Geological attractions of Roşia Montană (Apuseni Mountains, Romania)

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ABSTRACT
The Roşia Montăna ore deposit has been exploited for about 2000 years. This fact implicates the rich cultural and historical heritage of the area. Also noteworthy are the natural and geological values. Due to the ongoing negotiations on the future operation of the company Rosia Montana Gold Corporation, the village for a few years is in the spotlight of international public opinion. This paper presents the geological structure of the deposit, the history of the exploitation and associated plans for the future. There are also described geoturistic attractions of the village of Rosia Montana and the surrounding area.

Key words: Roşia Montăna, gold, history of the exploitation, natural monuments

INTRODUCTION

Roşia Montană is a traditional mining community located in the Apuseni Mountains in North-Western Romania. It is widely known because of the largest gold and silver deposits in Europe. Since the middle of 19th century many authors have described the ore deposit. One of the most prominent was František Pošepný, an imperial geologist who made in 1868 the oldest still preserved geological and mining map of Roşia Montană area (Gligor, Tămaş, 2009).

Some of the benefits of the past development of the area are: long history proved by the archeological patrimony, as well as the diversity of the religion and culture. Unfortunately, mining activity has caused also serious problems, including pollution of soils and water.

The described territory is geographically located in the Metaliferi Mountains (Southeast Apuseni Mountains), within the Alba county, The Metaliferi Mts. consists of Lower Cretaceous flysh accompanied by very well developed Upper Jurassic – Lower Cretaceous ophiolites and Upper Cretaceous molasse formation. The topographic relief is typical for the mountainous landscape of the Metaliferi Mountains region. The area of Roşia Montană is located between 600 and 1300 m above sea level. The main feature of the relief is the Abrud River valley, with incoming from the east three tributaries valleys. The valleys and ridges system forms a natural cirque around Roşia Montană. The Roşia Montană depression is framed by a number of "hills" i.e. Rotunda, Cirnic, Dealul Cetății, which are old volcanic cones. These hills hiding metal ores are cut with great number of galleries and mine works, which attests the mining history of the area.

GEOLOGY

The famous mining districts of the Apuseni Mountains, to the north of the city of Deva, is known as the Golden Quadrilateral. Mineralisation within the district includes mesothermal porphyry intrusive-related gold-silver, copper-gold and copper deposit types associated with

Neogene volcanic rocks, and associated sub-volcanic intrusive rocks.

The geology of the Golden Quadrilateral consists of Mesozoic aged, shallow marine and non-marine sedimentary rocks overlying Palaeozoic and Precambrian sedimentary and metamorphic basement (*www.gabrielresources.com)*. During the late Cretaceous north-directed thrust faulting took place.

The Roşia Montană volcanic sequence is interpreted as maar-diatreme complex emplaced into Cretaceous sediments, predominantly black shales, with sandstone and conglomerate beds. The three dimensional geometry of the area is well established due to the extensive network of underground mines that have been developed since the Austro-Hungarian Empire period, and from the extensive drilling conducted from the surface and underground over the last 30 years (Rus, 2012).

The Miocene volcanism is subdivided into three cycles (*www.gabrielresources.com)*:

1 – Badenian, containing andesitic volcanics and rhyolitic ignimbrite overlain by andesitic and rhyodacitic volcanics.

2 – late Badenian to early Pannonian, represented by andesite and dacite overlain by a very thick sequence of quartz andesite that is, in turn, overlain by pyroxene andesite.

3 – continued into the Quaternaty period is characterised by pyroxene andesite and potassic basalt.

The middle and upper sequence of the second cycle represents the principal host to gold-silver mineralisation currently being mined in Roşia Montană. Significant occurrences of copper, lead and zinc are also present in the sequence (Report..., 2006). The gold-slilver mineralisation is present in the following types of rocks: dacites, sub-vertical breccia zones, vent breccia, diatreme breccia pipe and Cretaceous sediments (Fig. 1). The genetic type of the deposit is from low to intermediate sulfidation. The ore bodies are differentiated, including veins, breccias, stockwerks, impregnations and placers (Tămaş, 2010). The high ore mineralization is present especially in breccia structures, however not all breccia structures are mineralized.

There are distinguished four ore bodies: Cărnic, Cetate, Jig and Orlea (Fig.2). The dominant lithology at Cărnic and Cetate is dacitic intrusion. Gold-silver mineralisation at Orlea occurs both within the vent breccia and to the west, in the Cretaceous shales. The Jig area represents the semi-continuous zone of mineralisation located on the NE side of the maar complex. The mineralisation consists of disseminated pyrite, locally associated with minor sphalerite, galena and chalcopyrite with economic grades of gold and sliver.

Fig. 1 Black breccia – the exhibit of new Mining Museum (photo by: M.Labus)

HISTORY OF MINING

Roşia Montană is regarded as the oldest mining settlement in Romania. Gold mining

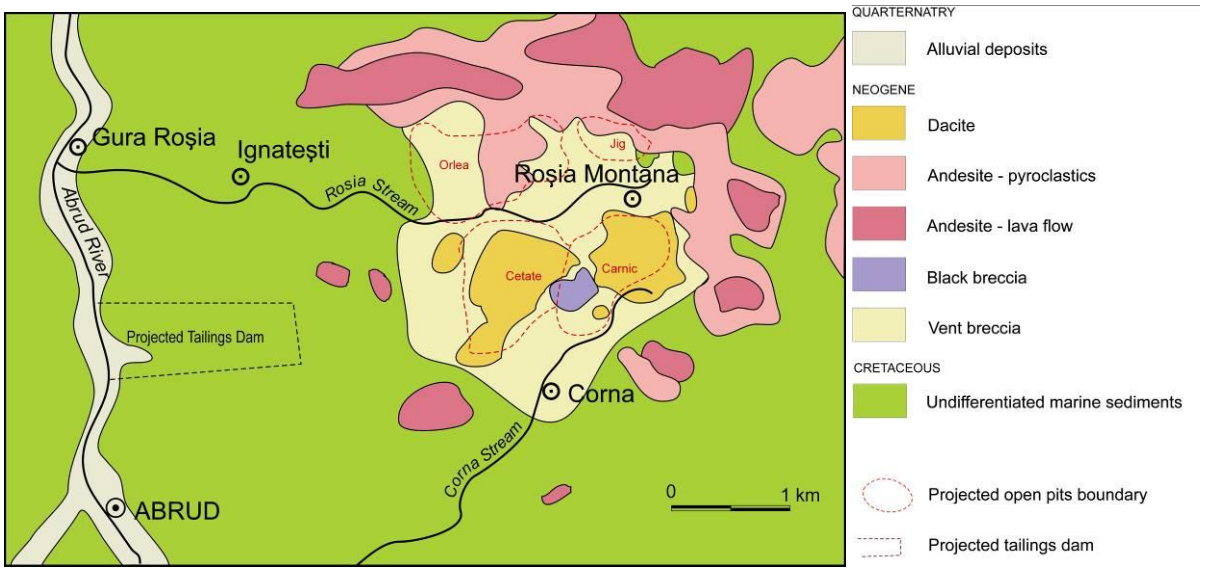

Fig. 2 Simplified geological map of the area of Roşia Montană (according to: (Report..., 2006, changed).

has occurred here for over 2000 years, what has strongly influenced the social, economic, cultural and environmental conditions of Roşia Montană.

In the history of gold mining in the area there are distinguished four principal periods (Żmudziński, 2007):

- Roman conquest period (106 - end of the 3rd century)
- Austrian-Hungarian Empire conquest (from the end of the 17th century until 1918)
- The period between the two World Wars (1918 - 1939)
- Modern Age (1939 up to present).

Dacian-Roman mining works begun after conquering Dacia by Roman emperor Traian (106 AD). In fact, the gold ore deposits from this area were one of the reasons behind the Roman conquest of Dacia. Roşia Montană then was known under the name: Alburnus Maior. The Romans left behind numerous mine galleries following gold rich veins direction. During the period of the Austro-Hungarian Empire the district reached peak production. In those times mining operations were developed in Carnic, Cetate, Jig and Orlea along the more highly mineralized veins using underground methods.

Between the two World Wars many concession contracts were awarded to local people which permitted the mining of gold for a defined period of time, resulting in many of the rich gold veins being mined out. The ore was transported by foot to water powered stamp batteries from which the gold contained in the veins was collected. Gold was then extracted using amalgom (mercury) which was burnt off to recover the bullion (gold and silver) (*www.gabrielresources.com*).

After Second World War the gold mines from the Apuseni Mountains have been nationalized by the Romanian pro-Soviet Government in 1948. Almost two decades of extensive mining in Roşia Montană were conducted by the so-called Sovrom Aur only for the benefit of the former Soviet Union (Gligor, Tămaş, 2009).

Due to modern mining methods and the lower grade disseminated style mineralization within the bulk of the rock, mining operations were developed underground using stope and pillar bulk mining methods and as the average gold content of the remaining rock decreased further, ore was recovered using open pit methods with gold recovered in a flotation plant situated at Gura Rosiei. The resulting

concentrate was then trucked to Baia de Aries, 28 km away, and gold and silver were recovered using conventional cyanide leaching techniques (*www.gabrielresources.com*).

The now-defunct RoşiaMin mine at Roşia Montană has been designated an environmental "hot-spot" by the International Commission for the Protection of the Danube River. The impact of past mining activities shows in the poor quality of water and soil and in human health. The water of streams and rivers (Roşia and Corna streams, drained by Abrud River which subsequently flows into the Aries River) is polluted in a result of "acid mine drainage" discharging from the old underground mines, as well as drainage from mine wastes and tailings. "Roşia" means "red" – as the color of the rivers reflects the high levels of acidity and other heavy metals pollutants in the water. The waters contain heavy metals above the legal limits: an average of 110 times for Zn, 64 times for Fe, 3,4 times for As and 3 times for Cd.

Starting with 1990, the population, mainly the young generation, start to leave the area and a gradual aging of the population is now very pronounced. In 1999 year, after four-year Cooperation Agreement between the Government of Romania and Gabriel Resources, Roşia Montană Gold Corporation (RMGC) was granted the mining license. In May 2006 RoşiaMin SA, a company owned by the Romanian Government was shut down because it was unprofitable and could not meet EU regulations.

Up to now (2012) there are no necessary permits for RMGC to open the new mine. The project provides exploitation in four separated opencast pits within the area mined in the past, either in opencast or underground. Conducting mining operations requires Company obtaining surface rights to the land, so there is developed the Resettlement and Relocation Action Plan for people living now in Roşia Montană area. There is also designed an advanced gold and silver recovery plant (with use of cyanides), meeting all EU and international standards. The proposed project would be active for about 25 years, what means 2 year' construction, 16 years' operation, about 7 years' closure and remediation. After the mine is closed, Romanian and European legislation demands another 30-50 years of monitoring and inspection.

WHAT WILL BE THE FUTURE?

The mining rights for the gold and silver deposit owns now SC Roşia Montană Gold Corporation SA (RMGC). The Romanian Government owns almost 20% of the Corporation; whereas the remaining 80% is held by a Canadian company: Gabriel Resources Ltd. A gold mining project established by the RMGC is strongly controversial, resulting in ongoing public protest in Romania (Labus, 2007).

The RMGC promise that when the new project receives the necessary permits to proceed, a modern mine will be built with four separated open cast pits and an advanced gold and silver recovery plant, designed to meet all EU and international standards (*http://en.rmgc.ro*). The land area where the mine is to be situated comprises largely of land that is directly affected by past mining activities.

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Like other large industrial and economical projects, this one also implies benefits, as well as certain risks, and this is the reason the project has strong promoters and opponents (Labus, 2007). In order to gain full public support for the mining project, RMGC conducts wide-ranging information campaign and a range of activities. Since its foundation the Corporation (RMGC) supported to the "Alburnus Maior" National Research Program protecting the cultural patrimony

values of the Roşia Montană area.

THE MOST INTERESTING PLACES TO VISIT IN ROŞIA MONTANĂ NEIGHBORHOOD

Roşia Montană village houses two museums of gold mining, entrance to the Roman galleries, archeological sites dating back to the Roman times, historical churches, houses and associated structures. Maybe the most important historical item are the wooden wax tablets (dating back to 131-167 A.D.) known for their importance in the Universal Law, as well as from social, economic and ethnologic points of view. Archeological sites comprise, among others: Roman circular funerary monument, Roman buildings, Roman mining workings with a water wheel drainage system, etc.

Visiting Roşia Montană it is worth to see the historical center of the village. The Historical Center or the so called Piaţa ("main square"), including also upstream and downstream roads and buildings, was delineated as a protected area. Within the protected area are also three great man-made lakes ("tăuri") built in the 18th century, as a result of mining activity in time of Austro-Hungarian conquest.

In future RMCG plans to restore the Roşia Montană Historical Center and to preserve traditional living style. There is also a plan to create the new Roşia Montană Mining Museum, open to the public access through the Cătălina-Monuleşti mining network. The museum will display replicas of several types of mining works that occur in other mining fields of the site.

The first step towards creating the new mining musem was opening the exhibition in February 2010. The exposition is located in the first restored house in the village (house no. 325), being one of the nine intended to host a **Modern Mining Museum**. In the building that was already put into use there are exposed archeological, ethnographical and gold mining history displays.

Visiting Roşia Montană you musn't miss the current **Mining Museum** situated inside the former exploitation site of the RosiaMin SA company. There the Roman mining galleries from the Orlea Massive can be visited with a guide (Fig. 3). In the open air there are exhibited over 50 Roman period stone monuments including votive altars, funerary stelae, aedicule and sarcophagus lids from the Roman period, in addition to mining tools made of stone and wood, and other mining related items. Most of these chance find artifacts were uncovered from the 18th-20th century during agricultural work.

Not very far from the Historical Center of the village are located two objects included on the list of natural monuments: Piatra Despicată and Piatra Corbului. The further described below is a selection of geotouristic objects, located in the vicinity of Roşia Montană (Fig. 4).

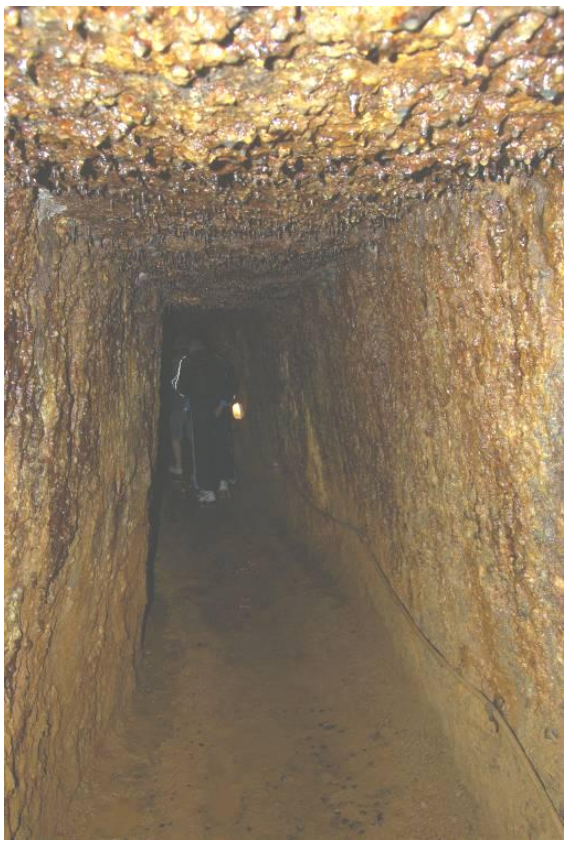

Fig. 3 Roman gallery in the Orlea Massive – part of the "old" Mining Museum in Roşia Montană (phot. M.Labus)

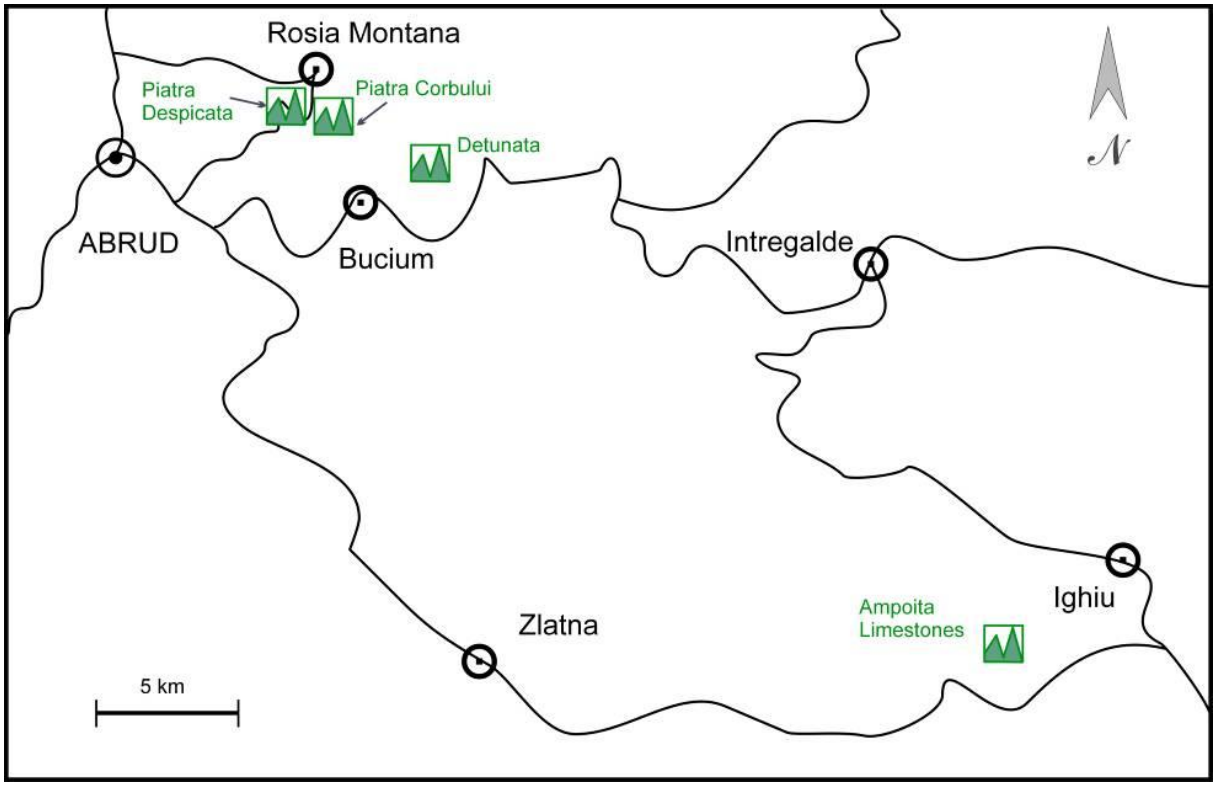

Fig. 4 Localisation of described rock outcrops in the vicinity of Roşia Montană

Piatra Despicată

Piatra Despicată is located at the southern boundary of Napoleon open pit, on the interfluves between the Roşia and Corna Valley streams. The protected, as a natural monument, is a 6 tones block of isolated andesite rock. It was formed in a final stage of the late subsequent magmatism of the Upper Pannonian. As it was mentioned in the description of the geology of the area, there were three crystallization cycles in the magmatism development. The second cycle is considered to be the most active and long term, starting with the Upper Badenian up to the Pannonian. The basalt andesite rock at Rotunda belongs to the Volcanism of the third cycle. Piatra Despicată belongs to these effusions and it is now an isolated erosion resistant block. The rock is formed of feldspar, hornblende, phenocryst and a microcrystalline matrix of volcanic glass and microlith.

Piatra Corbului

Piatra Corbului is located between Ghelaru and Curmătura Hills, in the distance of about 0,5 km from Piatra Despicată. The name ("Piatra Corbului" means: "Raven Stone") derives from the dark colour, which is the result of the weathering of the pyroxene andesite, and its special shape, resulted from historic mining operations (fig.5). It belongs to the volcanic structures formed in the second eruption cycle which starts with the Quarternary and ends in Pannonian. In the neighbourhood of Piatra Corbului are visible traces of Roman mining (surface and underground).

Both of the described outcrops (Piatra Despicată and Piatra Corbului) are relatively small and their aesthetic quality is minimized by their location on the degraded slopes of Cetate and Cirnic. The waste rock dumps developed in time closely surround both outcrops.

Detunatele

Detunatele (the Thunderstruck Rocks) is a natural geological and geomorphological reservation. It comprises two objects: Detunata Goăla (the Bare Thunderstruck Rock) and Detunata Flocoasă (the Bushy Thunderstruck Rock), of which the first one

is obviously more picturesque. Detunatele are basalt massifs, almost 70 m high, separated by the erosion from the sedimentary formations of the Abrud Platform, dating from Miocene. The basalt rocks originate in the third cycle of the Neocene eruption, the weakest one which take place in the Metaliferi Mountains. The remarkable is the presence of hexagonal columns of the basalt (Fig. 6).

Ampoița Limestones

The Ampoița Limestones (Calcarele de la Ampoița) are 10 km away from Alba Iulia, in the district of Alba. The three white stone blocks can be spotted from a distance, emerging from the surrounding planes (Fig. 7). The isolated limestone blocks are quite large: 44 m, 27 m and 15 m high. The blocks are olistolites, separated from a calcareous cliff of Tithonian age (Upper Jurassic). Then they slipped on the continental slope and were imbedded in the formations of the Cretaceous flysh, getting detached from the relief by selecting erosion.

A closer look at the limestone blocks reveals their breccious nature. This calcareous breccia is made up of angular to subrounded poorly sorted clasts, with sizes varying from gravel to boulder size; they are embedded in scarce, very fine-grained matrix (Catincuț, 2011).

Described here the Ampoița Limestones is just the example of many occuring in this area (between Zlatna and Alba Iulia) of limestone island mountains of similar origin.

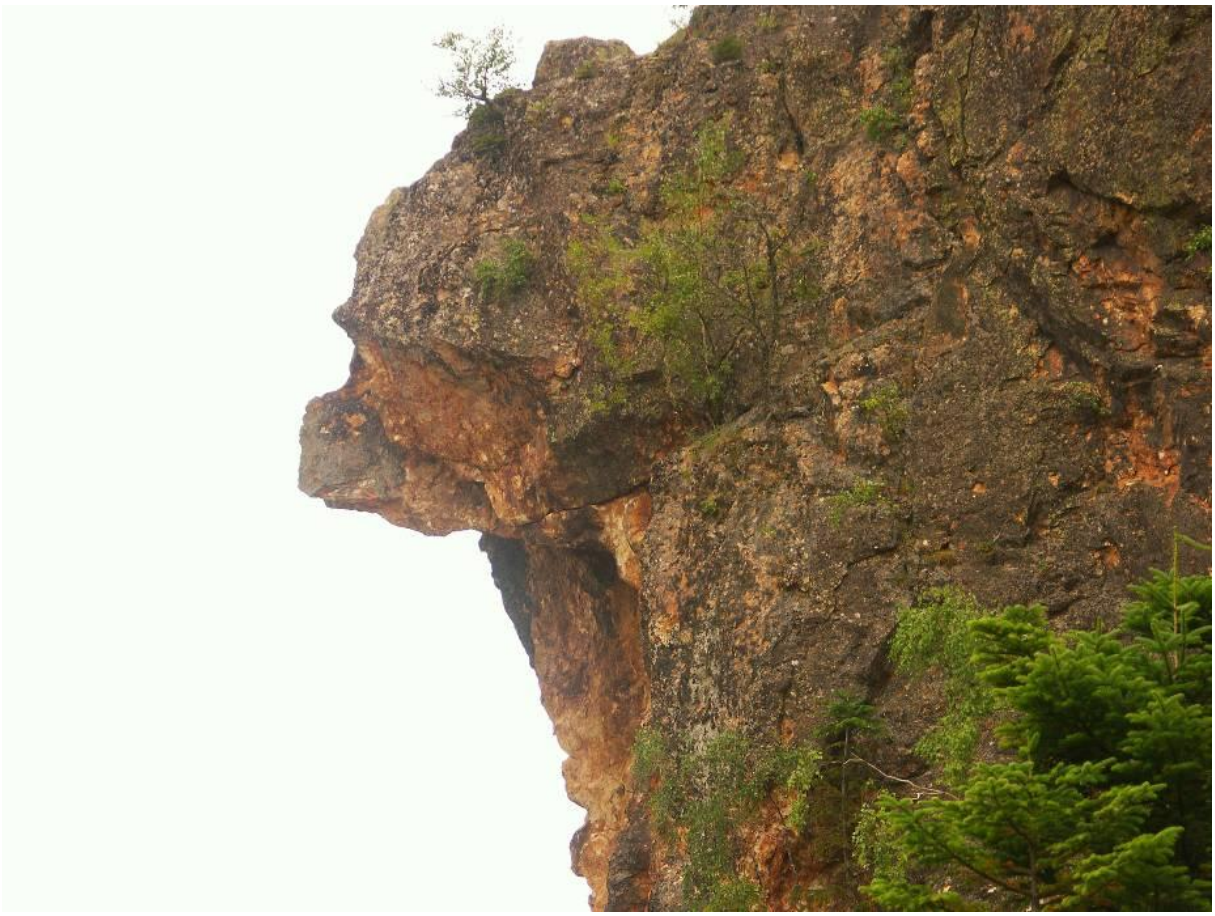

Fig. 5 Natural monument - Piatra Corbului (photo by: M.Labus)

Fig. 6 Basalt columns of Detunata Goăla (photo by: M.Labus)

Fig. 7 Ampoița Limestones (photo by: M.Labus)

CONCLUSIONS

Roşia Montăna in the Apuseni Mountains is a special place on the map of Europe. It is fascinating, because of the rich history, culture, and also because of the great intensity of the changes taking place today. The exploitation of gold and silver deposit, lasting over 2000 years, implicates the rich cultural and historical heritage of the area. Also noteworthy are the natural and geological values. The place can be visited for educational purpose, in the field of archeology, geology, mninig, economics, planning, etc.

Some of the original, dating to the Roman Empire, tunnels still exist, offering unforgettable impressions for the lovers of archaeology and history alike. Old and new excavations, as well as dumps, reveal geological structure of the area. Additional attractions are the natural monuments, few of which were listed above in the article.

Very interesting aspect is also the future of the village. Roşia Montăna Gold Corporation (RMGC) intends to develop a modern mining activity, promising at the same time to restore the historical center and to preserve traditional living style. The future mine itself become a tourist attraction, as the largest operation of its type in the EU, potentially one of the largest world-wide. The Romanian government believes that Roşia Montăna could be the example of place where mining and tourism become joint instruments towards a vastly improved regional development.

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