

# METROPOLITAN MUSEUM JOURNAL

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FOR JULIE JONES

A meticulous and probing reader who significantly  
broadened the *Journal's* scope

FOR BRUCE CAMPBELL

An exceptional designer  
who lavished his talents on this publication



# Contents

*Adam* by Tullio Lombardo

<i>Adam</i> by Tullio Lombardo LUKE SYSON AND VALERIA CAFÀ	9
Ancient Sources for Tullio Lombardo's <i>Adam</i> VALERIA CAFÀ	33
The Treatment of Tullio Lombardo's <i>Adam</i> : A New Approach to the Conservation of Monumental Marble Sculpture CAROLYN RICCARDELLI, JACK SOULTANIAN, MICHAEL MORRIS, LAWRENCE BECKER, GEORGE WHEELER, AND RONALD STREET	49
A New Analysis of Major Greek Sculptures in the Metropolitan Museum: Petrological and Stylistic LORENZO LAZZARINI AND CLEMENTE MARCONI	117
Hellenistic Etruscan Cremation Urns from Chiusi THERESA HUNTSMAN	141
Redeeming Pieter Coecke van Aelst's <i>Gluttony</i> Tapestry: Learning from Scientific Analysis FEDERICO CARÒ, GIULIA CHIOSTRINI, ELIZABETH CLELAND, AND NOBUKO SHIBAYAMA	151
Trade Stories: Chinese Export Embroideries in the Metropolitan Museum MASAKO YOSHIDA	165
A Greek Inscription in a Portrait by Salvator Rosa MICHAEL ZELLMANN-ROHRER	187
Honoré de Balzac and Natoire's <i>The Expulsion from Paradise</i> CAROL SANTOLERI	193
Another Brother for Goya's "Red Boy": Agustín Esteve's Portrait of Francisco Xavier Osorio, Conde de Trastámara XAVIER F. SALOMON	201
Nature as Ideal: Drawings by Joseph Anton Koch and Johann Christian Reinhart CORNELIA REITER	207
A Buddhist Source for a Stoneware "Basket" Designed by Georges Hoentschel DENISE PATRY LEIDY	225

## Manuscript Guidelines for the *Metropolitan Museum Journal*

The *Metropolitan Museum Journal* is issued annually by The Metropolitan Museum of Art. Its purpose is to publish original research on works in the Museum's collection. Articles are contributed by members of the Museum staff and other art historians and specialists. Submissions should be emailed to: journalsubmissions@metmuseum.org.

Manuscripts are reviewed by the *Journal* Editorial Board, composed of members of the curatorial, conservation, and scientific departments. **To be considered for the following year's volume, an article must be submitted, complete including illustrations, by October 15.** Once an article is accepted for publication, the author will have the opportunity to review it after it has been edited and again after it has been laid out in pages. The honorarium for image costs is \$300, and each author receives a copy of the *Journal* volume in which his or her article appears.

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## ABBREVIATIONS

MMA	The Metropolitan Museum of Art
MMAB	<i>The Metropolitan Museum of Art Bulletin</i>
MMJ	<i>Metropolitan Museum Journal</i>

Height precedes width and depth in dimensions cited.

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# A New Analysis of Major Greek Sculptures in the Metropolitan Museum: Petrological and Stylistic

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Interest in the provenance of ancient marbles used in Greek and Roman sculpture is long-standing, going back to the very foundation of the study of ancient art, Johann Joachim Winckelmann's *History of the Art of Antiquity*, published in 1764. In Part 1 of this seminal text, the German scholar addresses the materials selected by Greek sculptors in two important passages. In the introductory chapter, which discusses the origin of art and the reasons for its diversity among peoples, Winckelmann proposes a line of development for ancient sculptors' materials that begins with clay and gradually progresses to wood and ivory, and finally to stone and metal. In Chapter 4, on the art of the Greeks, section 4, devoted to the "Mechanical Part of Greek Sculpture," he addresses first the materials in which Greek sculptors worked and then the manner of their workmanship. In the passage, Winckelmann begins—in keeping with the taste of his time—with marble, and he not only presents the relevant literary sources but also discusses the qualities of different kinds of marble, including texture, consistency, and color. He focuses on marble from the island of Paros but also mentions Thasian, Pentelic, and Carrara marble. He explores the correlation between the qualities of these marbles and their different workabilities and appearances, thus proposing a strong connection between the material and the aesthetic quality of ancient sculpture.<sup>1</sup>

After such a start, it would seem inevitable that the identification of the marbles used in antiquity would have been a constant concern of both historians of ancient art and archaeologists. However, it was not until more than one hundred years after Winckelmann that the German

geologist Richard Lepsius developed the first scientifically correct approach, one that can unreservedly be defined as archaeometric in the strict sense of the term.<sup>2</sup>

Archaeometry is a rather new science, officially dating to the end of the 1950s when the University of Oxford's Research Laboratory for Archaeology and the History of Art began publishing a bulletin for the purpose of "fostering the close integration between the physical sciences, archaeology, and art history."<sup>3</sup> The bulletin soon became *Archaeometry*, an international journal now published six times a year that reports on the applications of scientific disciplines, such as biology, chemistry, physics, geology, and informatics, to archaeology, architecture, and art. Among other topics, its contributors discuss methods for determining the age and authenticity of all kinds of artifacts, the nature of their materials, and their sources and manufacturing techniques.

One important application of archaeometry concerns marbles.<sup>4</sup> Technically, marbles are pure carbonatic (calcitic or dolomitic) rocks with a carbonatic content that is usually well in excess of 95 percent. These rocks are crystalline; they may be white or gray, more rarely black, red, or green; and they will have been produced by contact or regional metamorphism. Marbles are quite common throughout the Mediterranean area. We know when some of them were first used by builders and sculptors, and we have information from various sources that enables us to reconstruct at least a partial picture of their distribution and the ways they were traded and transported. In most cases, however, we know very little, mostly because of the fundamental difficulty of reliably identifying marbles when they are found in use as structural or decorative members of ancient buildings, or as sculptures, or when they have been reused in medieval or Renaissance monuments.



1. Fragment of a funerary stele of a youth, from Athens, ca. 530 B.C. Marble, Hymettian, H. preserved 48 in. (121.9 cm). The Metropolitan Museum of Art, Rogers Fund, 1912 (12.158)



2. Head of a horse, from Eleusis, 575–550 B.C. Marble, Pentelic, H. 13 3/8 in. (34 cm), L. 13 3/4 in. (34.9 cm). The Metropolitan Museum of Art, Bequest of Walter C. Baker, 1971 (1972.118.106). Photographs of Figures 2, 4, 22: Juan Trujillo, The Photograph Studio, MMA



Although some white marbles, such as the Proconnesian, Lunense, and Pentelic holotypes, are so distinctive in color, translucency, and grain size that they can at times be identified with the naked eye, it is much better to confirm their identification with scientific methods and data obtained from laboratory analyses. These methods are still being developed. Despite the application of numerous analytical techniques for “fingerprinting” white marbles and then determining their provenance in antiquity, results have been no more than partial.<sup>5</sup>

Nevertheless, over the last twenty years, many museums housing important collections of marble statuary and institutions responsible for archaeological sites with a substantial number of marble artifacts have launched more or less extensive campaigns of laboratory analysis to determine the quarries of origin of their works. These include, among others, the Museum of Fine Arts in Boston,<sup>6</sup> the Arthur M. Sackler Museum, Harvard Art Museums,<sup>7</sup> the National Archaeological Museum in Naples with its well-known Farnese Collection,<sup>8</sup> the Museum of Art and Archaeology of the University of Missouri, Columbia,<sup>9</sup> and the Villa Adriana near Tivoli.<sup>10</sup>

These scientific studies of marble are extremely important for those immersed in the history of ancient Greek and Roman art as well as for those interested in technical art history more generally, including the study of materials and carving techniques. To archaeometrists, the spate of new studies is of particular significance, as it provides fresh data concerning the opening of ancient quarries and their periods of use, the necessary point of origin—in all senses—of ancient sculpture and architecture.

It is within this context, and with these goals in mind, that The Metropolitan Museum of Art launched an archaeometric investigation of some Greek marbles—especially statues but also architectural elements and one inscription—in its collection. The laboratory methods used for the identification of the marble sources have been based on the combination of minero-petrographic and isotopic analyses, the most suitable and reliable methods to date: the methods are fully described below. When fear of damaging the works in the sampling process ruled out these methods, the identification of the marbles was tentatively made based on systematic visual autopsy, considering the main macroscopic features of the marble artifacts, including color, grain size, and translucency.

## EXPERIMENTAL

All determinations were made on a single, very small (a few square mm) fragment of marble removed from areas already broken and hidden, using a sharp little chisel or a spatula as a lever. Part of the sample was finely ground in an agate mortar, and the powder subjected to standard

diffractometric (X-radiation CuK $\alpha$ /Ni at 40KV, 20mA) and isotopic analysis. The remaining part was used for the preparation of a thin section for a detailed minero-petrographic study of the marble under a polarizing microscope.

## MINERO-PETROGRAPHIC ANALYSES

The purpose of the minero-petrographic examination was to determine the fabric, accessory, and secondary minerals in addition to the calcite and dolomite characteristics that are usually the principal constituents of all types of marble.

More specifically, the following parameters were determined:

1. type of fabric (homeoblastic, with roughly isodiametric grains; or heteroblastic, with grains of various dimensions), in direct relationship to the type of metamorphism (equilibrium, nonequilibrium, retrograde, polymetamorphism, etc.) and metamorphic grade;
2. boundary shapes of the calcite or dolomite grains, also connected to the type of metamorphic event or events that generated the marble;
3. maximum grain size (MGS, the longest dimension of the largest crystal identified in the section), a parameter of significant diagnostic importance because it is linked to the grade of metamorphism achieved by the marble.
4. quality and semi-quantitative determination of accessory minerals (e.g., minerals different from calcite/dolomite present in very small amounts).

For the petrographic description, previous specific studies of ancient marbles<sup>11</sup> as well as classical treatises on proterotectonics<sup>12</sup> were taken into consideration.

## ISOTOPIC ANALYSES

The isotopic analyses were carried out on the carbon dioxide derived from small portions (20–30 mg) of the powdered sample subjected to a chemical attack with 100 percent phosphoric acid at 25° in a special vacuum line, following the procedure suggested by J. M. McCrea and Harmon Craig.<sup>13</sup> The resulting CO<sub>2</sub> was then analyzed by continuous flow mass spectrometry. The instrument used is endowed with a triple collector and permits the measurement of both isotopic ratios (<sup>13</sup>C/<sup>12</sup>C and <sup>18</sup>O/<sup>16</sup>O) at the same time.

The analytical results are conventionally expressed in  $\delta$  units, in parts per thousands:

$$\delta = \frac{R_{\text{sample}}}{R_{\text{std}}} - 1 \times 1000$$

in which R sample and R std represent the isotopic ratio of oxygen and carbon in the sample and in the reference



3. Head of a kouros, from Sounion, 560–550 B.C. Marble, Pentelic, H. 8 $\frac{5}{8}$  in. (21.9 cm), L. of face 6 $\frac{1}{4}$  in. (15.8 cm). The Metropolitan Museum of Art, Rogers Fund, 1921 (21.88.16). Photograph: Karin Willis, The Photograph Studio, MMA



4a. Finial of a funerary stele, from Attica, ca. 530 B.C. Marble, Pentelic, H. 12 $\frac{3}{8}$  in. (31.5 cm). The Metropolitan Museum of Art, Rogers Fund, 1944 (44.11.5). 4b: Head of a youth from a funerary stele, from Attica, ca. 530 B.C. Marble, Pentelic, overall 10 $\frac{1}{4}$  x 15 $\frac{1}{2}$  in. (26 x 39.4 cm), thickness at top 15 $\frac{1}{4}$  in. (38.7 cm), thickness at bottom 16 in. (39.3 cm). The Metropolitan Museum of Art, Rogers Fund, 1942 (42.11.36)



5. Fragment of the funerary stele of Kalliades, from Spata, ca. 510 B.C. Marble, Pentelic, overall 21 $\frac{1}{2}$  in. (54.6 cm), H. without tenon 20 $\frac{7}{8}$  in. (53 cm), median thickness 5 $\frac{3}{4}$  x 15 $\frac{3}{4}$  in. (14.6 x 40 cm). The Metropolitan Museum of Art, Rogers Fund, 1955 (55.11.4)



6. Fragment of a stele with the head of a youth, from Megara, 470–460 B.C. Marble, Pentelic. H. 9¾ in. (24.8 cm). The Metropolitan Museum of Art, Rogers Fund, 1912 (12.59). Photographs of Figures 6, 8, 15, 16, 18: Oi-Cheong Lee, The Photograph Studio, MMA



7. Detail of a funerary stele of an athlete, from Nisyros (Incirli Ada), 480–450 B.C. Marble, H. 72 in. (182.9 cm). Istanbul Archaeological Museums (1142T). Photographs of Figures 7, 10, 13: Clemente Marconi



8. Statue of a lion, from Marathon, 340–330 B.C. Marble, Pentelic, overall 27⅞ x 12 x 50 in. (70.8 x 30.5 x 127 cm). The Metropolitan Museum of Art, Rogers Fund, 1909 (09.221.9)

9. Fragment of a relief with Lapith and centaur, from Attica, late 3rd–first half of the 2nd century B.C. Marble, Pentelic, H. 19⅞ in. (48.5 cm), L. 18⅞ in. (47.9 cm), D. 6¼ in. (16 cm). The Metropolitan Museum of Art, Rogers Fund, 1945 (45.11.5). Photograph: Paul Lachenauer, The Photograph Studio, MMA



standard, respectively. The standard adopted is PDB for both oxygen and carbon (the PDB standard is the rostrum of the *Belemnitella americana* of the Cretaceous Pee Dee Formation of South Carolina).

Isotopic characterization has proved to be very useful in the marble identification of ancient artifacts.<sup>14</sup> Its use is becoming more widespread due to its outstanding sensitivity, the small quantity of material necessary for the analysis, and the availability of a rapidly growing database that permits increasingly reliable comparisons,<sup>15</sup> especially if the isotopic data are evaluated together with the minero-petrographic results from the same samples, as in the present study.

## RESULTS AND OBSERVATIONS

The results of the archaeometric analyses are summarized in the Table in the Appendix, with the attribution of each marble to the most probable quarry of provenance. The isotopic signatures of all the marbles analyzed here are reported in Diagrams 1–3 in the Appendix. Considering the results in detail, interesting observations emerge.

Under consideration first is the fragmentary Attic grave stele of a youth (Figure 1),<sup>16</sup> to which join two fragments, one found in 1953 in the Agora area.<sup>17</sup> This stele is datable to about 530 B.C. based on the similarity in the proportions, profile, and rendering of the anatomy of the lower body to the kouros said to have been found at Anavysos in 1936.<sup>18</sup> It is characterized by isotopic data that fall slightly out of the reference isotopic field of the marble of Mount Hymettus (see Diagram 1) but may, nevertheless, be safely attributed to that source. This attribution is based on its petrographic features, which closely match those of the reference samples from the quarries on Mount Hymettus.

The head of a horse statue (Figure 2),<sup>19</sup> which was in the Eleusis Archaeological Museum in 1908 and was presumably found locally, is datable to 575–550 B.C.<sup>20</sup> based on the rendering of the mane, which is comparable to works, especially Late Corinthian vases,<sup>21</sup> of this period. It is made of Pentelic marble, not Island marble, as Waldemar Deonna suggested.<sup>22</sup>

The head of a kouros (Figure 3)<sup>23</sup> is said to be from near Sounion, and it is datable to 560–550 B.C. based on the close similarity with the kouros from Volomandra and a kouros head probably from Aegina.<sup>24</sup> It is made of Pentelic, not Island or Cycladic, marble as suggested, respectively, by Gisela Richter and Dietrich von Bothmer.<sup>25</sup> The authenticity of the Metropolitan Museum's head was previously questioned by Max Wegner, Frank Brommer, and Josef Floren,<sup>26</sup> who regarded the head as a modern forgery after the Volomandra kouros, partly because of the dull appearance of the marble surface. That is very likely due, however, to an improper cleaning done with an acid that has given the surface an artificial sheen, as Richter and



10. Copy of the Ince Athena, from Palestrina, 1st–2nd century A.D. Marble, Pentelic, H. 26½ in. (67.3 cm), L. of face 5⅞ in. (15 cm). The Metropolitan Museum of Art, Fletcher Fund, 1924 (24.97.15)



11. Statue of a kore, from Paros, 525–500 B.C. Marble, Parian, H. 41½ in. (105.4 cm). The Metropolitan Museum of Art, Gift of John Marshall, 1907 (07.306)

Bothmer pointed out.<sup>27</sup> In addition, careful study of the thin section prepared from a sample taken from an internal part of the neck has revealed clear, although weak, traces of intracrystalline decohesion of the calcite grains due to intensive weathering. This finding speaks in support of the piece's authenticity.

Two Attic grave stele fragments (Figures 4a, 4b) consist, respectively, of a finial<sup>28</sup> and of the head of a youth.<sup>29</sup> The first piece is said to have been found in Attica, and dated about 530 B.C. in the literature. The second piece is also said to have been found in Attica and can be dated to the same years based on close similarities to the Peplos kore<sup>30</sup> in the rendering of the anatomy. The two fragments are both made of Pentelic marble, not Parian, as tentatively suggested by Richter.<sup>31</sup> In addition, they were manufactured from the same marble block as demonstrated by identical isotopic ratios (see Diagram 1). This finding proves that the two fragments originally belonged to the same funerary stele, as argued by Richter based on the fact that the two pieces were found “not far” from each other.<sup>32</sup>

Two other pieces attest to the continued use of Pentelic marble down to the early fifth century B.C. The first is the fragment of the grave stele of Kalliades (Figure 5),<sup>33</sup> featuring

a running Gorgon. The stele, said to have been found at Spata, Attica, is difficult to date with precision due to the weathering of its surface (we tentatively suggest 510 B.C.). The second piece is a grave stele fragment (Figure 6) said to be from Megara,<sup>34</sup> showing the head of a youth. The relief is datable to 470–460 B.C. based on a comparison with the head of the young athlete on the stele from Nisyros (Figure 7). The material of Figure 6 reinforces its reported provenance from Megara, in the face of skepticism from some who favor a provenance in East Greece, such as Hilde Hiller.<sup>35</sup>

The statue of a lion (Figure 8)<sup>36</sup> said to be from Marathon provides evidence of the later use of Pentelic marble. This statue is datable to 340–330 B.C. based on a comparison of the rendering of its mane with that of the Lion of Chaeronea, a funerary statue honoring the soldiers of the Sacred Band of Thebes fallen in the battle (338 B.C.) against Philip II of Macedon.<sup>37</sup> Also of Pentelic marble is an interesting relief fragment featuring a Lapith fighting a centaur (Figure 9).<sup>38</sup> The sculpture, most likely architectural and possibly from a continuous frieze, is said to be from Attica. It can be dated between the late third and the first half of the second century B.C., based in particular on the rendering of the youth's body. Finally, the upper part of a copy of





12. Pedimental relief of a lion devouring a bull, from Athens, ca. 500 B.C. Marble, Parian, H. 25¼ in. (64 cm), L. 28¾ in. (72 cm). The Metropolitan Museum of Art, Rogers Fund, 1942 (42.11.35)



13. Relief with animal fight, from Paros, ca. 500 B.C. Marble, Parian, H. 28¾ in. (73 cm). Paros Archaeological Museum (759).



14. Statue of a crouching lion, from Rome, first half of the 5th century B.C. Marble, Parian, H. 31¼ in. (79.4 cm), L. 63½ in. (161.3 cm). The Metropolitan Museum of Art, Purchase, Rogers Fund, and James Loeb and Anonymous Gifts, 1909 (09.221.3)

the Ince Athena (Figure 10),<sup>39</sup> said to have been found in Palestrina and whose original is dated about 400 B.C., is also of Pentelic marble.

The torso of a kore (Figure 11), seen on Paros in the nineteenth century and presumably from that island, is comparable for the rendering of the folds to a series of korai from Delos, and may be dated to the same years (525–500 B.C.).<sup>40</sup> Richter identified the material of the torso as Island marble.<sup>41</sup> Our analysis shows that the kore is in fact made of Parian 2 marble, from the open pit quarries of Lakkoi. These are the quarries that provided by far the largest quantity of marble on the island.

The fragment from the central part of a pedimental relief originally featuring two lions devouring a bull (Figure 12),<sup>42</sup> which joins with a fragment in Athens,<sup>43</sup> is made of marble from the same quarries in Lakkoi. The relief originally decorated a small building in the area of the Olympieion in Athens, where the adjoining portion was found in 1862. It is datable to about 500 B.C., based on a comparison with a relief featuring an animal fight from Paros (Figure 13). It may be noted that the two reliefs may be attributable to the same workshop, as they show a very similar rendering of both animals, particularly their heads.

We can also now assign with certainty a provenance from the Lakkoi quarries at Paros to the marble of a statue of a crouching lion (Figure 14)<sup>44</sup> said to have been found in Trastevere, near Porta Portese, in Rome. The dating of the sculpture is rather controversial, with suggestions ranging from 480–460 B.C. to 400–390 B.C.,<sup>45</sup> and a Roman copy of a bronze original dating to 440 B.C.<sup>46</sup> The different dates derive from varying interpretations of the statues of a lion and a lioness found near the Nereid Monument in Xanthos,<sup>47</sup> which seem to offer the closest point of comparison in terms of style. The sculptures have been regarded as either Early Classical (and belonging to a predecessor of the Nereid Monument) or High Classical but deliberately archaizing in style. Either way, it seems that the statues should not be considered a particularly reliable point of reference toward a down-dating of the Metropolitan's lion. Instead, a sima lion's-head waterspout from Agrigento, which shows very similar features, lends support to a dating of the Museum's piece within the first half of the fifth century B.C. The origin of the marble of the Metropolitan's lion supports its attribution by Madeleine Mertens-Horn to a Parian workshop, based on its Early Classical dating and relationship to the Agrigento sima.<sup>48</sup>

A small homogeneous group of materials from Sardis, donated to the Museum in 1926, is also significant. The group includes a statue of a seated lion (Figure 15),<sup>49</sup> which is datable, along with the very similar lion in Istanbul,<sup>50</sup> to about 500 B.C., based on comparison with a lion statue from Knidos;<sup>51</sup> an inscribed stele with a Lydian inscription (Figure 16),<sup>52</sup> tentatively dated to the sixth century B.C.; the fragment of an abacus of an Ionic capital (Figure 17)<sup>53</sup>; and a



15. Statue of a seated lion, from Sardis, ca. 500 B.C. Marble, Sardis, H. 16¼ in. (41.3 cm), L. 41 in. (104.1 cm). The Metropolitan Museum of Art, Gift of The American Society for the Excavation of Sardis, 1926 (26.59.9)



16. Stele with a Lydian inscription, from Sardis, 6th century B.C. (?). Marble, Sardis, overall 64¼ x 24½ x 8 in. (163 x 62.2 x 20.3 cm). The Metropolitan Museum of Art, Gift of The American Society for the Excavation of Sardis, 1926 (26.59.7)

17. Fragment of the abacus of an an Ionic column capital, from the Temple of Artemis at Sardis, ca. 300 B.C. Marble, Sardis, L. 16 in. (40.6 cm). The Metropolitan Museum of Art, Gift of The American Society for the Excavation of Sardis, 1926 (26.199.283)



18. Portion of an Ionic column with base and capital, from the Temple of Artemis at Sardis, ca. 300 B.C. Marble, Sardis, H. 142⅞ in. (361 cm). The Metropolitan Museum of Art, Gift of The American Society for the Excavation of Sardis, 1926 (26.59.1). Photograph: Joseph Coscia Jr., The Photograph Studio, MMA





19. Relief with a fragment of Nike, late 5th century B.C. Marble, probably Parian, H. 18 $\frac{1}{8}$  in. (45.9 cm). The Metropolitan Museum of Art, Rogers Fund 1918 (18.145.61). Photograph: Rona Chang, The Photograph Studio, MMA

portion of an Ionic column with base and capital (Figure 18). The last two pieces belong to the local Temple of Artemis, dated to about 300 B.C. All of the objects were tested, and they are made of the same medium-grained marble from the quarry of the Mağara Deresi Gorge near Sardis, very likely one of the most important quarries used by the ancient town.<sup>54</sup> This finding is of interest particularly in reference to the seated-lion statue. Floren suggested that, based on its high quality, it might represent an import from East Ionia,<sup>55</sup> but this proposition is disproved by the new analysis.

Finally, the results of a petrographic analysis confirm Olga Palagia's identification of the material of a relief with a fragment of the goddess Nike (Figure 19) as Parian marble, which she based solely on its isotopic signature.<sup>56</sup> The new petrographic analysis included the comparison of a thin section of the relief with sections of marble from the two possible quarries of provenance, Mani, Laconia,<sup>57</sup> and Lakkoi, Paros;<sup>58</sup> the latter proved the more likely point of origin. The relief is without indication of provenance and is datable to the late fifth century B.C. Palagia attributed it to one of the metopes of the Temple of Apollo at Bassai,<sup>59</sup> the sculptures of which offer close stylistic comparisons for the rendering of the drapery.

The accurate macroscopic analysis of a number of other Greek sculptures of the Archaic and Classical periods prompted a series of further observations.



20. Detail of a statue of a kouros, from Attica, 600–590 B.C. Marble, Naxian, H. without plinth 76 $\frac{5}{8}$  in. (194.6 cm), H. of head 12 in. (30.5 cm), L. of face 9 in. (22.6 cm), shoulder width 21 in. (51.6 cm). The Metropolitan Museum of Art, Fletcher Fund, 1932 (32.11.1)



21. Detail showing the head of a kouros from the Sacred Gate of the Kerameikos, 600–590 B.C. Marble. H. 57 $\frac{1}{8}$  in. (145 cm). Kerameikos Museum (1700). Photograph: Album/Art Resource, NY

First, the statue of a kouros (Figure 20)<sup>60</sup> is said to be from Attica (Phoinikia?) and datable to 600–590 B.C. based on a comparison with the Dipylon head<sup>61</sup> and the kouros recently discovered near the Sacred Gate of the Kerameikos (Figure 21). Richter defined the material of the statue in Figure 20 as Island marble.<sup>62</sup> More precisely, it should be regarded as Naxian in origin and very likely of the coarse-grained variety quarried in the central area of the island in the valley of Phlerio near the village of Melanes. The marble is, in fact, coarser than that found in the northern quarries of Apollona, with an average grain size of well above 5 millimeters, sometimes reaching a maximum grain size about 1 centimeter, as observable in this statue.

The head of a youth (Figure 22), said to be from mainland Greece or the islands and datable to 480–470 B.C. based on a comparison with a head from Aegina, has been carved out of a first-quality, perfectly white, fine-grained marble that can be identified as Parian *lychnites*.<sup>63</sup> The piece was notoriously connected with Paros by Ernst Langlotz and Hilde Hiller<sup>64</sup> and, alternatively but less convincingly, with the northeastern Peloponnese (Claude Rolley).<sup>65</sup>

An archaic lamp (Figure 23),<sup>66</sup> which joins to a fragment in Boston,<sup>67</sup> is said to have been found near Thebes, although the Boston fragment is said to come from between Athens and Eleusis. The piece, dated to the second half of the sixth



22. Head of a youth, Cycladic, 480–470 B.C., Marble, Parian, H. 9¾ in. (24.8 cm), Diam. 5¼ in. (13.3 cm). The Metropolitan Museum of Art, Rogers Fund, 1919 (19.192.11)



23. Archaic lamp, reportedly from Thebes, second half of the 6th century B.C. Marble, Parian, H. 2½ in. (6.4 cm), Diam. 6½ in. (16.5 cm). The Metropolitan Museum of Art, Rogers Fund, 1906 (06.1072)

century B.C., is very likely of the fine-grained Parian *lychnites* from the quarries of Stephani,<sup>68</sup> or it may be from the quarry of Karavos on the same island.<sup>69</sup> This identification reinforces J. D. Beazley's attribution of the lamp to East Greece,<sup>70</sup> far from its presumed findspot. In fact, low relief is well attested on Paros, from early on, including a somewhat earlier Gorgon relief.<sup>71</sup>

The monumental, well-preserved grave stele of a youth and a young girl with a capital and a finial in the form of a sphinx (Figure 24)<sup>72</sup> joins with fragments in Berlin and Athens<sup>73</sup> and is said to have been found in Attica, possibly Anavysos. The monument is datable to about 530 B.C. based on the comparison between the girl's head in Berlin and the above-mentioned Peplos kore. The stele is made of a marble that has some grayish areas and a medium-grain size, very likely from Lakkoi, Paros. The same holds true for the sphinx on a cavetto capital in Figure 25.<sup>74</sup> The sculpture, said to have been found in Attica, is datable to about 580 B.C. based on a comparison with the first generation of Attic kouros. Also of marble from Lakkoi, Paros (Island marble, according to Richter),<sup>75</sup> is the cavetto capital (Figure 26)<sup>76</sup> with extensive traces of polychromy, said to have been found in Attica. This capital is datable to 550 B.C. based on the style of the reliefs on a comparable stele capital from Lamptraí.<sup>77</sup>

The lower part of a grave stele of a warrior (Figure 27)<sup>78</sup> is said to have been found in Attica. The sculpture is datable to about 520 B.C., between the dates of the more fragmentary stele shown in Figure 1 and of the warriors and chariots on one of the bases from the Themistoclean wall.<sup>79</sup> The warrior relief is identical to the fragmentary stele, which our analysis shows as being of Hymettian marble. In fact, both sculptures are made of a fine-grained marble characterized by a strong foliation evidenced by iso-parallel gray stripes. The evidence supports the idea that both stelae were produced from the same marble from the same quarry on Mount Hymettus and even in the same workshop, a connection advocated by Floren, who suggested that the two





24. Funerary stele of a youth and a young girl, from Attica, ca. 530 B.C. Marble, Parian, total H. 166<sup>3</sup>/<sub>4</sub> in. (423.4 cm). The Metropolitan Museum of Art, Frederick C. Hewitt Fund, 1911; Rogers Fund, 1921; and Anonymous Gift, 1951 (11.185a–c, f, g)



25. Sphinx on a cavetto capital, from Attica, 580 B.C. Marble, Parian, H. with akroterion 28<sup>3</sup>/<sub>8</sub> in. (72 cm). The Metropolitan Museum of Art, Fletcher Fund, 1924 (24.97.87)



26. Cavetto capital, from Attica, 550 B.C. Marble, Parian, H. 25 in. (63.3 cm). The Metropolitan Museum of Art, Rogers Fund, 1917 (17.230.6)

reliefs were carved in the workshop that was also responsible for the kouros said to be from Anavysos.<sup>80</sup>

The two fragmentary stelae (Figure 28)<sup>81</sup> and (Figure 31)<sup>82</sup> lack provenance. The former is datable to 520–510 B.C. based on a comparison with the stele fragment in Rome<sup>83</sup> and the stele of Artition;<sup>84</sup> the latter is generically dated 510–500 B.C. Both are of a slightly gray marble and are of Athenian origin, either Pentelic or Hymettian.

The upper part of a grave stele with palmette finial (Figure 30),<sup>85</sup> which lacks a provenance and is dated 530–520 B.C. based on a comparison with the similar stele of Antiphanes,<sup>86</sup> is made of a fine-grained marble, very likely Pentelic. The grave stele of Antigones (Figure 29)<sup>87</sup> is of the same marble, on a base likely of Hymettian marble. The piece, said to be from Attica and dated to 510–500 B.C. based on the type of palmette finial with single volutes, shows the typical Pentelic foliation marked by white mica levels.

Finally, the upper torso of a male statue (Figure 32),<sup>88</sup> which lacks provenance and is variously regarded as a Greek original of the Classical period or, more likely, a Roman copy, is made of a fine-grained marble of a color showing a homogeneous weak gray tonality and a waxy appearance. Both features are typical of Carrara marble. These characteristics, however, are also sometimes present in a type of Pentelic marble not commonly used in antiquity. An archaeometric study of the marble could solve this problem definitively and help determine whether the piece is Greek or a Roman copy.

## CONCLUSIONS

Archaeometric and macroscopic studies of the rich collection of Greek sculpture in the Metropolitan Museum produced important results with regard both to individual pieces and to Archaic Greek sculpture in general. We may note preliminarily that in Greek art and architecture there was not only a particular appreciation for white marble in comparison with other kinds of stones<sup>89</sup> but also a clear awareness of the various textural (grain size, hardness, response to surface polish) and aesthetic qualities (degree of whiteness and of sparkling in the light, translucency) associated with the different kinds of white marble, with regard to their workability and surface effect.<sup>90</sup>

A critical text is book 36 of Pliny the Elder's *Naturalis Historia*, which is dedicated to stones and expresses a clear preference for Parian *lychnites* and *lunense* (Carrara) marble for sculpture. This literary source is supported by the material record. There was a preference for certain kinds of imported marble in regions that were otherwise rich in this material, the local output apparently judged to be of lesser value by both sculptors and their patrons. A case in point is



27. Fragment of a funerary stele of a warrior, from Attica, ca. 520 B.C. Marble, Hymettian, overall 56 x 20<sup>1</sup>/<sub>8</sub> in. (142.1 x 51.1 cm). The Metropolitan Museum of Art, Fletcher Fund, 1938 (38.11.13)



28. Fragment of a funerary stele of a warrior, from Attica, 520–510 B.C. Marble, either Pentelic or Hymettian, overall 15¾ x 10 in. (40 x 25.2 cm). The Metropolitan Museum of Art, Gift of Norbert Schimmel Trust, 1989 (1989.281.83)



Attica, where despite the presence of good sources of indigenous marble—both Hymettian, which is fine-grained, but either pale gray or bluish-gray and often with dark streaks, and Pentelic, which is very fine-grained but subject to foliation and sometimes with brownish-greenish streaks—favor was generally accorded, particularly for statuary, to marble from Paros, at least until the end of the fifth century B.C. After that period, Parian marble was still used in Attica for heads of statues or for special commissions; a similar use of Parian marble is found elsewhere, which further attests to the ancient appreciation of the different kinds of white marble.<sup>91</sup>

Greek sculptors and workshops appear to have had a particular predilection for specific kinds of marble. It might be assumed that they would think first of the material in which they had been trained or with which they had more familiarity, as in the case of Aristion of Paros, who carved the statue of Phrasikleia out of marble from his own island.<sup>92</sup> However, the case of the Athenian sculptor Praxiteles—maker of several statues in Parian marble including the Knidia—shows that a sculptor's preference for a certain kind of marble was not limited to his training and experience. The choice may have been related to other factors, including a patron's appreciation of a particular material.<sup>93</sup>



29. Funerary stele of Antigenes, from Attica, 510–500 B.C. Marble, Pentelic, with Hymettian base, H. reconstructed 88½ x 25 x 20 in. (224.8 x 63.5 x 50.8 cm). The Metropolitan Museum of Art, Rogers Fund, 1915 (15.167)



30. Funerary stele with palmette finial, from Attica, 530–520 B.C. Marble, Pentelic, width of shaft 13½ in. (34.3 cm), thickness of shaft at bottom 4⅞ in. (11.1 cm). The Metropolitan Museum of Art, Rogers Fund, 1921 (21.88.179)



31. Fragment of a funerary stele, from Attica, 510–500 B.C. Marble, either Pentelic or Hymettian, overall 8⅞ x 9⅞ in. (21.3 x 24.5 cm). The Metropolitan Museum of Art, Rogers Fund, 1915 (15.167.1)



32. Fragment of a torso of a man, unknown provenance, Roman copy of ca. 450–400 B.C. of Greek original (?), Marble, Pentelic (?), overall 15½ x 22 x 10½ in. (39.4 x 55.9 x 26.7 cm). The Metropolitan Museum of Art, Rogers Fund, 1919 (19.192.38)

The identification of the source of a given white marble is important for a variety of reasons: assessing ancient trade in this material, understanding the evolving ideas of sculptors and patrons about the textural and aesthetic qualities of the different kinds of white marble, validating attributions of works to sculptors or workshops, and helping to detect the probable locations of particular workshops.<sup>94</sup> The last point is the case with the identification of the material of the kouros statue (see Figure 20) with marble from the quarries of Phlerio, near Melanes on Naxos. The finding is influential to understanding the origins of marble monumental sculpture in Attica, as it supports the idea of a Naxian origin of the earliest Attic kouros (as argued recently by Claude Rolley, Mary C. Sturgeon, and Anna Maria D’Onofrio),<sup>95</sup> while denying the alternative proposal for a Parian origin of the statues (as argued recently by Palagia).<sup>96</sup> This particular connection between Attica and Naxian marble in the late seventh and early sixth century B.C. offers insight into a flat tile of Naxian marble from the Acropolis marked “By” and likely connected with Byzes of Naxos. That individual is cited by Pausanias (*Description of Greece* 5.10.3) as the inventor of marble roof tiles, and some modern scholars attribute the roof of the Oikos of the Naxians on Delos (580–560 B.C.) to him.<sup>97</sup>

Analysis of the two grave stelae shown in Figures 1 and 27 confirms the provenance of their marble as Mount Hymettos. This marble was used for sculpture as early as the second quarter of the sixth century B.C., including the architectural sculptures attributed to the decoration of Temple H on the Acropolis (ca. 570–560 B.C.)<sup>98</sup> and the Moschophoros.<sup>99</sup> Its use is documented throughout the last decade of the sixth century B.C. by three statues of scribes carved in this material.<sup>100</sup> It is generally thought that Hymettian marble was mainly used for the cavetto capitals of funerary stelae, bases

of funerary monuments, and possibly statue bases during the sixth century B.C., but the Museum's pieces confirm that it could also be employed for fine reliefs. In fact, very few materials of this marble have, thus far, been subjected to archaeometric analysis and accurate macroscopic study. In light of the difficulty of distinguishing Hymettian from Pentelic marble, it is possible that the former was used more often than is generally assumed. The idea that Hymettian marble had limited use in carving depends on recognizing the predilection for Parian marble in Attica during the Archaic period. Yet the findings in this study show that there are exceptions. It is possible that for Attic Archaic funerary stelae which made significant use of polychromy,<sup>101</sup> Hymettian marble with its color and streaks would have had limited appeal for both sculptors and patrons.

Our analysis not only supports the authenticity of the kouros head in Figure 3 but also confirms that it was made of Pentelic marble. Indeed, it appears to be one of the earliest documented examples of carving in this material.<sup>102</sup> The use of this marble for sculpture in the Archaic period—formerly hypothetical, given the lack of corresponding archaeometric studies—is clearly documented by a series of unfinished sculptures in the quarries at Mount Pentelikon. The quarries are said to have opened in the second quarter of the sixth century B.C., with the kore with the pomegranate from the Acropolis, dated 560–550 B.C.,<sup>103</sup> representing one of the earliest examples. The gradual increase in the use of this material throughout the sixth century B.C., particularly for funerary stelae, is confirmed by the two fragments shown in Figures 4a and 4b (which, according to our analysis, belong to the same monument), the stele of Kalliades (Figure 5), and the relief from Megara (Figure 6). The horse head in Figure 2 provides a further example of the use of Pentelic marble for statuary. The closeness of the isotopic ratio of all the pieces analyzed clearly indicates a unique quarry area, exploited throughout the period, very likely the lower quarries of Mount Pentelikon.<sup>104</sup> The evidence further indicates that Pentelic marble, although already in use during the Archaic period, was still far from being exploited on such a large scale as it came to be between the Classical and Late Classical periods. Once again, the particular appreciation of Parian marble in Attica during the Middle and Late Archaic periods may be one of the factors explaining the more limited use of Pentelic marble.

Regarding Parian marble, a series of pieces attests to the importance of the quarries in Lakkoi (so-called Paros 2 type): these are the kore in Figure 11, the grave stele in Figure 24, the pedimental relief in Figure 12, and the lion statue in Figure 14. By comparison, only two pieces can be identified with *lychnites* (so-called Paros 1 type), namely the head in Figure 22 and the lamp in Figure 23. This ratio agrees with the general rarity of the latter versus the more

widespread use of the former.<sup>105</sup> In fact, the importance of marble from Lakkoi during the Archaic and Classical periods is now confirmed by an extensive archaeometric investigation of the marble sculptures from Magna Graecia, Sicily, and Cyrene.<sup>106</sup> From this point of view, the findings of archaeometric analysis give a more nuanced understanding of the appreciation of Parian marble, particularly during the Archaic and Classical periods. Based on book 36 of Pliny the Elder's *Naturalis Historia*, one would assume that Greek sculptors would have made nearly exclusive use of *lychnites*.<sup>107</sup> However, the present study documents that the employment of *lychnites* was not so widespread—understandably so, as it was quarried in an underground cave—while the use of the medium-grained variety from Lakkoi was particularly significant for export to colonies in the West and in North Africa. This is definitely not the case of a material of lesser quality shipped abroad to undiscerning patrons. Lakkoi marble could also be used for local commissions, as demonstrated by the kore in Figure 11, or for a clientele familiar with Parian marble, such as the Attic one, shown by the pedimental relief in Figure 12. In addition, Lakkoi marble was used for the Mozia Charioteer, one of the most superbly carved marble statues from Greek antiquity.<sup>108</sup> Thus the relevant pieces in the Metropolitan Museum are especially important for determining that the medium-grained variety of Parian marble was highly regarded by local sculptors and patrons and much in demand abroad.

After these general considerations about the use of Naxian, Parian, Hymettian, and Pentelic marble in the Archaic and Classical periods, we may conclude with two smaller notes. The possible provenance from Paros of the marble of the relief with Nike in Figure 19 supports the identification of the piece as forming part of the decoration of the Temple of Apollo at Bassai. In addition, the analysis demonstrates the extensive use of local marble, specifically from the quarries of the Mağara Deresi Gorge, for the lion statue in Figure 15, the stele in Figure 16, and the architectural elements of the Artemision in Figures 17 and 18, all from Sardis. The use of Sardis marble, a material seldom studied and discussed, appears to have been exclusively local, as it is rather coarse-grained and more suitable for architectural elements than for sculpture.<sup>109</sup>

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## NOTES

1. Winckelmann 2006, pp. 244–51.
2. Lepsius 1890.
3. *Archaeometry: The Bulletin of the Research Laboratory for Archaeology and the History of Art* 1, no. 1 (Spring 1958), cover.
4. See Herz 2006 for a general introduction to the studies and techniques for determining the provenance of marbles.
5. Lazzarini 2004.
6. Van der Merwe et al. 1995.
7. Ibid.
8. Lazzarini, Piccioli, and Turi 2002.
9. Kidd, Attanasio, and Tykot 2012.
10. Pensabene et al. 2012; Lapuente Mercacadal et al. 2012a; and Lapuente Mercacadal et al. 2012b.
11. Lazzarini, Moschini, and Stievano 1980; and Gorgoni et al. 2002.
12. Spry 1969.
13. McCrea 1950 and Craig 1957.
14. Gorgoni et al. 2002.
15. Barbin et al. 1992; Gorgoni et al. 2002; and Attanasio, Brillì, and Ogle 2006.
16. See Richter 1954, p. 10, no. 13, pl. 14a; Richter 1961, p. 24, no. 33, figs. 93, 95, and 175; Harrison 1965, pp. 41–42, no. 99, pl. 19; Dörig 1967, pp. 15–19, fig. 4; Frel 1973, figs. 1–3; Floren 1987, p. 285n22; Trianti 1991, pp. 237–40, pls. 77–78; Ridgway 1993, p. 261n6.41; and Brinkmann 2003, no. 306.
17. National Archaeological Museum, Athens (hereafter Athens NAM; 4.808) and Agora Museum, Athens (S 1751), respectively.
18. Athens NAM (3851).
19. Deonna 1908, pp. 195–96, fig. 4; Vermeule 1981, p. 28, no. 3, ill.; Floren 1987, p. 278n8; Mertens 1987, p. 33, no. 18, ill.; Walter-Karydi 1987, pp. 70, 72, figs. 100, 101; Ridgway 1993, p. 214n5.43; Eaverly 1995, p. 82n30; and Picón et al. 2007, p. 420, nos. 76, 79 ill.
20. Elena Walter-Karydi dates the piece 550–525 B.C. See Walter-Karydi 1987, p. 70.
21. For example, the column-krater in the Vatican, Museo Gregoriano Etrusco (126).
22. Deonna 1908, p. 195.
23. See Wegner 1932, p. 200, pl. 46.4; Richter 1954, pp. 2–3, no. 2, pl. 4a–c; Brommer 1963, pp. 439–50, figs. 1–3; Bothmer 1964, figs. 1–4; Brommer 1965; Richter 1970, p. 81, no. 64, figs. 217, 218; Floren 1987, p. 253n11; Spier 1990, p. 626; and Meyer and Brüggemann 2007, p. 217, no. 370.
24. The kouros from Volomandra is in the Athens NAM (1906) as is the kouros head probably from Aegina (48).
25. Richter 1954, p. 3, and Bothmer 1964, p. 615.
26. Wegner 1932, p. 200; Brommer 1963; Brommer 1965; and Floren 1987, p. 253n11.
27. Richter 1954, p. 3, and Bothmer 1964, p. 615.
28. For more on the finial see Richter 1954, p. 15, no. 18, pl. 21b; Richter 1961, p. 31, no. 43, fig. 125; Ridgway 1993, p. 234; and Picón et al. 2007, p. 421, nos. 80, 81 ill.
29. For more on the head of a youth see Richter 1954, pp. 14–15, no. 17, pl. 21a; Richter 1961, pp. 35–36, no. 52, fig. 132; Jeffery 1962, p. 148, no. 5; Tsirivaku-Neumann 1964, pp. 120–21, pl. 65; Stewart 1976; Floren 1987, p. 286n25; Mertens 1987, pp. 12–13, ill.; Trianti 1991, p. 239n20; Ridgway 1993, pp. 234, 238, fig. 105; Brinkmann 2003, no. 313; and Picón et al. 2007, p. 421, nos. 80, 81 ill.
30. Acropolis Museum, Athens (679).
31. See Richter 1961, pp. 31, 35, respectively.
32. Ibid., p. 31.
33. See Bothmer 1958, pp. 187–88, ill.; Karusos 1961, p. 99n76; Jeffery 1962, pp. 136–37, no. 43; Neumann 1979, p. 14n44; Woysch-Méautis 1982, fig. 361; Schmaltz 1983, p. 173; Floren 1987, p. 287n40; Krauskopf 1988, p. 306, no. 238b, pl. 178; Ridgway 1993, pp. 236–37; and Keesling 1999, p. 540n144.
34. See Richter 1954, p. 18, no. 22, pl. 22c; Blümel 1968, p. 16, fig. 6; Hiller 1975, p. 95n116; Floren 1987, p. 311n6; and Walter-Karydi 1987, pp. 124, 127, fig. 200.
35. See Hiller 1975, p. 95n116.
36. See Richter 1910, p. 41; Richter 1954, p. 82, no. 145, pls. 105c–d, 106; Vermeule 1968, p. 100; and Vermeule 1972, p. 50.
37. Ridgway 1997, pp. 144, 166, pl. 37.
38. See Richter 1954, pp. 114–15, no. 231, pl. 160a. Clemente Marconi thanks Kyriaki Karoglou, assistant curator, Department of Greek and Roman Art, for the opportunity to examine closely MMA 45.11.5.
39. See Richter 1926, pp. 127–28, fig. 2; Richter 1954, p. 43, no. 65, pl. 54d–f; Waywell 1971, p. 381, no. 12; and Delivorrias 2011, p. 73, fig. 4.
40. For the torso of a kore (Figure 11), see Richter 1954, pp. 4–5, no. 5, pl. 8; Richter 1968, p. 89, no. 151, figs. 483–86; Pedley 1976, p. 43, no. 32, pls. 20, 21; Floren 1987, p. 166n46, pl. 10.5; Ridgway 1993, p. 169n4.45; Karakasi 2003, pp. 89, 159, pls. 80, 81; and Picón et al. 2007, p. 420, nos. 74, 77 ill. As a comparison, see especially the kore, Archaeological Museum, Delos (A4063).
41. Richter 1954, p. 5.
42. See *ibid.*, pp. 5–6, no. 7, pl. 10a–c; Gabelmann 1965, pp. 96, 122, no. 150a; Bookidis 1967, pp. 54–55, no. P14; Richter 1970, pp. 82–83, 89, figs. 19, 33; Hölscher 1972, p. 73, no. G5; Floren 1987, p. 243n31, pl. 24.2; Mertens 1987, p. 32, no. 17, ill.; Walter-Karydi 1987, p. 159n349; Markoe 1989, p. 101n58, pl. 16; Ridgway 1993, p. 296; Rolley 1994–99, vol. 1, p. 193; Kaltsas 2002b, pp. 69–70, no. 98, ill.; and Picón et al. 2007, p. 423, nos. 91, 87 ill.
43. Athens NAM (1673).
44. See Marshall 1910, pp. 210, 212–13; Richter 1954, p. 46, no. 72, pls. 58, 59; Gabelmann 1965, pp. 76–77, 118, no. 95, pl. 19.1; Vermeule 1968, p. 99; Richter 1970, pp. 75, 77, fig. 6; Vermeule 1972, p. 53; Mertens-Horn 1986, pp. 6–18, pls. 5.2, 6; Kokkorou-Alewras 1993, pp. 92, 94n29, 96, 99–100, pl. 25.3; and Picón et al. 2007, p. 131, no. 144 ill.
45. See Mertens-Horn 1986, p. 18, and Picón et al. 2007, no. 144, respectively.
46. See Vermeule 1972, p. 53.
47. British Museum, London (929, 930).
48. See Mertens-Horn 1986, p. 18. The sima lion's-head waterspout is in the Museo Archeologico Regionale, Agrigento.
49. See Butler 1922, pp. 125–26, figs. 136, 137; Richter 1954, p. 5, no. 6, pl. 9; Vermeule 1968, p. 99; Hanfmann and Ramage 1978, no. 235, figs. 405, 406, 409; and Floren 1987, p. 410n12.
50. Istanbul Archaeological Museums (4028).
51. Pergamon Museum, Berlin (1724). See Blümel 1963, no. 32.
52. *MMAB*, n.s., 26, no. 5 (January 1968), p. [198], no. 6.
53. See Butler 1922, pp. 52–53, fig. 46a–b; Butler 1925, pp. 65–68, figs. 73–76, pls. B, C, Atlas pls. VIII–XI; Richter 1926, p. 7, figs. 1, 10, 11; Richter 1953, pp. 109–10; Richter 1970, pp. 91–92, fig. 36; Mertens 1987, pp. 74–75, no. 55, ill.; and Picón et al. 2007, pp. 181 ill., 446, no. 208.
54. See Ratté, Ramage, and Tykot 2011, pp. 127–32.

55. Floren 1987, p. 410n12.
56. See Pinney 1924, p. 240; Palagia 2002 and Jenkins 2006, p. 139.
57. See Bruno et al. 2002.
58. See Gorgoni et al. 2002.
59. Palagia 2002, p. 382.
60. See Richter 1954, pp. 1–2, no. 1, pls. 1–3; Richter 1970, pp. 41–42, no. 1, figs. 25–32, 60–62; Guralnick 1985; Floren 1987, p. 252n6; Mertens 1987, pp. 28–29, no. 14, ill.; Brinkmann 1998, pp. 70–71, no. D42, fig. 101; Ridgway 1993, pp. 34, 88, 100n3.20, fig. 28; Rolley 1994–99, vol. 1, pp. 165, 167, 280; Kyrieleis 1996, pp. 56–57; Niemeier 2002, pp. 40–53; Vorster 2002, pp. 120–25, 304, fig. 190a–e; Brinkmann 2003, no. 311; Boardman 2006, pp. 13, 15, figs. 8, 21, 24; Palagia 2006b, p. 247; Sturgeon 2006, pp. 36, 38–39; Meyer and Brüggemann 2007, p. 199, no. 299; Picón et al. 2007, p. 419, nos. 67, 70, 71 ill.; D’Onofrio 2008, *passim*; Kleemann 2008, pp. 35–37; Carter and Steinberg 2010, *passim*, fig. 2a; Neer 2010, pp. 24–25, figs. 6, 7; and Palagia 2010, pp. 44–45, fig. 15.
61. Athens NAM (3372).
62. Richter 1954, p. 2.
63. See Langlotz 1927, pp. 132, 134, pl. 80; Richter 1954, p. 3, no. 3, pl. 5; Richter 1961, pp. 141–42, no. 172, figs. 505, 506; Hiller 1975, pp. 84, 111, 112n22; Sheedy 1985, p. 621; Rolley 1994–99, vol. 1, p. 325, figs. 333, 326; and Picón et al. 2007, p. 425, no. 100, 95 ill. The head of a youth from Aegina is in Athens NAM (3459).
64. See Langlotz 1927, p. 132, and Hiller 1975, p. 84.
65. See Rolley 1994–99, vol. 1, p. 326.
66. See Beazley 1940, pp. 40–42, fig. 21, pl. 7; Richter 1954, p. 6, no. 8, pl. 11; Gabelmann 1965, pp. 59, 115, no. 57; Comstock and Vermeule 1976, p. 16, no. 24; Mertens 1979, p. 35n70; Vermeule 1981, p. 29, no. 4; Floren 1987, p. 317n52; and Picón et al. 2007, p. 416, nos. 42, 57 ill.
67. Museum of Fine Arts, Boston (01.8212).
68. On the quarries, see Lazzarini 2007b.
69. See Bruno et al. 2000.
70. See Beazley 1940.
71. Paros Archaeological Museum (172).
72. See Richter 1954, pp. 11–13, no. 15, pls. 15–18; Richter 1961, pp. 27–29, 159–65, no. 37, figs. 96–109, 204, ill. 27; Deyhle 1969, pp. 31–33, pl. 1.1; Karuzu 1976; Neumann 1979, pp. 8, 23, pl. 3a; Schmaltz 1983, *passim*, pl. 1.2; Floren 1987, p. 288n43, pl. 25.3; Mertens 1987, pp. 30–31, no. 16, ills.; Stewart 1990, p. 120, fig. 143; Ridgway 1990, pp. 589–90, figs. 3, 4; Ridgway 1993, pp. 100n3.20, 227, 235, 261–62, 262n6.44, fig. 98; Rolley 1994–99, vol. 1, p. 39, figs. 34, 234; Brinkmann 1998, pp. 28, 44n119; Andreiomenou 2000, pp. 102–6, pl. 5.1; Karanastassis 2002, pp. 211–12, 316, fig. 292a–b; Brinkmann 2003, nos. 304, 305; Sturgeon 2006, pp. 46, 61; Picón et al. 2007, p. 420, nos. 71, 74, 75, ills.; Scholl and Platz-Horster 2007, p. 144, no. 82; and Neer 2010, pp. 27–28, fig. 12.
73. Pergamon Museum, Berlin (Sk 1531); Athens NAM (4518, 4551), respectively.
74. See Richter 1954, p. 8, no. 10, pl. 12; Richter 1961, p. 10, no. 1, figs. 1–7, 191; Floren 1987, p. 283n4; Ridgway 1993, pp. 171n4.57, 232, 255n6.27, 261n6.41; and Sturgeon 2006, p. 62.
75. See Richter 1961, p. 10.
76. See Richter 1954, pp. 9–10, no. 12, pls. 13d–f, 14c; and Richter 1961, pp. 19–20, no. 21, figs. 72–76.
77. Athens NAM (229).
78. See Richter 1954, pp. 13–14, no. 16, pls. 19, 20; Richter 1961, pp. 32–33, no. 45, figs. 126–28, 179; Floren 1987, p. 286n28; Ridgway 1993, p. 237; Brinkmann 2003, no. 312; and Picón et al. 2007, p. 419, no. 68, 72 ill.
79. Athens NAM (3477).
80. Floren 1987, p. 286n28.
81. For more on Figure 28, see Thomas 1988; Milleker 1992, p. 44, ill.; and Ridgway 1993, pp. 260n6.40, 436n10.8, 441n10.26.
82. For more on Figure 31, see Richter 1954, pp. 17–18, no. 21, pl. 22e; Richter 1961, p. 49, no. 72, fig. 170, 49, ill.; Floren 1987, p. 289n47; and Brinkmann 2003, no. 308.
83. Museo di Scultura Antica Giovanni Barracco, Rome (MB 73).
84. Athens NAM (29).
85. See Richter 1954, pp. 15–16, no. 19, pl. 22b, d; Richter 1961, pp. 40–41, no. 55, fig. 141 and ill. p. 40; Jeffery 1962, p. 148, no. 6; and Brinkmann 2003, no. 309.
86. Athens NAM (86).
87. See Richter 1954, pp. 16–17, no. 20, pl. 22a; Richter 1961, pp. 44–45, no. 61, figs. 147, 188, 210; Floren 1987, p. 289n47; and Mertens 2010, p. 133, fig. 44.
88. See Richter 1954, p. 27, no. 32, pl. 30d, e.
89. See Neer 2010, pp. 73–77.
90. See in general Rolley 1994–99, vol. 1, pp. 58–59; and Lapatin 2014, p. 220.
91. See Palagia 2000.
92. Kaltsas 2002a.
93. Corso 2000.
94. Identification of the white marble of some kouroi from eastern Sicily could help specify the location of their originating workshop based in Syracuse; see Basile and Lazzarini 2012.
95. Rolley 1994–99, vol. 1, pp. 165–67; Sturgeon 2006, pp. 43–44; and D’Onofrio 2008.
96. Palagia 2010, pp. 45–46, 61–63.
97. See most recently Ohnesorg 1993, pp. 65–66, 141, no. 1, pls. 6, 37.2.
98. For example, Acropolis Museum (701).
99. Acropolis Museum (624). On the use of Hymettian marble in the Archaic period, see most recently Sturgeon 2006, pp. 44–46, and Palagia 2010, p. 44.
100. Acropolis Museum (144, 146, 629).
101. See Brinkmann 2003 and Brinkmann and Wünsche 2007.
102. On the use of Pentelic marble in the Archaic period, see most recently Sturgeon 2006, pp. 34, 46, 62; and Palagia 2010, p. 44.
103. Acropolis Museum (593)
104. Korres 1995, p. 98.
105. On the use of Parian marble in the Archaic period, see most recently Sturgeon 2006, pp. 34, 44, 48, 62; and Schilardi and Katsonopoulou 2000.
106. Magna Graecia: Lazzarini 2007a; Sicily: Gorgoni et al. 1993; Gorgoni and Pallante 2000; Basile and Lazzarini 2012; and Cyrene: Lazzarini and Luni 2010.
107. “Omnes autem candido tantum marmore usi sunt e Paro insula, quem lapidem coepere lychniten appellare.” Pliny the Elder, *Naturalis Historia* (36.14).
108. For more on the Mozia Charioteer, see Gorgoni et al. 1993, pp. 50–52; Gorgoni and Pallante 2000, p. 503; and Marconi 2014. Identification of the marble was confirmed by the more recent analyses of the statue by Jerry Podani at the J. Paul Getty Museum, Los Angeles.
109. See Monna and Pensabene 1977, pp. 177–80; and Ratté, Ramage, and Tykot 2011. A thorough study of the ancient quarries of Sardis and their marbles is in progress by Nicholas Cahill and Lorenzo Lazzarini.

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APPENDIX

TABLE. SUMMARY OF THE MINERO-PETROGRAPHIC AND ISOTOPIC ANALYSES OF SAMPLES  
(H, heteroblastic; Py, Pyrite; He, Hematite; +++, very abundant; ++, abundant; +, present; ±, trace)

Figure Number Object MMA acc. no.; Richter (1954) cat. no.	Sample Number	Fabric, Notes	Calcite Crystals Boundaries	Maximum Grain Size (mm)	Quartz
Figure 1 Stele of a youth MMA 12.158; Richter 13	11	H., mosaic, lineated	Curved	0.88	
Figure 2 Head of a horse MMA 1972.118.106	14	H., mosaic , lineated, slight intracrystalline decohesion	Embayed	0.73	
Figure 3 Head of a kouros MMA 21.88.16; Richter 2	6	H., slightly lineated and strained, slight intracrystalline decohesion	Embayed	0.88	
Figure 4a (top) Finial of a stele MMA 44.11.5; Richter 18	18	H., mosaic, polycrystalline quartz	Curved	0.72	+++
Figure 4b (bottom) Head of a youth MMA 42.11.36; Richter 17	17	H., mosaic, slightly lineated	Curved-to-embayed	0.82	+++
Figure 5 Stele of Kalliades MMA 55.11.4	16	H., mosaic, strongly lineated, slight intercrystalline decohesion, Albitic plagioclase ±	Curved-to-embayed	0.90	±
Figure 6 Fragment of a stele MMA 12.59; Richter 22	12	H., mosaic, lineated	Embayed	1.28	
Figure 8 Statue of a lion MMA 09.221.9; Richter 145	1	H., mosaic with fine-grained areas	Curved-to-embayed	0.72	±
Figure 9 Fragment of a relief with centaur and Lapith MMA 45.11.5	9	H., slightly lineated, quartz well rounded	Embayed	0.96	±
Figure 10 Copy of the Ince Athena MMA 24.97.15; Richter 65	2	H., mosaic, slightly lineated	Embayed	1.68	±
Figure 11 Statue of a kore MMA 07.306; Richter 5	10	H., mosaic, severe inter- and intracrystalline decohesion	Embayed	2.08	±
Figure 12 Relief of a lion devouring a bull MMA 42.11.35; Richter 7	15	H., mosaic, slightly strained, severe inter- and intracrystalline decohesion	Curved-to-embayed	1.60	
Figure 14 Statue of a crouching lion MMA 09.221.3; Richter 72	4	H., mosaic, inter- and intracrystalline decohesion	Embayed	2.80	
Figure 15 Statue of a seated lion MMA 26.59.9	5	H., lineated and slightly strained, inter- and intracrystalline decohesion	Embayed to sutured	2.16	
Figure 16 Stele with a Lydian inscription MMA 26.59.7	7	H., lineated and very strained, inter- and intracrystalline decohesion	Sutured	2.64	
Figure 17 Fragment of an Ionic column capital MMA 26.199.283	8	H., lineated and strained	Sutured	3.60	
Figure 18 Portion of an Ionic column with base and capital MMA 26.59.1	3	H., lineated and slightly strained	Sutured	2.42	
Figure 19 Relief with a Nike MMA 18.145.61	13	H., mosaic, intracrystalline decohesion	Embayed	2.24	±

K-mica	Titanite	Apatite	Carbonaceous Matter/ Graphite	Opaque Minerals/ Iron Ore	Dolomite (XRD)	$\delta$ $^{13}\text{C}$ (+)	$\delta$ $^{18}\text{O}$ (–)	Probable Provenance
+		±	+++	+ Py	±	1.9	0.8	Mount Hymettus (Attica, Greece)
			++	±	–	2.6	7.7	Mount Penteli (Attica, Greece)
			+		–	2.6	7.3	Mount Penteli (Attica, Greece)
			++	+ Py	– Quartz ±	2.8	6.9	Mount Penteli (Attica, Greece)
			++		–	2.9	6.9	Mount Penteli (Attica, Greece)
+++			+++	± Py	–	2.6	6.2	Mount Penteli (Attica, Greece)
++				± Py	–	2.5	8.2	Mount Penteli (Attica, Greece)
			++	±	+	2.8	6.5	Mount Penteli (Attica, Greece)
±			+		–	2.3	6.7	Mount Penteli (Attica, Greece)
		±	+		±	2.8	4.9	Mount Penteli (Attica, Greece)
			++		–	1.9	–0.9	Lakkoi (island of Paros, Greece)
			++		–	1.9	1.3	Lakkoi (island of Paros, Greece)
		±	+		–	2.3	1.1	Lakkoi (island of Paros, Greece)
				+ Py	–	4.5	8.2	Mağara Deresi quarry (Sardis, Sart, Turkey)
				+ Py	–	4.6	6.3	Mağara Deresi quarry (Sardis, Sart, Turkey)
			+++	++ Py	–	4.5	6.5	Mağara Deresi quarry (Sardis, Sart, Turkey)
++	±	+		++ Py, He	–	4.7	7.9	Mağara Deresi quarry (Sardis, Sart, Turkey)
			+		–	2.02	1.22	Probably Lakkoi (island of Paros, Greece)

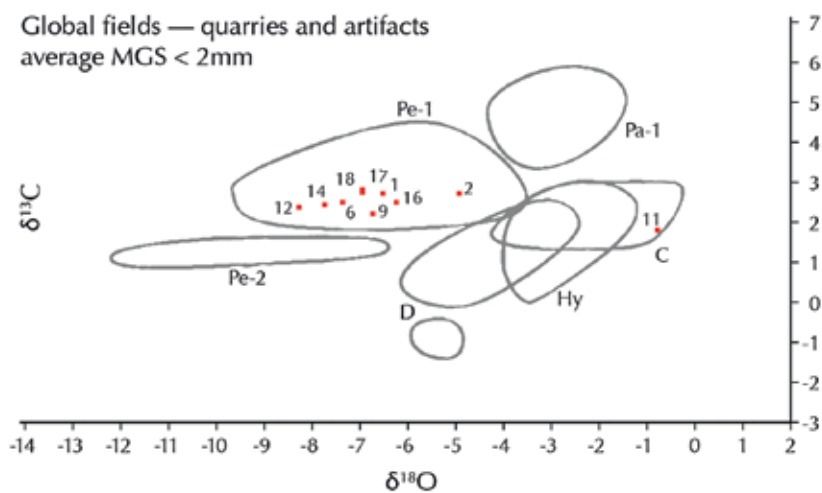


Diagram 1. Isotopic signatures of the marbles analyzed in this article: Hymettian, Paros 1, Pentelic.  
Diagrams 1–3: Lorenzo Lazzarini

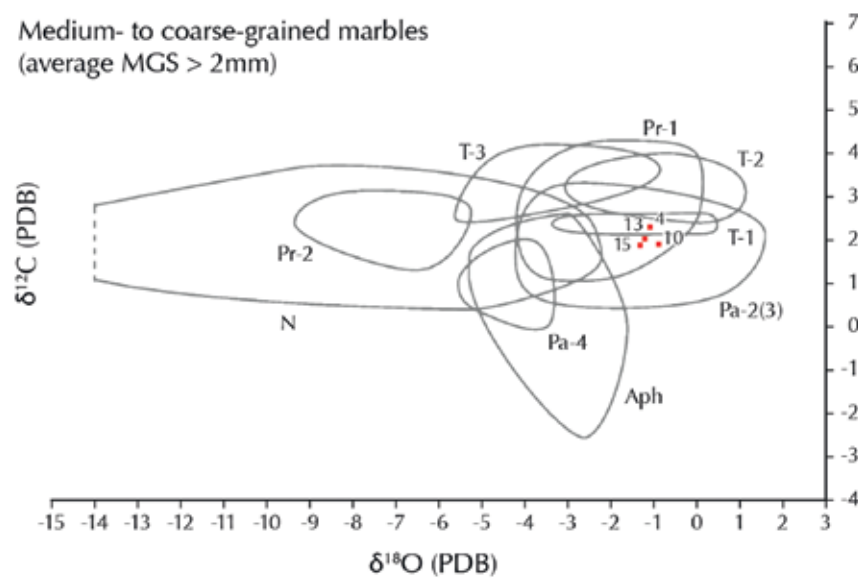


Diagram 2. Isotopic signatures of the marbles analyzed in this article: Paros 2

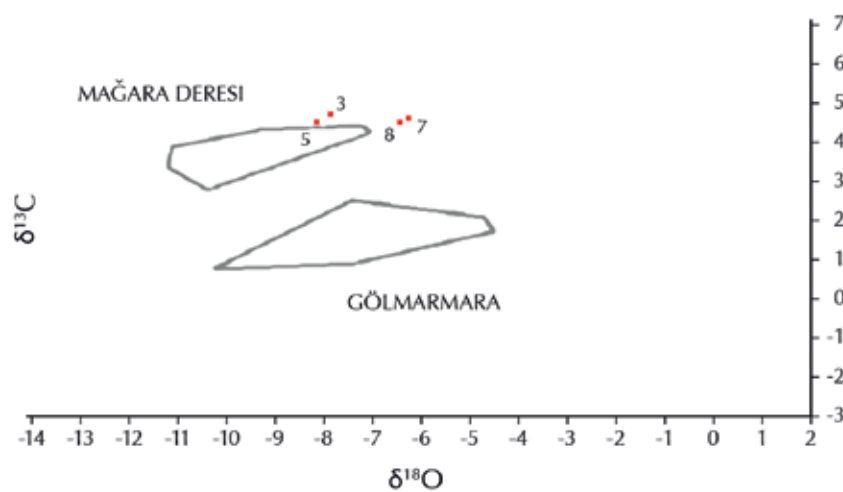


Diagram 3. Isotopic signatures of the marbles analyzed in this article: Sardis