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S U M A R

CONTENTS – SOMMAIRE – INHALT

STUDII ȘI ARTICOLE – *STUDIES AND ARTICLES*

RESTAURARE – CONSERVARE – INVESTIGAȚII

RESTORATION – CONSERVATION – INVESTIGATIONS

VARIA

RECENZII ŞI NOTE DE LECTURĂ

REVIEWS AND READER'S NOTES

COMEMORĂRI

COMMEMORATIONS

MINING ARCHAEOLOGY IN TRANSYLVANIA: THE BUCIUM - ZLATNA PROJECT

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National Museum of Union Alba Iulia
Peter THOMAS
Deutsches Bergbau-Museum Bochum

Cuvinte cheie: arheologie minieră, mine romane, Bucium, Transilvania, minerit aurifer, Alburnus Maior, Alburnus Minor, Ampelum.
Keywords: mining archaeology, Roman mines, Bucium, Transylvania, gold mining, Alburnus Maior, Alburnus Minor, Ampelum.

1. Introduction

It has long been recognised that because the character of landscape change in the Apuseni Mountains (Transylvania) has historically been gradual and piecemeal, when compared with other countries in northern and western Europe, the region is still rich in visible, upstanding archaeological sites and monuments. The number of pre-Roman and Roman mining sites is extremely high but it has not been completely estimated yet. Except for some early works in the late 19th century[1], the study of the mining sites remained outside the archaeological agenda. V. Wollmann's work regarding the Roman mining in the province of Dacia was the major contribution in the second half of the 20th century[2]. Several archaeological projects dedicated to the ancient ore mining in Transylvania started soon after 2000. Impressive Late Bronze Age salt mines were discovered in the North-West of Transylvania at Figa[3], while the Alburnus Maior project was dedicated to the Roşia Montană gold mines[4]. The gold and copper mines in the Bucium - Zlatna area (**Fig. 1**) became the main target of a Romanian-German archeological project[5], **funded by the Fritz Thyssen Foundation**, its preliminary results being presented in this paper.

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[1] Pošepný 1868a; idem 1868b; Téglas 1888; idem 1889; idem 1890.
[2] Wollmann 1996.
[3] Harding, Kavruk 2010.
[4] Damian 2003; Simion *et alii* 2004; Damian 2006; Cauuet 2011.
[5] At the outset, it should be noted that this project developed from a pilot study commissioned to one of the authors (H. Ciugudean) in 2004 by Alburnus Maior Association and Pro Patrimonio Foundation. We would like to express our gratitude to the former president of the Pro Patrimonio

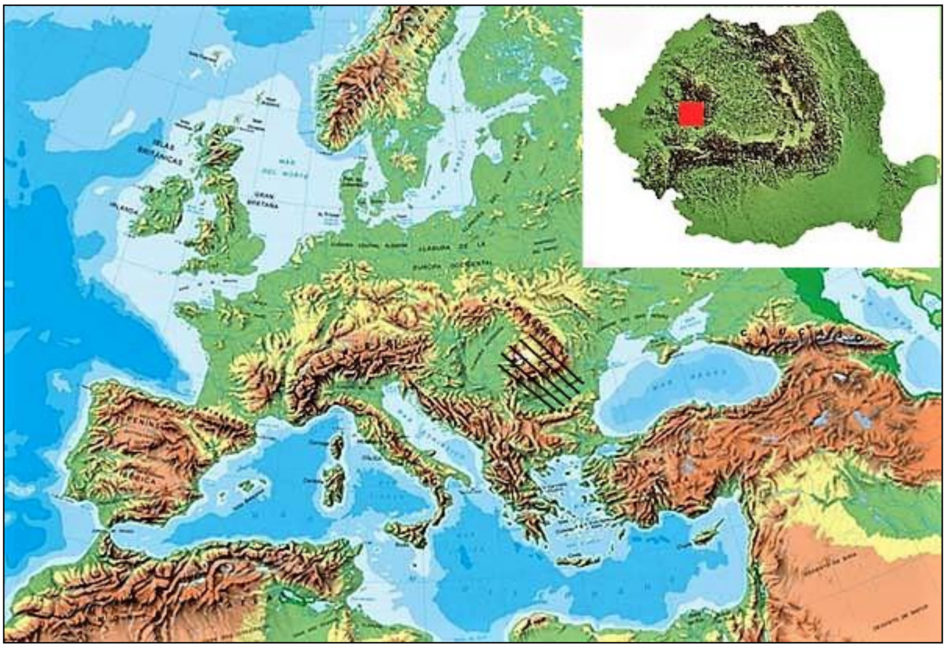

Fig. 1. The location of the Bucium - Zlatna project.

2. Geological Background

Romania has some of the most important gold mineralizations in Europe and mining dates back to prehistoric times. The gold deposits are found in three major districts, a) the Baia Mare area in the north, b) the so-called “Golden Quadrangle” in the Apuseni metalliferous mountains, and c) in the south central Carpathians. The “Golden Quadrangle” in the Apuseni Metalliferous Mountains (**Fig. 2**) has been the main producer of gold in Europe[6]. Epithermal veins and disseminations are hosted by volcanic rocks such as andesites, dacites and rhyodacites of Tertiary age. Breccia pipes and subvolcanic intrusions typical host rocks and display strong hydrothermal alteration and hydraulic fracturing. Porphyry copper type deposits are widespread and known to bear considerable amounts of gold.

Faundation, the architect Şerban Cantacuzino, who warmly supported us and made several visits in the area before his death.

[6] Huber, Huber 1983; Lehrberger 1995; Udubaşa *et alii* 2001.

The chemical characteristics of melted gold from Roşia Montană seem to be silver contents of 20-25 %, copper contents of up to 0.4 %, and tellurium contents of up to 0.1 %.

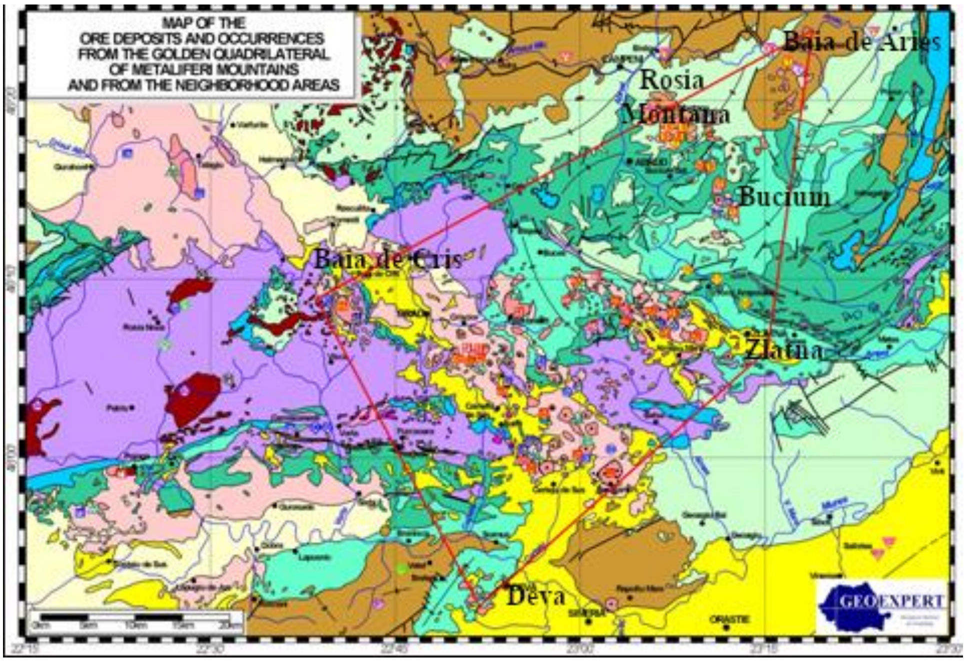

Fig. 2. The Golden Quadrangle and the position of the Bucium gold/silver and copper deposits (graphic: Geoexpert Deva).

Hartmann suggested, for instance, that the gold of his group A3 that is, on average, characterised by 25% Ag, 0.3% Cu and occasionally small contents of tin, may have its origin in Transylvania. It is mainly to be found in artefacts of the Early and Middle Bronze Age and he also suggested that this type of gold may be the earliest that derived from hard rock mining[7]. It is tempting to relate this group to the native gold of Roşia Montană but Hartmann detected tellurium in just one sample. This would raise the question if Roşia Montană was indeed an important source for prehistoric gold in south-east Europe as is held[8]. At this stage, one must concede that too few samples have been analysed in order to characterise the elemental range of minor elements within an ore deposit[9]. At present, the question of the prehistoric gold sources must remain unanswered,

[7] Hartmann 1970.
[8] Bacskay 1985; Boroffka 2006, p. 73, footnote 4.
[9] For recent lead izotope analysis, see Baron *et alii* 2011.

but the recent progress in mining archaeology has shown that underground mining for copper was already well known in the European Bronze Age, so that it is more than likely that also gold was mined in this way. The Golden Quadrangle remains as a very good candidate in this respect.

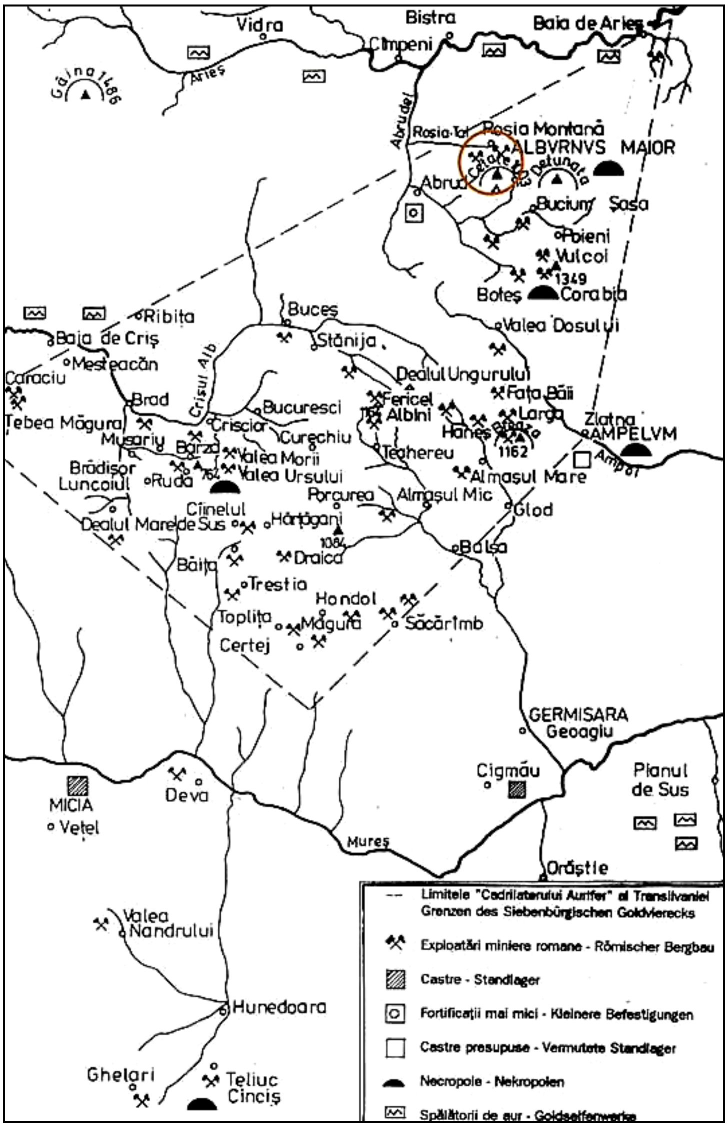

Fig. 3. The Roman sites in the frame of the Golden Quadrangle (after Wollmann 1996).

3. Project location

The Bucium - Zlatna area lies within the Southern Apuseni Mountains in the Transylvania region of Romania. The area is located about 80 km to the northeast of the town of Alba Iulia, capital of the Alba county and about 10 km east-southeast of the town of Abrud. Administratively, the ground of the area belongs to the Bucium commune that comprises several villages (Bucium Cerbu, Bucium Muntari, Bucium Şasa, Bucium Poieni, Bucium Izbita) and partially to the Zlatna town (the Poduri area). The gold deposits of the Bucium area are located within the so-called „Golden Quadrilateral", toward its north-eastern extremity (**Fig. 2)**, in the so called Roșia Montană - Bucium metallogenetic district, southeast of the well-known Roșia Montană gold deposit.

4. The history of research in the Bucium area

Geological and archaeological research recognised the existence of outcropping gold veins and ancient opencast mines north to the Zlatna town already in the 19^{th} century[10]. A Late Bronze Age hoard consisting of golden earrings has been found on the Vâlcoi - Corabia mountain[11]. Dacian silver coins were also found in the same area (**Fig. 4**), apparently in the ancient mines[12]. Both these discoveries may be a good indication for an early, pre-Roman start of the gold mining in the huge opencast mine called "Ieruga", which cuts the southern and northern slopes of Corabia mountain (**Fig. 5)**.

Fig. 4. Silver coin found in the Vâlcoi - Corabia area (after Téglás 1890).

Roman clay lamps and other tools were discovered in the Peter and Paul mine (known today as Baia Domnilor)[13]. Part of the main gallery has the characteristic trapezoidal section, well-known from the other Roman mines at Roşia Montană. Probably the most remarkable feature is the conservation of the original Roman entrance, although the mine has been worked till modern times.

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[10] Ackner 1856, p. 13; Téglás 1890.
[11] The ornaments were found in the 19^{th} century (Roska 1942, p. 308) and they are exhibited now in the Naturhistorische Museum in Wien.
[12] Téglás 1890.
[13] Téglás 1889, p. 260.

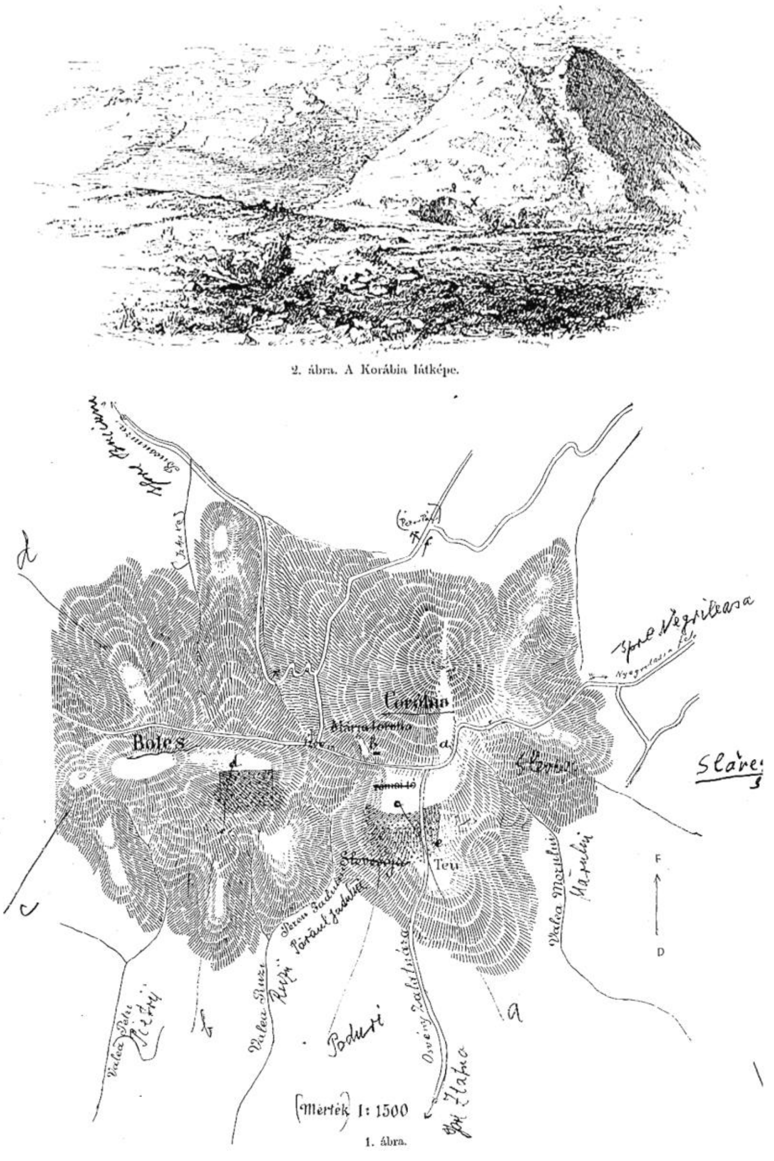

Fig. 5. a) View of the southern slope of Corabia with the ancient Ieruga opencast mine; b) The map of the Boteş - Corabia mining sites (after Téglás 1890).

By the end of the 19th century, Lukacs Bella and Téglás Gabor excavated several Roman burial mounds on the saddle between Corabia and Boteş massifs[14]. Other Roman cremation graves were excavated in 1938[15], but less attention was paid to the study of the ancient mining workings known in the area[16]. According to the funerary customs, the Roman miners originated from Illyricum, a situation similar to the one already known at Alburnus Maior[17].

In 2004-2006, an ethnoarchaeological project took place in the Bucium area and the main results were published a few years later[18]. The artefacts collected during the survey, mainly grinding stones and Roman ceramics, were published in 2012[19].

In 2005-2006, an archaeological team from the Deva museum performed excavations in the Rodu - Frasin and Corabia sites, brief technical reports being published afterwards[20]. In 2016, the Muzeul Naţional al Unirii Alba Iulia and the Deutsches Bergbau-Museum Bochum started an extensive programme in the Apuseni Mountains, with the Bucium - Zlatna area as its primary target[21].

5. Metalogenetic setting of the Bucium - Zlatna area

The Bucium gold deposits are located within the Bucium volcanic complex, within the northernmost volcanic belt of the Golden Quadrangle (**Fig. 2**). This complex is similar in size and geology to the nearby Roșia Montană complex. It contains similar types of epithermal style gold-silver and porphyry style gold-copper mineralisation associated with dacitic and andesitic intrusions, respectively. The Bucium complex, which measures approximately 6 x 3 km in plan, is elongated NW-SE and comprises several distinct sub-volcanic intrusions aligned along three separate NW-trending zones sub-parallel to the major Neogene tectonic trend of the Golden Quadrilateral.

Gold +/-silver, base metals +/- gold and porphyry copper mineralisations develop in the area and they are related to the Neogene volcanic activity. Gold mineralisation is related to the subsequent volcanic dacitic activity in the Badenian time, in the Rodu - Frasin and Contu areas[22]. It develops as veins

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[14] Téglás 1890.
[15] Floca 1941.
[16] Wollmann 1996, p. 140-142.
[17] Bărbulescu 2003, p. 410-413.
[18] Ciugudean 2010.
[19] Idem 2012.
[20] Pescaru *et alii* 2005; idem 2006.
[21] A first scientifical cooperation agreement has been signed between the two institutions for the period 2016-2020, extended in 2020 for a longer period.
[22] Leary *et alii* 2004.

(Rodu, Frasin, Contu), cross-cutting veins (so called “chairs” - Rodu) and stockworks (Rodu).

It should be noted that the metalogenetic fields Conţu, Arama and Vâlcoi - Corabia are related to a majore fracture system developing NNV-SSE (**Fig. 4**) on approximately 8 km length. Some authors consider that in antiquity this fractural vein system represented, at least at a certain moment, the most important mining field of the Apuseni Mountains.

6. The 2018 survey

In 2018 a Romanian-German team[23] started a drone survey to provide a DEM (digital elevation model) of the visible structures. Furthermore, on the base of 2017 preliminary results, several areas were chosen for test trenches, GPR measurements and coring. In addition, ore samples were collected from heaps and outcrops.

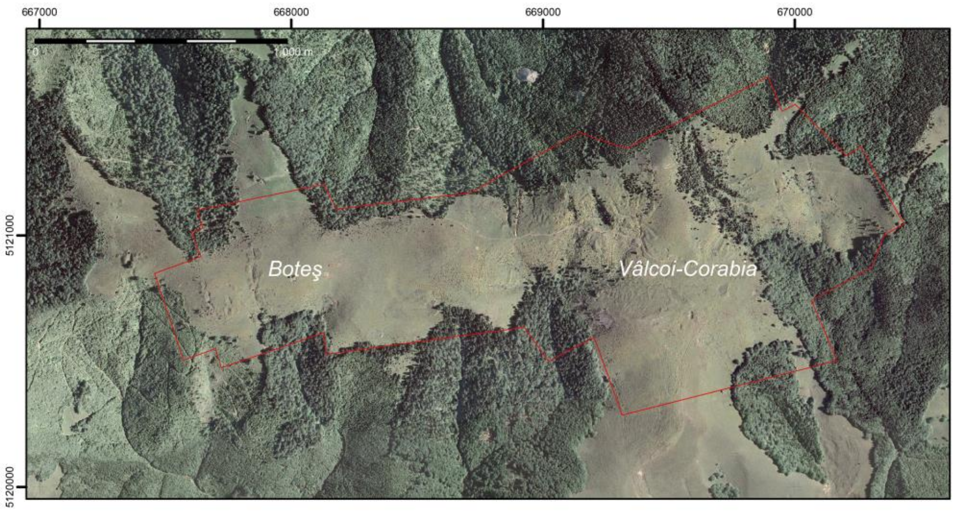

Fig. 6. The mining districts of Vâlcoi - Corabia and Boteş in the mining area of Bucium: red line – outline of the area covered by the drone survey (map based on: ANCPI).

[23] Members of the team were Horia Ciugudean, Gabriel Bălan (National Museum of Union Alba Iulia), Peter Thomas, Petra Fleischer, and Fabian Schapals (Deutsches Bergbau-Museum Bochum), Călin Șuteu (Gigapixel Art S.R.L.), Caroline Olivia Grutsch (Universität Innsbruck), Theresa Rafflenbeul (Ruhr-Universität Bochum), and Leandra Reitmaier-Neaf (Universität Zürich).

6. 1. Drone Survey

The drone survey in the districts of Vâlcoi - Corabia and Boteş aimed to cover the areas of the sites not covered with forest. It was performed with a *DJI Inspire II*-Drone with 24-megapixel MFT-camera and 15 mm lens. A total area of 2.3 km^2 was covered in 2018 with roughly 6000 images (**Fig. 6**). The resulting DEM has an average resolution of 10 cm^2 per dot. The high density and quality of structures in the districts of Vâlcoi - Corabia and Boteş are known since the 19^{th} century. The new DEM provides the possibility to identify and to describe the structures in detail as well as to determine their spatial relations. Due to the high resolution of the model, even structures hardly visible in the field can now be recognised clearly, in particular by means of different visualisation methods (**Fig. 7**).

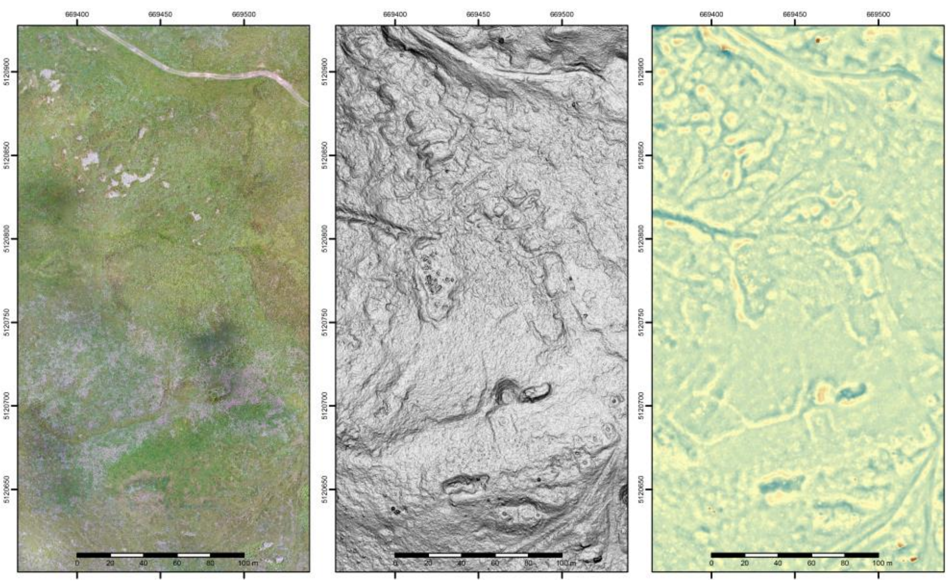

Fig. 7. Different visualisations of the archaeological structures on the plateau of Poduri: left – aerial photo; middle – slope-model based on the DEM; right – LRM (local relief model) based on the DEM.

6. 2. Test Trenches

Test trenches were excavated on six locations within the district of Vâlcoi - Corabia (**Fig. 8**). Test trench 1 is located in the Eastern Mining Field in the course of mining trench 4. The dirt road is cutting the mining trench and the accompanying heaps. Therefore, cleaning the profile on the northern side of the road provided easy access to the upper stratigraphy of the structure. The profile is 13.7 m long and 1.3 m high (**Fig. 9**). The stratigraphy consists of 17 features forming at least three heaps. Two older heaps are overlaid by a third and younger structure. The variety in the composition of the sediment even within single heaps might be the result of different dumping events. Furthermore, coarse stone material is to be noticed on the sides of the youngest heap and might be interpreted as intentional stone setting to stabilise the slope.

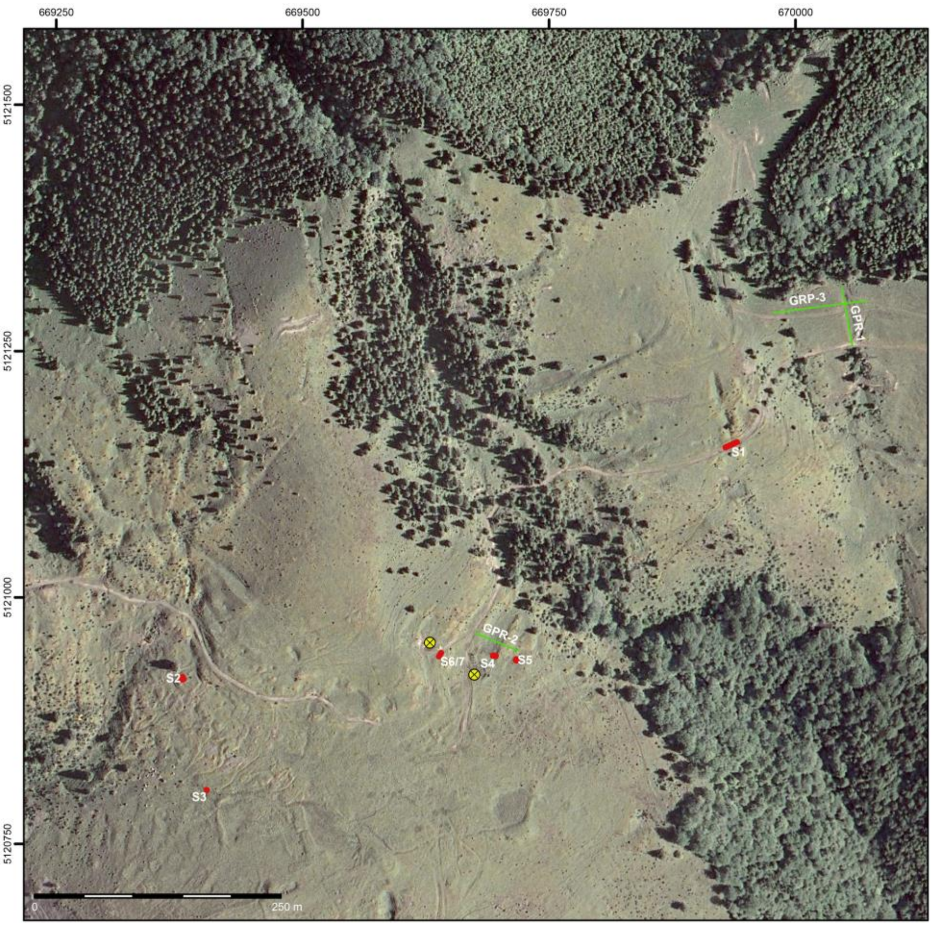

Fig. 8. Test trenches, drillings and GPR-measurements during the 2018 survey in the district of Vâlcoi - Corabia: red squares – test trenches (S1 – S6/7); yellow dots – drillings (not labelled); green lines – GPR-measurements (GPR-1 – GPR-3) (map based on: ANCPI).

The bottom of the anthropogenic layers was not reached in the profile. Four charcoal samples were recovered from the stratigraphy.

Fig. 9. Test trench 1/2018, northern profile of the road, cutting mining trench 4 with accompanying heaps.

Test trench 2 is located on the western edge of Poduri. In this area, numerous stone heaps must be noticed. Bricks mixed within these stones could be an argument for Roman buildings and settlement structures in this part of the plateau. At the beginning of the campaign, an illegal excavation was documented in this area. Therefore, the trench was cleaned, and finds were recovered (**Fig. 10**). More than 200 brick fragments including pieces of *tegula* and hexagonal tiles were collected as well as 85 pieces of ceramic, charcoal and the fragment of a lead object (**Fig. 6**). The ceramic belongs mainly to a jar or amphora. Clear building structures were not recognised for sure.

Fig. 10. Test trench 2/2018, cleaned surface of the stone structures disturbed by illegal excavations.

Test trench 3 is located in the big channel crossing the plateau of Poduri from east to west. On the northern wall of the channel, a profile was cleaned on a width of 0.75 m and a height of 1 m. The stratigraphy consists of four sterile layers, representing most likely the natural sequence of soil formation. No anthropogenic layers were identified in the profile.

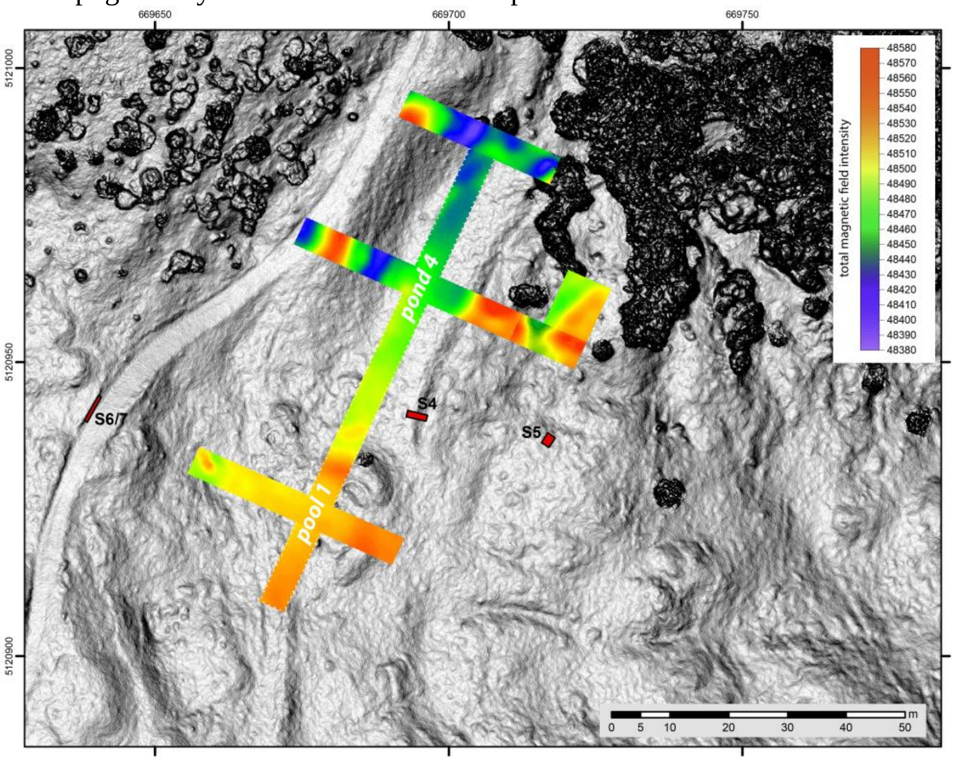

Fig. 11. Geomagnetic investigations (campaign 2017; and test trenches (campaign 2018) in the area of pool 1 and pond 4 on the eastern edge of Poduri (graphic: V. Schmidt; map based on: slope-model, DEM).

Test trench 4 is located in the area of pond 4 on the eastern edge of Poduri. This pond was already investigated by geomagnetic measurements and coring during the 2017 campaign (**Fig. 11**). The test trench is cutting the dyke of the pond. It is oriented from Northwest to Southeast with a length of 3 m and a width of 1 m. The stratigraphy consists of 11 features. The sterile erosion layer of the local rock forms the bottom of the sequence. On the inside of the pond, this layer is excavated to a depth of 0.35 m. The dyke consists mainly of sterile soil, covered with lumps of pinkish clay. The top layers are humus, reaching up to a thickness of more than 0.8 m on the bottom of the pond. Three charcoal samples and an iron nail were recovered from the stratigraphy.

The dyke was constructed by removing the top soils and piling it up as a dyke. The pinkish clay on top of the dyke is the waste material from digging the pond into the sterile erosion layer. On the bottom of the pond, no still water sediments were documented. The humus is resting directly on the erosion layer (**Fig. 12**).

Fig. 12. Test trench 4, north-eastern profile cutting the dyke of pond 4.

Test trench 5 is located on the eastern edge of Poduri just below pond 4. The spot was chosen due to a high density of stone artefacts found during the last years in this area. The trench has an orientation from Northeast to Southwest with a length of 2 m and a width of 1.5 m.

The stratigraphy consists of five features. The sterile erosion layer of the local rock forms the bottom of the sequence, followed by erosion layers with large stones and the topsoil. Clear anthropogenic layers could not be identified. Small pieces of charcoal, ceramic, slag and burned clay could be recovered from the erosion layer and the superimposed soil.

Test trench 6 and 7 are located on the eastern part of Poduri just above pond 4. The dirt road is cutting several heaps on the slope. On the northwestern road profile, a grinding stone fragment was observed in the stratigraphy. Therefore, the profile was cleaned first on a length of 1.15 m (test trench 6; **Fig. 13**), and later widened on a length of 5 m and a height of 1.45 m (test trench 7).

Fig 13. Test trench 6, north-western profile of the road: 1 – fragment of a grinding stone; 2 – Roman pottery fragments.

The stratigraphy consists of ten features forming several heaps, dipping from Southwest to Northeast, covered by an erosion layer of loose consistency. Several pieces of ceramic and six charcoal samples could be recovered from the heap layers. The grinding stone was embedded in the erosion layer.

The stratigraphy is cut in its upper part, probably due to later activities like a modern drilling platform located just above the profile. The bottom of the anthropogenic layers was not reached.

6. 3. Measurements with ground penetrating radar

Measurements with GPR (ground penetrating radar) were performed in the area of mining trench 1 in the eastern mining field and in the area of pond 4 on the eastern edge of Poduri. The device provided by the Institute of Geophysics of the Westfälische Wilhelms-Universität Münster was a *TerraSIRch SIR System-3000* used with both 200 MHz and 400 MHz antennas. However, the 200 MHz antenna provided better results due to the uneven surface of the terrain. In both cases, the GPR measurements were an addition to geomagnetic and geoelectric investigations carried out on these structures in the last two years.

GPR 1 was set along the longitudinal extension of mining trench 1 in the eastern mining field, starting on top of the ridge and following the trench down the slope on a length of 60 m with an orientation from north to south. The result corresponds well with the findings of the ERT measurements down to a depth of 5 m, although the interpretation is still a matter of discussion.

GPR 3 was set in a right angle to GPR 1, cutting the mining trenches 2 and 1 just above the dirt road on a length of 95.7 m with an orientation from west to east. Although both trenches are visible in the finding, the result cannot be completely understood without a further and more detailed investigation.

GPR 2 was set across pond 4 on the eastern edge of Poduri, cutting both dykes on a length of 47.5 m with an orientation from northwest to southeast. The result corresponds well with the findings of geomagnetic measurements. Both dykes are clearly visible as well as a structure on the bottom of the pond. The latter was also visible in the geomagnetic picture as high value anomaly as were the dykes.

6. 4. Coring

The coring was conducted with an *Atlas Copco Cobra Typ 248* drill hammer and 40 mm probes, provided by the Institute of Prehistory of the Philipps-Universität Marburg. Both cores were drilled on the eastern edge of Poduri.

The first drilling was performed on a plateau above the dirt road, 15 m northwest of test trenches 6 and 7. It provided a layer of charcoal with a thickness of several centimetres in a depth of 1 m. Although the core reached a depth of 4.15 m, the bottom of the anthropogenic layers was reached at 3.05 m depth.

The second core was drilled in a small round pool – pool 1 – in the southwestern extension of pond 4. Below the humus a thick layer of pinkish clay with small stones reached down to a depth of 1.08 m, followed by sterile sediment. The pinkish clay can be interpreted as sediment accumulated in still water environment.

6. 5. Ore samples

Ore samples were collected from various locations. Some small pieces were found on the dirt road crossing the district of Vâlcoi - Corabia from east to west. A larger collection originates from the heap of the Abraham Pureca gallery on the northwestern slope of the Vâlcoi massive.

Discussion

The results of this year's campaign provided important information to understand the internal structure of the ancient mining sites in the districts of Vâlcoi - Corabia and Boteş.

The DEM resulting from the drone survey is impressively showing the quality and diversity of features, especially on the plateau of Poduri. Settlement areas can be recognised on the western and eastern part of the plateau due to terraces and base walls of buildings, matching well the distribution of Roman ceramic finds and brick fragments. Between the two settlement areas, a network of large lakes and small round pools is visible. Channels are connecting the different basins and grouping them into an eastern and a western regime. In both cases, smaller channels are distributing the water stored in the lakes and leading it to settlement terraces and buildings. Longitudinal ponds are forming a further group of basins. They can be found exclusively on the sides of mining trenches, especially in the east and west of the large Ieruga mining trench. Except for one possible example on the eastern edge of Poduri, these longitudinal ponds show no connection to the described system of channels and basins. In the south of the plateau, a bundle of road trails is visible as well as the Roman cemetery. Some tumuli are grouped on terraces, others have rectangular enclosures. Both features are signs for the internal structure of the cemetery. Mining trenches are visible in the DEM, especially in the eastern mining field as well as in the district of Boteş. In the western mining field, mining trenches are covered mostly by forest.

Test trenches, in combination with coring and geophysical measurements, provided information concerning the construction and usage of certain structures. On the eastern edge of Poduri pool 1 as well as a pond 4 were covered with geomagnetic measurements during the campaign of 2018. Especially the dykes were visible due to high value anomalies. According to test trench 4, these high values can be connected to deposits of pinkish clay, dumped on top of the dykes. The clay belonged to the sterile erosion layer of the local rock and was excavated during the construction of the pond. Similar material, but finer and argillaceous, was found during coring in the filling of pool 1. This finer material is an indicator for long lasting still water environments in the pool. In pond 4 this material is missing, and the sequence of humus layers is resting directly on the sterile erosion layer. Therefore, long term water storage in this pond must be doubted.

In addition, test trenches provided in situ features of heaps and possible settlement structures as well as stratified artefacts and charcoal samples. However, it is noteworthy that stone tools could not be detected in functional context. They were found exclusively on the surface, reused as a building material in the Roman settlement area or in erosion layers.

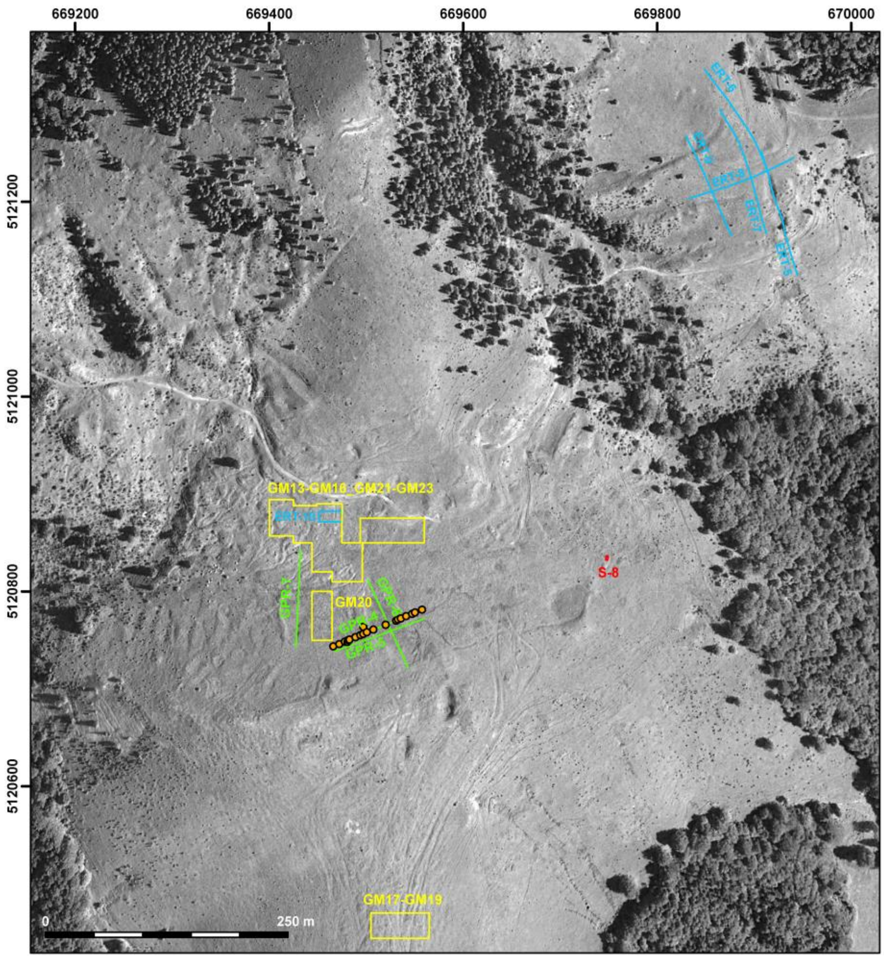

Fig 14. The central part of the district of Vâlcoi - Corabia including the plateau of Poduri with the locations of 2019 investigations; blue – geoelectric investigations, yellow – geomagnetic investigations, green – measurements with ground penetrating radar, red – test trench, orange – coring (map based on: ANCPI).

7. The 2019 survey

During the period between the 10th and the 17th of June 2019, the Romanian-German team[24] continued surveying the ancient mining sites in the mining area of Bucium. The focus was set on the district of Vâlcoi - Corabia in the south of Bucium. Members of the Institute for Geophysics of the Westfälische Wilhelms-Universität Münster supported the team, who carried out geophysical measurements as part of an Advanced Field Course. In addition, a test trench was excavated and a coring program was conducted (**Fig. 14**).

7. 1. Geoelectric measurements (ERT)

The geoelectric investigations were carried out in two areas. First of which was a smaller mining trench in the eastern mining field (**Fig. 15**). Over a length of 120 m, two depressions string from north-northwest to south-southeast. With a length of about 50 m each and a width of 10 m, they are of comparable size. Another structure possibly belonging to this mining trench is a small funnel, which adjoins the upper depression at a distance of 25 m north-northwest. Possible dumps lie on the sides of the lower trench. Five profiles were measured along the trench as well as in the immediate surroundings, using a geoelectric SYSCAL device (IRIS Instruments) with 48 electrodes. The aim was to investigate the internal structure of the trench and to evaluate the influence of the geological underground on the results of the measurements.

The profiles ERT-5 and ERT-6 were measured with an electrode spacing of 3 m within the trench and continuing roughly 130 m towards north-northwest. Two parallel profiles (ERT-7 and ERT-9) were measured in the west of the trench. Finally, one profile was set up from west-southwest to east-northeast (ERT-8), cutting the lines of the profiles mentioned before (**Fig. 15**). Especially profile ERT-5, that is running through the depressions of the mining trench, is showing low resistivity anomalies on the bottom of the depressions. These anomalies might be interpreted as loose and wet sediment filling up the old mining works.

[24] Members of the team were Horia Ciugudean and Gabriel Bălan (National Museum of Union Alba Iulia), Peter Thomas, Petra Fleischer, Katja Kosczinski, and Fabian Schapals (Deutsches Bergbau-Museum Bochum), Călin Șuteu (Gigapixel Art S.R.L.), Nicole Boenke and Theresa Rafflenbeul (Ruhr-Universität Bochum), Volkmar Schmidt, Malin Chrzon, Catharina van Alen, Carolin Zander, and Sebastian Schwind (Westfälische Wilhelms-Universität Münster).

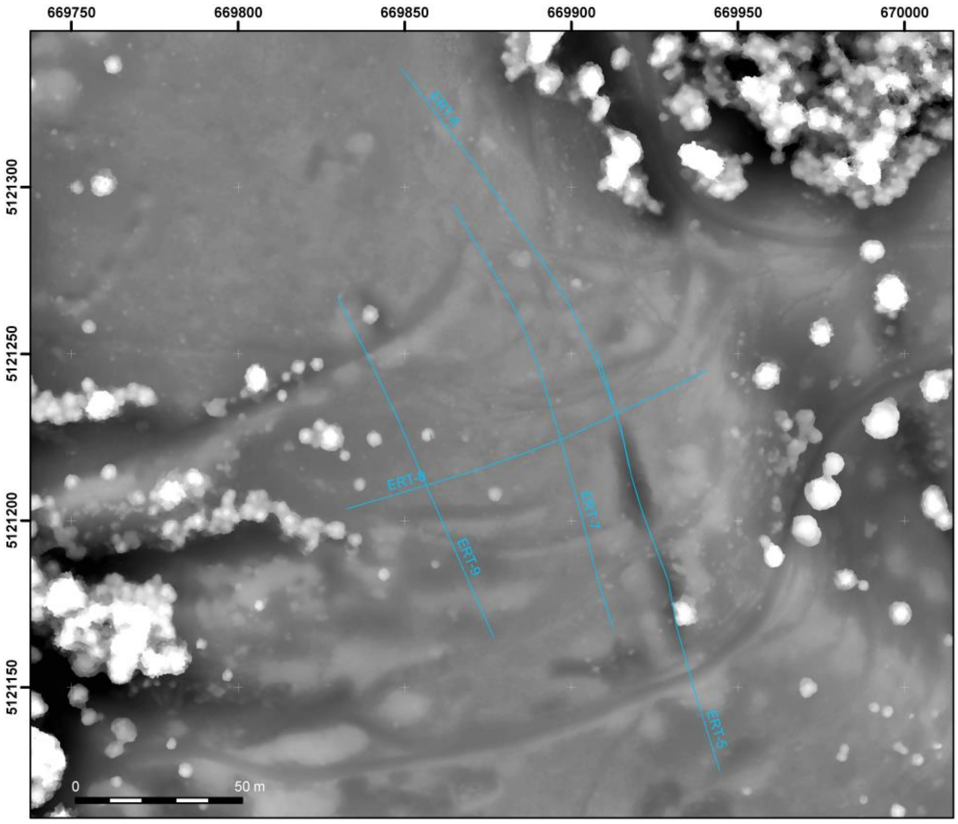

Fig 15. Location of the geoelectric profiles on the mining trench in the eastern mining field (map: local relief model [LRM]).

The cross profile ERT-8 is showing a comparable anomaly at 90 m, the intersection with profile ERT-5 (**Fig. 16**). Although the mining depression is below the line of ERT-8, the influence of the conductive sediment is still visible in the profile. Similar resistivity values are widely missing in the north-northwestern extension of profile ERT-6 as well as in the parallel profiles. Merely profile ERT-9 is showing low resistivity anomalies. Since mining traces are missing here, these anomalies might be caused by higher humidity due to underground water.

The second area of geoelectric investigations lies on the plateau of Poduri. According to the digital elevation model made in 2018, a building structure could be identified with a rectangular plan and walled channels on both sides (**Fig. 5, 1**). Measurements were conducted with the above-mentioned device in 12 parallel profiles (ERT-10_01 to ERT-10_12) with an electrode spacing of 0.5 m and a line spacing of 1 m. The aim of this quasi-3D ERT measurement was the 3D investigation of a part of this building to get a coherent representation of the underground.

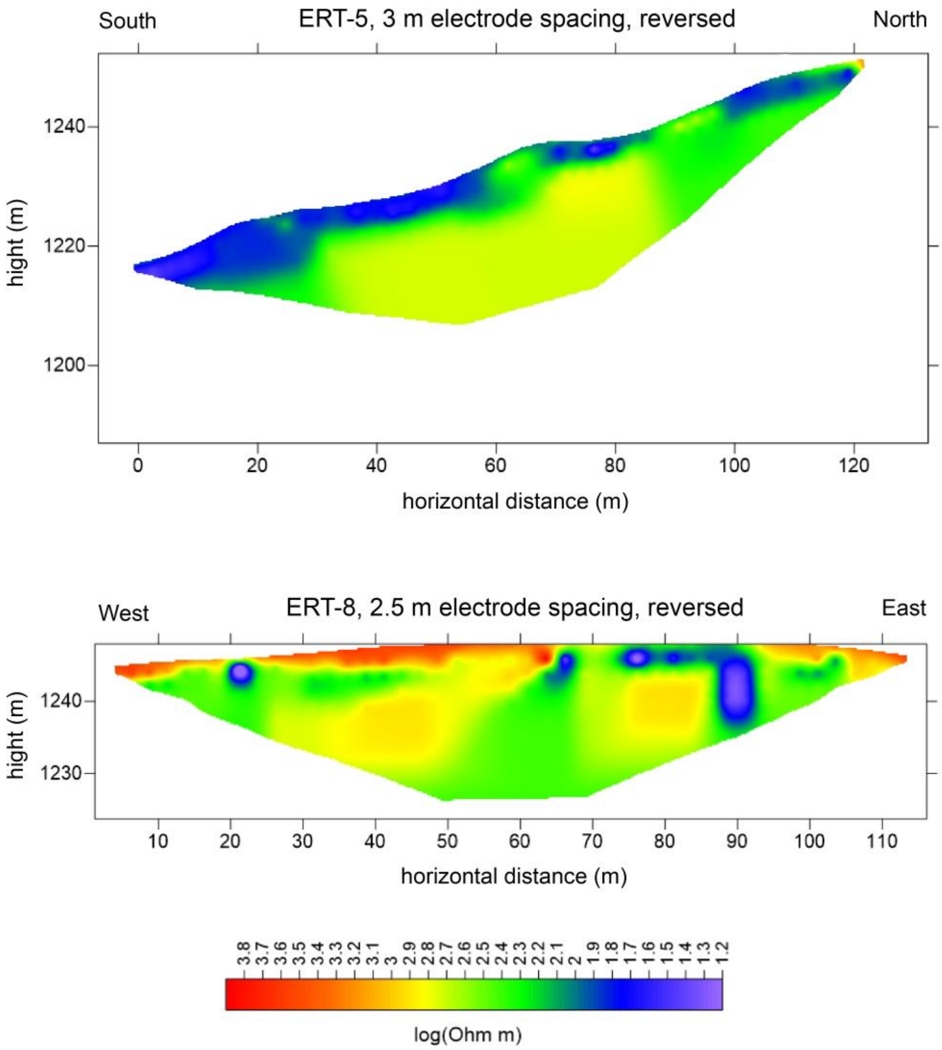

Fig. 16. Results of the geoelectric measurements along profile ERT-5 and ERT-8 (graphic: M. Chrzon, C. van Alen, V. Schmidt, WWU).

The results of the investigation are horizontal slices cutting the structure in different depth. Especially in a depth of 0.74 m and 1.03 m several linear anomalies are visible that correspond quite well with the elements of the building visible in the topography (**Fig. 17, 3-4**). The high resistivity values can be interpreted as walls build of dry stones, forming a contrast to the humid and conductive sediment in between.

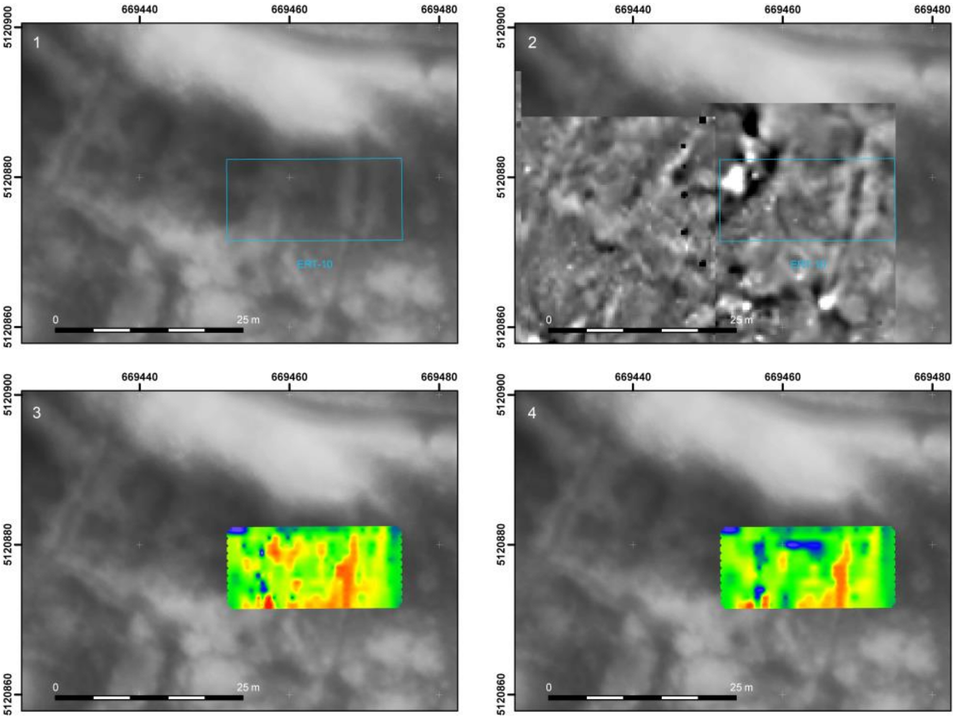

Fig. 17. Investigations on the building complex in the northern part of Poduri: 1 – local relief model of the terrain, 2 – geomagnetic measurements, 3 – result of the 3D-ERT in 0.74 m depth, 4 – result of the 3D-ERT in 1.03 m depth (resistivity scale between 32 Ohm*m [blue] and 10.000 Ohm*m [red]) (graphic: M. Chrzon, C. van Alen, C. Zander, S. Schwind, V. Schmidt, WWU).

7. 2. Geomagnetic measurements

Geomagnetic measurements were carried out in two areas using a Sensys 5-channel Fluxgate-gradiometer, provided by the Institute of Archaeologies of the Ruhr Universität Bochum.

The first area lay on the plateau of Poduri and was also partly covered by the geoelectric investigation ERT-10 (**Fig. 5, 2 and Fig. 6**). Several grids were measured covering an area of 7470 m^2. Their exact position and size were

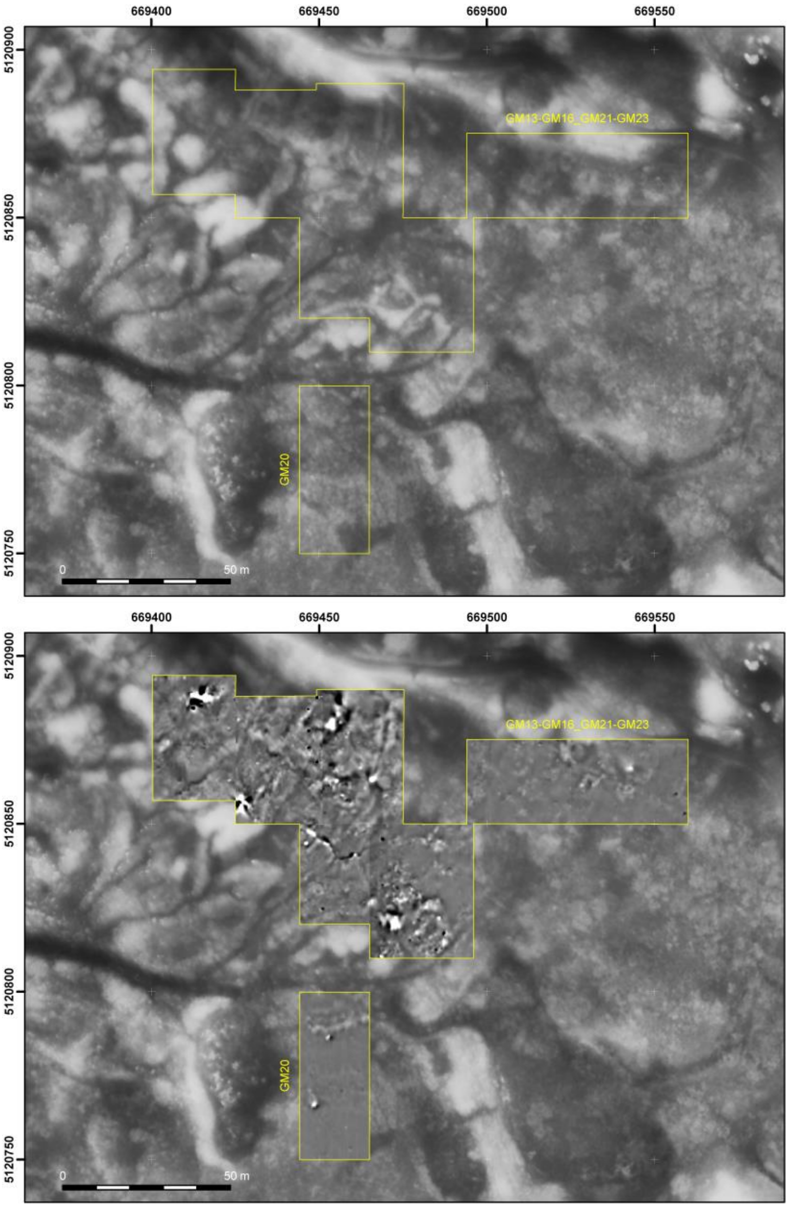

Fig. 18. Result of the geomagnetic measurements on Poduri in comparison with the local relief model (LRM): above – LRM, below – magnetogram (graphic: C. Zander, S. Schwind, V. Schmidt, WWU).

adjusted to the topography, since deep channels and steep terrain could not be crossed easily with the device and would result in bad data quality.

Several building structures and channels could be identified in this area based on the digital terrain model. With the geomagnetic measurements, these structures could be verified and details not visible in the topography became apparent.

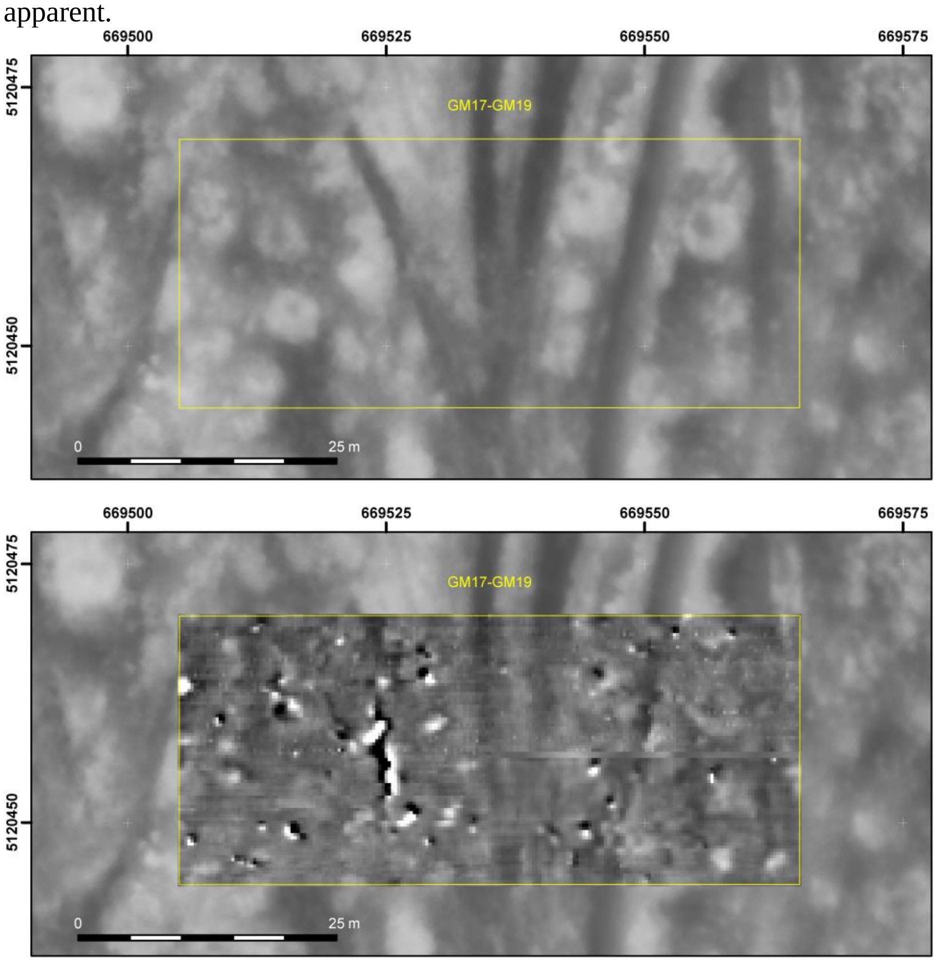

Fig. 19. Result of the geomagnetic measurements in the south of Poduri in comparison with the local relief model (LRM): above – LRM, below – magnetogram (graphic: C. Zander, S. Schwind, V. Schmidt, WWU).

The second area of geomagnetic investigations lies on the southern slope of Poduri (**Fig. 19**). Several grids covering an area of 1560 m^2 were measured, including several burial mounds and tracks. One of these tracks is the modern dirt road leading to the plateau of Poduri, others are older and covered with vegetation.

The tracks are clearly visible in the magnetogram due to their longitudinal extension. The burial mounds are also visible, although the strongest anomalies seem to be concentrated in the centre of disturbed mounds. They might be caused by dislocated material like bricks and tiles, moved by illegal excavations.

7. 3. Ground penetrating radar (GPR)

Measurements with GPR (ground penetrating radar) were performed in the area of large ponds on the plateau of Poduri (**Fig 20**). The device provided by the Institute of Geophysics of the Westfälische Wilhelms-Universität Münster was a *TerraSIRch SIR System-3000* used with a 200 MHz antenna.

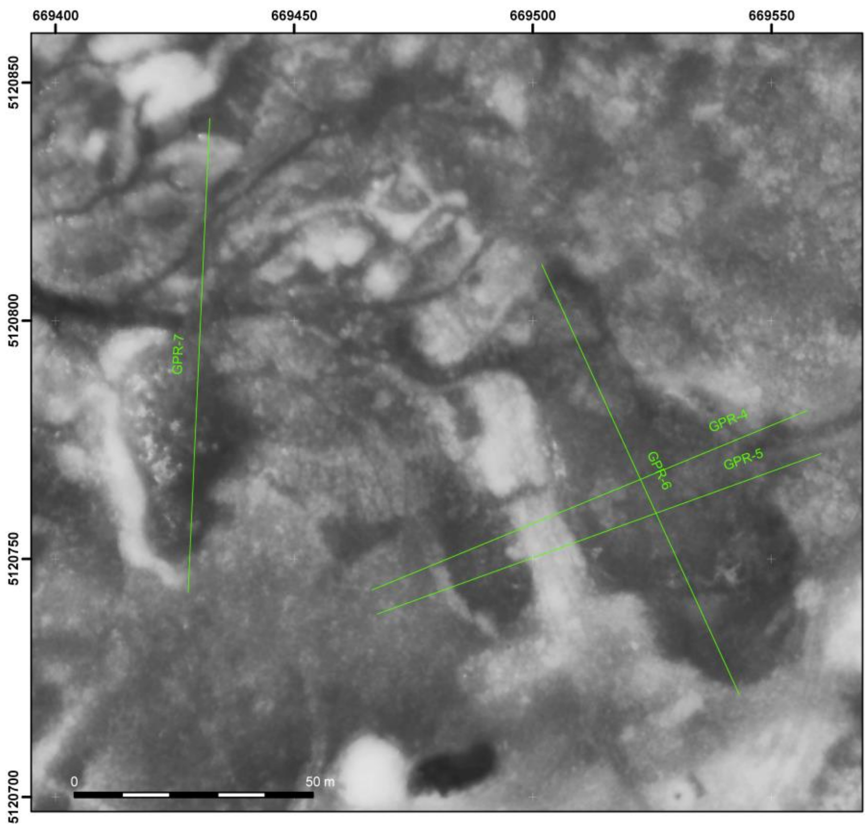

Fig. 20. Location of the measurements with ground penetrating radar on the plateau of Poduri (map: local relief model [LRM]).

Two lines (GPR4 and GPR5) were set up crossing the largest pond from northeast to southwest including a smaller pond just below the large one in the southwest. The two lines had a length of 99 m each and a distance of several meters from each other. GPR6 was set in a right angle to GPR4 and GPR5 and therefore is crossing the large pond from northwest to southeast on a length of 99 m. In all the profiles, the filling of the large pond with sediment became apparent as well as the dams (**Fig. 21**). Similar results were obtained by GPR7, crossing a second large pond from north to south.

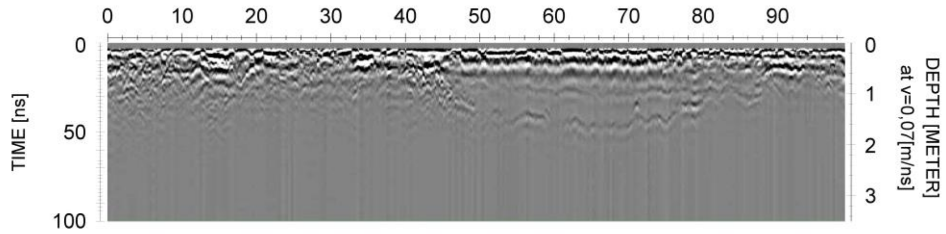

Fig. 21. Result of GPR-5 measured from southwest to northeast with the bottom of the large pond between 45 m and 90 m (graphic: P. Thomas, DBM).

7. 4. Coring

The coring was conducted with an *Atlas Copco Cobra Typ 248* drill hammer and 40 mm probes, provided by the Institute of Prehistory of the Philipps-Universität Marburg. In total, 21 wells were drilled following the line of GPR4 to evaluate the results of the ground penetrating radar (**Fig. 14**). Both the dam and the filling of the pond could be verified. The latter reaching up to almost 2 m of depth, containing organic material like charcoal and wood fragments, that were recovered for further analysis and dating. Of special importance are still water sediments like clay, that were deposited when the pond was water-filled.

7. 5. Test Trenches

One small test trench (S-8) was excavated on the eastern edge of Poduri in the area of a large rectangular feature visible in the digital terrain model. This feature has a length of 20 m and a width of 12 m. Small openings in the walls are oriented towards the south and the east. The aim of the test trench was to find datable material as well as to understand the internal structure of the walls surrounding the feature.

In a first step, the vegetation and loose earth was removed on an area of 4 m in length and 2 m in width. In a second step, the sediment inside the wall was removed in a small trench with 1 m in width. The wall consists of large irregular blocks of local stone material, set on a bank of yellowish sediment mixed with stones (**Fig. 22**). A clear foundation or regular setting could not be observed. Datable finds were also missing except for some minor traces of probably Roman bricks and charcoal, that was recovered for dating. For the stones excavated from the structure, the magnetic susceptibility was recorded to provide reference data for the interpretation of geomagnetic investigations of stone features.

Fig. 22. Test trench S-8 with the profile through the wall of the rectangular structure on the eastern edge of Poduri. Note the bank of yellowish sediment below the setting of large blocks on top (photo: P. Fleischer, DBM).

7. 6. Discussion

The 2019 campaign provided important information concerning the detection and evaluation of various structures due to a combination of different geophysical measurements as well as coring and test trenches. Especially, the combination of the digital terrain model with geomagnetic and geoelectric measurements provide detailed information on the structure of building complexes like the one investigated on the northern part of Poduri. Different elements of the building became apparent and can therefore be compared to other features from Roman contexts. In the present case, it is very tempting to compare the building structure with Roman water mills, as they were excavated in France[25]. If this interpretation is correct, the installation in Poduri must be regarded as a water powered ore mill that had major importance in the processing of gold bearing ores. This would be the first time that such an installation could be investigated for Roman contexts.

Large features like ponds and dams had been surveyed with ground penetrating radar and coring. The results are complementary and give insight into the structure and the filling of the ponds with different sediments that can be attributed to various conditions of deposition. Since structures of that size can hardly be excavated completely, the importance of non-destructive methods must be stressed for their investigation. The same applies to mining trenches, whose internal structure could successfully be investigated with geoelectric measurements.

The geomagnetic measurements in the south of Poduri were a first attempt to evaluate the visibility of burial mounds provided by this method. Since many mounds are damaged or destroyed by the modern dirt road and illegal excavations since the 19th century at least, geomagnetic measurements could help to provide a complete plan of the cemetery.

The test trench provided information concerning the structure of the large rectangular feature. In respect of the size of the structure and since clear foundations and regular stone settings are missing so far, it is unclear, if this structure was a roofed building or an open enclosure.

8. Preliminary Conclusions

The mining districts of Vâlcoi-Corabia and Boteş can be described as complex landscapes in terms of their chronology as well as their spatial structure. Especially, the plateau of Poduri provides a high density of different structures that can be described now based on the new DEM. Since forested

[25] Sellin 1983.

areas could not be included in this model, a LIDAR scan will be necessary to cover the whole area of the districts, especially the northern slopes of Vâlcoi massive. The geophysical investigations in combination with coring and test trenches were able to provide information suitable for a first interpretation of the constructions as well as functional aspects of the structures. Finally, the charcoal samples collected from test trenches and coring will be dated in the near future to establish a first chronological framework of the sites[26]. The continuation of this methodological approach will provide a complete plan of the mining district and together with systematic excavations will allow the interpretation of characteristic features in respect of their function within the *chaîne opératoire* of Roman gold production.

Other preliminary interpretations might be argued here, in the frame of ancient topography of the Roşia Montană – Bucium – Zlatna region. The most important part of *aurariae Dacicae*, this territory was strongly defended by military units that were settled in Zlatna (former *Ampelum*)[27] and Abrud[28], as well as by the *XIII Gemina* legion, closely quartered in its camp at *Apulum*[29]. A functional network of roads connected all the Roman gold mines with the residence of *procurator aurariarum* in *Ampelum*[30], as well as with the camp of Micia, located on the imperial road along the Mureş valley. The Roman road between Bucium and Zlatna has been identified on several occasions, both in 2004 and in 2016-2018 (**Fig. 23**). There were already two proposals in the literature, one advanced by Téglás, the other by I. T. Lipovan[31], the last one being closer to reality. The road was also identified West of Corabia in 2004-2005, reaching the Abruzel valley at Cerbu, around 2 km South of Abrud (**Fig. 24**). It may be supposed that the road was heading to the Abrud fortlet, where it made the connection with the road to Brad and Micia. The connection between the Boteş - Corabia mining site and Roşia Montană is not clearly identified in the field. However, according to the local geomorphology, it is very difficult to travel straight North, so we suppose Abrud camp played the role of a crossroad and the road to Alburnus Maior might have followed the ridge between Corna and Roşia valleys. However, the presence of a Roman mining site at Rodu - Frasin[32], near Bucium Saşa, opens the possibility of another secondary road between Boteş - Corabia site and Roşia Montană.

[26] The first 4 samples have been dated in the 1st – 2nd century AD by the Manheim Laboratory.
[27] Petolescu 2002, p. 137-138; Timoc 2007.
[28] Moga, Mesaroş 1980.
[29] Ţentea 2003; Ţentea 2009.
[30] Wollmann 1996, p. 179-187; Ardevan 1998, p. 51-55.
[31] Wollmann 1996, pl. LXVI.
[32] Pescaru *et alii 2006.*

Fig. 23. The Roman road from *Ampelum* reaching the south of the Poduri plateau.

The 2017-2018 surveys clearly show that, in terms of scale and complexity, the mining site of Vâlcoi-Corabia and Boteş can be assessed as the second in size, after *Alburnus Maior*, in the whole area of the Golden Quadrangle. This estimation, based on the archaeological record, allow us to presume the identification of the Bucium site with *Alburnus Minor*, a Roman settlement supposed to exist as a logical pair for *Alburnus Maior*. So far, there is no epigraphical evidence for this supposition, but the same can be said for *Alburnus Maior*, only the fortunate preservation of the wax tablets allowing its location. The only proposal for the place of *Alburnus Minor* was within the territory of Abrud, but excepting for the fortlet at Cetăţuia, there are no other archaeological finds there[33]. The recent excavations in Roşia Montană offered the possibility to identify the location of some *kastellae* and *vici*, already known from the wax tablets[34]. Each of them had its own cemetery and sacred place and belonged to one of the Illyrian and Dalmatian groups of miners, colonised in Dacia[35]. As long as there are at least two different cemeteries near Corabia, it is

[33] All the Roman monuments preserved in the walls of some churches and old buildings in Abrud were brought during the Middle Age and Modern time from Roșia Montană. The same can be said for the former collection of Roman antiquities preserved in the Abrud college.
[34] Ciongradi *et alii* 2008.
[35] Bărbulescu 2003; Piso 2004.

reasonable to presume that the Roman site was not a single *kastellum*, but a group of them and accordingly, it might represent a good candidate for the ancient *Alburnus Minor*.

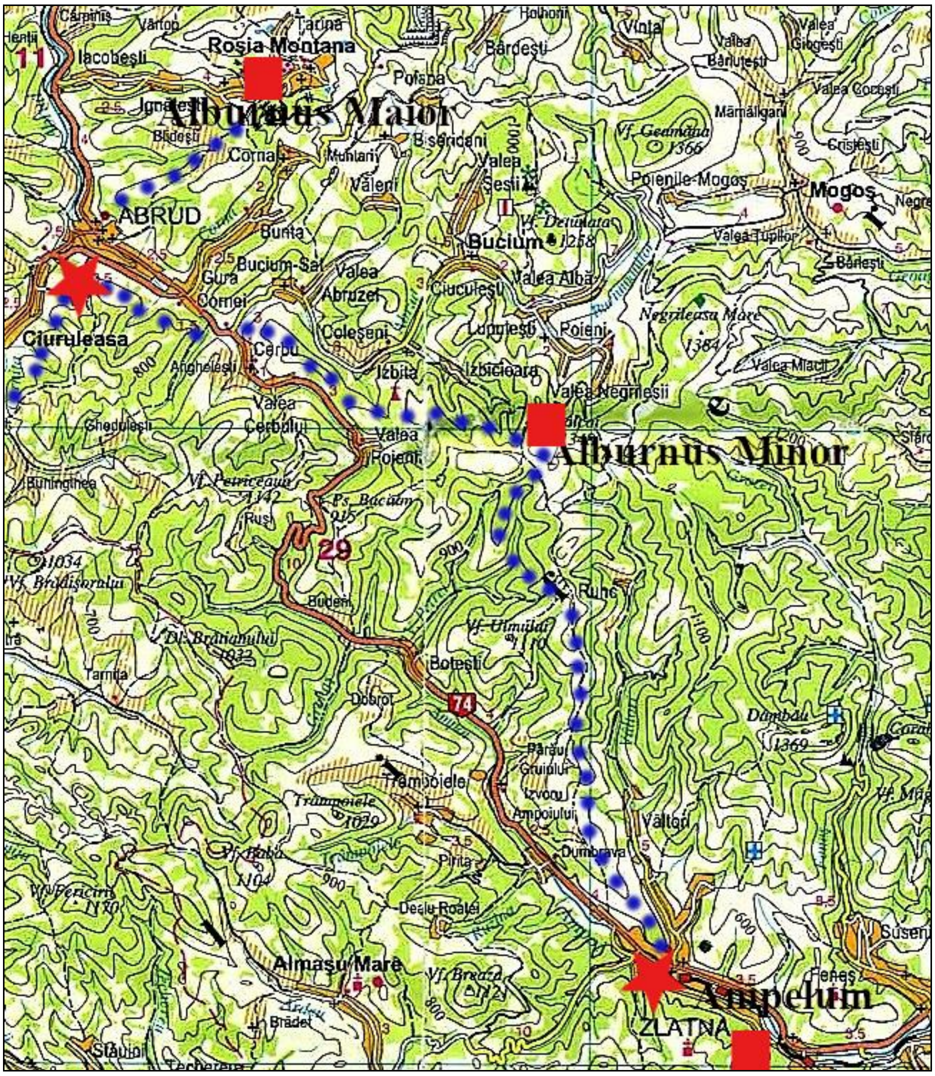

Fig. 24. The ancient topography of the Zlatna (*Ampelum*) – Bucium (*Alburnus Minor*) – Roşia Montană (*Alburnus Maior*) region. (blue dots = Roman road; red star = Roman fortlet; red square = Roman town or vicus).

ARHEOLOGIE MINIERĂ ÎN TRANSILVANIA: PROIECTUL BUCIUM - ZLATNA

REZUMAT

Prin studiul de faţă sunt prezentate cercetările preliminare întreprinse în siturile miniere din zona Bucium - Zlatna în perioada anilor 2017-2019. Aceste cercetări sunt parte a unui program de colaborare încheiat între Muzeul Naţional al Unirii Alba Iulia şi Deutsches Bergbau-Museum Bochum., care vizează exploatările antice din zona Munţilor Apuseni. Cercetările de teren întreprinse cu o multitudine de tehnici moderne (fotografiere cu drona, geomagnetism etc.) au permis conturarea unui peisaj cultural de o deosebită complexitate, incluzând galerii şi exploatări la suprafaţă antice, ateliere, aşezări şi cimitire tumulare ale minerilor illiri şi dalmaţi, o vastă reţea de drumuri. Aceste prime rezultate sprijină identificarea sitului minier de la Boteş - Corabia cu antica localitate *Alburnus Minor.*

LISTA FIGURILOR

Fig 13. Sondajul 6/2018, profilul nord-vestic al drumului: 1 – fragment de râşniţă; 2 – fragment ceramic roman.
Fig 14: Partea centrală a districtului Vâlcoi - Corabia, incluzând şi platoul Poduri cu localizarea cercetărilor din 2019; albastru – investigaţii geoelectrice, galben – investigaţii geomagnetice, verde – măsurători cu GPR, roşu – sondaje, portocaliu – foraje (harta bazată pe: ANCPI).
Fig 15. Localizarea profilelor geoelectrice pe tranşeul minier din zona minieră estică (harta: [LRM]).
Fig. 16. Rezultatele măsurătorilor geoelectrice de-a lungul profilului lui ERT-5 şi ERT-8 (grafica: M. Chrzon, C. van Alen, V. Schmidt, WWU).
Fig. 17. Investigaţiile complexului cu edificiu din partea nordică a platoului Poduri: 1 – modelul de relief local (LRM) al terenului, 2 – măsurători geomagnetice, 3 – rezultatul a 3D-ERT la 0.74 m profunzime, 4 – rezultatul a 3D-ERT la 1.03 m profunzime (scara rezistivităţii între 32 Ohm*m [albastru] şi 10.000 Ohm*m [roşu]) (grafica: M. Chrzon, C. van Alen, C. Zander, S. Schwind, V. Schmidt, WWU).
Fig. 18. Rezultatul măsurătorilor geomagnetice pe Poduri în comparaţie cu modelul local al reliefului (LRM): sus – LRM, jos – magnetograma (grafica: C. Zander, S. Schwind, V. Schmidt, WWU).
Fig. 19. Rezultatul măsurătorilor geomagnetice din zona sudică a platoului Poduri în comparaţie cu modelul local al reliefului (LRM): sus – LRM, jos – magnetograma (grafica: C. Zander, S. Schwind, V. Schmidt, WWU).
Fig. 20. Localizarea măsurătorilor cu GPR pe platoul Poduri (harta: LRM).
Fig. 21. Rezultatul GPR-5 măsurat de la sud-vest la nord-est, cu fundul iazului mare între metrii 45 şi 90 (grafica: P. Thomas, DBM).
Fig. 22. Sondajul S-8/2019 cu profilul prin zidul structurii rectangulare de pe marginea estică a platoului Poduri. De reţinut depunerea de sediment gălbui sub blocurile mari de piatră de deasupra (foto: P. Fleischer, DBM).
Fig. 23. Drumul roman de la Ampelum ajungând pe platoul Poduri.
Fig. 24. Topografia antică a zonei Zlatna (*Ampelum*) – Bucium (*Alburnus Minor*) – Roşia Montană (*Alburnus Maior*) (puncte albastre = drum roman; stea roşie = fortificaţie romană; pătrat roşu = oraş sau vicus).

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