The amazing architecture of the Dacians. Few thoughts concerning the use of mortars based on new analyses

Cristina Montana Pușcaș, Iosif Vasile Ferencz, Ciprian Cosmin Stremțan, Tudor Tămaș, Adrian Căsălean

Abstract

In 2016, while carrying out a campaign on a Dacian "tower-house" type structure identified in earlier years on the Cetățuie Hill in Ardeu, an atypical material was noticed on the inferior surface of a stone block sitting perpendicular on the revetment. Its appearance, of different colour and texture compared to the stone block it was attached to, led us to immediately assume it could be mortar. Based on this working hypothesis a series of questions were formulated, with the purpose of extracting as much valuable information as possible from the sample. Powder X-ray diffraction and petrographic investigations were carried out in order to answer these questions.

Keywords: Dacia, XRD, petrography, mortar, masonry, building materials, Transylvania

Although the precise deeds and chronology of King Burebista are still debated in historical literature, the period's portrayal illustrates a strong manifestation of power at a very different scale compared to earlier periods. It is neither the place, nor the time to rekindle the debate on the intricate aspects of the history of Dacia during the reign of its first king. Several years ago, Ion Horațiu Crișan tried, through a monographic study, to coherently present Burebista's achievments (Crișan 1975; Crișan 1977), the work being translated to other languages as well (Crișan 1978; Crișan 1980). The study brought on an intensified interest in the subject from the part of scholars, but then slowly lost its appeal. Recently the period of the great king's rule has been approached from a double perspective, archeological and hystorical, with an emphasis on the Southwestern region of Romania (Rustoiu, Ferencz 2018).

From an archeological point of view, in Dacia and especially in Southwestern Transylvania a new type of settlement develops – the so-called "Dacian fortresses". The majority of their characteristic traits reveal their social, economical, and symbolic functions, rather than the military ones (Pupeză 2012; Ferencz 2014, 125-126; Rustoiu 2015, 354-358; Rustoiu, Berecki 2018, 70-77). The most impressive among them were built in the South and Southwest of Transylvania. They are present especially in the intra-Carpathian area, although there are some examples on the Eastern and Southern slopes of the

Carpathians as well (Glodariu 1983, 75-110). They are set on heights and surrounded by an agricultural hinterland, where the settlements that rely on the fortresses are also positioned (Egri 2014, 177; Rustoiu 2015, 358).

The entire organization, vertical as well as horizontal, illustrates the fact that this type of habitat was created by a strongly hyerarchized social structure and that it represents fortified aristocrathic residences (Florea 2011, 93-94; Ferencz 2014, 115). At the top of the hierarchy seem to be the Dacian kings, their center of power lying in the Southwest of Transylvania. The structure of this type of settlement appears to represent a means of adaptating configurations from the Mediterranean region to the symbolic and practical needs of the local elite. The monumental stone buildings appear to fully illustrate this aspect.

Walls built using a technique that confers them monumentality were meant to support terasses, to form enclosures, and were raised to become the base of ostentatious buildings. The so-called *murus Dacicus* can be described as a special technique consisting of revetments made from sizeable stone blocks. The two revetments are sparsely connected by wooden beams, and the space between them packed with pieces of rock and soil (Glodariu 1983, Fig. 12.2; Gheorghiu 2005, 107-117; Pupeză 2010, 160; Pupeză 2011, 148; Bodó 2015, 470). In fact, in most cases, the technique is an adaptation of the one used in the Hellenistic world, in general, and the walls of the Greek colonies on the Black Sea, in particular (Pârvan 1926, 476-477; Gheorghiu 2005, 132–141; Pupeză 2011, 148; Bodó 2015). The style was borrowed from the Mediterranean region, through master builders, probably of Greek origin. The phenomenon seems to have intensified following Burebista's campaigns on the Western shore of the Black Sea (Bodó 2015, 470). Such walls are 2-3 m in thickness. The oldest monument built in such a manner is probably the one from Cetățuia hill from Costești (Glodariu 1983, 129), where the two so-called "tower-houses" with Hellenistic wall bases, brick elevations, and tilled roofs impress to this day. Also impressive are the monumental stairwell and the enclosure walls. Some scholars believe that the fortress on top of Cetățuia hill from Costești served as residence for King Burebista (Glodariu 1983, 29). A number of other monuments in Sowthwestern Transylvania have buildings and walls erected using the same technique.

Analysing the Dacian settlements and fortresses known to date it is easy to discern that the number of buildings where this technique was implemented is very small, in fact it is nearly an exception (Pupeză 2011, 150). This observation can be explained from the perspective of the symbolic function of the walls and buildings, as well as other monumental structures (Pupeză 2011, 150). Their construction is the result of a decision taken by an authority who imposes limits and makes them known (Pupeză 2011, 151-152). In order to support the similarity that borderlines reproduction between the walls of Greek fortresses from the Western shore of the Black Sea and those of Dacian fortresses from Southern Transylvania, Ion Horațiu Crișan quotes the description of a segment of Histria's wall (Crișan 1977, 328, 358).

The monumental structures employing faceted limestone blocks found in Southwestern Transylvania have polarized the attention of specialists and general public alike, ever since their discovery. The building techniques and materials have also been the object of attention. Key moments in the research history of this topic were marked by contributions from Téglás Gábor (Téglas 1885, 306; Téglas 1888, 134; Téglas 1902; Téglas 1905), Dimitrie M. Teodorescu and Márton Roska (Teodorescu, Roska 1923), Alexandru Ferenczi (Ferenczi 1951), Ioan Glodariu (Glodariu 1983), Dinu Antonescu (Antonescu 1984), and Paul Pupeză (Pupeză 2011; Pupeză 2012). Within this topic the use of mortars has been a particular issue (Daicoviciu 1954, 61-63; Daicoviciu 1960, 321; Daicoviciu 1972, 133) Radu Popa (Popa 1977) and Ioan Glodariu (Glodariu 1983, 137-138), are some of the researchers who have taken on this subject from different perspectives. It is currently accepted that mortar was used as binder in the construction of the cistern from Blidaru, while the walls erected with the use of mortar from Piatra Roșie or Bănița are thought to be Medieval in age (Popa 1977).

Several researchers have supported the ideea of the contribution to the erection of such walls from Greek master builders, who were present in Dacia after Burebista's millitary campaigns against the Greek fortresses on Pontus Euxinus (Daicoviciu 1954, 42; Crișan 1977, 328, 342; Glodariu, Moga 1989, 29; Pupeză 2011, 152; Bodó 2015). However, Roman architects were familiar with building techniques, including the Greek ones, as noted by Vitruvius Pollio (Vitruvius, II, VIII, 12-16). Opinions didn't always converge, some researchers claiming that walls lacking boutisses were a later creation pertaining to the Dacian master builders (Glodariu 1983, 124; Pupeză 2011, 148). There are also those of the opinion that such walls are entirely of local creation (Daicoviciu 1979, 106; Antonescu 1984, 108-109), despite all of the above-mentioned remarks. All of the discrepancies observed in the building technique can be more likely ascribed to the large number of master builders and architects involved in the construction work (Bodó 2015, 471-476).

A "tower-house" type structure was identified in Ardeu, on the top of Cetățuie hill, within a fortified Dacian enclosure (Ferencz, Căstăian 2019). The first architectural elements indicating the presence of the edifice were discovered in 2002 during an archeological evaluation of the site (Ferencz et al.

Fig. 1. The infilling on the Northern side of the tower house's wall (foto I. V. Ferencz 2002).

2003). Téglás Gábor had noticed, more than a century earlier, on the top of Cetățuie hill the presence of a number of hand-chiseled, "cubical", limestone blocks, similar to those found at Sarmizegetusa. This find allowed him to assume that their source was a construction made from such stone blocks, possibly a bastion or gate (Téglas 1885, 306; Téglas 1888, 134).

The site layout observed during the 2002 campaign (Fig. 1) led us to believe for a long time that the tower was built as a wodden structure, raised on a base made of local stone, with a perimetral dry masonry wall. The identification of an assemblage (cca. 2 m wide and 0.30 m in length; Fig. 1) of local stone, bound with clay pointed in this direction back in 2002. The context was interpreted as being a wall (Ferencz et al. 2003, 41). Later we considered it to be a stone platform meant to ensure a horizontal surface on which to build the edifice (Ferencz 2014, 123). During investigations of the hummock area, traces of construction were observed on both the surveyed and un-surveyed surfaces, permitting us to hypothesize on the presence of a monumental building on the area of the hummock, interpreted as being a "tower-house" (Bodó, Ferencz 2004, 150). Verifying this hypothesis began with the 2013 campaign, when surface Sp6 was surveyed (Ferencz, Căstăian, Dima, Popa, Roman 2014). Work was continued by campaigns throughout the following years (Ferencz, Căstăian, Popa, Roman 2015; Ferencz, Căstăian, Roman, Socol 2016). In 2014 work was started on sectioning the hummock, and implicitly the "tower-house", along its West-East axis (Ferencz, Căstăian, Popa, Roman 2015, 27-28), which proved to be an inspired decision, as it allowed the identification of representative *in situ* segments of the edifice's wall (Fig. 2; 3). It proved to be a construction based on a wall built in a Hellenistic manner (Fig. 4), with two revetments from sizable stone blocks (Ferencz, Căstăian, Roman, Socol 2016, 267), cut from oolitic limestone (Cetean, Ferencz 2016, 48-49), and with infilling (Ferencz, Căstăian, Popa, Roman 2015, 28).

Fig. 2. The interior revetment and the infilling of the tower house's wall (Foto C. C. Roman 2014)

Fig. 3. The Western wall of the tower house (Foto C. C. Roman 2014).

Fig. 4. The exterior revetment on the Eastern side of the building (foto I. V. Ferencz 2017)

The hypothesis of the "tower-house" was also verified through non-invasive methods, more precisely by means of electrical resistivity tomography (Micle 2017). Their summation contributed to formulating a series of conclusions and working hypotheses that will be either confirmed or infirmed in the following years, depending on the amplitude of invasive (archaeological) and non-invasive research carried out. Electrical resistivity also allowed to establish the building's planimetry (Ferencz, Căstăian 2019, Pl II/2). The plan drawn from the measurements indicates that the building's foundation is quadrilateral in shape, each side cca. 12-14 m in length (Micle 2017). Invasive survey demonstrated that the

Fig. 5. Boutisse (oolitic limestone block, set perpendicular to the wall surface), from the surface of which the mortar sample was taken (Foto I. V. Ferencz 2016).

wall's thickness, measured at the exterior of each revetment is about 3.15 m, while the width of the entire edifice, on its West-Est axis, is cca. 11.5 m from one exterior revetment to the other (Ferencz, Căstăian 2019, Pl II/2).

On the Southern flank of the plan the electrical resistivity survey showed a discontinuity in resistivity values for both the exterior and interior wall. This represents most likely the acces way to the base of the "tower-house". The discontinuity is approximately 2 m long and based on the morphology of the terrain it could have been the location of an access ladder (Micle 2017).

During the 2016 campaign, on the inferior surface of a block sitting perpendicular on the revetment, a so-called „boutisse" (Fig. 5), we noticed the presence of a material of different texture and color compared to the stone block. We sampled the material in order to identify it. Its appearance led us to immediately assume it could be mortar. A series of thermal analyses were carried out in the Faculty of Chemistry, Biology, and Geography (West University of Timișoara), the manuscript being currently in preparation (Vlase, Vlase, Ferencz, Sfârloagă, Micle, Vlase 2019). Samples were also provided for analysis to Dr. Valentina Cetean (Romanian Geological Survey, Bucharest).

In this paper we aim to present preliminary results from a third set of analyses carried out on a sample of the same material, as well as a first series of conclusions derived from these.

Our choice of analytical methods was based on questions formulated ever since the material was discovered. These questions are as follows:

1. Is the sampled material a mortar?
2. If so, then which are its components?
3. In what percentage are each of the identified elements present?

In order to find answers to the above questions we prepared petrographic thin sections from the material collected from the site, as well as carried out powder X-ray diffraction (XRD). Sample preparation is simple and relatively quick for both methods. For XRD approximately 1 gram of sample is powdered to cca. 10-50 μm particle size, then placed into a specially designed holder and measured. For petrographic thin sections, a billet ca. 1 cm^2 in surface of the solid sample is cut and polished on one side, then the polished side glued to a glass microscope slide using bi-component epoxy resin. Once the resin has cured, the excess sample is trimmed down and polished to a thickness of cca. 30 μm.

The powder X-ray diffraction was performed on a Bruker D8 Advance diffractometer with Bragg-Brentano geometry, $CuKa_1$ with $\lambda = 0.15418$ nm, Ni filter and a one-dimensional detector, at the Department of Geology, Babeş-Bolyai University Cluj-Napoca, using corundum (NIST SRM 1976a) as internal standard (NIST: U.S. National Institute of Standards and Technology reference material). The data were collected on a 5 - 64° 2θ interval, at a 0.02° 2θ, with a measuring step of 0.5 seconds. The identification of the mineral phases was performed manually with the Diffrac.Eva 2.1 software from Bruker AXS, using the PDF2 (2012) database from the International Centre for Diffraction Data (www.icdd.com).

Powder X-ray diffraction has been used for over a hundred years in the study of natural and synthetic crystalline structures (Debye and Scherrer, 1916; Pecharsky and Zavalij, 2009). The method compares the diffractogram (or pattern) of an unknown sample consisting of crystallized material with standard patterns from an internationally recognized database (Pecharsky and Zavalij, 2009). It is applied in a large array of research fields, comprising among others physics, chemistry, and geological studies. The analyzed material usually consists of crystalline powder obtained by grinding the collected sample in an agate mortar, in order to avoid contamination (Pecharsky and Zavalij 2009, 302).

Masonry mortars are generally described as synthetic (i.e., man-made) compounds used to physically bind building materials, such as stones, bricks, etc. They are usually multicomponent systems (e.g., inert mineral aggregates, seldom mineral additions, binders, and binder-related particles), in which each of the comprising materials helps strengthen the mechanical properties of the final material. This particular property stems out of the physical hardness of the components (e.g., inert mineral aggregates), and the chemical reactions that take place during manufacturing and hardening of the mortars (e.g., formation of authigenic minerals, binders, etc.). One particularity of mortars is

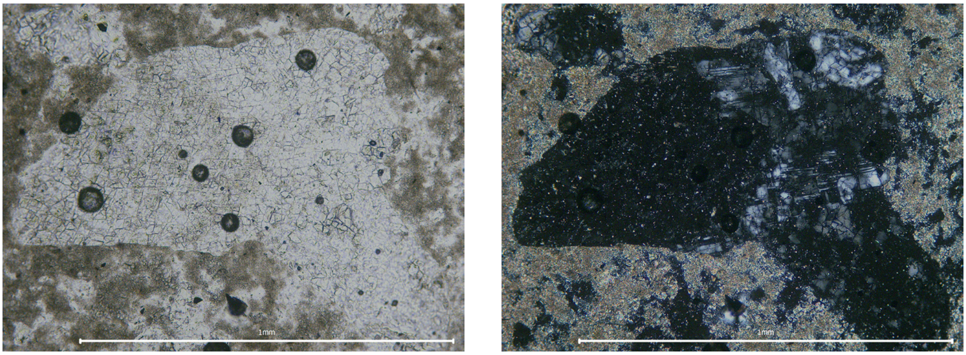

Fig. 6. Large alkali feldspar (orthoclase and microcline) lithoclast, with quartz and zircon micro-inclusions. Image on the left – plane polarized light; image on the right – crossed polarized light.

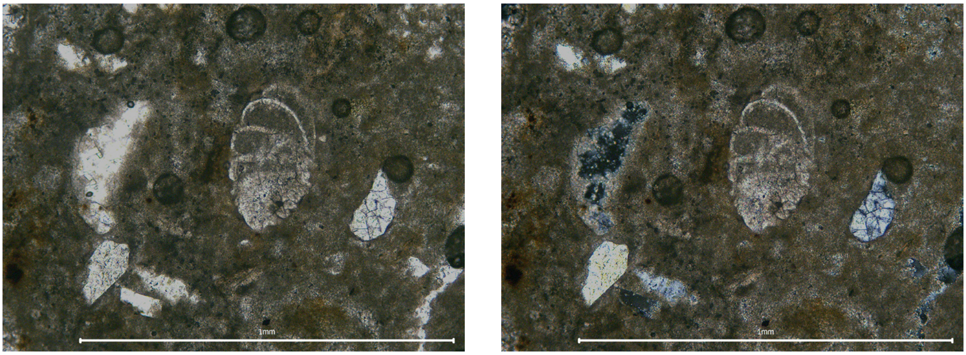

Fig. 7. Angular quartz and feldspathic aggregates, showing poor sphericity. Image on the left – plane polarized light; image on the right – crossed polarized light.

that each of the original components retain their chemical and mineralogical composition (Goffer 2007, 144; Elsen 2006). In other words, the mineral aggregates used will easily be identified long after the mortar was put in place. In most cases this applies to the binder as well, especially for lime masonry mortars.

The type of inert aggregates used for the manufacturing of the mortars is very diverse as they tend to be sourced from the lithologies available locally, including sand sources, crushed rock formations, or from re-used construction materials, such as bricks and stone blocks. Identification of the mineral composition of the aggregates is a powerful tool for understanding the source of the raw material as well as the technology used. The petrographic analysis of the Ardeu samples has shown that the main mineral components of the aggregates are quartz, plagioclase feldspar (mainly Ca-rich albite, but also anorthite dis-

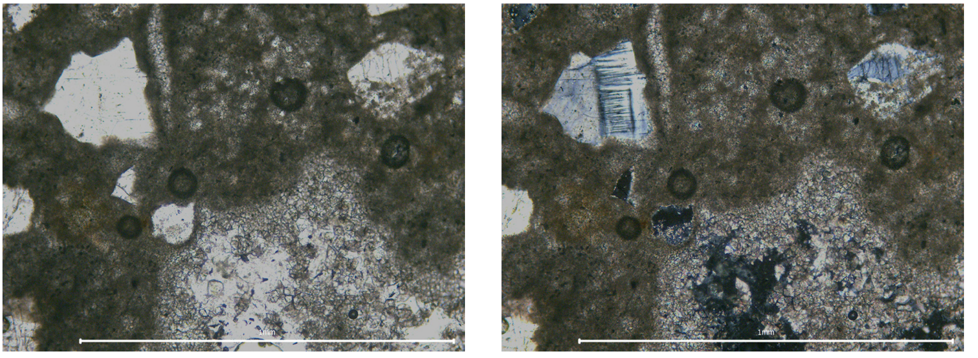

Fig. 8. Photomicrograph (20X) showing micritic and sparitic calcite, as well as feldspathic and quartz aggregates. Primary and secondary porosity are visible. Image on the left – plane polarized light; image on the right – crossed polarized light.

playing typical polysynthetic twinning), potassium feldspar (orthoclase and subordinately microcline with cross-hatch twinning; (Fig. 6; 7), micas (muscovite and subordinately biotite), as well as minute heavy minerals (e.g., titanite, rutile, zircon).

The mineralogical composition suggests a granitic/andesitic source for the aggregates, in agreement with the local lithology (Cetean, Ferencz, Rustoiu 2018). Also, the fact that mineral grains are poorly sorted (i.e. a wide range of grain sizes is present), sub-angular to sub-rounded in shape, and have low sphericity (Powers 1953), further supports the hypothesis that raw materials for the aggregates were sourced locally and are alluvial (i.e. river sand) in origin.

The typical binder identified in the Ardeu samples is lime. The calcium carbonate (calcite) is finely crystalized (micritic), with larger, well defined crystals developing on the inside of the pores. In some cases, dissolution-reprecipitation processes can be observed (Fig. 8), together with the formation of secondary binder porosity features (Fig. 8). No binder related particles (i.e., lime lumps) have been identified, which is a possible indication of a proficient lime manufacturing technology. The mineralogical composition and texture identified in thin section support the initial hypothesis that the sample represents a man-made material, more precisely a mortar.

Based on the XRD pattern (Fig. 9) the principal components of the material are calcite (the main component of limestone, which is used to make lime), quartz, muscovite, feldspar (plagioclase and potassic), aragonite and heavy minerals (e.g., rutile), which are practically omnipresent in alluvium (i.e. sand; used as an aggregate). Together, these two analytical methods paint a pretty clear image of the makeup of the sampled material, and exclude the possibility that we are dealing with a naturally occuring compound.

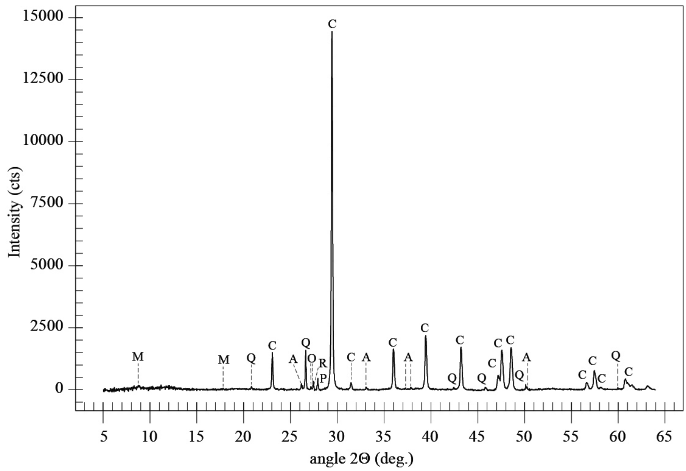

Fig 9. XRD pattern of sample Ard-1/2019: C – calcite, M – muscovite, Q – quartz, A – aragonite, P – plagioclase feldspar, O – orthoclase feldspar, R – rutile.

Conclusions

As already mentioned, the wall building technique employing faceted stone blocks, with two revetments, supported by wodden beams set in channles dug in the blocks and with infilling is specific to the Hellenistic world (Pârvan 1926, 476-477; Daicoviciu 1954, 42; Crișan 1977, 328; Glodariu 1983, 28). Inspiration for the design of tiles and pantiles found in certain sites from Southern Transylvania can also be attributed to the same area (Glodariu 1983, 28).

Also specific to the Hellenistic walls are the „boutisse", blocks disposed perpendicular on the revetment, ensuring the connecton to the infilling (Glodariu 1983, 124), as is also the case in Ardeu the block from which our samples were sourced.

One other architectural ellement considered to be of Hellenistic inspiration are plans of fortresses such as Costești - „Cetățuie", Blidaru, and Piatra Roșie (Crișan 1977, 342; Glodariu 1983, 126). The Greek letters carved into one of the blocks from Blidaru, Căpâlna or Grădiștea Muncelului are also noteworthy (Crișan 1977, 342; Bodó 2015, 474-475).

In our opinion, walls built in this manner were erected by master builders originating from the pontic region, possibly from other areas as well. We are referring here to walls constituting enclosures, those representing the base of "palaces", as well as those with or without boutisses. We ascribe the elements that set them apart to a personal preference of the particular master builder (Bodó 2015, 471). Probably the most evident particularity was noted at Piatra Craivii, where the wall is of Mediterranean origins and copies the so-called "*murus africanus*" (Bodo 2001, 319-324). This is in concordance with the observation of Vitruvius Pollio, who recommends adapting construction methods to the site's prospect (Vitruvius I. 10).

Therefore, in our opinion, a better understanding of the use of mortar in certain constructions is imperative. The issue of mortar use in buildings dating from the Dacian Kingdom period is still open. The analytical results presented in this contribution are, in our view, only the very first elements upon which to build a solid, utterly needed data base.

The analytical methods employed enabled us to find answers to two of the three questions we set when initiating this study. The answer to the first question, "Is the sampled material a mortar?" is an unequivocal yes; the sample represents a synthetic compound, intended for use as a binder for building materials.

To the second question, "which are the mortar's components?" the answer is sand (most likely sourced locally), aggregate (made up of lithic clasts compatible with the local geology, and crushed fragments of recycled building material – bricks and rocks), and qood quality lime.

In order to succesfully approach the third question – "in what percentage are each of the identified elements present?", we plan to carry out additional analyses in the near future.

We strongly believe that the same type of analysis is necessary for the mortars discovered in the walls of fortresses from Piatra Roșie and Bănița, and of course from the fast deteriorating Blidaru cistern as well. Similar materials from walls of buildings and enclosures from other time periods must be analysed as well, contributing to such a data base. In our opinion, future survey of other sites will eventually lead to the identification of similar situations to that in Ardeu.

As a logical next step, we intend to extend the analysis to other materials of similar nature collected from the top of Cetățuie Hill in Ardeu (i.e. medieval phase). Until that time, this recent discovery from Ardeu enables the re-opening of discussions around this remarkable topic.

Bibliography

Antonescu, Dinu. 1984. *Introducere în arhitectura dacilor*. București: Editura Tehnică.

Bodó, Cristina, Ferencz Iosif Vasile. 2004. „Câteva considerații privind fortificația şi aşezarea dacică de la Ardeu (com Balşa), jud. Hunedoara." *Istros* XI: 147-158.

Bodó Cristina. 2015. „Lucrări ale arhitecților greci în zona capitalei regatului dac." *Istros* XXI: 465-497.

Cetean Valentina, Iosif Vasile Ferencz. 2016. „Studiu mineralogic preliminar privind tipurile de roci de pe șantierul arheologic Ardeu - Cetățuie, jud. Hunedoara." *Sargetia* 7 S. N.: 45-66.

Cetean Valentina, Iosif Vasile Ferencz, and Aurel Rustoiu. 2018. „Surse de materii prime pentru construcțiile de pe acropola cetății dacice de la Ardeu – Dealul Cetățuia. Cercetări interdiscipinare/Sources of raw materials for the constructions built on the acropolis of the Dacian fortress at Ardeu – Cetățuie Hill. Interdisciplinary research". In *Cercetări interdisciplinare la siturile din epoca fierului în spațiul tiso-nistrean. Materialele colloquium-ului de vară de la Saharna (Saharna, 13-16 iulie 2017 /Interdisciplinary research in Iron Age sites from the Tisa-Dnister area,* edited by Aurel Zanoci, Mihail Băţ, Sorin-Cristian Ailincăi, Alexandra Țârlea, Proceedings of Saharna Summer Colloquim, Saharna, July 13th-16th, 2017, 145-179, 209-237. Tulcea-Chișinău-Cluj-Napoca: Mega.

Crişan, Ion Horațiu. 1975. *Burebista şi epoca sa*. First edition. Bucureşti: Editura enciclopedică română.

Crişan, Ion Horațiu. 1977. *Burebista şi epoca sa*. Second edition. Bucureşti: Editura Ştiințifică şi Enciclopedică.

Crişan, Ion Horațiu. 1978. *Burebista and his time*. Bucureşti: Editura Academiei.

Crişan, Ion Horațiu. 1980. *Burebista és kora*. Bucureşti: Tudomànyos és Enciklopédiai Könyvkvkiadò.

Daicoviciu, Constantin, Octavian Floca, Mihail Macrea, Mihai Dediu, P. Duka, Ștefan Ferenczi, Mihai Gostar, A. Ilieș, D. Mitrofan, D. Radu, and Winkler Iudita. 1954. „Şantierul arheologic Grădiştea Muncelului – Blidaru." *SCIV* V, 1-2/1954: 123-155.

Daicoviciu, Constantin. 1954. *Cetatea dacică de la Piatra Roșie,* București: Editura Academiei Republicii Populare Romîne.

Daicoviciu, Constantin. 1960. „Apariţia și formarea relațiilor sclavagiste în Dacia". In *Istoria României,* 255-238. București: Editura Academiei.

Daicoviciu, Hadrian. 1972. *Dacia de la Burebista la cucerirea romană*. București: Dacia.

Debye, Peter, Paul Scherrer. 1916. Interferenzen an regellos orientierten Teilchen in Röntgenlicht. I., In *Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse,* 1916, 15 Pages (1-15). Berlin: Weidmannsche Buchhandlung.

Egri, Mariana, 2014. „Enemy at the gates? Interactions between Dacians and Romans in the 1st century AD". In *The Edges of the Roman World,* edited by Marko A. Janković, Vladimir D. Mihajlović and Staša Babić, 172-193. Cambridge: Scholars Publishing.

Elsen, J. 2006. „Microscopy of Historic Mortars-a Review." *Cement and Concrete Research*, 36 (8): 1416–1424.

Ferencz, Iosif Vasile, Mihai Căstăian, Cristina Bodó, Cristian Ioan Popa, Ștefan Andrei, and Roxana Stăncescu. 2003. „Ardeu, com Balșa, jud. Hunedoara, punct Cetățeaua". In *CCA, Campania 2002*, 40–42. Covasna.

Ferencz, Iosif Vasile, Mihai Căstăian, Cristian Dima, Cristian Ioan Popa, Cristian Constantin Roman. 2014 „Raport privind cercetările arheologice pe şantierul Ardeu (com. Balşa, jud. Hunedoara)". In *CCA, Campania 2013*, 18. Oradea.

Ferencz, Iosif Vasile, Mihai Căstăian, Cristian Ioan Popa, Cristian Constantin Roman. 2015. „Raport privind cercetările arheologice pe şantierul Ardeu (com. Balşa, jud. Hunedoara)". In *CCA, Campania 2014*, 26-28. Pitești.

Ferencz, Iosif Vasile. 2014. „The Dacian fortress before the Roman conquest. Case study - the fortress at Ardeu." *Acta Archaeologica Carpathica* Vol. XLIX: 113-129.

Ferencz, Iosif Vasile, Mihai Căstăian, Cristian Constantin Roman, Socol Ionuț Mihai Dealmar. 2016. „Raport privind cercetările arheologice pe şantierul Ardeu (com. Balşa, jud. Hunedoara)" In *CCA, Campania 2015*, 17-18. Tg. Jiu.

Ferencz, Iosif Vasile and Mihai Căstăian. 2019. „Turnul-locuință -simbol al puterii nobiliare în Dacia. Studiu de caz, Ardeu-„Cetățuie". In *Contribuții la preistoria şi istoria antică a spațiului carpato-danubiano-pontic. In honorem professoris Ion Niculiță natalia sua octogesima celebrantis,* edited by Aurel Zanoci and Mihail Băț, 409-420. Chișinău: Cartdidact

Ferenczi, Alexandru. 1951. „Studiu topografic al așezărilor" In *Așezările dacice din Munții Orăștiei,* edited by C. Daicoviciu, Al Ferenczi, 9-17. București: Editura Academiei RPR.

Florea, Gelu. 2011. *Dava et oppidum. Débuts de la genèse urbaine en Europe au deuxième âge du Fer.* Cluj-Napoca: Académie Roumaine, Centre d'Études Transylvaines.

Gheorghiu, Gabriela. 2005. *Dacii pe cursul mijlociu al Mureşulu*. Cluj-Napoca: Editura Mega.

Glodariu, Ioan. 1983**.** *Arhitectura dacilor. Civilă și militară (sec II î. e. n. – I e. n.).* Cluj-Napoca: Dacia.

Glodariu, Ioan, Vasile Moga. 1989. *Cetatea dacică de la Căpâlna*. București: Editura Ştiințifică şi Enciclopedică.

Goffer, Zvi. 2007. *Archaeological Chemistry,* New Jersey: Wiley-Interscience, Hoboken. NIST SRM 1976a. „www.nist.gov/programs-projects/powder-diffraction-srms" seen 12.09.2019.

Pârvan, Vasile. 1926. *Getica. O Protoistorie a Daciei*. Bucureşti: Cultura Natzională.

Pecharsky, Vitalij K., and Peter Y. Zavalij. 2009. *Fundamentals of Powder Diffraction and Structural Characterization of Material*. New York: Springer.

Popa, Radu. 1977. „Observații privind zidurile cu mortar din cetățile dacice hunedorene." *Sargetia* XIII: 277-283.

Powers, M.C., 1953. „A new roundness scale for sedimentary particles." *Journal of Sedimentary Petrology* 23: 117-119.

Pupeză, Luca Paul. 2010. „Murus dacicus between function and symbol." *Transylvanian Review*, XIX, Supplement No. 2: 159-170.

Pupeză, Luca Paul. 2011. „Murus Dacicus, simbol al războiului sau al păcii?". *Revista Bistriței* XXV: 148-158.

Pupeză, Luca Paul. 2012. „To see or to be seen. The Dacian fortresses from the Orăştie Mountains". *Annales d'Université Valahia Targoviste, Section d'Archeologie et d'Histoire*, XIV, No 2: 81-85.

Rustoiu, Aurel. 2015. „Civilian and funerary space in the Dacian fortified settlement at Cugir". In *Interdisciplinaritate în Arheologie și Istorie*. edited by Forțiu Sorin and Stavilă Andrei. Vol. 1 ArheoVest, No. III: In Memoriam Florin Medeleţ, 349-367. Szeged: Arheologie JATEPress Kiadó.

Rustoiu, Aurel and Berecki Sándor. 2018. „Symbols of Status and Power in the Everyday Life of Late Iron Age Transylvania. Shaping the Landscape." In *Representations, signs and symbols: proceedings of the symposium on life and daily life,* edited by Iosif Vasile Ferencz, Oana Tutilă, Nicolae Cătălin Rişcuța, 65-78. Cluj-Napoca: Mega.

Rustoiu, Aurel and Ferencz Iosif Vasile. 2018. „Burebista at the Banat's Danube. Archaeological and historical data regarding the evolution of settlements in the Iron Gates Region in the 1ST Century BC." *Banatica* 28: 123-149.

Téglas, Gábor. 1885. „Emlékek és leletek. Az Erdőfalvi barlangok." Archaeologiai Értesitő 5: 299-307.

Téglas, Gábor. 1888. „Az erdélyi Érczhegység déli felének öskori védmüvei és legrégibb lakossága." *Erdélyi Múzeum Egyesület* XV/9: 499-509.

Téglas, Gábor. 1902. „Hunyadmegye a dákok és a rómaiak idején." *Hunyadvármegye monographiája*, 34–211. Budapest.

Téglas, Gábor 1905. „Decebál végső menedékvárainak holléte." *MTAÉ*: 97–105.

Teodorescu D.M., Roska M. 1923. *Cercetări arheologice în Munții Hunedoarei*. Cluj-Napoca: Cartea Romaneasca.

Vitruvius Pollio, „On Architecture, De architectura libri decem". http://www.perseus.tufts.edu/hopper/text?doc=Vitr.%201&lang=original (seen 30.08.2019)

Vlase, Dan, Vlase Gabriela, Ferencz Iosif Vasile, Sfârloagă Paula, Micle Dorel, Vlase Titus 2019. „TG-DTA, XRD, SEM, EDS and FT-IR analyses of

various samples of mortars from Deva region", submitted to the *Journal of Thermal Analysis and Calorimetry*.

Uimitoarea arhitectură a dacilor. Câteva considerații cu privire la utilizarea mortarelor pe baza unor noi analize

Rezumat

Cercetările recente desfășurate la Ardeu au condus la identificarea unei clădiri cu ziduri din blocuri de calcar de talie, dispuse pe asize, cu două paramente și emplecton. În 2016, în timpul desfășurării unei campanii de cercetare care avea ca obiectiv acea construcție monumentală, un așa-zis „turn-locuință" dacic, a fost constatată prezența unui adaos de material cu textură și culoare diferite față de cele ale blocului din piatră. Aceasta a fost observată pe suprafața inferioară a unui bloc de piatră așezat perpendicular în zid, o așa-zisă „butisă". Descoperirea ne-a determinat să presupunem că ar fi mortar. Pe baza acestei ipoteze de lucru au fost formulate o serie de întrebări, cu scopul de a extrage cât mai multe informații valoroase din eșantion. Pentru a răspunde la aceste întrebări au fost efectuate o serie de investigații prin metoda difracției de raze X și investigațiile petrografice.

Cuvinte cheie: Dacia, XRD, petrografie, mortare, zidărie, materiale de construcții, Transilvania

Cristina Montana Pușcaș,
Terra Analitic, Alba Iulia, Romania.
E-mail: montana.puscas@terraanalitic.ro

Iosif Vasile Ferencz,
Museum of Dacian and Roman Civilisation Deva, Romania.
E-mail: fiosifvasile@yahoo.com

Ciprian Cosmin Stremțan,
Teledyne Photon Machines, Bozeman, Montana, USA.
E-mail: ciprian.stremtan@teledyne.com

Tudor Tămaș,
Department of Geology, Babeș-Bolyai University, Cluj-Napoca, Romania.
E-mail: tudor.tamas@ubbcluj.ro

Adrian Căsălean,
Museum of Dacian and Roman Civilisation Deva, Romania.
E-mail: adicasalean@yahoo.co.uk