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Provenance of White Marbles from the Roman City of Tauriana (Palmi, Reggio Calabria, Italy)

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Received: 18 February 2020; Accepted: 25 March 2020; Published: 26 March 2020

Abstract: The work shows the results of an archaeometric study performed on fourteen white marble samples from the Roman city of Tauriana (Palmi, Reggio Calabria, Italy), belonging to different architectural elements of the Municipal Museum Complex and artifacts reused in the modern town. Samples were studied by optical microscopy (OM), x-ray powder diffraction (XRPD), and isotope ratio mass spectrometry (IRMS) of ^{13}C and ^{18}O with the aim to identify their provenance. The comparison between the collected data and the historical ones, concerning the ancient quarries of white marble of the Mediterranean area, allowed us to prove that most of the marbles used in the city of Tauriana were from the Apuan Alps Basin (Carrara) and, in few cases, from Minor Asia (Proconnesos, Aphrodisias, Docimium) and Greek (Thasos and Pentelic) quarries.

Keywords: archaeometry; white marbles; provenance; isotopic analysis

1. Introduction

The Roman city of Tauriana is located in the south of Calabria, few kilometers from the town of Palmi, a municipality of about 20,000 inhabitants in the province of Reggio Calabria, in southern Italy (Figure 1a). The area is characterized by a plateau overlooking the sea, dominated by a sighting tower of the 16th century, with anti-Saracen function (Figure 1b). The long and complex history of the site is marked by settlement continuity and structural breaks that testify the occupation of the area, starting from the Bronze Age until the Middle Ages [1–4].

The first documented protohistoric villages date back to the second millennium BC. After a period of emptiness, at the end of the 4th century BC, the Italic people of the Taurians founded, along the valley of the Métauros River (today Petrace River), one of the strategic centers of their extensive settlement system. During the 2nd century BC, after the second Punic war, where the Taurians supported the Romans against the Carthaginians, there was a period of great transformations and the city underwent a first urban planning intervention, attested by the archaeological documentation and the brick stamps showing the ethnic "Tayrianoym" [3].

At the end of the 1st century BC, probably in the Augustan age, the city was subjected to a re-foundation process [4]. The city underwent massive architectural revitalization, demonstrated by the general terraced structure, the main urban sanctuary (Figure 1c), and a peculiar building simultaneously used for theatrical performances and gladiatorial games (Figure 1d). During the Roman period, there was also an extensive re-planning of the coastal strip, in the Scinà locality, with the construction of a new residential complex referable to a villa or a suburb, most likely connected to a port area [4]. The city remained functional until late-antiquity (4–5th centuries AD), when it was completely abandoned.

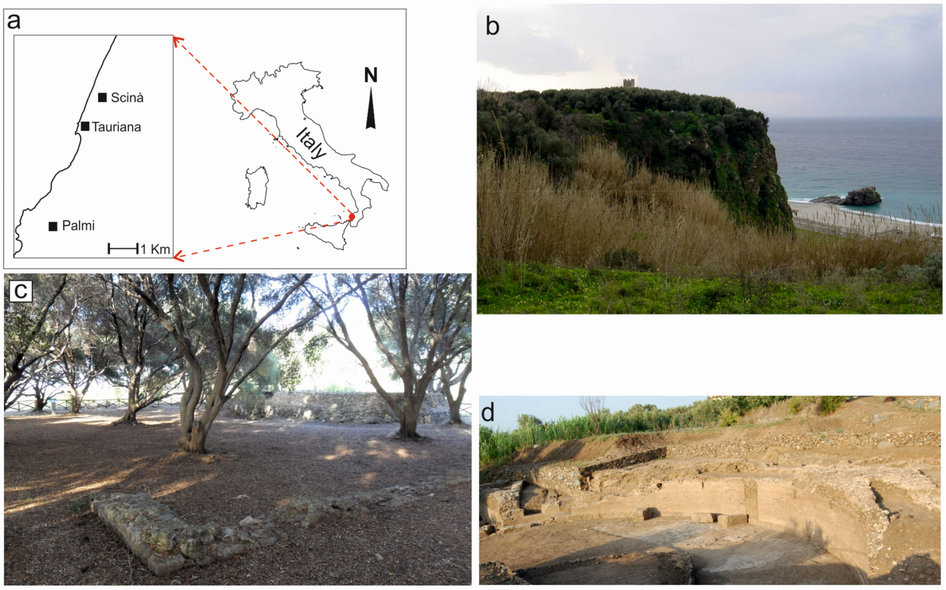

Figure 1. (**a**) Location of the Roman city of Tauriana (Reggio Calabria, Southern Italy); (**b**) Plateau overlooking the sea with the sighting tower of the 16th century; (**c**) Remains of the urban sanctuary; (**d**) Remains of the peculiar building for shows.

The aim of this work was to analyze, for the first time, the marble remains belonging to column shafts, capitals, bases and fragments of architectural decorations, found (between the end of the 19th and the beginning of the 20th century) in the area of the ancient city and fortunately survived the reuse and the thefts perpetuated over time. Indeed, Tauriana underwent a systematic and complete post-abandonment spoliation activity, which erased almost all traces and memories of the city. In the early Middle Ages, for example, the reuse of ancient artifacts was documented, particularly in the church of "San Fantino" (built on the edge of the ancient city) and in the archaeological area of Scinà [5,6].

The archaeometric approach adopted in this study will provide a geochemical and petrographic characterization of the marble samples in order to identify their provenance and to obtain information about the trade routes in the area.

As demonstrated by the scientific literature, many researchers have focused their attention on the archaeometric study of ancient marble samples using different methodological approaches [7–19] in order to determine the quarries of provenance, to verify the level of technological skills achieved in the use of some marble types, and to obtain information on the commercial relationships and trade routes in antiquity.

2. Materials and Methods

In this work, fourteen white marble samples from the city of Tauriana (Table 1) were analyzed. Eleven samples (C2–C8, C10–C13) were collected from different architectural elements present in the local archaeological section of the Municipal Museum Complex (Palmi, Reggio Calabria, Italy) (Table 1 and Figure 2a–e); two samples (C14 and C20) were taken from artifacts reused as elements of "urban furniture" of the modern town (Table 1 and Figure 2f,g), while one sample (C18) was a marble crushed to make lime from the Scinà locality. The hypothetical historical dating of the samples, based on archaeological data, ranged from the early Imperial Age to the beginning of the 4th century AD (Table 1), even if their provenance is unknown and their original context remains hypothetical.

Table 1. Analyzed samples of white marbles from the city of Tauriana with location, architectural typology and hypothetical historical period, based on archaeological data (for columns A, B and C, see Figure 2a).

Sample	Location	Architectural Typology	Hypothetical Historical Period
C2	Column A—Museum garden	Ionic capital	Early Imperial Age (1st–2nd cent AD)
C3	Column A—Museum garden	Column shaft	Early Imperial Age (1st–2nd cent AD)
C4	Column B—Museum garden	Ionic capital	Early Imperial Age (1st–2nd cent AD)
C5	Column B—Museum garden	Column shaft	Early Imperial Age (1st–2nd cent AD)
C6	Column C—Museum garden	Column shaft	Early Imperial Age (1st–2nd cent AD)
C7	Intact base D on the ground—Museum garden	Attic base	Early Imperial Age (1st–2nd cent AD)
C8	Base E without the corner, on the ground, Museum garden	Attic base	Early Imperial Age (1st–2nd cent AD)
C10	Capital F—Museum hall	Roman capital (Asian Corinthian type)	Imperial Age (middle 3rd–beginning 4th cent AD)
C11	Capital G—Museum hall	Roman capital (Composite type with smooth leaves)	Imperial Age (3rd cent AD)
C12	Capital H—Museum hall, sample reused as stoup	Capital (Corinthian with double S)	Imperial Age (3rd cent AD)
C13	Trabeation I—Museum hall, sample reused as an altar pluteus	Fragment of architrave	Imperial Age (3rd cent AD)
C14	Base L of the column placed in front of the “Carmine Church”	Column base (Ionic-Asian)	Imperial Age (3rd cent AD)
C18	Marble crushed to make lime, Roman settlement, Scinà locality, US80		Imperial Age (3rd cent AD)
C20	Reused fragment of the column of the medieval “San Fantino Church” US120	Column shaft	Imperial Age (3rd cent AD)

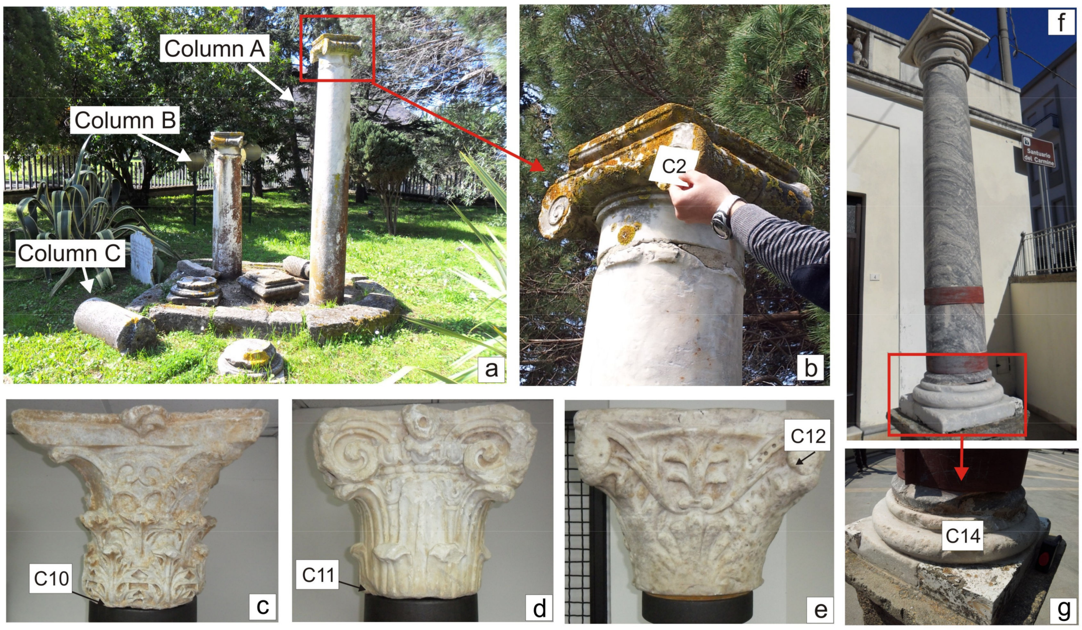

Figure 2. Some white marble samples taken from the architectural elements present in the local archaeological section of the Municipal Museum Complex (**a**–**e**) and from artifacts reused in the modern town (**f**,**g**).

White marble samples were studied by mineralogical and petrographic investigation and by carbon and oxygen stable isotopes analysis.

The petrographic study was carried out by polarized light microscopy on thin sections, using a Zeiss petrographic microscope (Zeiss Axioskop 40, Oberkochen, Germany) equipped with a Canon PowerShot A640 photo camera to determine the maximum grain-size (MGS), the grain-size uniformity (GSU) and the rock texture including the boundary shapes of the carbonate grains (GBS).

The mineralogical composition of the samples was defined by x-ray powder diffraction (XRPD) using a Bruker D8Advance x-ray diffractometer (Bruker, Karlsruhe, Germany) with Cu–K_α radiation operating at 40 kV and 40 mA. Scans were collected in the range of 3–60° (2θ) with a step interval of 0.02° (2θ) and a step-counting time of 3 s. EVA software (DIFFRACplus EVA, version 11.0. rev. 0, Bruker, Karlsruhe, Germany) was used for facilitating the identification of the mineralogical phases through the comparison with the 2005 PDF2 reference patterns.

Measurements of the isotopic ratios $^{18}O/^{16}O$ and $^{13}C/^{12}C$ were performed using the mass spectrometry at the Stable Isotope Mass Spectroscopy Laboratory of the Institute of Geosciences and Earth Resources, National Research Council of Italy (Pisa, Italy). The stable isotopic ratios of carbon and oxygen, expressed in delta values $\delta^{13}C$ ‰ and $\delta^{18}O$ ‰, were measured in accordance with the international standard Pee Dee Belemnite (PDB) [20], a carbonate fossil from South Carolina. The standard error for the delta values is ±0.1‰ for both carbon and oxygen.

The results of the mineralogical, petrographic and isotopic analyses were carefully compared with data reported in the most updated databases for white Mediterranean ancient marbles [21].

3. Analytical Results

3.1. Mineralogical Composition and Petrographic Textures

Table 2 shows the main petrographic features of the analyzed white marbles. Most samples (C2–C8 and C11–C12) showed a homeoblastic granoblastic isotropic texture and a grain boundary shape (GBS) of the calcite grains mostly from straight to curved (Figure 3a,b). Sample C14 was characterized by a homeoblastic/heteroblastic granoblastic isotropic texture, while samples C10, C13 and C20 had a heteroblastic granoblastic anisotropic texture. Finally, sample C18 had a heteroblastic sutured and anisotropic texture. The grain boundary shape of the calcite/dolomite grains were lobate for samples C10, C13 (Figure 3c) and C18 (Figure 3e) and from curved to lobate for samples C14 (Figure 3d) and C20 (Figure 3f).

XRPD analysis revealed a high content of calcite in all of the analyzed samples, except for sample C18, which was characterized by the presence of abundant dolomite. Traces of dolomite were present in samples C3, C4, C6, C7, C8, C10, C11 and C20. Other accessory minerals were phyllosilicates (in particular mica-like minerals) in samples C6, C7, C11, C12 and C20 (Figure 3f); quartz in all the analyzed samples; plagioclase (albite) in samples C3, C5, C11, C14, C18 and C20; graphite in sample C20; and opaque minerals in samples C2, C3, C6, C8, C11, C13, C14, C18 and C20 (Table 2).

Table 2. Main mineralogical and petrographic features, carbon–oxygen isotopic data and the most probable provenance of the marble samples coming from the city of Tauriana.

Sample	GSU	Texture	GBS	MGS (mm)	Cal	Dol	Phyll	Qtz	Pl	Gr	Om	$\delta^{13}C$ (‰)	$\delta^{18}O$ (‰)	Provenance
C2	Ho	G, I	St/Cr	0.7	+++			tr			tr	2.2	−1.8	Carrara
C3	Ho	G, I	St/Cr	0.9	+++	tr		tr	tr		tr	2.5	−1.8	Carrara
C4	Ho	G, I	St/Cr	0.9	+++	tr		tr				1.8	−1.9	Carrara
C5	Ho	G, I	St/Cr	1.0	+++			tr	tr			2.2	−1.7	Carrara
C6	Ho	G, I	St/Cr	0.7	+++	tr	tr	tr			tr	2.5	−1.6	Carrara
C7	Ho	G, I	St/Cr	0.8	+++	tr	tr	tr				2.4	−2.1	Carrara
C8	Ho	G, I	St/Cr	0.6	+++	tr		tr			tr	2.2	−1.9	Carrara
C10	He	G, A	Lo	2.5	+++	tr		tr				3.3	−2.3	Proconnesos-1
C11	Ho	G, I	St/Cr	0.5	+++	tr	tr	tr	tr		tr	2.3	−1.5	Carrara
C12	Ho	G, I	St/Cr	0.5	+++		tr	tr				2.0	−1.9	Carrara
C13	He	G, A	Lo	1.8	+++			tr			tr	0.2	−5.9	Docimium
C14	Ho/He	G, I	Cr/Lo	2.9	+++			tr	tr		tr	2.3	−3.1	Aphrodisias
C18	He	S, A	Lo	2.3	tr	+++		tr	tr		tr	3.5	−4.8	Thasos-3
C20	He	G, A	Cr/Lo	1.9	+++	tr	tr	tr	tr	tr	tr	2.0	−7.5	Pentelic

GSU: Grain Size Uniformity (Ho: homeoblastic, He: heteroblastic); Texture (G: granoblastic, S: sutured, I: isotropic, A: anisotropic); GBS: Grain Boundary Shape (St: straight, Cr: curved, Lo: lobate); MGS: Maximum Grain Size of calcite/dolomite grains; Cal: calcite; Dol: dolomite; Phyll: phyllosilicates; Qtz: quartz; Pl: plagioclase; Gr: graphite; Om: opaque minerals (detected by XRPD); +++: abundant; tr: trace; $\delta^{13}C$ and $\delta^{18}O$: carbon (C) and oxygen (O) isotopic values.

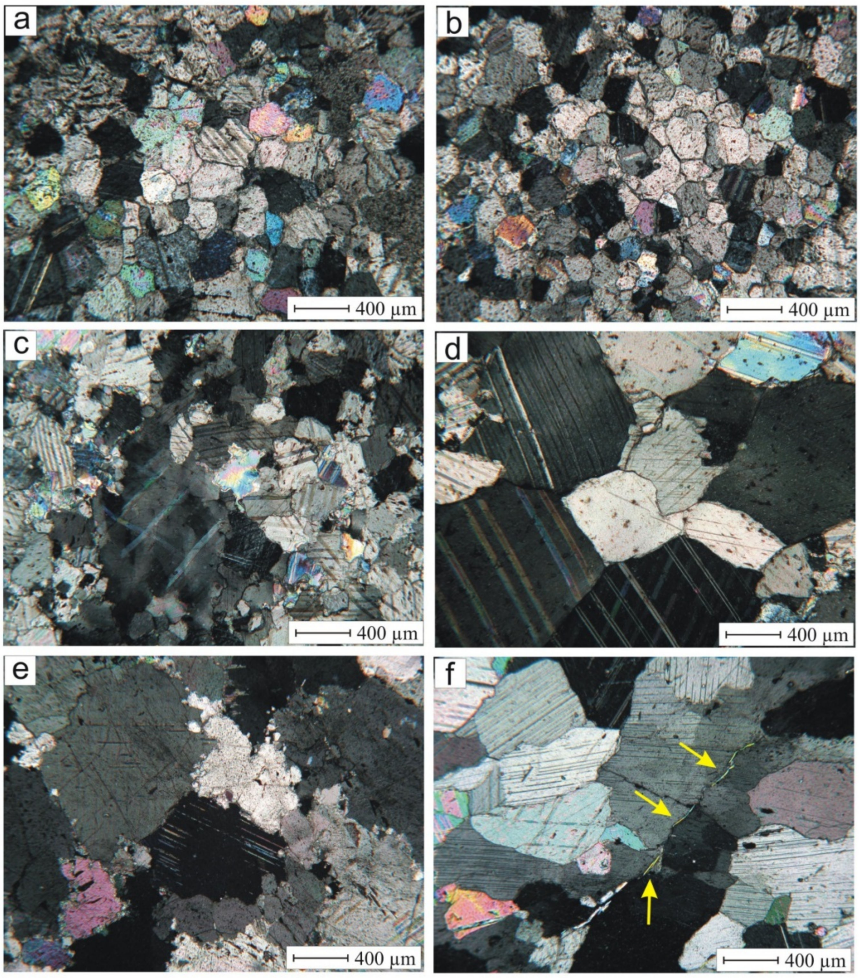

Figure 3. Microphotos in thin section by polarized optical microscopy, images under crossed nicols. (**a**) Sample C2; (**b**) Sample C11; (**c**) Sample C13; (**d**) Sample C14; (**e**) Sample C18; (**f**) Sample C20, where microcrystals of white mica are visible.

Most samples are fine-grained marbles with a maximum grain size (MGS) ≤ 1.0 mm, except for samples C10, C13, C14, C18 and C20, characterized by MGS values from 1.8 to 2.9 mm (Table 2 and Figure 4). Based on MGS values [21], it is possible to attribute to the samples the following different provenance: the marbles with MGS ≤ 1.0 mm are, most likely, from Carrara, Göktepe, Docimium, Pentelic, or Hymettos quarries, while the marble samples with MGS > 1.0 mm are from the Aphrodisias, Proconnesos, Paros, or Thasos quarries.

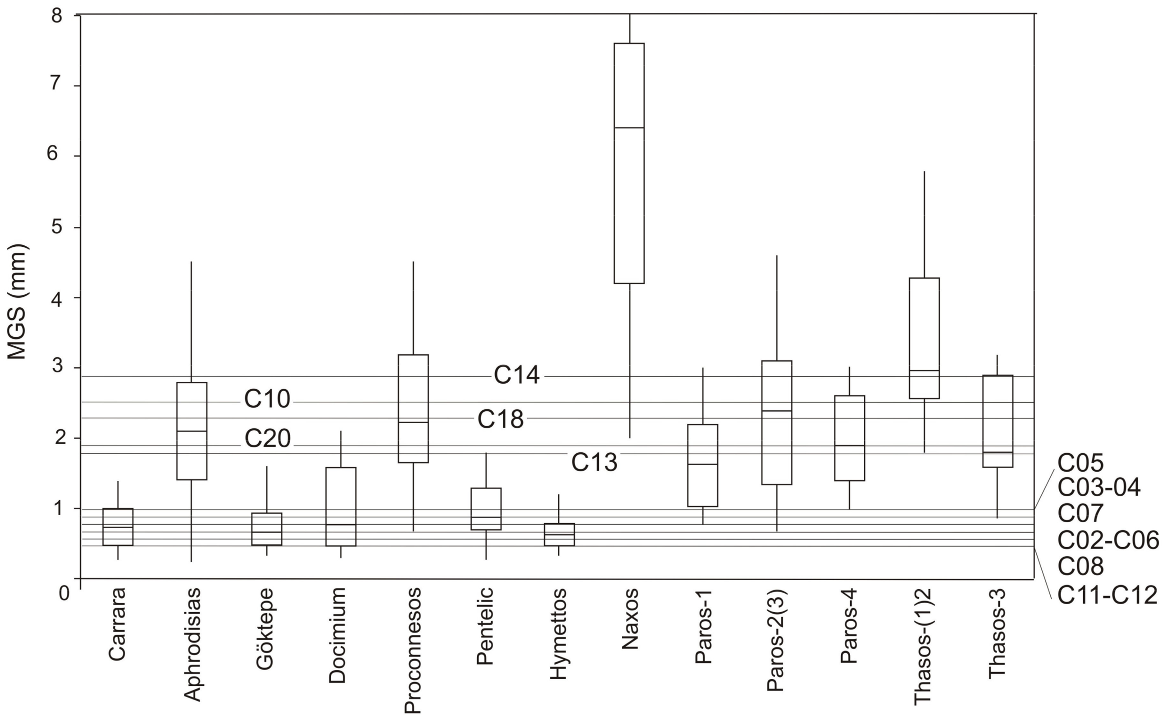

Figure 4. Maximum grain size (MGS) values of the analyzed marble samples compared with those of the Mediterranean area used in antiquity [21].

3.2. Isotopic Analysis

To better define the provenance of the marble samples, the carbon and oxygen isotopic ratios ($\delta^{13}C$ and $\delta^{18}O$), summarized in Table 2, were plotted into two distinct bivariate isotopic diagrams ([21] and reference therein) related to fine-grained white marbles (Figure 5) and to medium- and coarse-grained white marbles (Figure 6).

Observing the graph in Figure 5, it is evident that the analyzed marble samples with fine MGS values fell into the field of Carrara and Hymettos marbles, except for samples C13 and C20. Sample C13 was inside the field of the Docimium and Göktepe marbles, while sample C20 matched the Pentelic and Docimium marbles (Figure 5).

The graph of Figure 6, related to the isotopic signatures of the medium- to coarse-grained marbles, shows that sample C10 fell into the field of Proconnesos-1, Thasos 1(2), and Thasos-3 quarries; sample C14 matched that of the Proconnesos-1, Aphrodisias, Thasos, Paros-2, and Naxos quarries, while sample C18 was inside the field of the Thasos-3 and Naxos quarries.

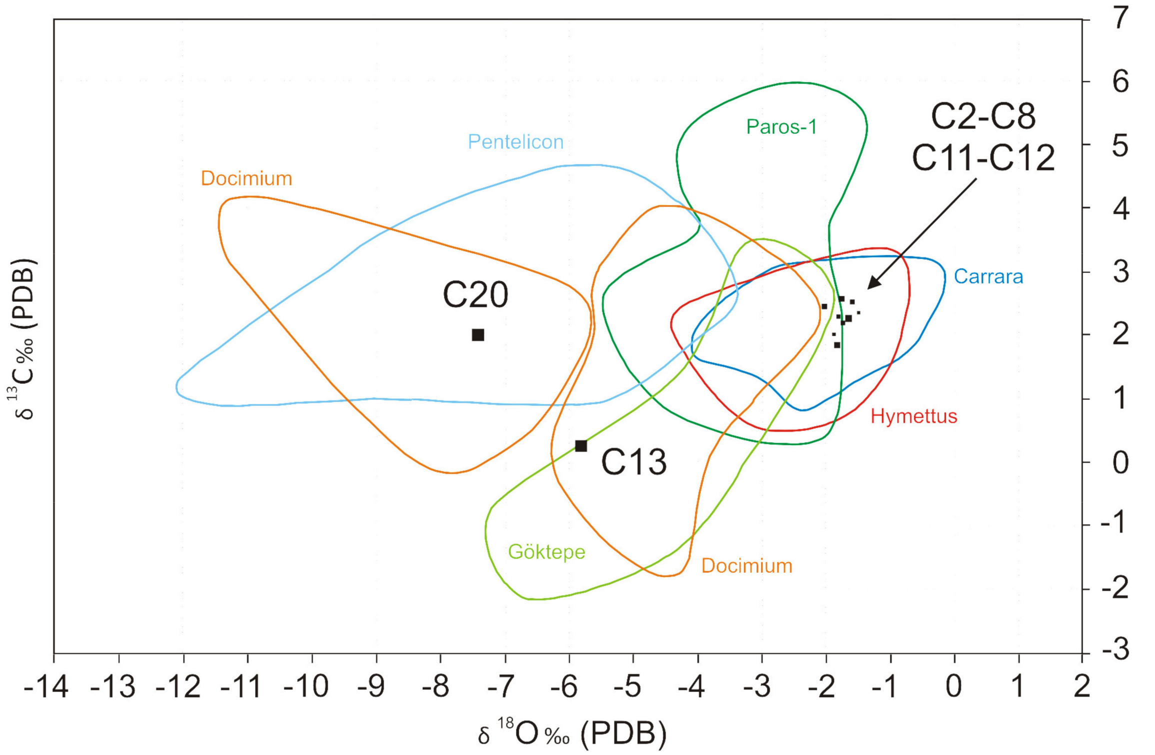

Figure 5. Comparison of the isotopic signatures of the marbles coming from Tauriana with the data for fine-grained marbles used in antiquity [21].

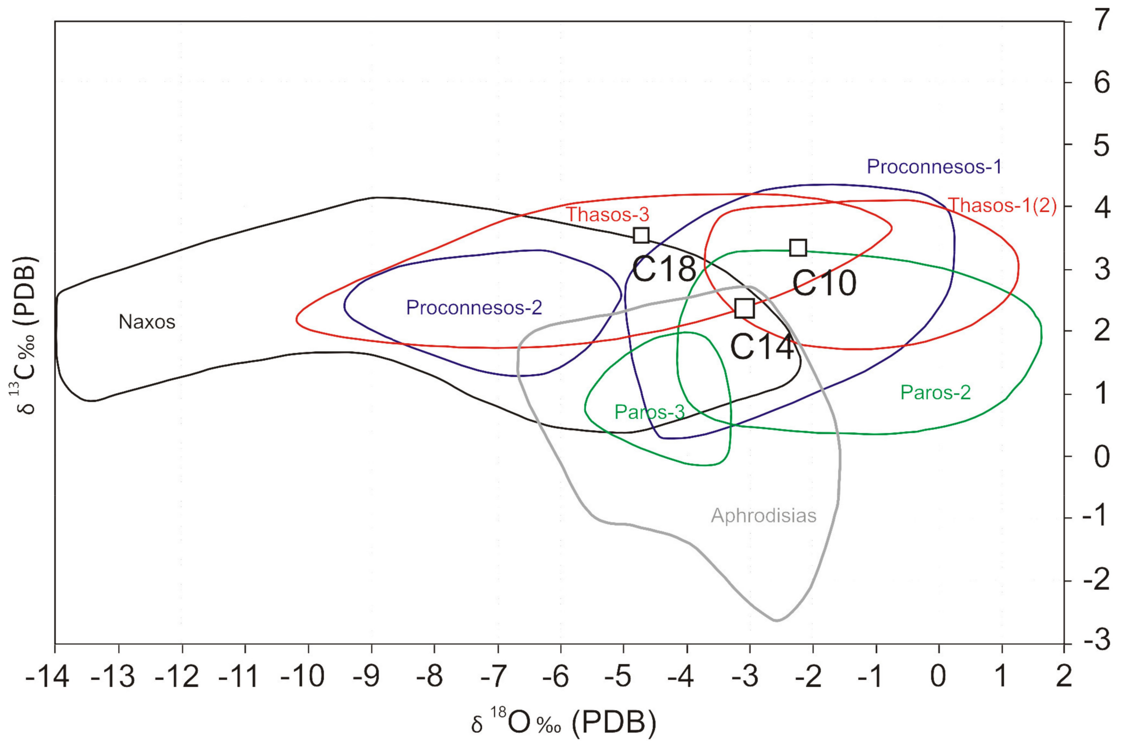

Figure 6. Comparison of the isotopic signatures of the marbles coming from Tauriana with the data for medium- to coarse-grained marbles used in antiquity [21].

3.3. Provenance of Marbles Combining the Collected Data

Considering the petrographic and mineralogical data and the carbon/oxygen isotope ratios, it is possible to attribute the analyzed samples as follows (Table 2):

- Samples C2–C8 and C11–C12 seem to have been extracted from the Carrara Basin, rather than from the Hymettos quarries; indeed, petrographic aspects, isotopic ratios, and accessory minerals have led to this conclusion. Quartz and plagioclase (albite) are more frequent in Carrara marbles than in any other marbles.
- Sample C20 is more likely to be a Pentelic marble for the presence of phyllosilicates, identified by both optical microscopy and XRPD analysis (Table 2). Phyllosilicates are much more frequent in Pentelic marble than in the Docimium variety.
- Sample C13 is a Docimium marble as the calcite grain size is too large to be a Göktepe marble and for the C–O isotope ratio.
- Sample C10 was identified as coming from the Proconnesos-1 quarry for texture and accessory minerals.
- Sample C18 comes from the Thasos-3 quarry due to its high percentage of dolomite.
- Sample C14 is an Aphrodisias marble, rather than Paros-2 or Thasos-1(2), due to its mineralogical composition including accessory minerals.

4. Discussion and Conclusions

The mineralogical and petrographic characterization of the fourteen white marble samples from the city of Tauriana revealed that Carrara marble is the most used rock for many of the analyzed artifacts. In particular, it was identified in the columns present in the Museum garden (shafts, capitals and bases; from sample C2 to C8), which belong to the early Imperial Age (between the 1st and the 2nd century AD). Carrara marble is also used in samples C11 and C12 that correspond, respectively, to a Composite and a Corinthian capital present in the Museum hall (Figure 2d,e), dating back to the Imperial Age (3rd century AD).

The other white marbles from Tauriana showed a different provenance. Marble from Minor Asia quarries such as Proconnesos, Docimium and Aphrodisias were identified in samples C10, C13, and C14, respectively. These samples were taken form an Asian Corinthian capital belonging to the middle of the 3rd–beginning of the 4th century AD (sample C10, Figure 2c) and an architrave fragment (sample C13) of the Imperial Age (3rd century AD), both exposed in the Museum hall. Sample C14 was taken from a base of a column (Figure 2f,g) belonging to the Imperial Age (3rd century AD), placed in front of the "Carmine Church".

The crushed sample to make lime (sample C18) was a white marble from the Greek quarry of Thasos-3, while the reused fragment of column of the medieval "San Fantino Church" (sample C20) came from Attica (Pentelic marble).

The collected data shows that Carrara marble, in Tauriana, is the most used marble during the Imperial Age (3rd century AD), while in the architectural artifacts belonging to the following periods, its use together with marbles of different provenance is noticeable. Therefore, between the 3rd and the 4th century AD, in Tauriana, there was a trade of precious marble coming not only from Italy (Carrara), but also from Minor Asia and Greece.

However, Tauriana is still under study, epigraphic and literary documentations are absent and only archaeological data are available. For this reason, this archaeometric study can be considered an important contribution to the reconstruction of the history of the city, even if further studies will be necessary to have terms of comparison and to identify the role of Tauriana within the wider Roman marble trade.

Author Contributions: M.M.S. contributed in the archaeological part; R.D.L., D.B., A.B., R.D., M.L., M.M.S., and D.M. performed the analyses, processed the data, and wrote the paper. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: The authors would like to thank Giancarlo Niceforo and Manuela Catalano for their support, respectively, in the XRPD analyses and in the sampling phase. We are also grateful to the journal editors and the anonymous reviewers for their useful comments and the suggested improvements during the revision of the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

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