La procedencia de artefactos de mármol de la metrópoli Romana "Carnuntum", Austria

The provenance of marble artefacts from the Roman metropolis of "Carnuntum", Austria

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Abstract

This study presents some results of the investigation of the provenance of 116 marble objects from the important Roman metropolis of Carnuntum. In order to obtain the maximum information on the entire collection of the marble objects they were divided into nine groups according to their macroscopic properties, prior to selecting those objects to be sampled for laboratory investigation. The results of the macroscopic, microscopic and geochemical investigations showed that most of the coarse and medium grained marbles originated from Gummern in Carinthia (Austria) or from Pohorje (Slovenia). The fine grained marbles were, however, mostly imported from the Mediterranean.

Key words: Marble, provenance, stable isotopes, petrography, Austria, Carnuntum

Resumen

Este estudio presenta algunos resultados de la investigación de la proveniencia de 116 objetos de mármol de la importante metrópolis Romana de Carnuntum. Con el fin de obtener la mayor información sobre la colección entera de los objetos de mármol, ellos fueron divididos en 9 grupos de acuerdo a sus propiedades macroscópicas, antes de seleccionar estos objetos muestreados para análisis de laboratorio. Los resultados de las investigaciones macroscópicas, microscópicas y geoquímicas mostraron que la mayoría de los mármoles de cristales gruesos y medios son originarios de Gummern en Carinthia (Austria) o de Pohorje (Eslovenia). Los mármoles de cristales finos fueron, pero fueron en su mayoría importados del Mediterraneo.

Palabras clave: Mármol, procedencia, isótopos estables, petrografía, Austria, Carnuntum.

Introduction

The ancient site of Carnuntum (Fig. 1), capital of the Roman province of Pannonia Superior, included the so-called civilian town (a municipium [status of a self-governing Roman city] and later a colonia [status of a self-governing Roman city, superior to the status of a municipium]) as well as the military zone with a legionary fortress, an auxiliary fort and the canabae legionis [military town outside the legionary fort] (Kandler 2004). The earliest known mention of Carnuntum in written sources dates from the year 6 A.D, and in the following centuries it became one of the most important military bases in the Roman Empire. At least 2000 pieces of antique stone sculpture have been found in the vicinity of the civilian and military settlements of Carnuntum, providing one of the most important historical records from the Roman period in this region (Kremer, 2007, Kremer *et al.,* 2009).

Figure 1: The Roman metropolis of Carnuntum and its location within the Roman provinces. The map also shows important Roman towns/camps, roads, navigable rivers as well as important marble quarries.

These objects, many of which were cultic and votive monuments, were mainly carved from locally quarried calcareous sandstones, but about 15% of the cultic stone objects found in Carnuntum were carved from marble (116 artefacts in total), including some of very high artistic quality and important epigraphical content. These marble objects are of special interest as marble had to be imported into Carnuntum and was therefore particularly expensive and rare. They consist mainly of so-called official monuments, which had been organised by groups of dedicants or by dignitaries in office; but cult statues from sanctuaries, monuments related to oriental religions, elements from Dionysiac mythology and minor votive articles are also well represented. One marble slab carries the following inscription: [Pro sal(ute) Imp(eratoris)] Caes(aris) M(arci) Aur(elii) Antonini / [Augusti ---]us tabulam marmor(is) can(didi) ded(it). [For safety of the emperor Caesar Marcus Aurelius Antoninus Augustus a panel of white marble was dedicated].

The evaluation of these sculptures and historical art research have to deal – amongst other things – with questions concerning their origin: in which workshops were they carved, who were the sculptors and where did the material that they used come from? This analysis of the stone material used, is one of the first steps towards answering these questions. A sufficiently broad database had to be created in order to take into account the economic and social history of the region during roman times.

Sampling

Because of the importance of the site as well as marble objects from Carnuntum, only a small number of objects could be sampled for further investigation. To ensure a representative spread of samples a detailed macroscopic investigation of those 92 marble objects that were accessible was firstly conducted, resulting in their classification into groups on the basis of colour, grain size, transparency of calcite crystals, visible characteristic minerals and fabric. Using these criteria it was possible to classify nearly 80% of the objects into nine distinct groups, even though an acidic surface treatment of the objects was not possible.

Objects were then chosen from each of the groups for more detailed analysis: following discussions with the owner and archaeologists, it was agreed that a total of 29 objects could be sampled for further detailed investigation. Cores between 3 and 4 cm long were collected from the selected objects using a water-cooled core drill with an external diameter of either 8 or 10 mm, which yielded cores of either 4 or 6 mm diameter, respectively. After removing any possibly weathered material from the outer part of the cores, the remainder was used for thin section petrography and for geochemical investigations.

Having collected the marble cores it was then necessary to seal up the boreholes in a reversible way, for which a new method was developed. The main part of the borehole was first filled with a glass bar and the external luting was then prepared from a mixture of colour-coordinated marble powder (in three basic colours yellow, grey and white) and Paraloid B72 (a product that is used in the preservation of historical monuments for surface consolidation). The main advantage of this new method is the very easy solubility of the mixture in acetone which means that, if necessary, it can be easily removed. Other advantages of this new material are limited yellowing, the high stability against deterioration and the lack of shrinkage or crack formation. An additional colour treatment of the cemented area is also possible.

Methods

After removing the weathering rim and a probably weathered outer part of the object (about 1 cm from the surface), some of the material from the inner part of the marble core was powdered for geochemical investigations. From the remaining core an un-covered polished petrographical thin section was prepared; in order to not only allow thin section studies by polarized light microscopy but also by cathodoluminescence microscopy.

a) Thin section analysis and cathodoluminescence microscopy:

The following mineralogical - petrographical characteristics were of special importance in the optical microscopy analyses:

- Maximum grain size (maximum grain diameter of the largest grain)
- Mean grain size (mean of the maximum grain diameters)
- Grain boundaries
- Concomitant minerals and impurities
- Twinning (after Burkhard 1993)

Especially grain boundaries, concomitant minerals and twinning characteristics were used to compare samples with each other as for these criteria until now no sufficient overall databases exist.

The luminescence characteristics of the samples were investigated by cathodoluminescence microscopy, using a low temperature CL (TECHNOSYN 8200 Mk II) device (cold cathode), intensity and colour of the luminescence are given in Table 4.

b) Geochemical analysis:

For the geochemical investigations the cleaned and dried material was pulverised in an agate mortar.

The measurement of stable isotopes of C and O ($\partial^{13}C$ and $\partial^{18}O$) was carried out at the University of Innsbruck on a Finnigan ThermoQuest DeltaPlusXL mass spectrometer following the procedure described by Craig & Craig (1972). In some cases two measurements were taken from one sample which delivered identical results.

For trace element analysis the finely pulverised marble powder was dissolved in some drops of HNO_3 65% and diluted with distilled water. The Mg, Sr, Ba, Mn, Fe, Cu, Pb, Ni, Cr and Zn contents were measured by means of ICP-OES after calibration with a MERCK multi-element standard. Due to lacking databases as well as very high variations within the trace element content of the samples these data could not be used to distinguish between the different marble sources and are not presented in this paper.

The rather low Mg content (mainly between 1000 and 3000 ppm) of all investigated samples proves that all the sampled objects consist of calcitic marble.

More detailes about the techniques and methodologies used may be found *e.g.* in Attanasio *et al.* (2006), Craig & Craig (1972), Cramer (2004) and Lazzarini *et al.* (1980).

Results of the macroscopic investigations

All 92 samples were classified through macroscopic investigations into nine groups on the basis of colour, grain size, visible accessory minerals, lamination and transparency of calcite crystals (Tab. 1).

Using these criteria alone it was possible to identify the source mining area of some objects with a high level of probability (group “HM”in Tab. 1). In particular, this was possible for four objects of grey-coloured marble with macroscopically visible minerals such as hornblende and muscovite, as illustrated in figures 2 and 3, which are characteristic of the "Hiesberg marble" from the former Großweichselbach quarry in Lower Austria (Uhlir *et al.,* 2006).

Figure 2: River god (Danuvius?, Object No. 22), Hiesberg marble, Lower Austria, size: 34,5 x 68 x 32 cm; see detail in Figure 3; picture width: 73 cm.

A clear link to a specific quarry was not possible to establish for the other 88 objects from macroscopic criteria alone but they were nevertheless classified into eight further groups (Tab. 1) using those criteria. The largest group (group “T”), containing more than one third of all the investigated marble objects, was characterised by transparent calcite crystals, a white to light yellow/brown colour and a rather coarse grain size. Groups “G” and “G1” were also coarse grained but were light grey and did not exhibit transparent calcite crystals. While group “G” was very pure, group “G1” was characterised by dark brown impurities, probably iron oxides. The other groups contained fine to medium grained, mostly white marble (groups “M”, “FW” and “FH” were light coloured while group “FB” had a bluish tinge), but also a number of grey marbles (group “FG”). A further 19 of the objects did not fit into any of these groups due to their distinctive appearances or patinas.

Figure 3: Platy hornblende and muscovite, characteristic of Hiesberg marble from the Großweichselbach quarry detail central part from Fig. 2; picture width: 21 cm.

Table 1: Using macroscopic criteria nearly 80% of the objects could be classified into 9 groups; a further 19 objects did not fit in any of the groups.

Group abbreviation	**Description of macroscopic characteristics**	**Number of samples falling into this group**
HM	Grey with macroscopically visible hornblende and mica	4
T	Transparent crystals	35
G	Coarse grained	8
G1	Coarse grained (like G) with brown impurities (Fe-oxides)	4
M	Medium grained, white	2
FB	Fine grained, bluish tinge	4
FH	Fine grained, light coloured	4
FW	Fine grained, white	3
FG	Fine grained, grey	9
Not relatable to any of the above mentioned groups		19

Table 2 contains sample numbers for the objects as well as their archaeological descriptions, reference numbers and the groups that the 29 sampled objects were allocated to, as well as the (Danuvius?) statuette of a river god (Fig. 2).

Table 2. Sampled objects from Carnuntum: their object numbers, descriptions, references and classification into groups (for details see Kremer et al. 2009).

Sample	**Object description**	**Reference**	**Group** (see Tab. 1)
2	Statuette of Jupiter enthroned	CSIR 2; Kat. 1992, 326 nr. 10	T
6	Statuette of Dionysos/Liber Pater	CSIR 7; Kat. 1992, 507–509 nr. 2	T?
7	Statuette of Dionysos/Liber Pater	CSIR 8; Kat. 1992, 509 nr. 3	T
22	Statuette of a river deity	CSIR 25	HM
24	Head of a bearded god (Jupiter?, river deity?)	CSIR 27	T
26	Torso of Minerva	CSIR 29	-
29	Upper part from the statuette of Diana	CSIR 33	T
32	Torso of a Menad, Diana or an Amazon	CSIR 36	FB
34	Head of Diana	CSIR 39; Kat. 1992, 327 nr. 12	-
42	Head of a female deity (Juno)	CSIR 48	T
59	Statuette of a genius dedicated by a *tesserarius*	CIL 13456; CSIR 65 + 76; Kat. 1992, 322 nr. 4	FW
64	Upper part of a genius	CSIR 70	FH
67	Head of a genius	CSIR 73; Kat. 1992, 322 nr. 3 fig. p. 320	T
100	Right foot on plinth of a statue	CSIR 131	-
104	Left foot and plinth of a statue	CSIR 135	FG
105	Fragment of a cornucopia	CSIR 136	G
145	Fragment of a Danubian Rider relief	CSIR 194; Kat. 1992, 337 nr. 1	-
151	Relief fragment of a *Genius centuriae*	CSIR 200; Hild 27	T
152	Relief fragment of a Genius	CSIR 201	-
161	Pillar with herm of Paniskos	CSIR 211	T
175	Relief fragment with Sol and bearded god (Jupiter?)	CSIR 377	T
446	Tablet fragment with dedication in honor of the emperor	CIL 14358.5; VZ 346	M
531	Base with honorific inscription of T. Flavius Probus	CIL 4495 cf. p. 1770, 2280f., 2328.32 ; CSIR 193	G1
618	Arm fragment of a statue	unpublished	G
619	Vestment fragment	CSIR 141,3	-
622	Fragment of a (dedicatory?) inscription	Hild 344 pl. 67,3	-
626	Lower part of a female statuette	unpublished	FG
627	Statuette fragment	unpublished	-
629	Tablet with dedicatory inscription	unpublished	-
647	Right foot on plinth of a statue	M. Groller, RLÖ 3 (1902) 111 fig. 21	G

Discussion of the petrographic and geochemical data

Since the Romans are known to have often transported material for important objects over considerable distances, possible provenances for the marble objects from Carnuntum were considered to include not only local source areas in the Eastern Alps, but also more distant quarries in Greece, Asia Minor and Italy, particularly in view of the importance of Carnuntum at that time.

The macroscopic, petrographic (especially grain size and mineral composition) and geochemical (stable isotopes) data were compared with data on Greek, Turkish and Italian marbles in published literature by Attanasio *et al.* (2006), Herz *et al.* (2000) and Gorgoni *et al.* (2002). The main reference used for this work was the Attanasio database.

For the Alpine and Central European marble quarries reference was made to Djuric et al. (2004), Müller *et al.* (1999), Uhlir *et al.* (2006), Unterwurzacher (2007) and Unterwurzacher *et al.* (2005) as these papers contain detailed geological, petrographic and geochemical descriptions and data from these quarries. An overview of the range of stable isotopes ($\partial^{18}O$ and $\partial^{13}C$) and maximum grain size (MGS) for the most important marbles of Eastern Austria and Slovenia is tabulated below in Table 3 (see also Figs. 4 and 5 for isotopic plots).

Table 3. Characteristics of Alpine and Central European marble quarries of importance as possible provenances for the Carnuntum objects.

Quarry	$\partial^{18}O_{min}$ ‰ VPDB	$\partial^{18}O_{max}$ ‰ VPDB	$\partial^{13}C_{min}$ ‰ VPDB	$\partial^{13}C_{max}$ ‰ VPDB	MGS mm (range)
POHORJE	- 22	- 6	- 1	+ 3	1.5 – 5.5
GUMMERN	- 9	- 4	- 1.5	+ 2.5	1.5 – 2.7
SPITZELOFEN	- 6	- 2	+ 1.2	+ 3.2	4 – 5.5
TIFFEN	- 5.26	- 9.49	+ 0.39	+ 1.06	1.5 – 2.0
TREFFEN	- 5.68	- 5.97	+ 0.42	+ 0.71	3.2 – 5.8
TENTSCHACH	- 11.46	- 13.71	+ 1.98	+ 4.13	1.4 – 1.7
SEKULL	- 8.6	- 10.64	+ 0.83	+ 1.73	1.3 – 1.7
STERZING	- 4.95	- 12.41	+ 0.09	+ 1.91	1.5 – 8.5
LAAS	- 5.11	- 12.55	- 0.43	+ 2.3	0.6 – 3.0
SALLA	- 7	- 3.7	0	+ 4.5	1.5 – 3
KAINACH	- 5	- 0.5	0	+ 5	2 – 3.5
SÖLK/ÖBLARN	- 11.5	- 7.5	- 0.2	+ 2.8	1 – 2.5
HIESBERG	- 10	- 4.5	- 4	+ 4	*

(*marbles from Hiesberg show characteristic accessory minerals (hornblende) and therefore can clearly be distinguished from the others).

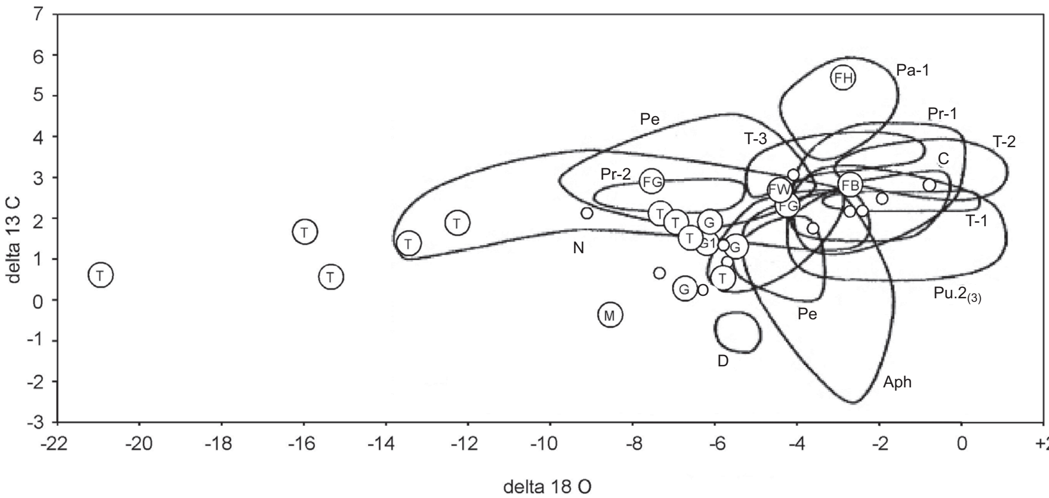

Figure 4. Isotopic clusters (∂[18]O and ∂[13]C) for the most important Mediterranean marbles (after Gorgoni *et al.* 2002): Aphrodisias Aph, Carrara C, Dokimeion D, Naxos N, Paros Pa, Penteli Pe, Proconnesos Pr, Thasos T. Samples from Carnuntum are also inserted in the figure as circles with the group abbreviation (Tab. 1). Samples that are not related to any group are shown by a small circle.

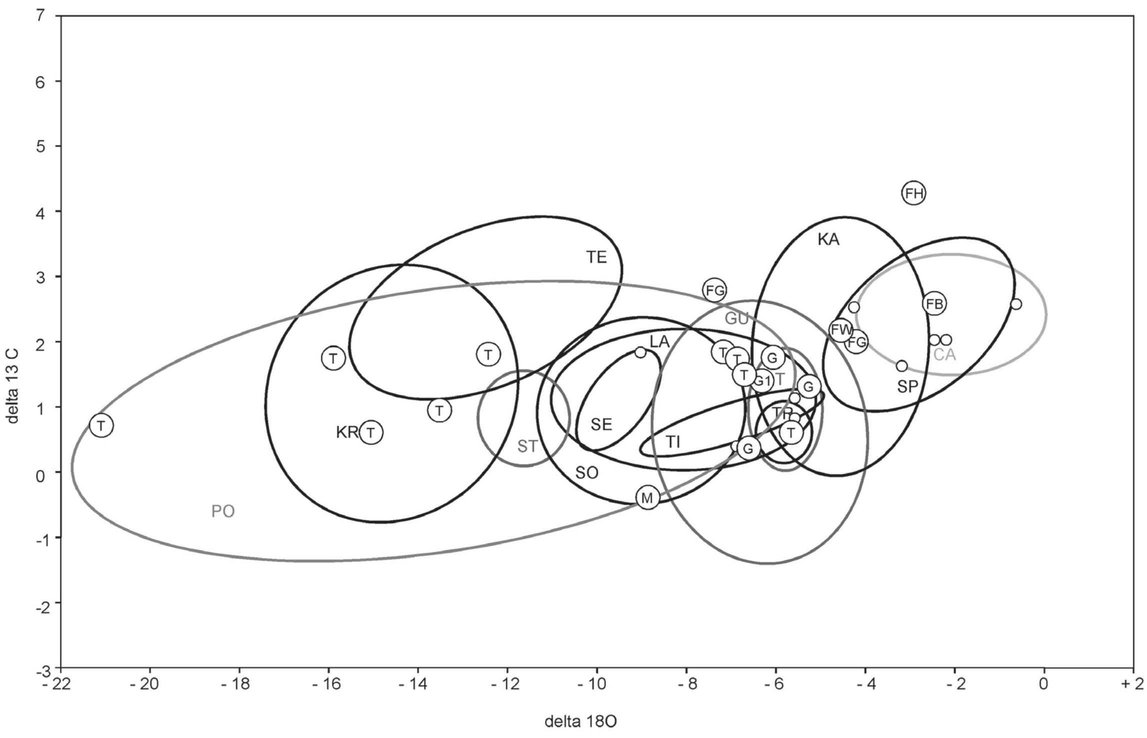

Figure 5. Isotopic clusters for C and O (‰ VPDB) from Alpine marbles (Kraig KR, Tenschach TE, Sterzing ST, Laas LA, Sölk-Öblarn SO, Tiffen TI, Treffen TR, Pohorje PO, Gummern GU, Spitzelofen SP, Kainach KA, Sekull SE) and Carrara marble (CA). Data from Djuric et al. (2004), Müller *et al.* (1999), Unterwurzacher (2007) and Unterwurzacher *et al.* (2005) and this work. Samples from Carnuntum are also inserted in the figure as circles with the group abbreviation (Tab. 1). Samples that are not related to any group are shown by a small circle.

Table 4. Roman marble objects sampled (see Tab. 2), their macroscopic group allocation (see Tab. 1), mineral composition (ACC=accessory minerals e.g. apatite, zircon etc., QZ=quartz, GLI=mica, TRE=tremolite, ERZ=opaque minerals, FEOX=iron oxides), stable isotope ratios ($\partial^{13}C$, $\partial^{18}O$), maximum (MGS) and mean grain sizes of calcite and dolomite grains in the thin section and cathodoluminescence intensity (0=(nearly) no luminescence, 1=weak, 3=medium, 5=bright) as well as catodoluminiscence (CL) colour, and the inferred provenance.

sample	**Groups**	**min. comp.**	**$\partial^{3}C$**	**$\partial^{8}O$**	**MGS**	**mean grain size**	**CL intensity**	**CL colour**	**Provenance**
			(‰ vs. PDB)	(‰ vs. PDB)	(mm)	(mm)			
2	T	ACC	1.40	-6.58	2.5	1.3	1	Red	**GUMMERN**
7	T	QZ, GLI	0.58	-5.90	1.8	0.8	1	Red	**GUMMERN**
24	T	GLI, ACC	1.96	-12.23	2.1	0.5	3	red-orange	**POHORJE**
42	T	TRE, QZ	1.90	-16.01	1..5	0.3	3	red-orange	**POHORJE**
151	T	TRE, QZ	0.77	-15.47	2.3	1.1	5	red-orange	**POHORJE**
161	T	QZ, ACC	0.84	-21.08	2	0.8	3	red-orange	**POHORJE**
29	T	-	1.10	-13.61	0.3	0.1	3	red-orange	**POHORJE??**
67	T	TRE, QZ, ACC	1.74	-6.89	2.5	1.2	1	Red	**GUMMERN/POHORJE**
175	T	QZ, ACC	1.90	-7.29	3.5	1.7	1	red-orange	**GUMMERN/POHORJE**
6	T?	-	1.59	-3.53	1.8	1.1	1	Orange	**APHRODISIAS/DENIZLI/THIOUNTAS/ PAROS/KAINACH??**
105	G	ACC	0.24	-6.81	2	1.4	3	red-orange	**GUMMERN/POHORJE**
531	G1	GLI, ACC	1.50	-6.38	1.5	0.8	1	red-orange	**GUMMERN**
618	G	-	1.17	-5.53	2.5	1.5	3	red-orange	**GUMMERN**
647	G	QZ, ACC	1.81	-6.08	3.5	1.3	1	Red	**GUMMERN**
446	M	GLI, ACC	-0.34	-8.53	3.5	1.9	1	red-orange	**POHORJE**
32	FB	-	2.84	-2.48	0.5	0.2	0	-	**HYMETTOS/CARRARA?**
64	FH	-	5.20	-2.81	1.4	0.7	0	-	**PAROS**
59	FW	ACC	2.13	-4.22	3.5	1.8	0	-	**NAXOS/GUMMERN/ SALLA/KAINACH?**
104	FG	ERZ	2.89	-7.50	0.5	0.3	3	Orange	**DOLIANA??**
626	FG	-	2.01	-4.20	3.5	0.2	0	-	**THASOS?**
627	-	-	1.96	-2.73	2.5	0.3	1	Red	**THASOS?**
26	-	-	1.93	-9.21	2	0.9	0	-	**POHORJE/SÖLK/ÖBLARN??**
152	-	ACC	0.48	-7.16	4	2	3	red-orange	**GUMMERN/POHORJE**
34	-	-	0.79	-5.78	0.2	0.1	0	-	**AFYON?**
619	-	-	1.06	-5.80	1	0.5	5	Orange	**AFYON**
622	-	QZ	2.73	-0.58	1.5	0.5	0	-	**PROCONESSOS**
629	-	-	2.23	-1.96	3	1.1	3	red-orange	**THASOS/PAROS?**
100	-	TRE, ACC	2.69	-4.15	2.2	1.2	1	Red	**EPHESOS/ SALLA/KAINACH??**
145	-	FEOX	2.00	-2.35	0.3	0.1	3	red-orange	**??**

Petrographic and geochemical results and interpreted marble provenance

It was noted that more than 50% of the Carnuntum marbles were coarse grained, whereas only 20% were macroscopically classified as fine grained. The coarse grained marbles, which belong to the macroscopically defined groups "T", "G", "G1", as well as the medium grained ones (group "M") originated from marble quarries in the Alpine region, at Gummern and Pohorje. None of the other groups sampled originated from these two areas, however, with the possible exception of marbles that could not be allocated to any of the nine groups.

For the medium to coarse grained marbles macroscopic grouping is therefore clearly a very useful tool for reducing the number of samples required. All tested marbles from group "G" appear to be from Gummern (one could also be from Pohorje), but marbles from group "T" may have come from either Gummern or Pohorje (Tab. 4, Fig. 5). The medium grained, white marbles from group "M" are also of Alpine origin, coming from the Pohorje quarries. These conclusions demonstrate that detailed macroscopic investigations can, at least in some cases, lead to very useful results, even though they may still need to be confirmed by additional mineralogical, petrographic and geochemical investigations.

Both of the groups with coarse grained and transparent calcite crystals fit into the provenance area of Gummern and / or Pohorje. Marbles from both of these quarries are similar in grain size and overlap in their isotopic data and are also very difficult to distinguish from each other through other observations such as their trace elements (not shown here due to too big variation) etc. Samples with very negative $\partial^{18}O$ values (below –9 ‰ vs.) and / or large grain sizes (i.e. maximum grain size above 2.7 mm) can be distinguished as being from Pohorje, but in many cases this is not possible.

Our study shows, however, that cathodoluminescence offers a possible way of distinguishing between the two areas: while marbles from Gummern mostly show only low cold cathode luminescence, those from Pohorje are characterized by medium to bright luminescence. Even though this observation is not a general one and not valid for all investigated samples (there are also marbles that we decided to be from Pohorje that have no luminescence, for example), further investigations on this topic are in progress at the moment.

For the groups characterized by fine grained calcite crystals and varying colours (groups "FB", "FH", "FW" and "FG") no local marble was used. All of the fine grained marble objects investigated were made of marble from Carrara, Greece or Asia Minor, and originated from Paros, Hymettos or Carrara, Afyon, Naxos (?), Thasos (?) or Doliana (?) - see Tab. 4 and Fig. 4. For some groups no clear provenance could be determined, particularly for the "FG" group in which the macroscopic grouping seems to have been erroneous, probably as a result of weathering crusts on the samples.

From Table 4 it can be seen that a highly probable provenance identification was possible for the objects numbered 2, 7, 531, 618, and 647 (Gummern), as well as for objects 24, 42, 151, 161 and 446 (Pohorje), 64 (Paros), 619 (Afyon) and 622 (Proconessos). The objects numbered 67, 105, 152 and 175 originated from either Gummern or Pohorje. Object number 29 is of uncertain provenance as the macroscopic features (group "T") and stable isotopes appeared to suggest that it was from Pohorje, but the grain size analysis appeared to contradict this suggestion. Object number 629 could have originated from either Thasos or Paros and number 26 is probably from Pohorje, Sölk or Öblarn (the latter is based on macroscopic criteria, in particular the colour, and is not very probable as a source area, but can not be excluded). Object number 32 could have originated from Hymettos or Carrara, object number 34 could have originated from Afyon (with some uncertainties) and number 104 could be from Doliana (with quite large uncertainties), while numbers 6 and 100 could have originated from any one of several quarries and no provenance at all can be given for number 145.

Object number 59 was allocated macroscopically to the "FW" group of white, fine grained marbles but subsequent microscopic investigation revealed that, in this special case, the macroscopic grouping was incorrect due to a patina on the surface of the object, and that the maximum grain size for this marble was, in fact about 3.5 mm making it one of the coarse grained marbles. Grain size combined with stable isotope values for C and O indicated that this was made from Naxian marble.

Trace element geochemistry did not yield the expected useful results because of the very high variations recorded, not only within the quarries but also within the samples. Trace element geochemistry therefore did not provide any significant results and will not be discussed any further.

Even though it was not possible to prove the provenance of all of the objects made from fine grained marble, it was possible to show by macroscopic, microscopic and geochemical methods that two of the objects that did not fit in to any of the macroscopic groups were actually made from the same material (Fig. 6). From the thin section analyses, grain boundaries, grain sizes and isotopic measurements objects 626 and 627 were both shown to have been made from the same material, which is assumed to have been marble from Thasos. Stylistic criteria for these two objects also appear to support this assertion.

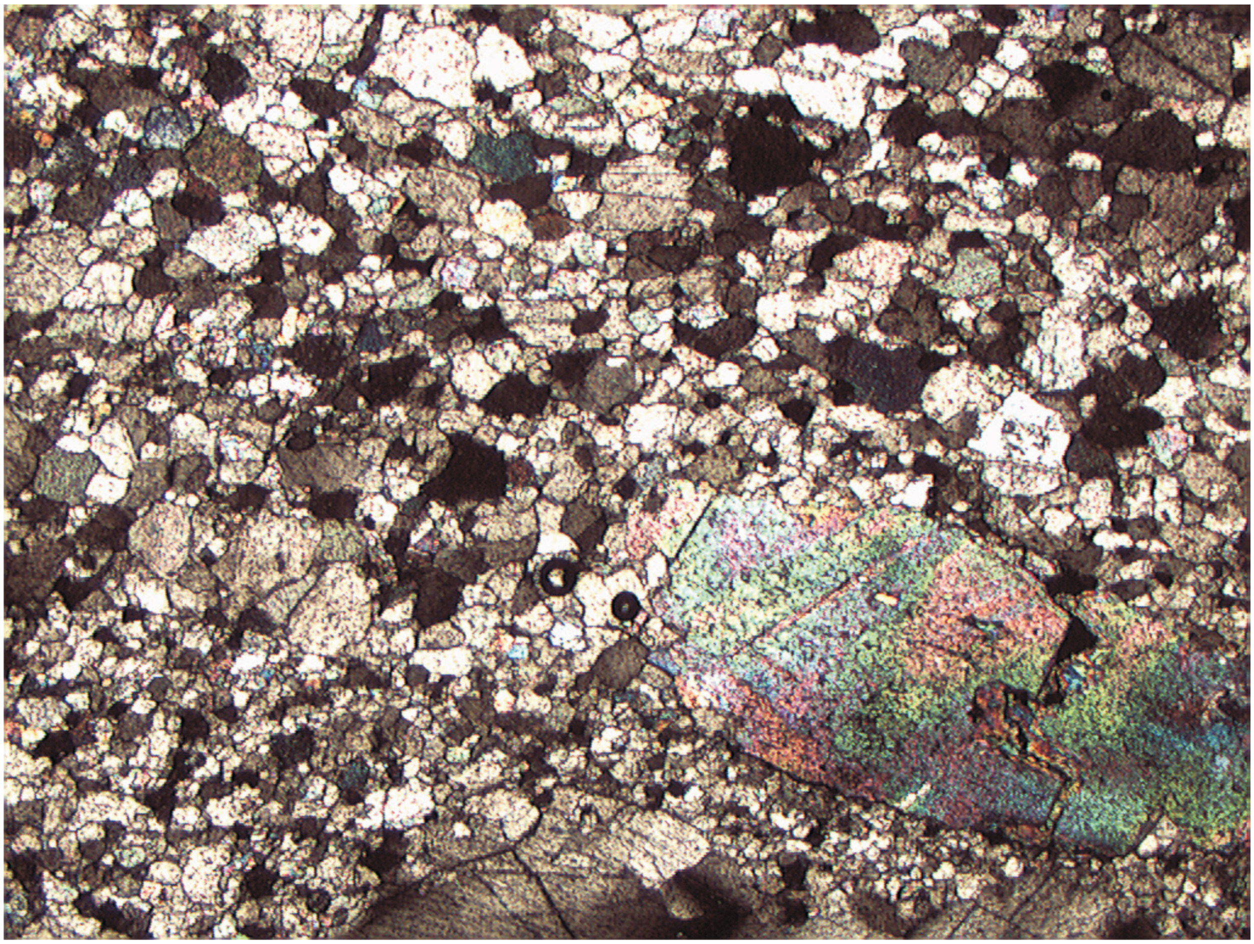

Figure 6. Thin section of sample No. 627, crossed Nicols, magnification 20X, straight grain boundaries, generally poorly sutured, type II twinning (Burkhard, 1999). This sample contains two different grain sizes of calcite crystals. Due to the high amount of small calcite crystals the mean grain size is only about 0,3 mm, the max. grain size 2,5 mm. The sample does not show any concomitant minerals.

Conclusion

As this study has shown, the high quality marble objects from Carnuntum can be classified macroscopically into a number of discrete groups. Although this method of classification is time-consuming, it is also necessary if the number of objects that can be sampled for detailed investigated by microscopic and geochemical methods is limited. In our case the macroscopic grouping was shown to have yielded good results for the medium to coarse grained marbles.

A new method to seal up the boreholes of the sampled marble objects in a reversible way with Paraloid B72 and differently coloured marble powder was established in the frame of this study.

The results of this study showed that the largest groups of objects investigated were carved from Alpine marbles: groups "T", "G", "G1" and "M" were all considered to have been made out of marble from either Gummern or Pohorje. The heterogeneous nature of these groups however indicated a need for further differentiation, since they included large cult statues as well as small votives and luxury objects related to mythological themes. In both cases we were able to distinguish sculptures of high artistic and technical quality from those with distinct provincial characteristics. The number of stylistically similar sculptures made from Alpine marble seems to indicate the presence of a local workshop producing marble artefacts.

The study also shows the difficulties we face distinguishing between Gummern and Pohorje marble. The additional investigations have to be made to find a method for distinguishing between these two important Eastern Alpine marbles.

Hiesberg marble was only used in Carnuntum for large monuments, and their technical quality indicates that they were made in a local workshop. Transport costs were probably the decisive factor for the choice of material in this case.

Marbles from Asia Minor and Greece (and Carrara) were almost exclusively found in small objects. Some artefacts of high quality and minor votives may have been imported as finished products, but others may have arrived as half-finished artefacts.

For Carnuntum we can therefore postulate the import of sculptures from the Mediterranean region and from southern Noricum, as well as the local production of artefacts from imported raw marble blocks of different provenance. The presence in provincial workshops of itinerant artisans with a Mediterranean tradition must, however, also be considered a possibility.

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