprint of 330–340 Ma [1,2,4]. They are intruded by Variscan granitoids and gabbro at 314–305 and  $\approx$ 290 Ma [2,7] and intruded and overlaid

by Late Cretaceous calc-alkaline magmatic rocks (intrusives/shallow intrusives, volcanics and volcanoclastics/epiclastics).

More than 150 ore deposits and mineral occurrences are known in the Panagyurishte ore region consisting mainly of porphyry copper and high-sulphide Cu-Au epithermal types [9]. The Asarel porphyry copper deposit is among the largest operating mines in the area of resources of 467 Mt of ore of average head grade of 0.32% Cu and 0.12 ppm Au [5]. The ore formation is associated with the consequent intrusion of pre-ore, syn-ore and post-ore shallow igneous bodies and dykes of predominantly transitional composition. A number of hydrothermal mineral parageneses have been identified: early quartz-magnetite-hematite; a major quartz-pyrite-chalcopyrite Cu-mineral association, related with propylitic, sericitic and transitional sericitic-propylitic alteration occurring in the host rocks as veins, small nests and disseminations; quartz-molybdenite association associated mainly with propylitic alteration; quartz-pyrite association locally occurring in veins and streaks; quartz-sphalerite-galena (pyrite, chalcopyrite) association occurring as veins in the deposit upper and outer parts; supergene alteration assemblage containing variable amounts of chalcocite, covellite, malachite and Fe-hydroxide. Specific and rare (Cu-Au-Te and Cu-Ag-Bi-Te with Se, Pb and Zn) associations have been described by [6].

The Asarel porphyry copper deposit poses a challenge in terms of its mineralogical and geochemical predictability. This fact is attributable to the availability of secondary overlying areas, vast alteration areas with significant argillic to advanced argillic alteration and complex structures such as pre-ore, syn-ore and post-ore faults. One of the faults (Mialski fault) displaces the eastern part of the deposit and led to the exhumation of the basement rocks with cross-cutting subvolcanic dykes exposing them at the same level as the volcanics in its western part.

#### SAMPLING AND ANALYSIS METHODS

The samples for this study have been collected from the Asarel open pit mine, from the exploration structural drillholes and the flotation plant. The JEOL JSM-6610 LV scanning electron microscope at the University of Belgrade (Faculty of Mining and Geology) was used for SEM-EDS definition of the predominant elements in the minerals. LA-ICP-MS analyzes of trace elements were performed at the Geological Institute of the Bulgarian Academy of Sciences using a NW excimer laser connected to a DRC-e PE system. SILLS (Signal Integration for Laboratory Laser Systems) software was applied for data reduction.

#### RESULTS AND CONCLUSIONS

Our preliminary studies of critical raw material potential at the Asarel deposit reveal high concentrations of several critical raw material elements in some ores and hydrothermally altered minerals. The Cobalt grade is up to 1,000-1,630 ppm in the tested pyrite, while Galena contains Selenium concentrations of 2-3 wt%. Molybdenite is not uniformly distributed in the tested pyrite and is the main carrier of Mo and Re, but the grade of the latter varies from 600 to 45,790 ppm. Considering the metasomatic altered

minerals, the hydrothermally altered Rutile concentrates trace elements such as V (110-6,700 ppm), Nb (2,300-4,600 ppm), Ta, W and Sc; epidotes and APS (aluminum-phosphate-sulfate) minerals contain elevated REE grades.

Along with the geochemical studies of hydrothermally ores and hydrothermally altered minerals, we also monitored the behavior of the critical raw materials in the grinding and flotation circuits under the conditions of the applied technology at Asarel-Medet JSC. Some elements follow Cu and Au to the final concentrate, while others concentrate in the tailings (for example, cobalt) or the by-products.

The innovations for state-of-the-art geophysical explorations which are to be developed and tested under genuine conditions to a technological availability level within the AGEMERA project will enable the underground depths to be characterized at different coverage, volume and time interval. Some of the innovations will support active and flexible data collection (satellite remote geophysical and drone methods), while others will passively provide valuable information at a longer time scale (muography and sensor technologies).

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