The Stones of Felix Romuliana (Gamzigrad, Serbia)

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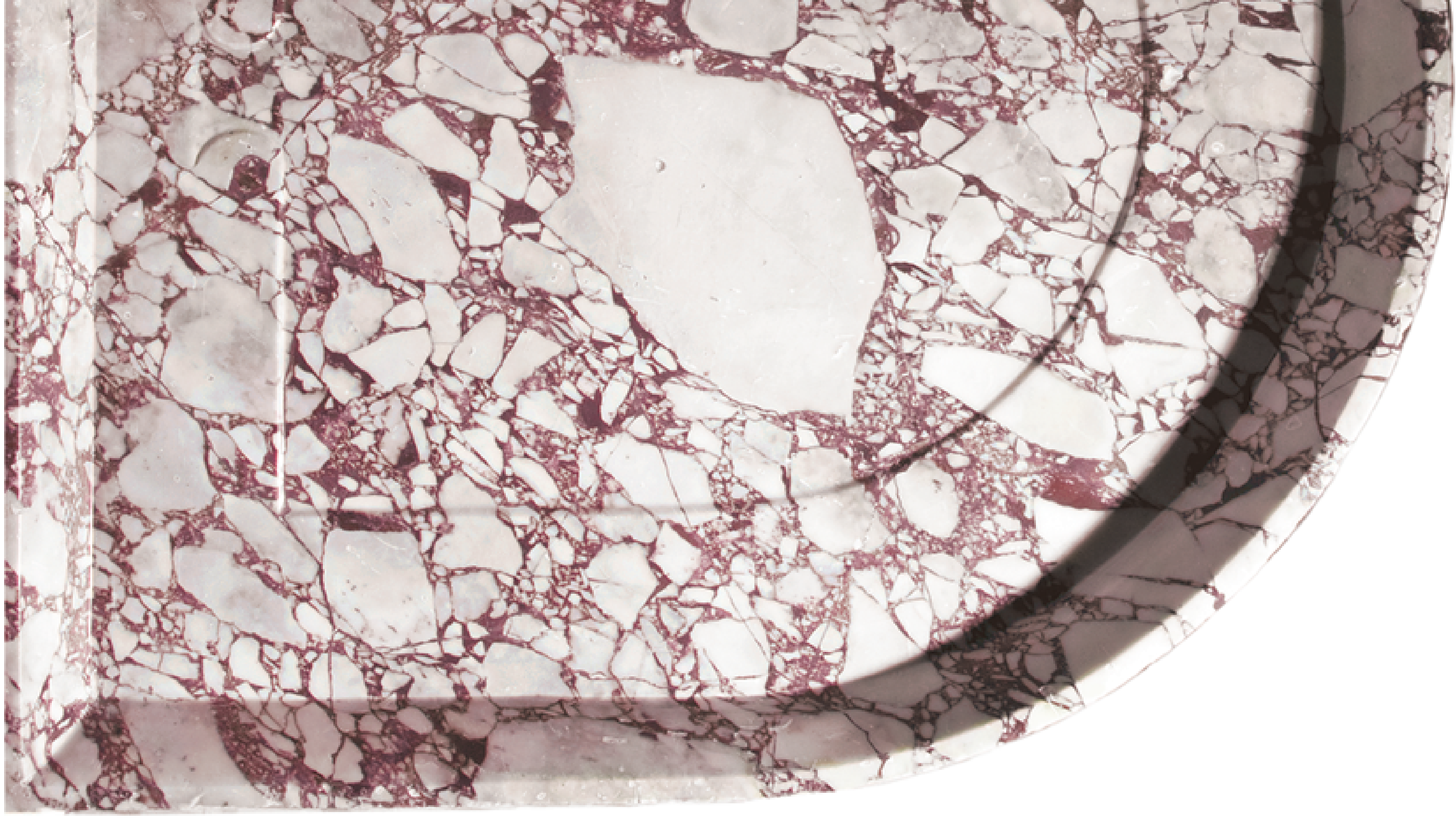

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CONTENT

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THE STONES OF FELIX ROMULIANA (GAMZIGRAD, SERBIA)

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Abstract

The Imperial "retreat palace" Felix Romuliana is predominantly constructed of local and regional rocks. The commonest building material is hornblende andesite available on site and used most extensively for the second fortification. The dimension stones for different parts of the fortifications, for the palace proper and the two temples are of local volcaniclastic sandstone, brought from the quarry on the adjacent Magura Hill, and of regional sandy limestone of Sarmatian age, which was quarried north of Romuliana. The first fortification is built of local silty-marly limestone also used for the core of the two mausolea on Magura Hill. The tetrapylon on the same hill is constructed of lithic wacke. Mediterranean marbles were also employed in the palace, for column shafts, capitals, bases, entablatures and doorframes, as well as for the wall and floor veneering in the palace proper.

Keywords
Imperial palace, andesite, sandstone, limestone, Mediterranean marbles

The palace

The remains of the fortified Imperial "retreat palace"[1] near the modern village of Gamzigrad (East Serbia) extend over 4.51 hectares of open countryside surrounded by low hills. The palace is located close to the stream of Draganov potok, which is a small tributary of the Crni Timok River (*Timacum*), and in the centre of an important Late Roman mining zone[2] in *Dacia Ripensis* (Fig. 1). It was first mentioned as an important Roman complex in the mid-nineteenth century by Siegmund August Wolfgang von Herder[3] and later by Felix Kanitz[4]. Since 1953, it has been systematically excavated almost without interruption[5]. The discovery of the inscription *Felix Romuliana* in 1984[6] confirmed the site as *Romulianum*[7] – *Romuliana*[8], a place named after Romula, mother of the Emperor *C Galerius Valerius Maximianus* (c. 260 – 311). From 293 to 305, he held the position of Caesar and designated successor of *C Aurelius Valerius Diocletianus Augustus*, and was himself Augustus from 305 to 311. Within this short period (293 – 311), the heavily fortified *Felix Romuliana* was constructed[9].

The palace (Fig. 2) is enclosed within thick fortifications constructed in two phases. The first fortification, probably from the late third century, had rectangular towers along its perimeter and polygonal ones flanking the west and east gates. In the first years of the fourth century, a new, more impressive fortification was erected along the exterior of the earlier one, with monumental polygonal towers, some of which survive up to 16 metres high. The plan of the fortified complex is irregular, particularly in its northern part[10].

The interior of the palace complex hosts a number of buildings arranged around the main open space that is elongated trapezoidal in plan. This space is delimited in

1 DUVAL 1997, 148; v. BÜLOW 2011.

2 PETKOVIĆ 2009.

3 HERDER 1845, 20-21.

4 KANITZ 1861, 8-9; KANITZ 1868, 315-318.

5 MANO-ZISI 1956. For the bibliography until 1982 see SREJOVIĆ *et al*. 1983, and for the history of the excavations ŽIVIĆ 2011a.

6 SREJOVIĆ 1985.

7 Aur. Vict., *Epit*. XL, 16.

8 Proc., *De aedif*. IV 6, 19.

9 According to VASIĆ Č. 1995; VASIĆ Č. 1997, 149, it was constructed between 303 and 310. For different opinions see VASIĆ M. 2007 and v. BÜLOW 2016.

10 For the reconstruction of the fortifications and the residential complex see ČANAK-MEDIĆ 1978; for other constructions ČANAK-MEDIĆ, STOJKOVIĆ-PAVELKA 2011.

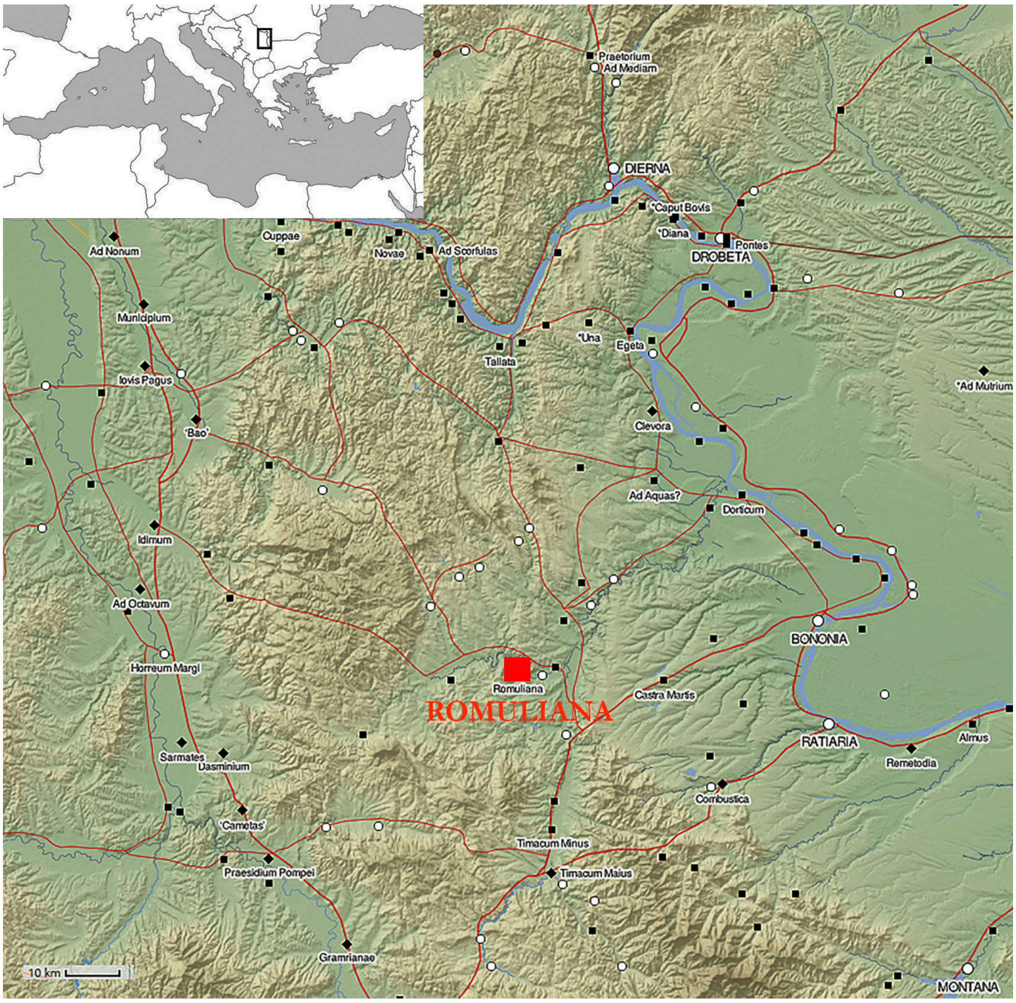

Fig. 1.
Geographical context of Felix Romuliana (map: Pleiades)

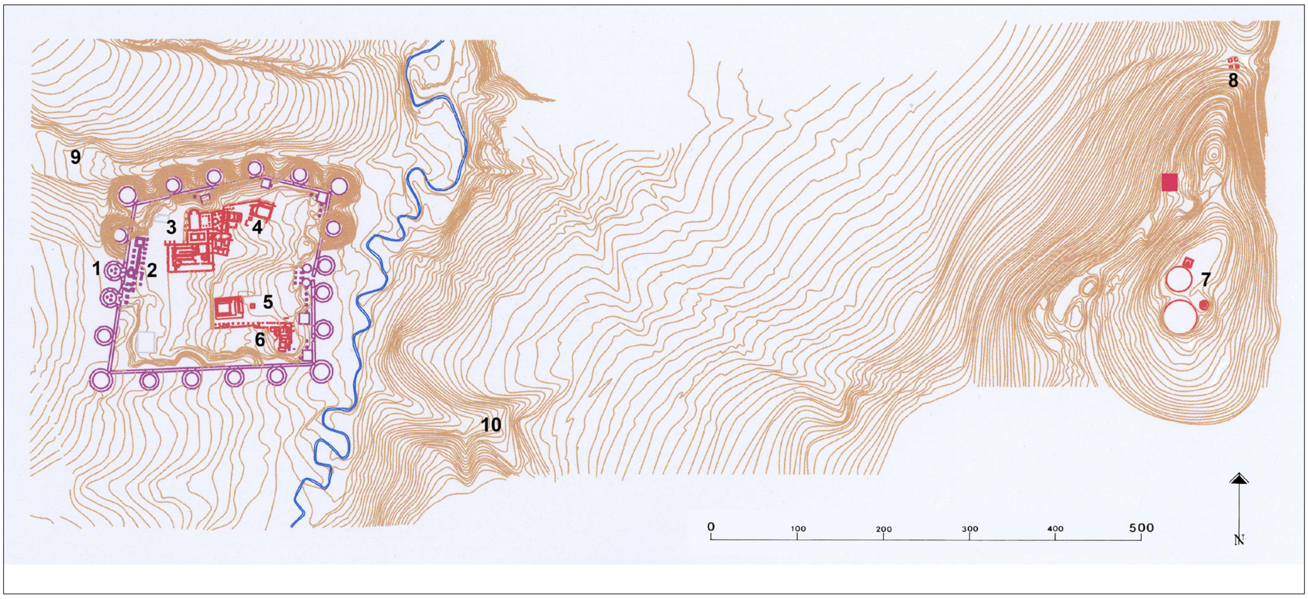

Fig. 2. Map of Felix Romuliana: 1 second fortification, 2 first fortification, 3 main residential complex, 4 tetrastyle prostyle temple, 5 temple of Jupiter, 6 baths, 7 mausolea and tumuli, 8 tetrapylon, 9 presumed hornblende andesite quarry, 10 presumed silty-marly limestone quarry (courtesy of Archaeological Institute, Belgrade)

the west by the façade of the luxurious residential complex, in the south by the long north wall of the portico around the main temple of Jupiter and Hercules (*templum cum porticibus*)[11], and in the north by the portico of a long building with a vestibule and a series of rooms. The central axis connects the main, east entrance to the palace with the architecturally enhanced entrance into the residential area[12]. Most of the rooms in this area were paved with mosaics[13], while the floors in the central part of the main apsidal room and in the *stibadium*[14] were made in opus sectile.

To the east of the residential area lies a small tetrastyle prostyle temple with an altar[15]. Further to the east is the second residential area, with a central courtyard and an apsidal hall. A large columnar building (called *horreum*) and a building of a cross-shaped plan[16] are located west of the great temple complex. Behind the portico of this temple, baths were constructed in the SE corner of the palace[17].

The road from the east gates of the palace leads eastwards to Magura Hill, where there are two tumuli and two mausolea. These are presumably the funerary monuments of the Emperor Galerius and his mother, Romula. Also on Magura, to the north of the funerary monuments, the architectural complex of Felix Romuliana is completed by a tetrapylon[18].

The geophysical investigations conducted at the site in recent years have shown a series of previously unknown built structures[19]. These include a settlement to the north of the palace, which is also enclosed within walls, but these are far less impressive.

During Late Roman times, Romuliana was gradually transformed into a fortified settlement[20]. The remains of the palace were incorporated into buildings frequently built of perishable materials such as wood, but also of reused brick and stone. In the fifth and sixth centuries, wooden houses and houses of mud-bound stone were constructed on top of the mosaics in the residential area, the porticoes and the towers. Part of the palace was reused as Christian basilicas in the late fourth and again in the sixth century.

11 For the form see EINGARTNER 2005.

12 v. BÜLOW *et al*. 2009, 119 and 158-160, figs. 9, 38b.

13 SREJOVIĆ D., JANKOVIĆ Đ., LALOVIĆ A. 1983, 69-77; JEREMIĆ 2006; ŽIVIĆ 2011b, 128-139.

14 VASIĆ M. 2006.

15 SREJOVIĆ *et al*. 1978.

16 SREJOVIĆ 1985; ČANAK-MEDIĆ, STOJKOVIĆ-PAVELKA 2011, 85-87.

17 ČANAK-MEDIĆ, STOJKOVIĆ-PAVELKA 2011, 100-102.

18 SREJOVIĆ, VASIĆ 1994a; SREJOVIĆ, VASIĆ 1994b; POPOVIĆ 2011.

19 v. BÜLOW *et al*. 2009.

20 PETKOVIĆ 2011b; PETKOVIĆ 2011a.

The rocks

The first to write more or less extensively about the rocks used for the construction of Felix Romuliana was Vidojko Jović[21], who also assembled a small collection of the different Mediterranean coloured marbles from the site[22]. His determination of the rocks is correct, but lacks a comprehensive description and characterisation.

Local and regional rocks

Our surveys and analyses have confirmed that four types of local and regional rocks were used in Romuliana as building material. One is **hornblende andesite**, which was extensively used for the construction of the second fortification, both as rubble in its core[23] and as roughly dressed blocks for its exterior faces[24]. In limited quantities, it was also used for the first fortification and for the buildings in the palace interior. The combination of this dark rock and the horizontal lines of red bricks creates a bichrome effect, the main colour scheme throughout the palace.

Hornblende andesite (Fig. 3) is a typical extrusive rock of middle-acid chemism that characterises the Timok Magmatic Complex (TMC). It has a holocrystalline porphyritic texture and is dominated by phenocrysts of plagioclase and hornblende, also present as microliths in the groundmass. Plagioclase occurs as 1-4mm large elongated prismatic crystals, rarely zonal. Hornblende occurs as basal and elongated crystals and exhibits green pleochroism. Small fragments of older volcanic rocks of the same chemism are rare. Opaque metallic matter and rare apatite, sphene and zircon are present as accessories (Fig. 4). The rock is highly tectonised.

It was most probably quarried just outside the NW corner of the fortifications, in the artificial depression within the bed of a small creek.

As opposed to the rest of the second-phase fortification, its SE corner was made of **volcaniclastic**

21 JOVIĆ 1983; JOVIĆ 1987-88; JOVIĆ 1998.

22 It is held in the Zaječar National Museum.

23 Around 75% of the core is made up of stone and 25% of mortar. It is estimated that roughly 96 000m^3 of stone was used for the second fortification alone.

24 This rock is locally known as *gvozdenac* (iron stone in translation) because of its hardness.

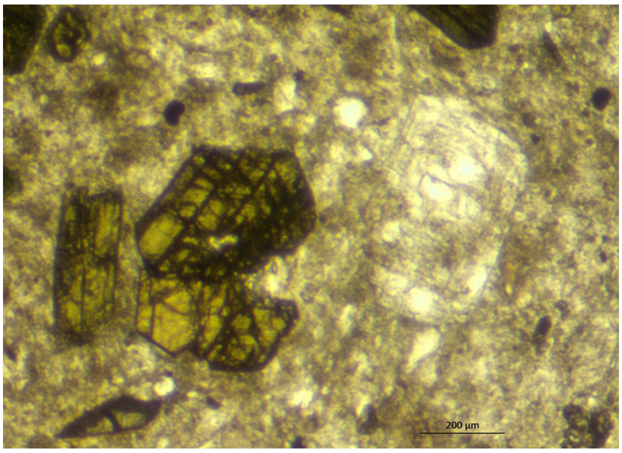

Fig. 3. Hornblende andesite, phenocrystals of hornblende (left) and plagioclase (right), NX (photo: D. Jovanović)

Fig. 4. Hornblende andesite, macroscopic appearance (photo: B. Djurić)

sandstone from Magura Hill. Elsewhere in the complex, this rock was used for the lower courses of the walls and towers, the cornerstones of the towers, the arches of the gateways, as well as the architectural elements (Corinthian capitals, fluted columns and relief-decorated pilasters) above the gateways of both fortifications (Fig. 5), the interior arcades as well as the decorative parts (entablature, door frame) and roof tiles of the small tetrastyle prostyle temple. Inside the residential area, we find it in the lower courses of the peristyles in combination with limestone to produce the same bichrome effect as at the gates. Outside the palace, it was used for tombstones.

The volcaniclastic sandstone (epiclastite) contains grains typical of sandstone with an abundance of material deriving from volcanites (Fig. 6). Its texture is massive; it is dense and fine-grained, thus suitable for dressing and for sculpture. It may contain $CaCO_3$. The groundmass is composed of volcaniclastics, silica and

Fig. 5. Architectural elements of volcaniclastic sandstone above the gateways (photo: B. Djurić)

sericite mixed with finely fragmented andesitic rocks and other grains. Unsorted, angular and subangular quartz grains predominate. Also present are plagioclase, pyroxene and hornblende (from andesite), unoriented sericite and muscovite. The groundmass is pigmented by opaque minerals. The fragments of different andesitic rocks are also unsorted and angular, and occur in different sizes. Grains of other rocks, such as claystones, are rare (Fig. 7).

The quarry of this rock was identified roughly a kilometre SE of the palace, on Magura, on the basis of wedge holes, which are also visible on a block in the core of the SW fortification (Fig. 8). We presume the overwhelming use of this rock in the SE part of the fortification to be in direct relation to the proximity of the construction site and the shortest transport route from the quarry.

Another rock quarried on the slopes of Magura is **silty-marly limestone**. It has been documented in two colour variants – reddish and greenish – and was only used in combination with bricks in the first-phase fortifications and later for several buildings dating to the period of Justinian the Great. It was, however, extensively used in the construction of the two Imperial mausolea on Magura, more precisely in the cores of their walls.

This limestone (pelagic mudstone-wackestone) (Fig. 9) is thin-bedded, stratified, fine-grained, with tiny

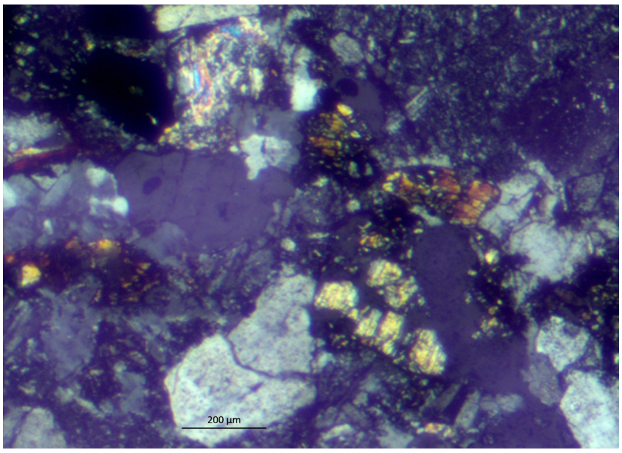

Fig. 6. Volcaniclastic sandstone (epiclastite), angular grains of quartz, plagioclase and femic minerals from andesite, NX (photo: D. Jovanović)

Fig. 7. Volcaniclastic sandstone, macroscopic appearance (photo: B. Djurić)

red and green coloured sericite flakes visible on the surface because of the fine dispersed ferruginous matter, which gives the colour and covers the main components. It is mostly made of microcrystalline calcite (micrite) mixed with clay. Very fine bioclastic and siliciclastic components are characteristic but unevenly distributed. The bioclastic component predominates and is represented by rare and poorly preserved pelagic microfauna, especially planktonic foraminifera (Globigerinelloides, *Whitenella, Marginotruncana coronata*, heterohelicids, *Globotruncana cf.* G. *hilli, Gl. lapparenti*, *Contusotruncana cf.* C. *fornicata, Marginotruncata* gr. *sigali*, calcispheras etc.), all Upper Cretaceous, more precisely Lower Senonian, in age[25]. The microfauna is often fragmented, sometimes in small (millimetre-sized) clusters, in the form of mm-lenses or laminae. Very fine, but precisely undeterminable biodetritus is

Fig. 8. Wedge holes in the quarry and on a block from the fortification core (photo: B. Djurić)

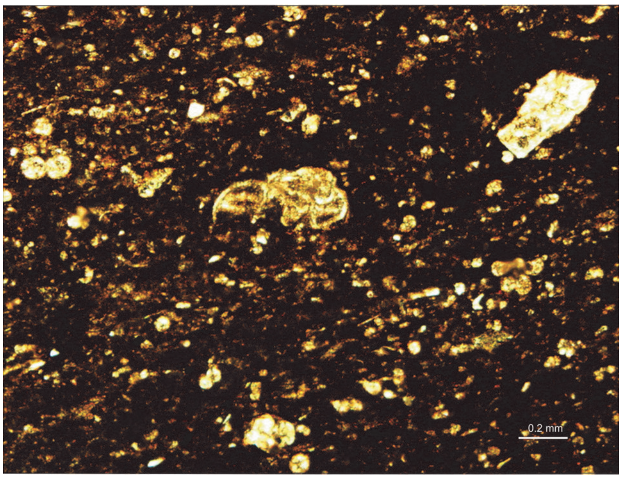

Fig. 9. Planktonic foraminifera in silty-marly limestone (photo: D. Jovanović)

25 Determination D. SIMIĆ, Geological Survey of Serbia.

Fig. 10.
Blocks of sandy limestone in the pediment of the temple of Jupiter (left) and in the wall of the west entrance zone (right), macroscopic appearance (photo: B. Djurić)

Fig. 11.
Small Ionic capital of pure lumachella limestone from one of the fortification's entrance zones (photo: B. Djurić)

also present. A siliciclastic component (small silty angular quartz grains and sericite) is rare and dispersed. The rock belongs to the Timok Eruptive Area, where volcaniclastics alternate with marly-clayey sandstones, sandy-silty marly limestones, marlstones and other rocks.

The rock was presumably quarried at the foothill opposite the main east entrance to Romuliana and on the western slopes of Magura just below the mausolea for which it was used.

At the arched gateways, the volcaniclastic sandstone was combined with a very pale brownish **sandy limestone** of Sarmatian age. The latter was also used in the palace's peristyles for the plinths of the column bases, alternating with the dark grey stone to again produce a bichrome effect. The sandy limestone was also used as blocks for the main temple (Fig. 10), of Jupiter, and both mausolea on Magura, but also for six small Corinthian-style capitals[26] and for tombstones. The special, decorative variant of pure lumachella limestone (different *Mactra* sp.) was used to make the small Ionic capitals at the fortification's entrance zones (Fig. 11).

This sandy limestone (biosparite-biomicrite; rudstone) of Middle Miocene (Sarmatian) age forms the Wedge of the Dacian Basin. It is either solid or friable depending on the lithotype, porous, weakly stratified, white or pale yellowish in colour. As allochems, it contains abundant detritus of biogenic origin, more precisely fragments of shells composed of coarse calcite with rims of fine calcite (Fig. 12). Also present are rare small foraminifera. The terrigenous component consists of unsorted, medium to coarse-grained, subangular-angular quartz grains. Muscovite, plagioclase, quartzites, fine-grained sandstones and altered volcanic rocks also occur, as lithoclasts. The limestone is cemented by coarse calcite – sparite, in part pigmented by organic matter.

Sandy limestone of different lithotypes appears W of the Danube and Timok rivers, some 40 to 60km N of the palace. The exact quarrying site has not been determined.

The fourth rock used in the palace is pale to reddish brown **lithic wacke** (Fig. 13). Its blocks appear, albeit sporadically, in the faces of the second fortification, while it is the only material used for the construction of the tetrapylon on Magura.

It is a massive rock, poorly to well cemented, predominately composed of fine to medium-grained (up

26 BREITNER 2011, Abb. 3.

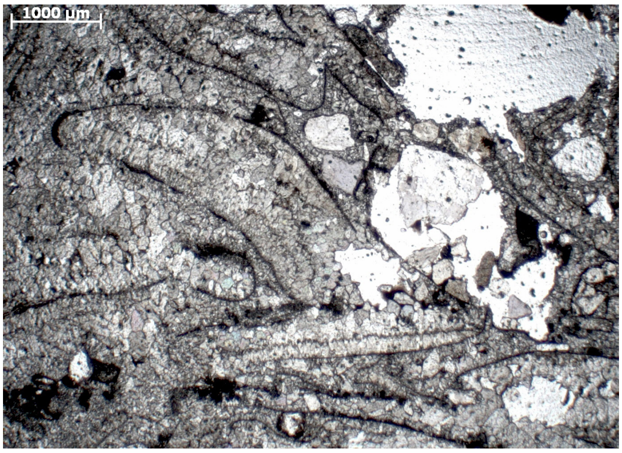

Fig. 12. Sandy limestone of Middle Miocene age with fragments of *Mactra*, NX (photo: L. Gale)

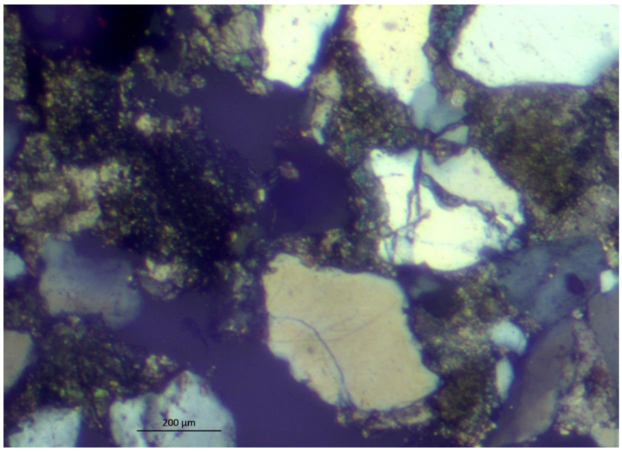

Fig. 13. Lithic calcareous sandstone of Middle Miocene age (photo: D. Jovanović)

Fig. 14. Unfinished Ionic capital and fragment of a sawn slab from the palace (photo: B. Djurić)

to 2mm in diameter), unsorted, subangular to angular quartz grains of undulose extinction, with subordinate feldspar, plagioclase and microcline grains, as well as individual grains of biosparitic limestone (mostly with biogenic detritus – echinodermates? – as well as some unidentifiable forms) and scarce quartzites. The cementing material is $CaCO_3$. This type of rock is known in the vicinity of Rgotina some 10km NNE of Romuliana[27].

Mediterranean marbles

Galerius' building program in Romuliana was an Imperial endeavour and therefore involved a number of white and coloured Mediterranean marbles popular in the Late Roman period. These were mostly used for architectural elements (columns, entablatures, door frames) and interior decoration (wall and floor veneering, *opus sectile*). The unfinished sawn slabs found within the palace (Fig. 14) show that the stone for veneering was probably brought in as blocks and worked on site, while the unfinished Proconnesian bases and monolithic column shafts indicate preparatory work done at the quarry. In the centuries following the abandonment of the palace, the general lack of stones for lime production in the wider area of Romuliana caused the white marble and limestone of the palace's architecture to be reused for this purpose. As a result, only a small portion of the architectural equipment of the palace has survived, with the remains of the column shafts, column bases, capitals, architraves and roof tiles broken into small pieces prepared for the limekiln (Fig. 15). Also broken into small pieces were the columns of granite and porphyry, though the reason for this remains unclear.

Surviving in front of the entrance to the palace proper are parts of three roughly 7m high column shafts

27 The geological map (OGK 1:100 000, Zaječar sheet) reveals that the same formation has been documented in the area around the tetrapylon.

Fig. 15.
Broken pieces of architectural elements prepared for the limekiln (photo: B. Djurić)

Fig. 16.
Ionic capital of Proconnesian marble from the temple of Jupiter (photo: B. Djurić)

of *marmor Thessalicum – lapis Atracius* (Larissa)[28], two fragments of a similar column shaft of *granito rosso antico* (Aswan)[29] and two fragments of a roughly 5m high column shaft of *marmor Troadense* (Çigri Dâg)[30]. The excavations at the east entrance of the second fortification also yielded small pieces of a column shaft of imperial porphyry (*porfido rosso antico*, Gebel Dokhan)[31].

28 Of *patrimonium Caesaris*. See LAZZARINI 2007, 223-244.

29 KELANY *et al.* 2009.

30 YAVUZ 2014.

31 MAXFIELD, PEACOCK 2001; MAXFIELD, PEACOCK 2007.

Over a thousand pieces of white marble used for architectural elements have been documented, of which 67 have been characterised (38 fragments of Ionic capitals, 18 fragments of Corinthian capitals, 7 fragments of Attic bases and 4 fragments of column shafts). All column shafts are of Proconnesian marble. The column bases and the Ionic capitals from the main peristyle of the palace proper are of Pentelic marble, while the Corinthian capital associated with this peristyle is of Proconnesian marble. A small group of capitals was made of Thassos marble.

We also documented a few pieces of pink marble of unidentified, but non-Mediterranean provenance. They were used for architectural elements (including a roof tile fragment), which belonged to a small building

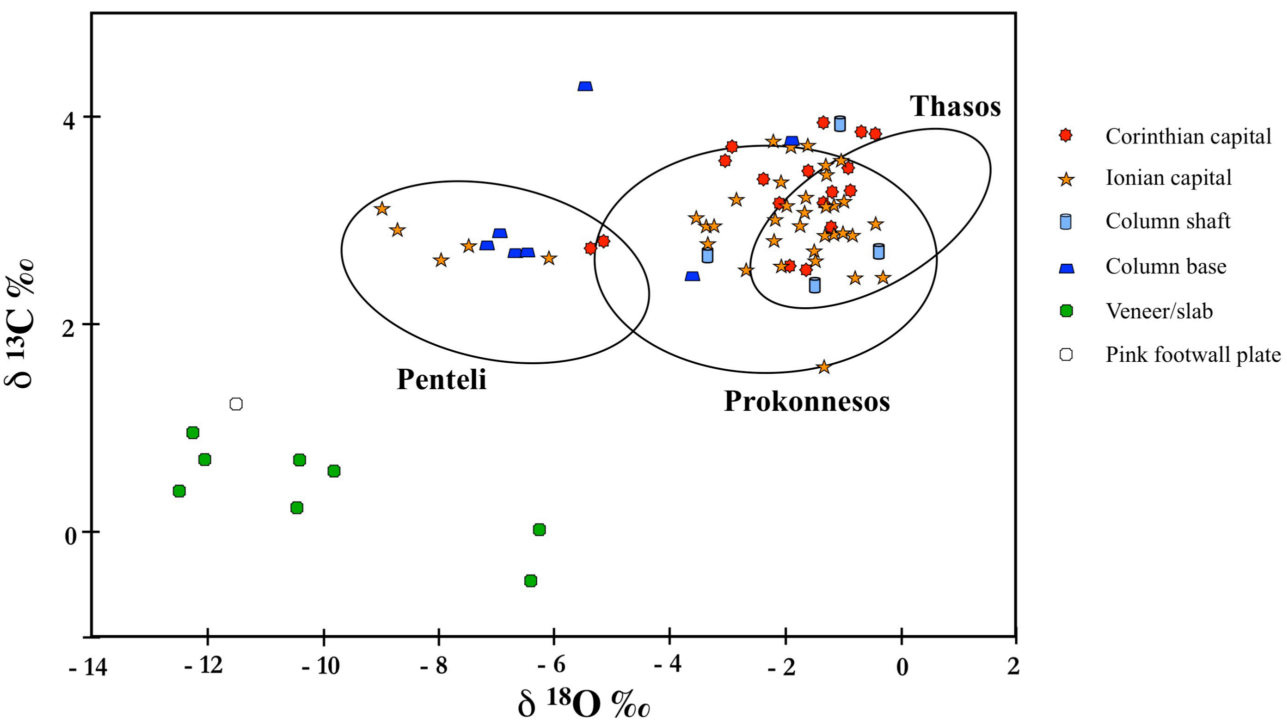

Fig. 17. Isotope diagram of the white marble samples from Felix Romuliana. The values for Proconnesian, Thasian and Pentelic marbles are presented as statistical 90% probability ellipses. The overlap of the former two prevents a clear assignment of individual samples

		Proconessos	Thasos	Penteli	total
No. of samples	Proconessos	84	2	2	88
	Thasos	5	72	0	77
	Penteli	1	0	86	87
%	Proconessos	95.5	2.3	2.3	100
	Thasos	6.0	93.5	0.0	100
	Penteli	1.1	0.0	98.9	100

Fig. 18. Degree of correctly reassigning the quarry samples (in number of samples and in %) from the database to their quarry areas using the Mg, Fe, Mn, DS, Li/Na, Cl/Na, K/Na, Br/Na, I/Na, δ18O ‰ and δ 13C ‰ variables

somewhere in the palace. The same rock was used for the large slabs paving the area outside the entrance into the main residential area.

It is as yet not possible to reconstruct the different combinations of stones used for the columns and other architectural elements within individual buildings. In part, this can only be suggested for the main peristyle of the palace proper and for the main temple, where both the Ionic capitals (Fig. 16) and the corresponding column shafts are made of Proconnesian marble.

The floors in the rooms of the main residential area boast rich polychrome mosaics with figural and geometric motifs, sometimes in combination with opus sectile. The latter was also used to decorate walls, though only a small portion of the slabs have survived. They do, however, suggest the prevalent use of *porfido rosso* (Gebel Dokhan), *cipollino verde* (Karystos), *porfido serpentino antico* (Krokees), *verde antico* (Larissa), *pavonazzetto* (Iscehisar) and *giallo antico* (Chemtou), accompanied by *rosso antico* (Cape Matapan), *marmo greco scritto* (Cap de Garde and Ephesos), *marmor Claudianum* (Mons Claudianus), *breccia corallina* (Verzirhan), *breccia policroma della Vittoria* (Kozani) and five other coloured marbles of as yet undetermined provenance.

		1ST CHOICE				2ND CHOICE	
SAMPLE	**ARCHITECTURAL PART**	**PROVENANCE**	**ABS.PROB**	**REL.PROB.**	**DISTANCE**	**PROVENANCE**	**REL.PROB.**
FRM-68	column shaft	Thasos	49.0	71.7	1.4	Proconnesos	28.3
FRM-69	column shaft	Proconnesos	56.1	99.4	1.2	Thasos	0.6
FRM-74	Corinthian capital	Proconnesos	55.6	83.7	1.2	Thasos	16.2
FRM 189	column shaft	Proconnesos	74.3	99.8	0.6	Thasos	0.2
FRM 208	Ionic capital	Proconnesos	38.0	66.4	1.9	Thasos	33.6
FRM 209	Ionic capital	Proconnesos	63.6	85.8	0.9	Thasos	14.2
FRM 211	Corinthian capital	Proconnesos	33.7	77.5	2.2	Thasos	22.5
FRM 218	Ionic capital	Proconnesos	59.0	97.9	1.1	Thasos	2.1
FRM 219	Ionic capital	Proconnesos	72.8	97.4	0.6	Thasos	2.6
FRM 220	Ionic capital	Proconnesos	43.0	91.4	1.7	Thasos	8.6
FRM 222	Ionic capital	Proconnesos	56.7	99.7	1.1	Thasos	0.3
FRM 224	Ionic capital	Proconnesos	65.3	91.4	0.9	Thasos	8.6
FRM 225	Ionic capital	Proconnesos	87.0	96.4	0.3	Thasos	3.6
FRM 226	Corinthian capital	Proconnesos	69.0	94.7	0.7	Thasos	5.3
FRM 227	Ionic capital	Proconnesos	54.8	99.3	1.2	Thasos	0.7
FRM 228	Ionic capital	Proconnesos	79.8	98.9	0.5	Thasos	1.1
FRM 229	Ionic capital	Proconnesos	89.0	99.0	0.2	Thasos	1.0
FRM 230	Ionic capital	Proconnesos	80.3	99.4	0.4	Thasos	0.5
FRM 231	Ionic capital	Proconnesos	95.2	98.7	0.1	Thasos	1.3
FRM 232	Corinthian capital	Thasos	40.5	75.0	1.8	Proconnesos	25.0
FRM 234	column base	Proconnesos	80.6	94.6	0.4	Thasos	5.4
FRM 235	Corinthian capital	Proconnesos	51.0	85.3	1.3	Thasos	14.7
FRM 239	Ionic capital	Proconnesos	85.9	98.6	0.3	Thasos	1.4
FRM 240	Corinthian capital	Proconnesos	61.3	83.8	1.0	Thasos	16.2
FRM 241	Ionic capital	Proconnesos	81.4	94.2	0.4	Thasos	5.8
FRM 242	Ionic capital	Proconnesos	98.3	99.3	0.0	Thasos	0.7
FRM 243	Ionic capital	Proconnesos	93.8	99.1	0.1	Thasos	0.9
FRM 244	Ionic capital	Proconnesos	36.8	96.7	2.0	Thasos	3.3
FRM 245	Ionic capital	Proconnesos	47.4	90.4	1.5	Thasos	9.6
FRM 246	Ionic capital	Proconnesos	81.2	93.1	0.4	Thasos	6.9
FRM 247	Ionic capital	Thasos	37.1	58.8	2.0	Proconnesos	41.2
FRM 248	Ionic capital	Proconnesos	49.9	95.9	1.4	Thasos	4.1
FRM 249	Ionic capital	Proconnesos	37.0	98.5	2.0	Thasos	1.5
FRM 250	Ionic capital	Proconnesos	77.9	97.4	0.5	Thasos	2.6
FRM 251	Ionic capital	Proconnesos	98.4	98.2	0.0	Thasos	1.8
FRM 252	Corinthian capital	Proconnesos	14.6	98.1	3.9	Thasos	1.9
FRM 253	Ionic capital	Proconnesos	84.7	94.3	0.3	Thasos	5.7
FRM 255	Ionic capital	Proconnesos	75.1	98.7	0.6	Thasos	1.3

Fig. 19. Table presents the calculated statistical results and the assignment of each sample. The basic statistical parameters calculated are: distance of the sample under consideration from the centre of the ellipse that represents the quarry probability field (the central point of the ellipse expresses the average and hence most characteristic values of a quarry. The closer a point is to the centre of an ellipse, the more likely is the provenance from that marble site); *relative (posterior) probability* of the sample to belong to some group within the assumption that it originates in any case from one of the selected groups. The relative probability values of the selected groups add up to 100%. The threshold is 60%. Low values indicate that sample's

FRM 256	Ionic capital	Proconnesos	74.6	91.2	0.6	Thasos	8.8
FRM 257	Ionic capital	Proconnesos	89.7	96.7	0.2	Thasos	3.3
FRM 258	Corinthian capital	Proconnesos	45.8	85.2	1.6	Thasos	14.8
FRM 260	Corinthian capital	Proconnesos	48.0	79.8	1.5	Thasos	20.2
FRM 261	Ionic capital	Proconnesos	63.6	94.1	0.9	Thasos	5.9
FRM 263	Ionic capital	Proconnesos	52.4	85.4	1.3	Thasos	14.6
FRM 265	Ionic capital	Proconnesos	51.7	97.5	1.3	Thasos	2.5
FRM 270	Corinthian capital	Proconnesos	85.8	96.4	0.3	Thasos	3.6
FRM 233	Corinthian capital	Proconnesos	36.4	100.0	2.0	Thasos	0.0
FRM 223	column shaft	Thasos	46.0	89.5	1.6	Proconnesos	10.5
FRM-57	column base	Penteli	72.1	100.0	0.7	Proconnesos	0.0
FRM-58	column base	Penteli	90.5	100.0	0.2	Proconnesos	0.0
FRM-59	column base	Penteli	48.1	99.8	1.5	Proconnesos	0.2
FRM-60	column base	Penteli	89.8	100.0	0.2	Proconnesos	0.0
FRM-61	Ionic capital	Penteli	71.4	100.0	0.7	Proconnesos	0.0
FRM-62	Ionic capital	Penteli	50.3	100.0	1.4	Proconnesos	0.0
FRM-66	column base	Penteli	2.4	97.2	7.5	Thasos	1.5
FRM-67	column base	Penteli	0.9	100.0	9.5	Proconnesos	0.0
FRM 207	Corinthian capital	Penteli	18.2	95.0	3.4	Proconnesos	4.9
FRM 210	Ionic capital	Penteli	31.3	100.0	2.3	Proconnesos	0.0
FRM 214	Ionic capital	Penteli	86.8	100.0	0.3	Proconnesos	0.0
FRM 215	Corinthian capital	Penteli	40.9	99.8	1.8	Proconnesos	0.2
FRM 237	Ionic capital	Penteli	44.9	100.0	1.6	Proconnesos	0.0
FRM 206	Corinthian capital	Thasos	68.9	99.5	0.7	Proconnesos	0.5
FRM 221	Ionic capital	Thasos	38.6	81.0	1.9	Proconnesos	19.0
FRM 236	Corinthian capital	Thasos	35.4	99.6	2.1	Proconnesos	0.4
FRM 264	Corinthian capital	Thasos	75.9	97.9	0.6	Proconnesos	2.1
FRM 259	Corinthian capital	Proconnesos	34.6	61.5	2.1	Thasos	38.5
FRM 267	Corinthian capital	Thasos	46.0	86.7	1.6	Proconnesos	13.3
FRM-63	veneer	unknown	--	--	--	--	--
FRM-64	veneer	unknown	--	--	--	--	--
FRM-70	veneer	unknown	--	--	--	--	--
FRM-75	slab	unknown	--	--	--	--	--
FRM-76	slab	unknown	--	--	--	--	--
FRM-78	slab	unknown	--	--	--	--	--
FRM-79	slab	unknown	--	--	--	--	--
FRM/12/23 pink	arch. element	unknown	--	--	--	--	--
FRM/12/24	arch. element	unknown	--	--	--	--	--

assignment is in doubt between two or more groups or that the sample does not belong to any of the chosen groups; *Absolute (typical) probability* is a distance dependent parameter measuring the absolute probability that the sample belongs to the chosen group or, in other words, is a typical representative of the group properties. In the centre of the ellipse the absolute probability is 100% expressing that the analysed variables of the sample completely coincide with the average numbers of the group. The threshold is 10%, corresponding to the position of a sample on the edge of the ellipse.

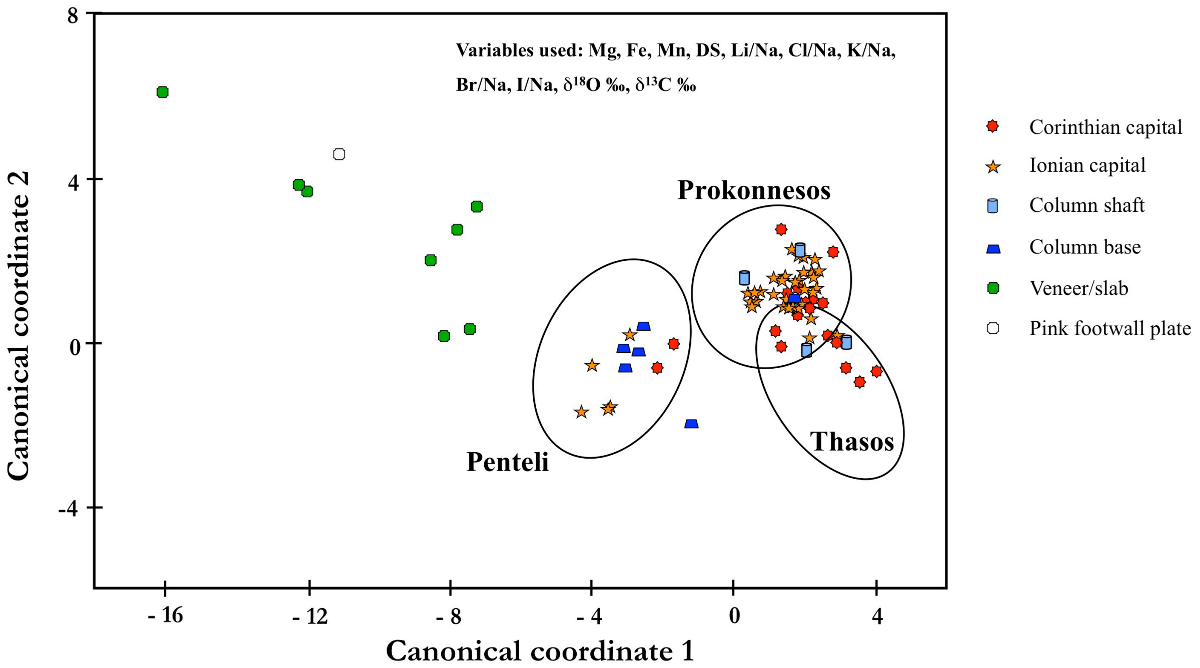

Fig. 20. The bivariate diagram with the two most powerful canonical factors of the multivariate calculation

Provenance analysis of the white marbles in the architecture of Romuliana

The marble analysis involved a total of 76 fragments of architectural elements (67) and veneer slabs (9). For geological reasons, the wider area of Romuliana is devoid of marble occurrences and the general petrographic characteristics and isotopic composition of the white marble samples pointed to Proconnesian, Pentelic and Thasian marbles. These were selected as reference groups and examined using a multivariate discrimination analysis based on the results of the isotope analysis, the trace element analysis of the structure bound trace elements and the chemical analysis of microinclusions.

The isotope diagram (Fig. 17) shows that the compositional fields of Proconnesos and Thasos samples overlap in a considerable measure, while that of Pentelic marble is clearly separated. The majority of the samples plot into the Proconnesos/Thasos area, preventing a clear separation and assignment of the samples on that basis alone. A group of nine slab and veneer samples, characterised by a very light O-isotopic composition, falls well outside these fields and a corresponding equivalent of quarry samples; it has as yet not been possible to determine the provenance of the marble used. A similar isotopic composition as these fragments has been observed in the architectural parts of pink marble from Felix Romuliana. The nearest source of pinkish marble is known in Dacia, near present-day Bucova and Ruşchiţa. We investigated these marbles, but their isotopic features are markedly different from those of the Romuliana samples.

To overcome the problem of overlapping data, a multivariate discrimination analysis was performed using the Statistika and SPSS software packages. The best discrimination between the marble populations and the best reassignment was achieved when using the Mg, Fe, Mn, DS, Li/Na, Cl/Na, K/Na, Br/Na, I/Na, $d^{18}O$‰, $d^{13}C$‰ variables. Our table (Fig. 18) clearly shows the improvement in the attainable discrimination and a very high degree of separation of the datasets, with almost no uncertainties left.

The bivariate diagram (Fig. 20) with the two most powerful canonical factors of the multivariate calculation shows that the compositional fields of the considered marble provenance areas are largely separated when considering a larger number of variables. It has to be kept in mind, however, that the graphic display is only an approximation because a multidimensional system cannot be displayed in a bivariate diagram. The correct degree (numerical data) of assignment of a given sample to a certain population can only be achieved by a mathematical, statistical calculation and these results are displayed in Fig. 19.

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