Stone Supply for Carnuntum and Vindobona – Provenance Analysis in a Historico-Economical Context

Gabrielle Kremer – Sophie Insulander – Erich Draganits – Michaela Kronberger – Beatrix Moshammer – Martin Mosser – Andreas Rohatsch

This paper presents selected results of the interdisciplinary Austrian Science Fund project "Stone Monuments and Stone Quarrying in the Carnuntum – Vindobona Area".[1] Conducted from 2014 to 2018 at the Institute for the Study of Ancient Culture (Austrian Academy of Sciences) in cooperation with the Vienna University of Technology, the Geological Survey of Austria, the Wien Museum, the Department of Urban Archaeology and the University of Vienna, the project was focused on the stone monuments from Carnuntum and Vindobona, two important military centres on the Pannonian Limes, and their respective hinterland (fig. 1).[2]

The project idea is based on the recent inventory of stone monuments realised within the framework of Corpus signorum imperii Romani[3] as well as on a former project centred on settlement development and stone quarrying in Vindobona.[4]

Apart from a detailed archaeological recording of the objects in their historical context, the project's main aims are a petrographic characterization of the locally and regionally quarried stone material used in antiquity,[5] consequently a detailed provenance analysis of the stone monuments and a discussion of mainly logistical, chronological and economical questions related to these results.

This approach is based on detailed geological methods:[6] The Roman period stone objects originating from the project area were petrographically analysed mainly by macroscopic investigation, but also by comparative thin-section studies. In certain cases, X-ray fluorescence spectrometry was used for investigating the chemical composition of fine-grained rocks. This enabled the development of a hierarchical classification of relevant lithotypes as a basis for the provenance analysis of the monuments. At the same time, following the evaluation of historical documents and maps, high-resolution airborne laser scanning (ALS) topographic data and geological databases and maps, presumable ancient quarry sources were investigated through surveys, during which important outcrops were logged and samples were taken.

Thus, as a major result, a number of quarry areas and higher ranked quarry regions, which are relevant for the region and period under investigation could be identified (fig. 2). These quarry areas are defined by hosting one or more of the lithotypes found among the monuments, provided the bedding thickness suited the production of sculptures and architectural elements.

Due to the geological and geographical investigation the quarry areas were grouped into seven quarry regions, located in the Leitha Mountains (regions I/II), the Rust Hills (region III), the Hainburg Mountains (region IV) and along the western rim of the Southern Vienna Basin (regions V–VII). These results form the basis for the evaluation related to

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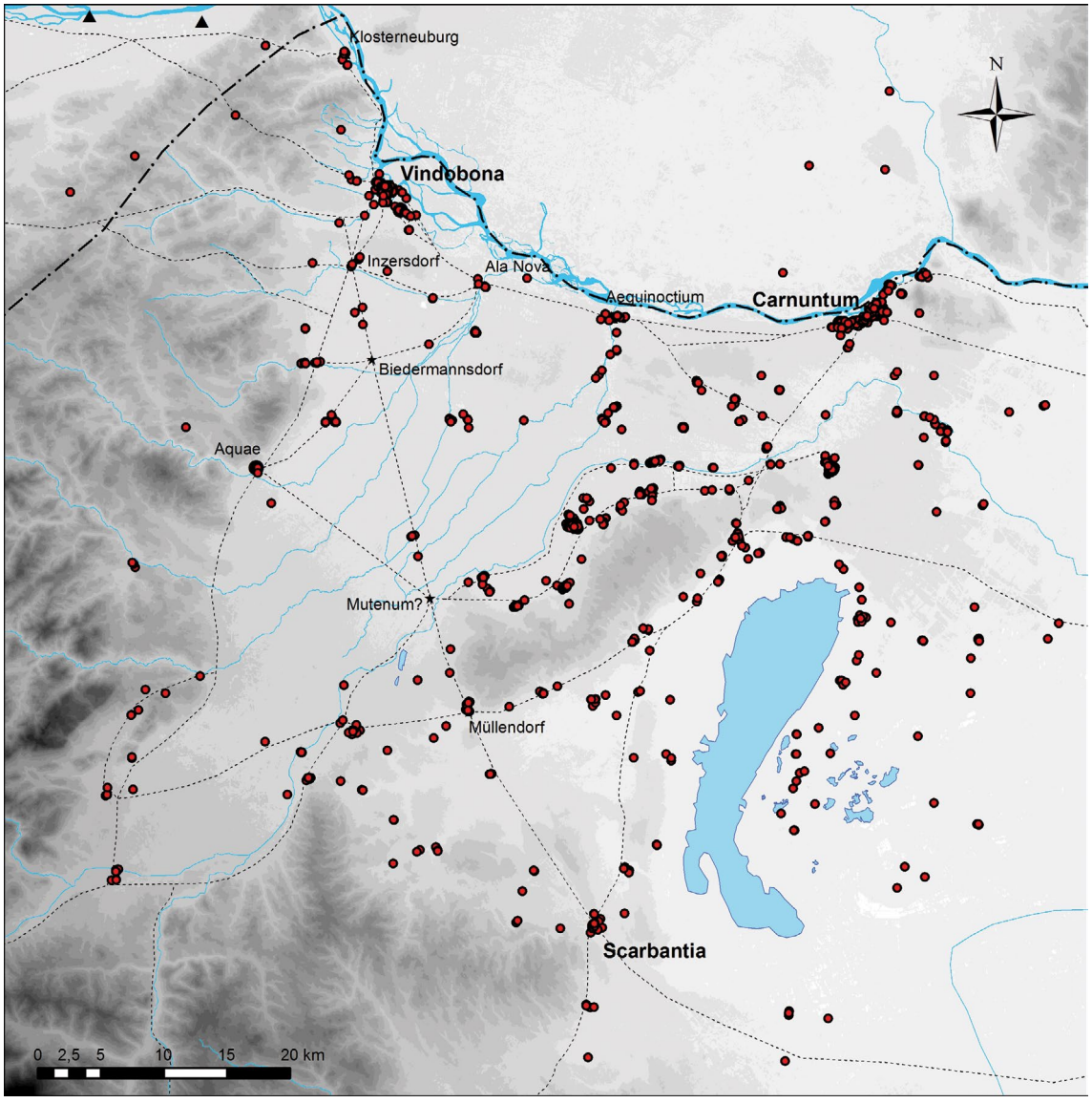

Fig. 1: Find-spots of stone monuments in the Carnuntum – Vindobona area.

the raw material resources, the qualification of certain lithotypes for the different end uses as e.g. sculpture production and the issues of provenance and transport.

The local and regional importance and the range of size of the quarries vary: Lithological investigation of more than 900 stone objects from the entire project area has shown that, while the quarries of the regions IV, V and VI are of mainly local importance for either Carnuntum (IV) or Vindobona (V, VI), the different lithotypes of Leitha Limestone[7], quarried in the Leitha Mountains (regions I/II) were used as material for monuments both in Carnuntum and Vindobona as well as in their respective hinterlands. Because

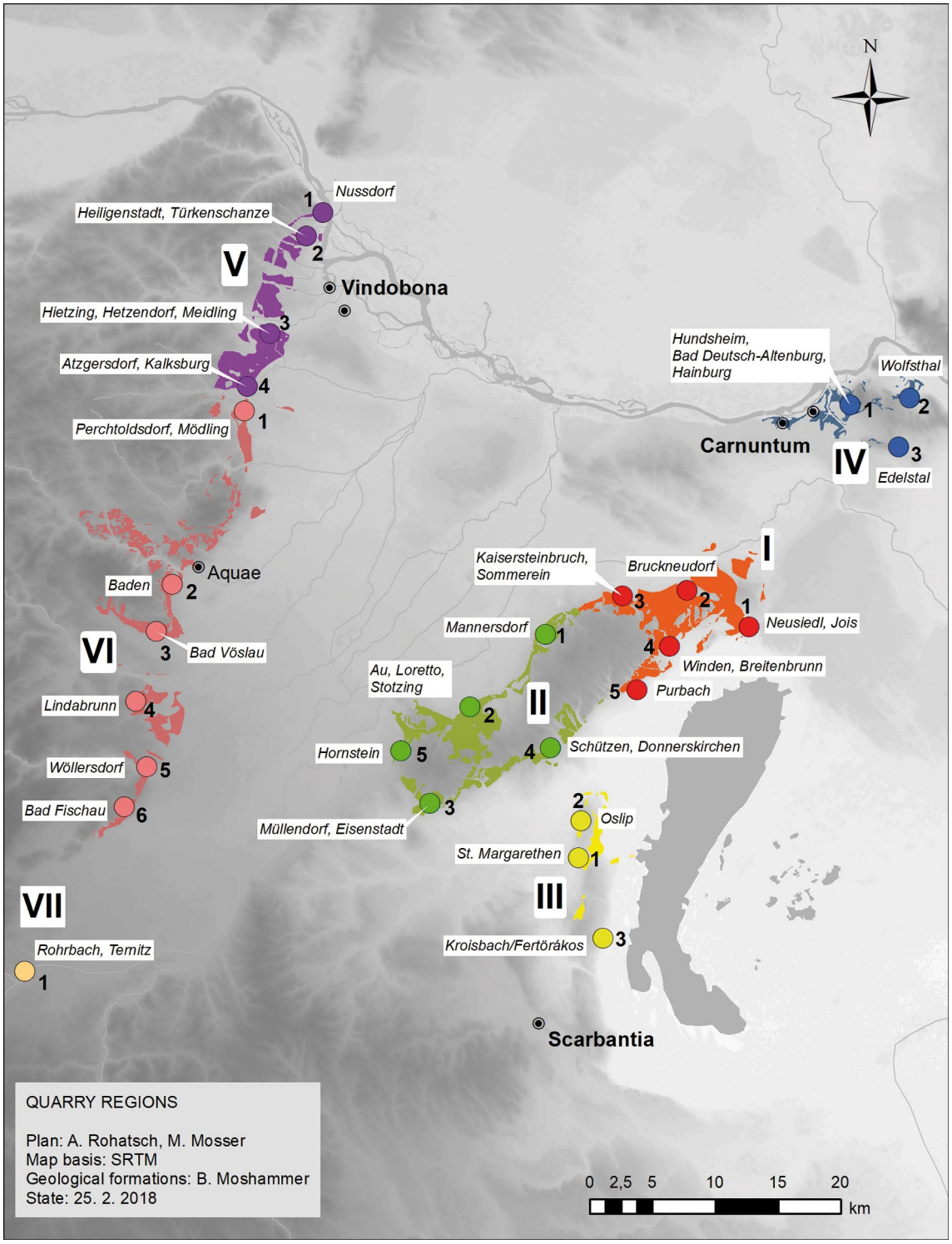

Fig. 2: Quarry regions (Latin numbers) and quarry areas (Arabic numbers).

Fig. 3: Presumptive ancient quarry near the reconstructed mithraeum in Fertőrákos.

of this, when analysing the distribution pattern of Leitha Limestone lithotypes, not only the questions of lithological properties, suitability and transport logistics, but also aspects such as workshop organisation, trade mechanisms and chronology have to be taken into consideration.

Furthermore, the situation in the two project areas differs in an important point: On the one hand, the relevant Badenian[8] and younger sedimentary rock resources used in Vindobona occur on the margin of the Vienna Basin near Vindobona and further south. They provide locally distinctive deposits of Leitha Limestones (recognizable by their clasts from the Flysch and Northern Calcareous Alps), breccias and conglomerates passing into this hinterland, siliciclastic coquinas and furthermore important resources of quartz rich sandstones. On the other hand, the stone artefacts made of Leitha Limestone used predominantly in Carnuntum, but in Vindobona too, have been quarried from around the name giving Leitha Mountains. Very important and large resources for this kind of freestone are found there and in the Rust Hills. In general, Leitha Limestones represent strata composed mainly of particles of calcified red algae (Corallinaceae) and other shallow marine biota, which were deposited on flat marine shelves in the Central Paratethys Sea, especially in the Badenian but were resedimented in younger times up to the Pannonian age/stage. Because of the partly very similar limestone successions in different parts around this low mountain range, from which high quality stones were

Fig. 4: Potential ancient toolmarks in a former quarry at Hundsheimer Berg near Carnuntum.

extracted, the exact provenance determination is much more difficult and more often open to several alternatives.

No Roman quarry has been verified with certainty in the area under investigation, nor have any inscriptions related to quarry organisation and administration been found in this area up until now. Since the Roman period, the landscape has undergone continuous and severe changes, which have caused ancient quarry faces to disappear by subsequent exploitation or become inaccessible without the use of heavy equipment. Moreover, without the presence of additional finds such as inscriptions, unfinished blocks or archaeological features, quarry faces and tool marks are still very difficult to date.[9] A certain number of possible and probable ancient quarries have however been identified, such as the quarry remains near the mithraeum of Fertőrákos[10] (belonging to quarry region III) (fig. 3), or certain outcrops located among the baroque and modern quarries on the Hundsheim Mountains (region IV), in the near vicinity of Carnuntum (fig. 4).[11]

As a next step, the different situations in Vindobona and Carnuntum have to be examined in detail.

About 600 Roman-period stone objects found in Vindobona itself as well as in its surrounding region have been preserved in different collections. This comparatively small number of objects enables the petrographic examination and archaeological

recording of various different object groups, ranging from architectural ornamentation, inscriptions or sculpture to infrastructural elements, construction material or quern stones.[12]

Results of the examination of approximately 300 of these objects demonstrate that Vindobona obtained its raw stone material from three different sources: About two thirds of all analysed monuments were made from rocks in the area of present-day Vienna (region V) and further south along the western rim of the Vienna Basin (region VI), while one third can be allocated to quarries in the Leitha Mountains (regions I/II).

The use of quarries situated along the western rim of the Vienna Basin can be attested from the earliest known point of military presence in Vindobona onwards: The funerary stele of T. Flavius Draccus (fig. 5),[13] a soldier belonging to the auxiliary unit ala I Flavia Augusta Britannica, which was stationed in Vienna during the reign of Domitian, was made from stone quarried in Perchtoldsdorf (region VI.1). About eight years later, in 98 AD, a legionary garrison was stationed in Vindobona and the construction of the legionary fortress began.[14] For certain infrastructural elements of the fortress, in particular the manhole cover stones, as well as for parts of the architecture of the legionary thermae and the fortification wall, stone from Perchtoldsdorf was used again.[15] This demonstrates a transfer of knowledge between the different branches of military units. Petrographic analysis of 23 architectural elements and building stones belonging to the enclosing wall of the legionary fortress have shown that a major part of these objects can be allocated to quarries from region V, namely Heiligenstadt/Türkenschanze (V.2) and Nußdorf (V.1).[16] This implies the use of close-by resources with short transport routes in order to ensure a continuous supply of construction material.

In contrast to this pattern of obtaining raw material from nearby quarrying areas, for other types of stone objects, like votive monuments, different tendencies can be observed. For these, stones quarried in the Leitha Mountains (regions I/II) were favoured and imported to Vindobona despite the longer transportation time.[17] This fact could be related to varieties of Leitha limestone with softer quality and finer texture being more suitable for the sculpting of reliefs and inscriptions than the local material. Since the exploitation of these quarries can be proved from the mid-1st century onwards, another possibility are pre-existing workshops in the Leitha Mountains region or the Carnuntum area whose market extended to Vindobona.

In Vindobona's hinterland, similar patterns concerning the stone deliveries can be detected.

Petrographic analyses of stone monuments found within small-scale settlement centres along the western rim of the Vienna Basin reveal that a large part of their stone material was acquired from very local individual quarries, which were more easily accessible. Simultaneously, the practice of importing stones for special monuments, like altars, from extraction areas situated further away in the Leitha Mountains can also be assured here.

Fig. 5: Funerary stele of Titus Flavius Draccus, 91–96 AD (Wien Museum, Inv. MV 670; CIL III 15197).

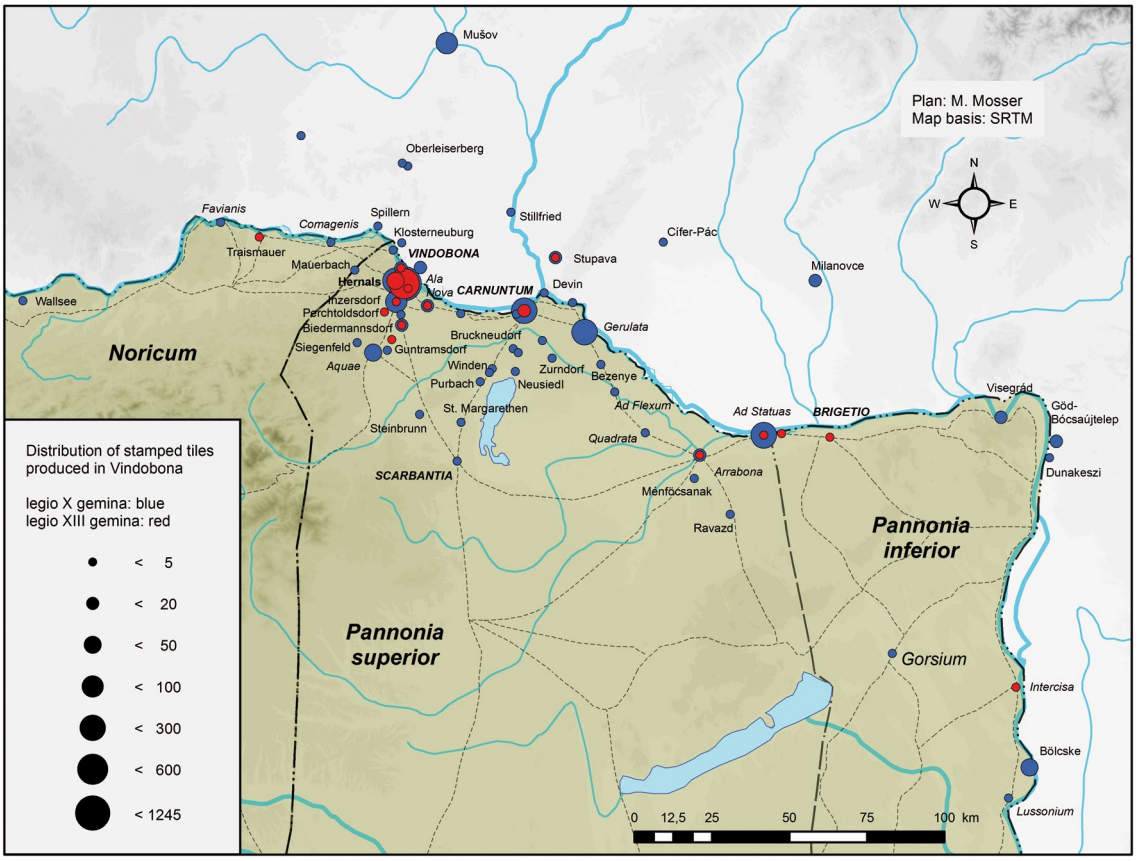

Fig. 6: Distribution of stamped military tiles produced in Vindobona.

In order to better approach questions related to the localisation of the ancient quarries and problems of transportation, a cross-linking of geological, archaeological and historical data is crucial. Since there is a strong possibility that the quarries, which were important for Carnuntum and Vindobona were opened and exploited by the military units stationed there, the localisation of finds related to the military is of relevance to the project. The most important object group connected with military activities are stamped tiles manufactured by the Roman legions.[18] Distribution maps of these objects show the existence of clusters of stamped tiles along the western rim of the Vienna Basin, which suggests a strong military presence in the same areas used as sources of raw stone material for Vindobona (fig. 6). Roads as transportation routes were vital for the delivery of this material; this is also evidenced by the existence of the two nearby Roman road stations Inzersdorf and Biedermannsdorf.[19] Within the framework of the project, least-cost path analyses were conducted[20] with the objective of reconstructing possible routes between the potential quarries and the settlement centres Carnuntum and Vindobona, thereby constituting a valuable contribution to the goals of the project.

In the project area of Carnuntum, research is facing a slightly different situation, as evidence from early large-scale building activities is hardly available today. Petrographic analysis had to concentrate on a careful selection of the far more than 2000 carved stone artefacts from Carnuntum made of Badenian and Sarmatian calcareous sandstone and limestone as well as on a selection of the objects found in the surrounding area. About 600 representative monuments have been analysed, such as for example building and votive inscriptions indicating the names of the consuls or providing other epigraphical clues for exact dating, military funerary stelae or sculptures and architectural elements out of specific archaeological contexts.

The results of the petrological analysis show that rocks from the Leitha Mountains (regions I and II) account for about two thirds of the limestone monuments in Carnuntum, one third being provided by the local quarries (region IV). According to the results obtained in Vindobona, this ratio would probably shift significantly in favour of local quarries if building material could be analysed extensively. The Leitha Limestones and conglomerates of the Badenian at the northern slope of the Hainburg Mountains in the immediate vicinity of Carnuntum – today's Bad Deutsch-Altenburg – have been nearly completely removed by mining activities or overbuilt from the Roman period onwards. At least since the Severan period (193–235 AD) the use of lithotypes from the Leitha Mountains is attested in considerable quantities for building stones and non-decorated architectural elements as well, for example in the auxiliary fort (stone period II)[21] and in the city wall of the civil town.[22]

It has been established that local stones from region IV were used for all kinds of carved monuments as well as for building activity in Carnuntum. Also the quarries in the Leitha Mountains provided material for both private funerary stelae and official sacral monuments and for architectural elements as well. This lithological inventory was primarily used for monuments in the hinterland of Carnuntum, too. Stone material from region III (Rust Hills) appears to have sparse presence in the investigated area and supplied mainly Scarbantia-Sopron and surrounding areas.

A precious evidence for the chronological evaluation of stone monuments and stone provenance in Carnuntum and surroundings is related to the consecutive presence and deployment of military troops (fig. 7). The Legio XV Apollinaris arrived at Carnuntum under Tiberius and built the first permanent fortress under Claudius before it was moved to the east in 63 AD, taking part in the first Jewish-Roman war (66–71). The early fortress was built of timber and earthworks, and only in the early 2nd century, it was replaced by stone buildings.[23] But the members of the 15th Legion already erected funerary slabs during the first period of their stationing and these are the earliest securely dated stone monuments of Carnuntum.[24] It seems evident that larger scale limestone-quarries started to be exploited when the 15th legion arrived, although we do not have any inscription or document related to a military quarry activity comparable to the votive inscriptions for Hercules Saxanus found in the limestone-quarries of Norroy-lès-Pont-à-Mousson in Gallia Belgica,[25] or in the tuff-quarries of Brohltal in Germania inferior.[26]

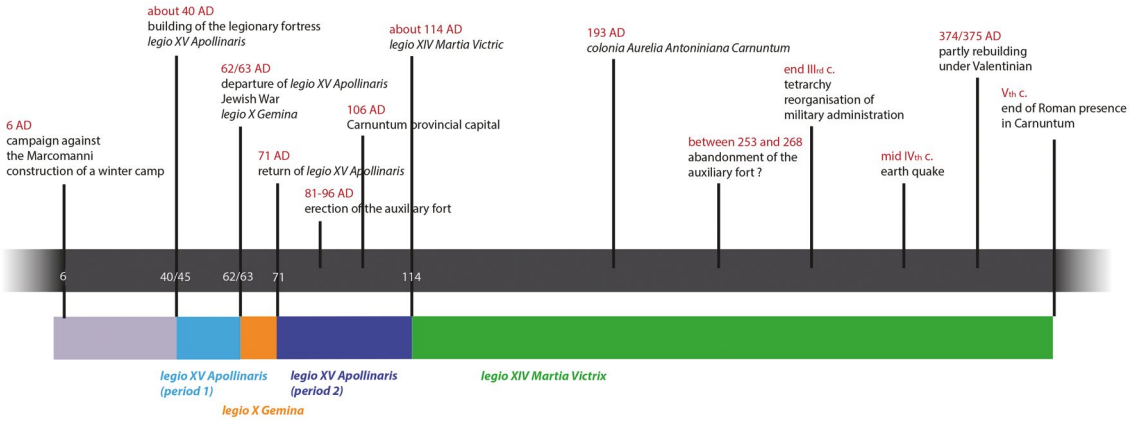

Fig. 7: Timeline of Roman military presence in Carnuntum.

The petrographic analysis of about 40 military stelae from this early period (40–63 AD; fig. 8) shows the following provenance pattern: Stone supply came mainly (60 %) from the region IV, namely the Leitha Limestone from the immediate vicinity of Carnuntum and furthermore from oolite quarries at Wolfsthal, located about 10 km east of Carnuntum. A considerable number of slabs (30 %) from this period were however made of Leitha Limestone from the Leitha Mountains, which means that these outcrops were already known and exploited before the large-scale military building activities started in Carnuntum.

Comparing the military stelae from Carnuntum according to the provenance of material shows that products made of stone material from one quarry region do not necessarily show the same stylistic characteristics. Very similar products have instead been carved in material of different provenance. One possible interpretation of this fact is that one (or several) workshop(s) located in Carnuntum used stones from different outcrops and also from different quarry regions. The work steps carried out in or near the quarries does not seem to have had a decisive impact on the shape and ornaments of the stelae in these cases. Typology and iconography of these early stelae is closely related to northern Italian products,[27] and we may assume that the sculptors working in these workshops were of Italian origin, as were the legionaries themselves in this period.

The following chronological marker is given by the short stay of the Legio X Gemina in Carnuntum, which replaced the 15th legion detached to the military campaigns in the eastern part of the Empire (63–71 AD). The six stelae of this period which have been analysed are stylistically very homogenous and have been made of stone material of the Leitha Mountains exclusively.

Nevertheless, also here different lithotypes have been established, probably originating from the regions I and II.

The next chronological group again contains monuments erected by members of the 15th legion, which came back to Carnuntum after the Jewish war in 71 AD and stayed

Fig. 8: Left: Funerary slab of Marcus Herennius, 40–57 AD (AMC Inv. CAR-S-900; AE 1992, 1403) made of corallinacean calcarenite (region I.2); right: funerary slab of Caius Vibius Secundus, 40–63 AD (KHM Inv. III 63; CIL III 4488) made of oolite (region IV.2).

until 114 AD. The analysed 54 objects of this period show a clear predominance of material from the northeastern Leitha Mountains, but material from the nearby quarries of the region IV was still used. Material from the local quarries around Carnuntum has been used until the very end of freestone carving in Carnuntum, as is shown by a series of votive monuments and building inscriptions of the 2nd half of the 3rd century.

Some conclusions concerning the main questions related to producer-resource dynamics of stone supply in our regions may be drawn:

Short distance transport seems to be the main factor for the choice of building material in the Vindobona area, and probably also (but less well documented) in the Carnuntum area.

Stone quality – and possibly related to it workshop organisation – may have been the crucial factor for the choice of material with fine carving products.

Workshops with military background from Carnuntum were using from the beginning material from different quarry regions and outcrops at the same time.

The quarries established in the earliest period of military presence in the Carnuntum area continue to deliver until the 3rd or even 4th century, but the relation moves away from local towards regional sources from the 2nd century on.

Further evaluation will show if stylistic or typological characteristics may be related to quarries – or even to workshops – located in the Leitha region in the hinterland of Carnuntum and how the transport routes between the quarry regions and the distribution areas may have functioned.

Notes

[1] FWF P 26368-G21 (project leader Gabrielle Kremer).

[2] Kremer 2016; Kremer – Kitz 2016; Kronberger et al. 2016; Rohatsch et al. 2016; Kitz – Insulander 2018; Rohatsch et al. 2018; Kremer et al. 2018; Insulander et al. 2018.

[3] Kremer 2012. – For the further inventory see Neumann 1967; Krüger 1967; Krüger 1970; Krüger 1972; <www.lupa.at> (5.11.2020).

[4] Kronberger et al. 2010.

[5] For the examination of imported marbles used in Carnuntum, see Kremer et al. 2009; Ch. Uhlir – M. Unterwurzacher, in: Kremer 2012, 421–430.

[6] Cf. Rohatsch et al. 2016, 177–184.

[7] See Rohatsch 2005; Rohatsch 2012; Bednarik et al. 2014.

[8] In the local time scale of the Para-Tethyan, the Badenian is a stage/age of the Miocene, lasting c. from 16–13.3 Ma.

[9] See e.g. Kurapkat – Wulf-Rheidt 2017.

[10] For the *mithraeum* see Gabrieli 1993.

[11] For the recent history of quarrying in this region see Lachmayer 1999; Geng-Sesztak et al. 2000.

[12] Kronberger et al. 2016, 87.

[13] CIL III 15197; Kronberger 2005, 27–30. 49–53; Lupa 627.

[14] Kronberger – Mosser 2015, 242.

[15] Kronberger et al. 2016, 92–93.

[16] Kronberger et al. 2016, 92.

[17] Kronberger et al. 2016, 93.

[18] Gugl et al. 2005.

[19] Talaa – Herrmann 2003; Kronberger – Mosser 2013, 114–116.

[20] Performed by the company Crazy Eye, Geoinformatics and Digital Archaeology, Vienna. <https://crazyeye.at/> (5.11.2020).
[21] Kandler 1997.
[22] Maschek 2012.
[23] Gugl – Kastler 2007.
[24] Mosser 2003.
[25] Boulanger – Moulis 2018, 247–263.
[26] Schaaff 2015.
[27] Beszédes – Mosser 2002; Weber-Hiden 2014.

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