Minero-petrographic characterization of white marble Roman finds from P.A. Garda Museum (Ivrea, TO)

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Abstract. The work provides a minero-petrographic characterization of the main roman finds in white marble of the Garda Civic Museum of Ivrea (Piemonte, Northern Italy). A multi-analytical approach based on optical and scanning electron microscopy, electron microprobe and stable isotope analyses has been performed. The chemical composition of the main mineral component (calcite and/or dolomite), and of subordinate or accessory minerals useful for discriminative purposes were attained. A database for archaeometric purposes of the artefacts was achieved and a comparison with the Italian and Mediterranean marbles reported in the literature was implemented. The marbles resulted generally of Alpine provenance. This suggests that *Eporedia* (the old name of Ivrea) in Roman times was a site of local importance, with the employment of goods coming from trade routes connected with the surrounding alpine areas.

1. Introduction

Marble has been widely used since ancient times as a material for architecture and sculpture and is perhaps the most widely employed stone material [1]. For its physical-mechanical and technical characteristics such as isotropy, low hardness, compactness, toughness, good resistance to compression and mechanical polishing, but above all, for its particular brightness and brilliance marble is suitable as row material for buildings and valuable historical sculptures.

During the whole Roman period the extraction of marble intensified in the Alpine territories: in north-western Italy, in fact, local marbles were exploited and used for public buildings and decorations in private homes [2]. In particular, at the archaeological site of *Eporedia* (now Ivrea, NW Italy), numerous finds in marble dated to the imperial age were found and they are currently preserved at the Pier Alessandro Garda Civic Museum (https://www.museogardaivrea.it/archeologica/). This Museum, after a long restoration and preparation of the collections, was reopened to the public in January 2014, which was thus able to regain a significant historical and cultural heritage. The preparation of the collections is the result of research, studies, comparisons conducted by specialists in different sectors and disciplines. The archaeological section of the Museum was implemented, in recent years, thanks to the collaboration of the Superintendence of Archaeology, Fine Arts and Landscape for the metropolitan city of Turin, the Municipality of Ivrea and the Guelpa Foundation, with the aim of enhancing and make the Ivrea archaeological heritage usable [3].

2. Sample and analytical techniques

A selection of 15 artifacts in white marble were chosen on the basis of their archaeological and scientific significance. A list of the samples studied, accompanied by the presumed geological unit of provenance, is shown in Table 1.

Table 1. Description of the main minerals of the marble finds and presumed geological unit of origin. Mineral abbreviation according with [4].

Find	Sample	Name of rock	Presumed geological Unit of provenance
Funeral epigraph of Dosomena	**MN 429**	Dolomitic marble with Cal and Tlc	External Piemonte Zone
Stelae gromaticus L.A. Faustus	**MN 431**	Calcitic marble with Dol and Tr	Sesia-Lanzo Zone
Fragment of figured pilaster	**MN 432**	Calcitic marble with Mrg-Phl-Ph	External Piemonte Zone
Memorial stone of edile	**MN 433**	Dolomitic marble with Cal	Not defined
Funerary stelae of an eporedian politician	**MN 434**	Calcitic marble with Phl-Prg-Dol	External Piemonte Zone
Funerary stelae of a senator	**MN 435**	Calcitic marble with Dol	Not defined
Marble antefix	**MN 439**	Calcitic marble with Srp and Dol	Piemonte Zone
Box relief with three portraits	**MN 444**	Calcitic marble with Dol-Ph-Tr-Qz	Dora-Maira Unit
Funerary epigraph dedicated to son and husband	**MN 446**	Calcitic marble with Wm	Mesozoic covers of alpine units (continental crust)
Funerary epigraph of the greek slave Diopaes	**MN 447**	Calcitic marble with Dol and Ph	Mesozoic covers of alpine units (continental crust)
Funerary epigraph dedicated to Officer Valerio	**MN 449**	Calcitic marble with Dol-Prg-Ph-Qz	Mesozoic covers of alpine units (continental crust)
Funerary epigraph of an unknown christian	**MN 452**	Veined marble with Qz	Not defined
Fragment of a fluted column	**MN 453**	Calcitic marble with Dol-Ph-Phl-Tlc-Clc	Piemonte Zone
Epistyle portion	**MN 454**	Pure calcitic marble	Not defined
Arula fragment	**MN 455**	Pure calcitic marble	Apuan

Among these is the precious funerary stelae of the *gromaticus* L.A. Faustus, a kind of surveyor who used the *groma* to accurately trace the cardines and decumanus on the ground. It consist of a particular white marble table engraved in the 1st century AD. It is a unique case of reproduction of this tool, used for the operations of division and measurement of agricultural land for cadastral purposes. The *groma* is depicted only on this eporedian slab and on a Pompeian one from the 1st century AD, in which it is however assembled and reproduced with less attention to detail [5]. The rarity of the subject dealt, together with the overall refinement of the execution and the use of marble, characterize this find as a valuable example (Figure 1).

The description of the marbles by optical and scanning electron microscope allowed to determine textural parameters such as the grain boundary shape (GBS) and the maximum grain size (MGS). The chemical composition of the main mineral component (calcite and/or dolomite), and the of subordinate or accessory minerals useful for discriminative purposes were also determined using an Oxford Instruments SEM–EDS system. Finally mass stable isotope ratios (i.e., $\delta^{13}C$ and $\delta^{18}O$) on calcite and on dolomite using a Mat 250 Finningan Mass Spectrometer was performed. The protocol reported by [6], was followed. The results were expressed as isotopic ratio relative to the PDB standard [7], following the convention defined by the International Atomic Energy Agency.

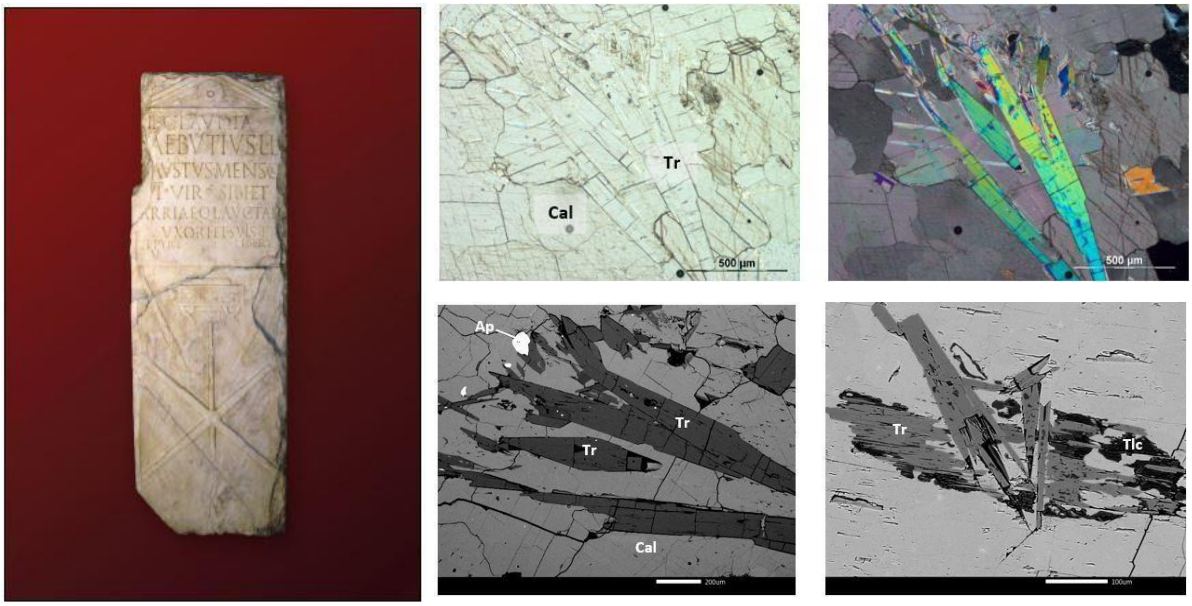

Figure 1. Stelae of *gromaticus L.A. Faustus* and light (at the top) and electron (at the bottom) micrographs. Mineral abbreviation according with [4]: Ap= Apatite; Cal = Calcite; Tlc = Talc; Tr = Tremolite.

3. Results

The marbles were identified and described from a petrographic and chemical-mineralogical point of view, reporting the corresponding geological units of provenance.

All marbles show very low Average Grain Size (AGS) values, resulting in the extremely fine grained. The MGS resulted also very low, with values generally <2 mm, with the exception of some avarage-grained samples (Table 2).

Table 2. Summary of the main minero-petrographic features of marble finds. HO: Homeoblastic, HE: Heteroblastic; Gr: Granoblastic; Xe: Xenoblastic; GBS: Grain Boundary Shape; MGS: Maximum Grain Size; AGS: Average Grain Size. Mineral abbreviation according with [4].

Section	Texture	Fabric Type	Micro-Structure	GBS	MGS (mm)	AGS (mm)	δ13C	δ18O	Accessory minerals
MN 429	Isotropic	HO	Gr	Straight to sutured	0.95	0.04			Qz, Tlc, Srp
MN 431	Anisotropic	HE	Gr	Straight to serrated	1.90	0.06	0.75±0.2	-7.04±0.2	Phl, Chl, Ab, Tlc, Srp, Tr
MN 432	Isotropic	HE	Xe	Straight to embayed	2.55	0.03	2.62±0.2	-0.04±0.2	Ph, Pg, Mrg, Phl
MN 433	Isotropic	HE, Mortar	Gr	Embayed to sutured	1.50	0.12	0.58±0.2	-3.30±0.2	
MN 434	Anisotropic	HE	Gr	Straight to embayed	2.01	0.02	3.23±0.2	-1.14±0.2	Prg, Phl
MN 435	Isotropic	HE	Gr	Fringed to embayed	1.38	0.08	2.92±0.2	-3.49±0.2	Qz, Ph, Kfs
MN 439	Isotropic	HO	Gr	Straight	0.42	0.09	3.63±0.2	-4.62±0.2	Qz, Tlc
MN 444	Isotropic	HO-HE	Gr	Straight to curved	1.09	0.06	1.12±0.2	-5.14±0.2	Qz, Ph, Tr
MN 446	Isotropic	HE	Gr	Sutured	0.67	0.09			Ph
MN 447	Isotropic	HO	Gr	Sutured to serrated	0.95	0.03			Ph
MN 449	Isotropic	HE	Gr	Embayed	1.91	0.06			Qz, Ph, Prg
MN 452	Isotropic	HE	Gr	Embayed	2.28	0.02			Qz
MN 453	Isotropic	HE	Gr	Embayed to sutured	1.05	0.09			Qz, Ph, Phl, Chl, Tlc
MN 454	Isotropic	HO	Gr	Serrated	1.06	0.03			
MN 455	Isotropic	HO	Gr	Straight and mosaic	0.72	0.06			

The petrographic parameters observed were also rather homogeneous. Most of the samples are characterized by a homogeneous grain and an isotropic texture. The microstructure is generally granoblastic, with some cases in which the typical mosaic appearance is evident. The greatest petrographic differences concerned accessory minerals. These include the abundant presence of phyllosilicates, and in particular of white mica with phengite composition. This implies that the marbles come from high pressure geological units. In particular, the sample MN 431 (the stelae of the *gromaticus*) is characterized by the abundant presence of tremolite amphibole, as well as talc and serpentine. In the sample MN 432, on the other hand, the simultaneous presence of phengitic mica, paragonite and margarite, allow to assign it to the Bardiglio marble, cropping out in the Aosta Valley (NW Italy) in correspondence of the External Piemonte Zone [8].

The isotopic data were compared with the isotopic results of the geologic units of the Piemonte (NW Italy) marbles reported in [9]. From their comparison, it appears that the *gromaticus stelae* (MN 431) falls in the field of Pont Canavese marble (Sesia-Lanzo Zone) and the *box relief with three portraits* (MN 444) plots in the Foresto marble field (Dora Maira Unit), the same used for the Arch of Augustus settled in Susa (Cottian Alps).

The analysis produced were also compared with the isotopic data for the Mediterranean marbles reported by [10]. The values are quite scattered, but they fall into fields rather common to historical marbles from different sites in the Mediterranean (Figure 2).

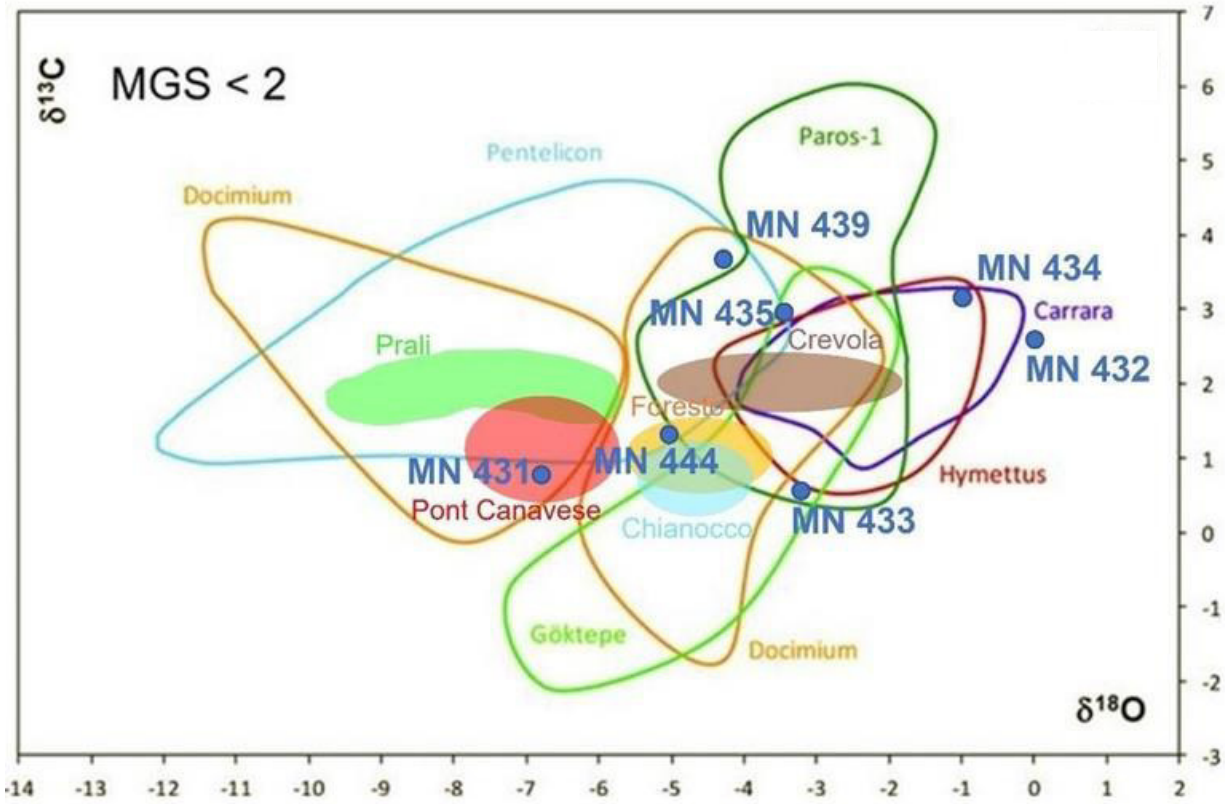

Figure 2. $\delta^{18}O$ versus $\delta^{13}C$ diagram for the investigated marbles. The data were compared with those of the Piedmont white marbles according to [9] (color fields)and the Mediterranean marbles according to [10] (color contours).

4. Conclusions

The 15 marble samples were characterized from a petrographic, mineral-chemical and archaeometric point of view in order to build a first petrographic database (Table 2) and a first classification of these artifacts never studied until now. In some cases it was possible to provide hypotheses on the probable

origin, in other cases the analysis carried out were not sufficient to provide a more precise place of origin (Table 1). In particular, the multidisciplinary approach allowed to establish with reasonable certainty the provenance of the sample of the *gromaticus* stelae to pre-Triassic marbles from the Sesia Lanzo Zone (Western Alps), of the sample MN 432 to the External Piemonte Zone and of the sample MN 444 to the Foresto marble (Dora Maira Unit, Western Alps). The minero-petrographic characterization also made it possible to assign an Apuan origin to MN 455 marble sample. The different origin of these materials suggests that *Eporedia* in Roman times was a center of local importance, with commercial exchanges and trade routes with the surrounding alpine areas.

5. References

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