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ISOTOPIC TESTING OF MARBLE FOR FIGURAL SCULPTURE AT GUELMA, ALGERIA

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Abstract

An inland region in northeastern Algerian has produced a rich harvest of white marble figural sculpture of the Roman Imperial period, most of which is preserved in the city of Guelma. Guelma lies a short distance from the quarries of Mt. Mahouana, and the Seybouse River gives it access to the the quarries of the Mediterranean, including those of coastal Algeria: Mt. Filfila and Cap de Garde. The great variability of marble from Mt. Filfila creates problems for identifying sources for sculptures in Algeria, but a combination of isotopic analysis, EPR, cathodoluminescence, and macroscopic observation makes it possible to identify sources with varying levels of confidence. In the Guelma collection, it is clear that the onyx marble/travertine of Mt. Mahouana was used for relief sculpture, and the marble of Filfila was used for sculptures of various levels of quality. The famous quarries of the Aegean area also provided a substantial part of the sculptures in this sampling.

Keywords

Mt. Filfila, Mt. Mahouana, Aegean quarries, isotopic analysis, statues, reliefs

Introduction

Guelma, ancient Calama, in northeastern Algeria, was an important city in antiquity and preserves the remains of a Roman bath building and a heavily restored theatre, which is used as museum for ancient sculpture (BLAS DE ROBLÈS, SINTES 2003, 211-216). Guelma lies on the Seybouse River and remains the center for a substantial region. Most of the Roman sculpture in its museum was actually found in the surrounding cities, which include Madaura (ancient Madauros), Announa (ancient Thibilis), and especially Khamissa (ancient Thubursicu Numidarum). The sources for sculptural marble in this area are especially intriguing since Algeria's quarries of white marble lie relatively nearby. The quarries of Cap

de Garde and Mt. Filfila are on the Mediterranean coast about 65 km to the north, and the quarries of Mt. Mahouana, lie a dozen km to the south of Guelma. These quarries may have been used as alternatives or supplements to the sources in Italy, Greece, and Turkey that usually provided the marble for ancient figural sculpture elsewhere in the Mediterranean.

The largest and most important of the quarries in modern times are those on Mt. Filfila, where pure white, patterned, and dark gray marble was produced until recently. The quarries on Cap de Garde are famous for their white and gray, striped and spotted marble, which includes a variant of *greco scritto* (ANTONELLI *et al.* 2009; ATTANASIO *et al.* 2012; Herrmann *et al.* 2012a). Usually Mt. Mahouana produces a vividly colored pink, brown, and white travertine or onyx marble, but some areas are predominantly white.

In 1983 the British Museum analyzed five samples from Mt. Filfila (WALKER, MATTHEWS 1990, 127, 130, 134, Fig. 3). All three northeastern Algerian quarries have recently been sampled and analyzed in connection with a study of marble use at Djemilia, Algeria (ANTONELLI *et al.* 2010, 599-594). We have also sampled these quarries independently, analyzing the stable isotopes of carbon and oxygen of the samples at the University of South Florida (USF) and their EPR (that is, paramagnetic resonance spectrometry) characteristics at the Istituto di Struttura della Materia, Rome. Our analyses significantly expand the isotopic fields for the quarries because of their greater number of samples, and they provide previously absent EPR data (Figs. 1-5).

Marble from these quarries has recently been identified in ancient sculpture and architectural decoration at Djemila (Antonelli *et al.* 2010) and in architectural decoration at other sites in Algeria, Tunisia, and Italy (HERRMANN *et al.* 2012a; HERRMANN *et al.* 2012b). The present provenance study is based on samples from twenty works of figural sculpture, all of which appear to date from the second or third century CE, in the Roman theatre and the Jardin Archéologique of Guelma. Some

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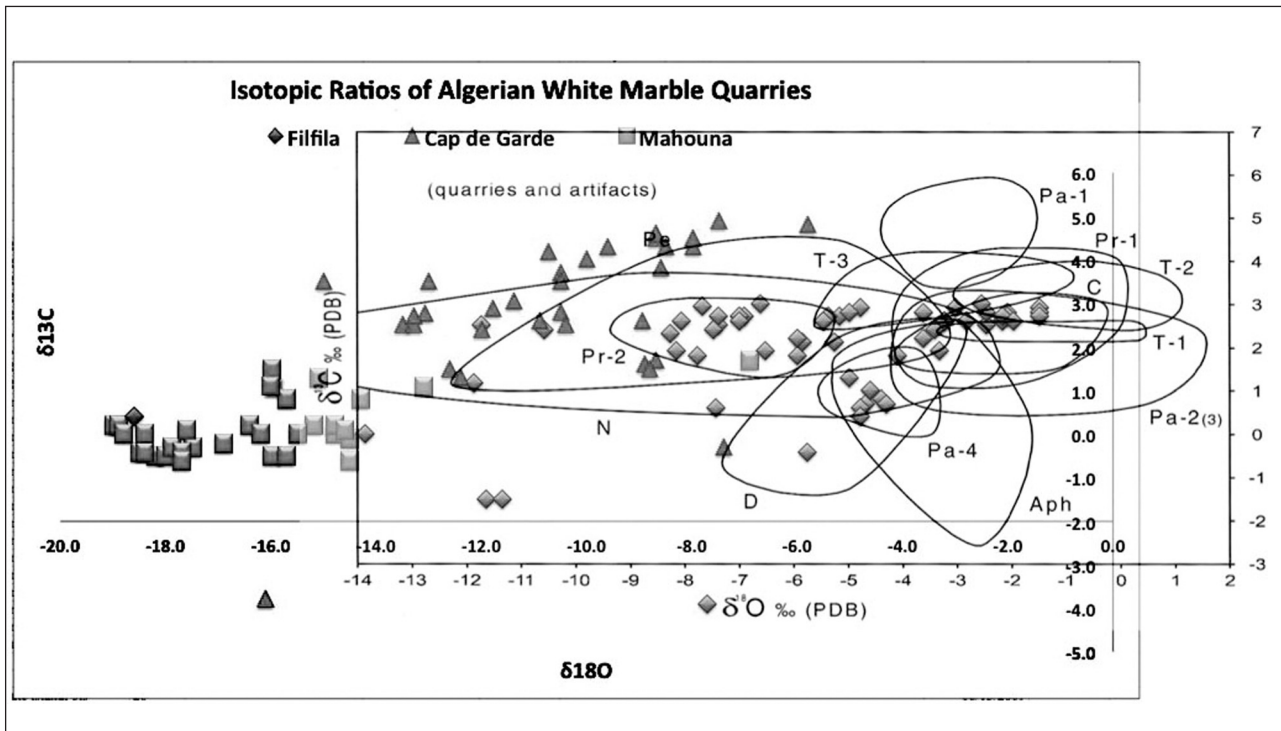


Fig. 1. Isotopic values of main Classical quarries (Gorgoni et al. 2002, fig. 5a) and Algerian quarries of white marble and travertine. Aph = Aphrodisias; C = Carrara; D = Dokimeion (Afyon); N = Naxos; Pa = Paros; Pe = Pentelikon; Pr = Prokonnesos; T = Thasos.

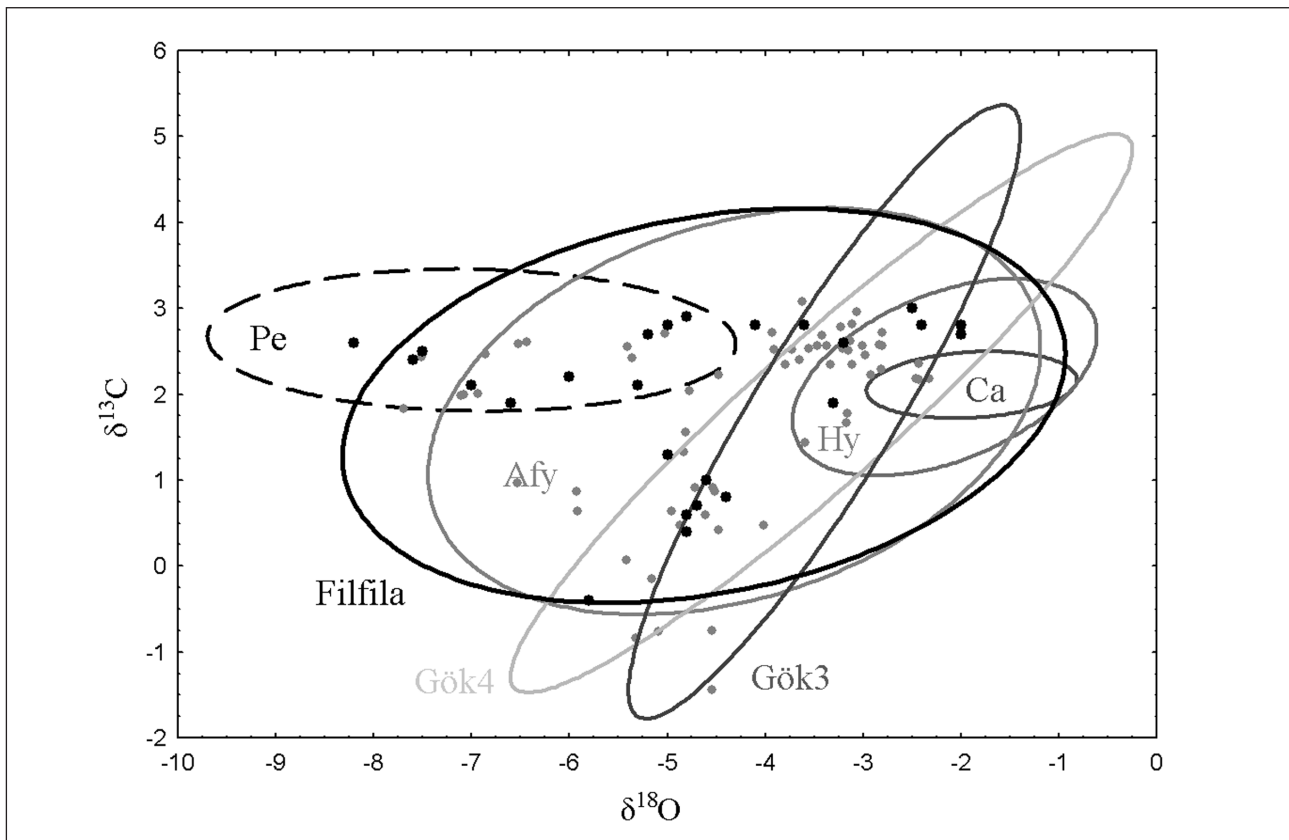


Fig. 2. Isotopic values of quarries of fine-grained marble. Afy = Afyon; Ca = Carrara; Gök = Göktepe; Hy = Hymettus; Pe = Pentelikon.

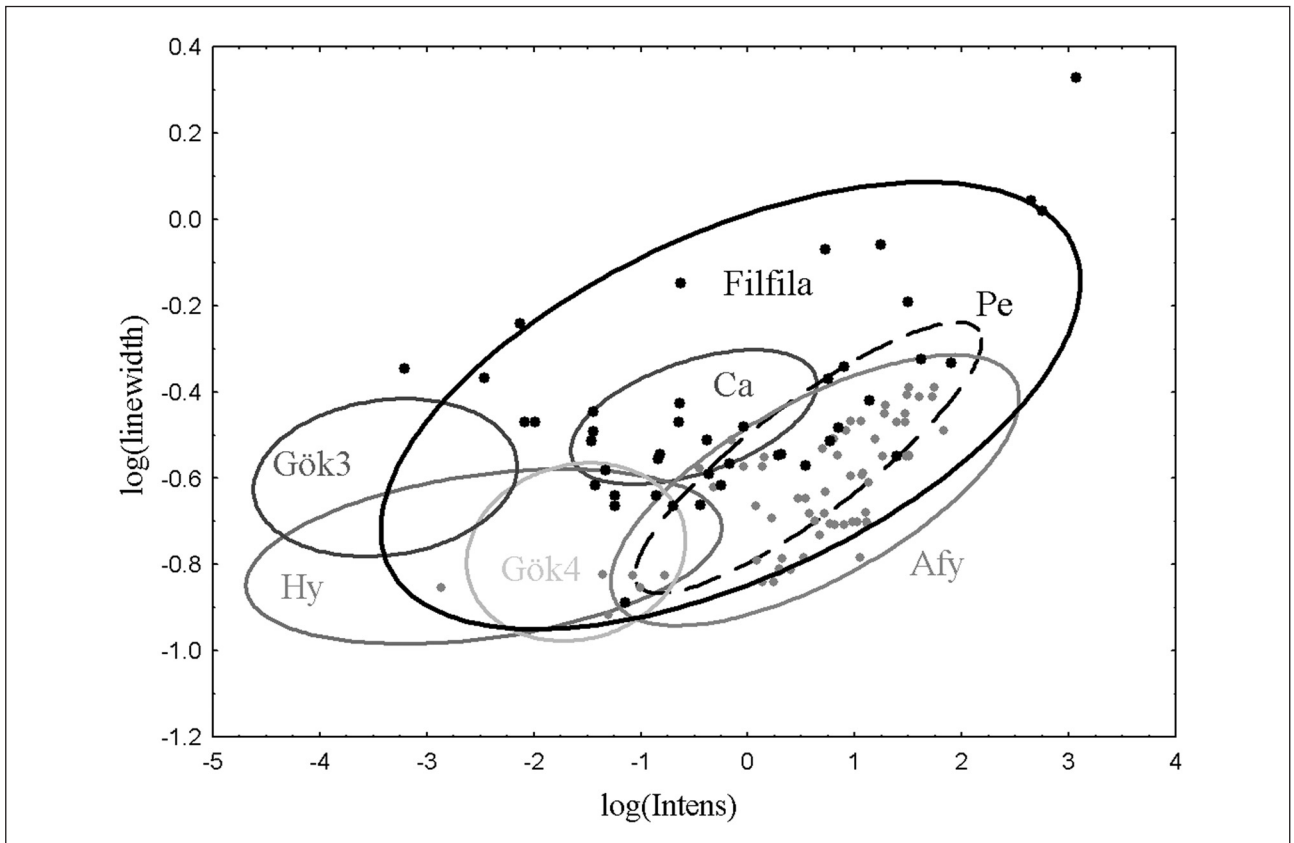


Fig. 3a. EPR diagram of main ancient quarries of fine-grain marble, which are partly or entirely overlapped by Filfila.

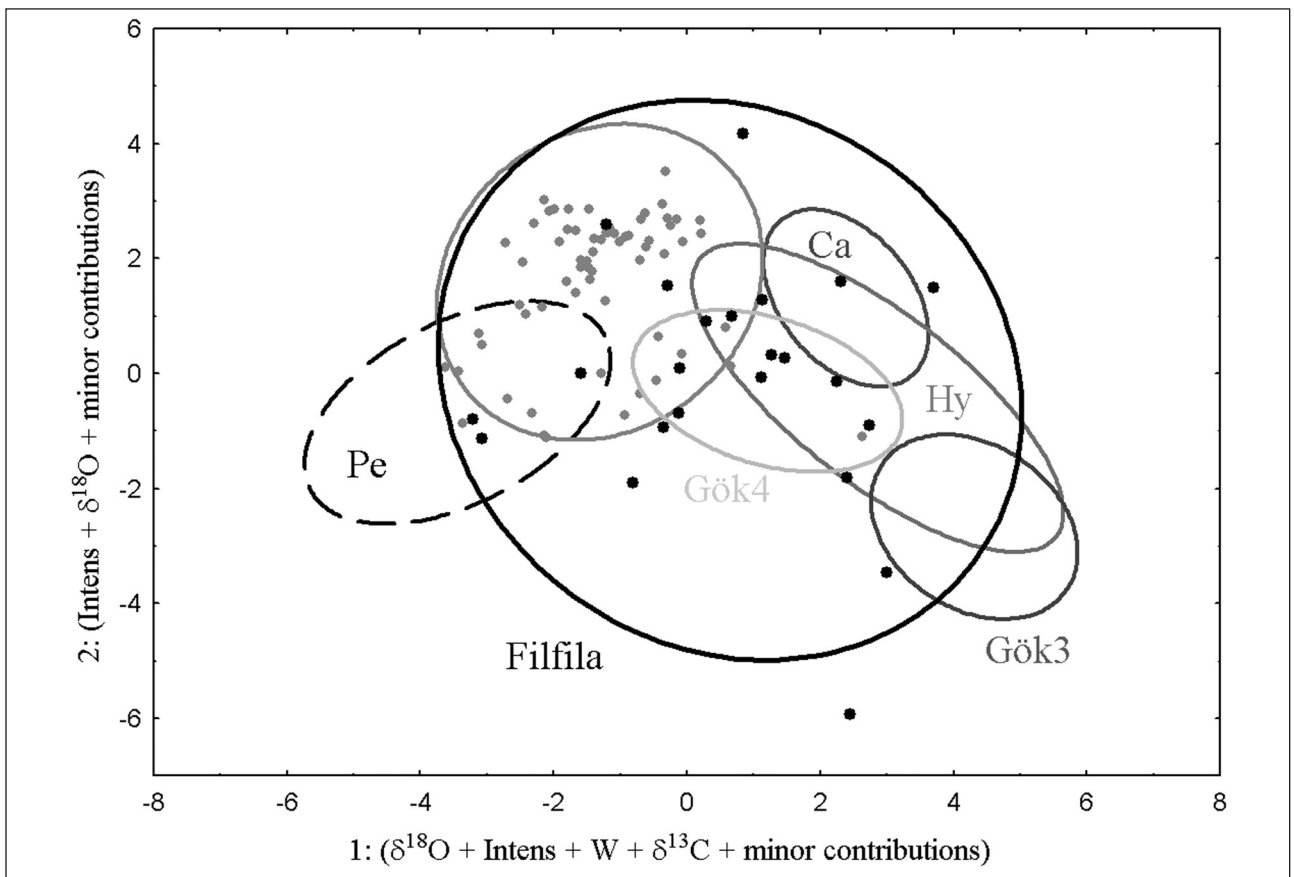


Fig. 3b. Combined isotopic and EPR values for main ancient quarries of fine-grain marble, which are partly or entirely overlapped by Filfila.

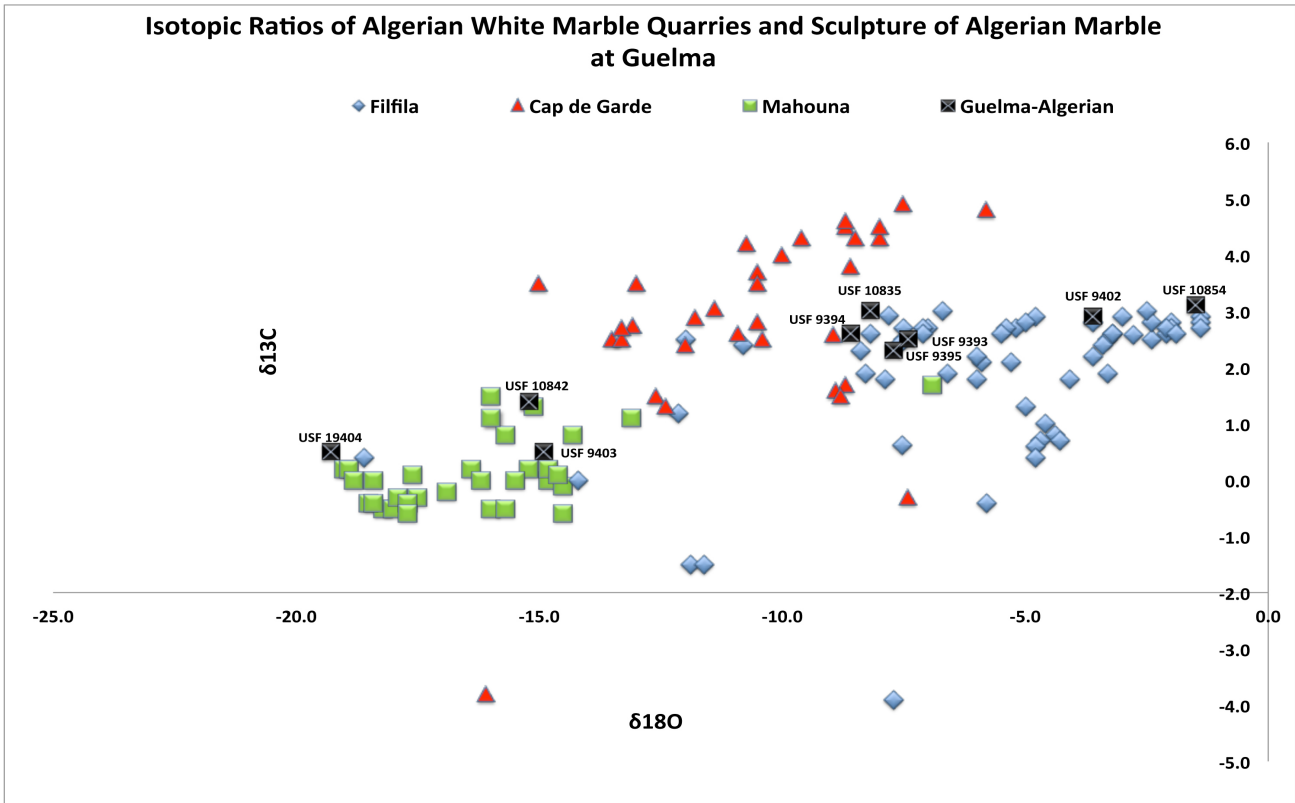


Fig. 4. Isotopic ratios of Algerian White Marble and Onyx Marble Quarries and sculptures of Algerian marble at Guelma.

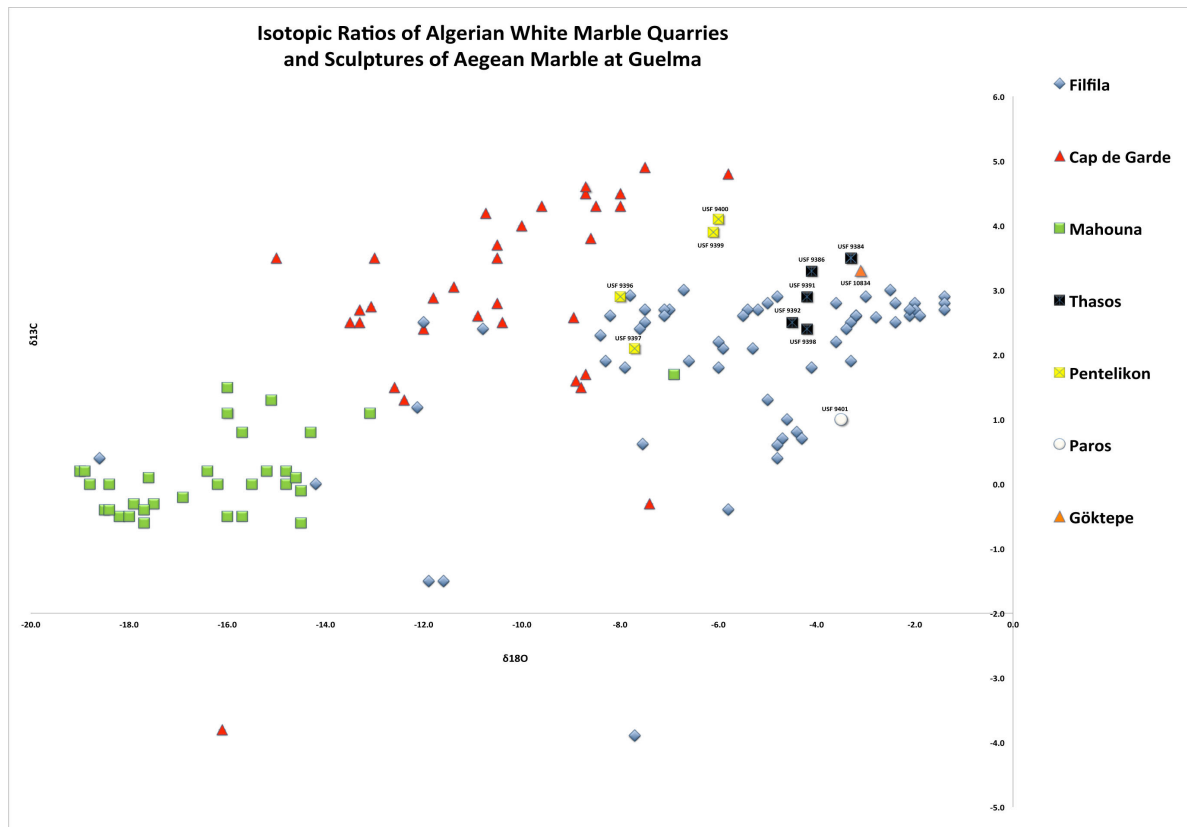


Fig 5. Isotopic ratios of Algerian White Marble Quarries and sculptures of Aegean marble at Guelma.

samples from these sculptures have also been analyzed with X-ray diffraction (XRD) and/or cathodoluminescence (CL) to determine whether they are calcitic or dolomitic.

Analytical techniques and Methodological strategies for provenance determination

The quarries of Cap de Garde and Mahouna have ratios of carbon and oxygen isotopes that tend to be very negative on the oxygen axis (Fig. 1). These ratios generally distinguish the two quarries from each other and from virtually all other ancient sources of white marble. Mt. Filfila, on the other hand, presents a severe problem for provenance studies; its isotopic field is huge and overlaps a large part of the internationally important ancient white marbles (Figs. 1-2).

EPR analysis of manganese impurities has again revealed great variation, and the EPR values again overlap those of most of the international marbles (Fig. 3a-b). EPR also shows that Filfila marble is usually calcitic, but 7% of the samples proved to be pure dolomite. Filfila marble varies greatly in its markings and color (ranging from dark gray to white, with much mottling and spotting). It has been considered fine grained (ANTONELLI *et al.* 2010, 599-594), but in our sampling its grain size varies from fine to coarse (Table II).

In spite of Filfila's variability, it is possible to some degree to separate it from "international" marbles. While Filfila's $\delta^{18}\text{O}$ isotopes spread widely, its ratios of $\delta^{13}\text{C}$ mainly fall into a band between +2.0 and +3.0. Many also fall below this band, but only one of the 62 quarry samples rose slightly above it (the total includes our 45 samples, the 12 previously taken by Antonelli *et al.* 2010, Table I, Fig. 12a, and the 5 tests reported by WALKER and MATTHEWS 1990, 127). Sculptures with values for $\delta^{13}\text{C}$ above +3.0 are therefore very likely to be imported marbles. Macroscopic characteristics – maximum grain size (MGS), markings, and color (whiteness) – can also provide a basis to separate Filfila from international marbles. Grain size has been measured in the laboratory when solid samples were taken and estimated in the field in the case of powder samples. These measurements and estimates can be compared with the data for international quarries provided in ATTANASIO 2003, Fig. 5. The presence or absence of dolomite can be a useful discriminating factor. Markings, which can only be assessed macroscopically, can be very revealing; cloudy grayish mottling, as will be seen, seems particularly characteristic of Filfila. Many sculptures in Guelma, however, are displayed out-of-doors, and the effects of air pollution and sandstorms must be taken into consideration.

Results: Table I, Figs. 2, 3

Two of the twenty sculptures analyzed had highly negative isotopic ratios for ^{18}O that could only be Al-

gerian. One of them was an ambitious altar decorated on all sides with figures in relief and dated by inscription to the year 164. The altar was made of two blocks of conspicuously layered travertine or marble, which could only come from Mahouna, USF9403-4 (Fig. 4).

The material, however, is porous, and the workmanship correspondingly lacks refined finishing.

The other sculpture with highly negative isotopic values was a headless statue of a draped woman, USF10842 (Fig. 4), a variant of the "Large Herculeanum Woman" type. Replicas are also preserved in Olympia, Patras, Cyrene, and Rome (CALZA *et al.* 1977, cat. 362, 368). Isotopically the marble of the Guelma statue could be from Mahouna, but it is not layered travertine. A few "outliers" from the Filfila quarry are just as negative isotopically, and it is highly probable that Filfila is the source of the marble. This sophisticated and well-carved production makes it clear that Algerian marble was not restricted to relief sculpture or lower levels of quality.

Six statues or parts of statues are made of coarse-grained, pure white marble, which macroscopically resembles the dolomitic marble of Thasos, USF 8701/9384, 9386, 9387, 9391, 9392, 9398. All have been proven to be dolomite with CL and/or XRD, confirming their Thasian origin (fig. 5). As mentioned above, 7% of the quarry samples from Mt. Filfila were dolomite, but they were either fine-grained or gray; none had the brilliant, uniform white color and glittering flakes of Thasian dolomite. All the Thasian-looking sculptures in Guelma have isotopic ratios compatible with dolomitic Thasian marble, and three have values for $\delta^{18}\text{O}$ higher than anything found at Mt. Filfila: that is, above +3.0 (Fig. 5). It is also significant that these Thasian-looking marbles form a compact group and don't display the isotopic scattering of Filfila quarry samples. One of the dolomitic pieces, a magnificent bust of Jupiter, USF9398, has a carbon value that is somewhat low for the Gorgoni field for Thasos, Cape Vathy (Gorgoni *et al.* 2002) (Fig. 1), but several other dolomitic, Thasian-looking sculptures have similar, "low carbon" isotopic ratios (HERRMANN, NEWMAN 1995, 74, Table II).

A Thasian marble man wearing a toga, USF9391, is equipped with a Thasian head, USF9392, which seems to have been correctly replaced on the body. Not only are both parts dolomitic, but also their isotopic ratios are similar. The head is that of an Isiac priest with shaved head, of a type that appears elsewhere, and in the case of an example in Athens, in Thasian marble (optical identification; THOMPSON 1948, 178, pl. 56 "Parian [?] Marble")

A high-quality armored torso in dolomitic Thasian marble, USF9387, is closely related typologically and stylistically to two statues of Trajan, one from Utica, Tunisia (in Leiden) and the other from Castel Gandolfo near Rome (Ny Carlsberg Glyptotek, Copenhagen, IN15840) (STEMMER 1978, 65). The Utica statue has also been proven to be dolomitic marble (HERRMANN

ISOTOPIC TESTING OF MARBLE FOR FIGURAL SCULPTURE AT GUELMA, ALGERIA

Tab. 1. Sculpture in the Guelma Musée Archéologique and Jardin Archéologique; Stable C and O isotopic analysis at the Department of Anthropology, University of South Florida (USF). CL at Université Pierre et Marie Curie, Paris.

USF #	$\delta^{13}C$	$\delta^{18}O$	Grain size, optical features	Guelma museum #	Description, provenance	Dolomite?	Prefered quarry & justification
8701	-1.1	-11.6		Jardin Arch. Sta JAG 001	Goddess with chlamys	Dolomite CL/XRD	Th: isotopes; see retest USF9384, XRD
9384	3.5	-3.3	Coarse; pure white	Jardin Arch. Sta JAG 001	Goddess with chlamys	Dolomite CL/XRD	Th: isotopes, XRD, optical
9386	3.3	-4.1	Coarse; pure white	Sta.guel. 027	Proserpina/ Orans	Dolomite XRD	Th: isotopes, optical, XRD
9387	3.5	-3.3	Coarse; pure white	M 397 Sta.guel. 013	Cuirassed torso; from Madaura ¹	Dolomite CL/XRD	Th: isotopes, XRD, optical
9391	2.9	-4.2	Coarse; white	Kh 242	Togatus; from Khamissa ²	Dolomite CL/XRD	Th: isotopes, XRD, optical
9392	2.5	-4.5	Coarse; white	Kh 243	Portrait head of Kh242; from Khamissa ³	Dolomite XRD	Th: isotopes, optical, XRD
9393	2.5	-7.4	Fine; broad faint grayish zones	Kh 244	Togatus; from Madaura ⁴		F or Pe: isotopes; optical characteristics
9394	-2.6	-8.6	Fine; grayish zones; thick intrusive vein	Kh 245	Head of Kh 244; from Madaura ⁵		F: isotopes; intrusive veins unknown in Pe
9395	2.3	-7.7	Fine; faint shadows?	Sta.guel. 002	Aesculapius; from Khamissa ⁶		F: isotopes, optical (no foliation)
9396 a&b	2.9	-8.0	Fine; mica, grayish, foliation	Sta.guel. 003	Neptune; from Khamissa ⁷		Pe: isotopes, optical character
9397	2.1	-7.7	Fine; mica, foliation	Sta.guel. 004	Aesculapius; from Khamissa		Pe: isotopes. Optical characteristics
9398 a & b	2.4	-4.2	Coarse: pure white	Sta.guel. 010	Jupiter head & torso; from Khamissa ⁸	Dolomite CL/XRD	Th: XRD, optical, isotopes
9399	3.9	-6.1	Fine; foliation	Sta.guel. 012	Cuirassed torso; from Madaura		Pe: isotopes, optical
9400	4.1	-6.0	Fine; foliation	Sta.guel. 012	Cuirassed torso: from Madaura ⁹		Pe: isotopes, optical
9401	1.8	-3.5	Coarse; glassy, grayish, translucent	Sta.guel. 014	Statuette of Neptune; from Khamissa ¹⁰		Pa: isotopes, optical
9402	2.9	-3.6	Fine; gray with white veins	Sta.guel. 28	Ceres/ Pudicitia from Announa ¹¹		F: isotopes, optical (color, markings)
9403	0.5	-14.9	Banded travertine	Th.462	Altar of Anstittii front; from Announa ¹²		M: isotopes, markings
9404	0.5	-19.3	Fine; white, scribbly veins	Th.462	Altar of Anstittii back; from Announa ¹³		M: isotopes
10834	3.3	-3.1	MGS 0.8mm	Theatre	Colossal torso, braid on shoulder, Bacchus		F or Afy: isotopes, grain, optical
10835	3.0	-8.2	MGS 0.4mm; gray zones	Garden behind Theatre	Aesculapius, H 102 cm. ¹⁴		F: isotopes, optical
10842	1.4	-15.2	MGS 0.8mm; clear white marble	Jardin Arch.	Herculaneum Woman variant H 102 cm. ¹⁴		F: isotopes, optical
10854	3.1	-1.5	MGS 6mm; long gray patch, translucent	Theatre	Tall togatus ¹⁵ beside huge Neptune ¹⁶		Proc 1, Thasos 2, F most probable

Abbreviations: Afy = Afyon; Eph = Ephesus; F = Filfila; G = Göktepe; H = Hasancavuslar (Ephesus); M = Mahouna; Pa = Paros, Marathi; Pe = Pentelikon; Proc = Proconnesus; Th = Thasos 3, Cape Vathy (dolomitic)

1. Stemmer 1978, 64-65, V 16, pl. 40, 5-6.
2. Goette 1989, 143, n. 3.
3. Pachtère 1909, 37, pl. 7.4.
4. Pachtère 1909, 37, pl. 7.6; Goette 1989, 141, n. 15, pl. 31.6.
5. Goette 1989, 143, n. 4, pl. 35.5.
6. Blas de Roblès and Sintès 2003, 50, 212-214.
7. Blas de Roblès and Sintès 2003, 213, 215.
8. Pachtère 1909, 26-7, pl. 4.4; Martin 1987, 135-136, fig. 31.
9. Hanfmann et al. 1987, 236, pl. 74; Vermeule 1959, 59, fig. 54.
10. Dorbane M., in *L'Algérie en héritage* 2003, 193, cat. 103; Baratte F., in Sintès, Rebà 2003, 169, cat. 80; "Marbre (des Cyclades?)".
11. Pachtère 1909, 50-1, pl. 10.3.
12. Pachtère 1909, 52-3, pl. 9.6.
13. Pachtère 1909, 52-3, pl. 9.4; Blas de Roblès and Sintès 2003.
14. Pachtère 1909, 31, pl. 5.6.
15. Pachtère 1909, 38, pl. 3.7.
16. Probably K 250: Goette 1989, 141, n. 16..



Fig. 6. Foddess wearing a military cloak over a tunic, USF9701/9384, Guelma, Jardin Archéologique. Dolomitic marble from Thasos. Jardin Archéologique.



Fig. 7. Proserpina/Orans, USF9386, Guelma Museum. Dolomitic marble from Thasos.

1992, 96; HERRMANN *et al.* 2002, 359, fig. 3), and the Castel Gandolfo statue looks Thasian (optical examination 1993). The head of the latter (JOHANSEN 1995, cat. 34), however, is more refined than that of the Utica statue (BASTET 1979, cat. no. 48). The statues are by three artists who followed the same fashions in marble and armor types and who evidently belonged to the same “school,” understood in a broad sense.

Two dolomite female torsos are good quality works of unusual types. A goddess wears a male military cloak, a chlamys or paludamentum, USF8701/9384 (Fig. 6). A Kore/Proserpina/Orans, USF9386, belongs to a well-known category, but most examples with well-wrapped right elbow normally have a veiled head (Filges 1997). This example was unveiled (Fig. 7). Two similar statues in Leiden came from Utica (BASTET 1979, cat. no. 49-50) but clearly are not Thasian marble.

Two sculptures of fine-grained marble had values for $\delta^{18}\text{O}$ above the upper limit of +3.0 for Filfila; both are likely to be imported material. One was a cuirassed torso, which fell into an isotopic field for which Mt. Pentelikon was the only plausible solution, USF9399 (Table I). The assignment to Pentelikon is confirmed by the macroscopic characteristics of the marble. The stone has fine grain, some grayish shadows, and long, parallel

streaks or “foliation”, all features typical of Pentelic marble.

The other relatively high-carbon sculpture of fine-grained marble was a beautiful and unusual torso of a nude Bacchus, USF 10834 (Fig. 8), which can be reconstructed on the basis of a statue in Naples and the Vatican (REINACH 1920, 250, pl 487 pl. 681, n. 1585). Isotopically the marble corresponds to the very fine-grained marble of Göktepe, District 3, quarry D (ATTANASIO *et al.* 2009, 348, Table C), but the EPR intensity is incompatible with Göktepe (Table II). The marble of the torso could be from Filfila, but EPR, isotopes, and grain size fit slightly better with Afyon, Turkey (ancient Dokimeion) (ATTANASIO *et al.* 2012B, table 1) (Table II).

Several statues had isotopic ratios that were possible for both Pentelikon (PIKE 1989, 2009) and Filfila. Macroscopic characteristics (foliation, micaceous glitter) can in some cases justify a preference for the one or the other. Isotopically a colossal statue of Aesculapius, USF9395, fits well into either Filfila or Pentelikon, but the absence of foliation favors the Algerian assignment (fig. 4). It thereby becomes another fine piece of virtually pure white, unflawed Filfila marble, like the female statue in the Jardin Archéologique, USF10842. In two other colossal statues, however, foliation makes it likely



Fig. 8. Torso of Bacchus, USF10834, Guelma Museum. Marble from Afyon, Turkey or Mt. Filfila.



Fig. 9. Neptune, USF9396, Guelma Museum. Foliation confirms that the marble comes from Mt. Pentelikon.

Tab. II: Archeometric comparison of Guelma Bacchus torso USF 10834, the Afyon quarries and, Göktepe quarry district 3. Median values and range (in parentheses)

Location and samples	EPR intensity %	$\delta^{13}\text{C}$	$\delta^{18}\text{O}$	MGS
Guelma Museum, USF 10834	272	3.3	- 3.1	0.8 mm
Afyon (Attanasio et al. 2012B)	242.5 (6/626)	1.80 (-1.4/3.1)	-4.32 (-4.3)	0.86
Göktepe, district 3, quarry Q3D GW07.2B7-9	3.9 (1/13)	3.10/3.42	-2.93 (-3.0)	0.35-0.55
Mt. Filfila (Tykot et al., in press)	237 (4/2148)	1.8±1.4 (-3.9/3.0)	-5.9±3.4 (-18.6/-1.4)	2.1±2.4 (0.3-14.0)

that the marble is from Pentelikon rather than Filfila: the Neptune from Khamissa, USF9396 (Fig. 9) and an Aesculapius also from Khamissa, USF9397 (Fig. 10). A portrait head, USF9394, which is mounted on an alien body of a toga-wearing man, USF9393, fits perfectly into the Pentelic isotopic field and is less centrally placed in Filfila. It has, however, a conspicuous vein of coarse, white stone passing through the back of the cranium (Fig. 11). The feature seems to be unknown in the Pentelic quarries (personal communication, Yannis Maniatis). Somewhat comparable features can be seen in the Filfila quarries, and this is the more probable source.

Several statues in Guelma have isotopic values and

markings so similar to what is seen in the Filfila quarries that there can be little doubt that this is the source of their marble: a Ceres/Pudicitia, USF9402, (Fig. 12) and an Aesculapius, USF10835 (Fig. 13). Their marble has cloudy gray tones, which at times are marked by white streaks. The workmanship expended on this rather dingy material tends to be quite lackluster.

A togatus with coarse grain, USF10854, could isotopically be either Filfila or Proconnesian marble (fig. 14). The gray area in the marble has a soft definition that seems more like Filfila. This and all the other togati in this study display a virtually identical compositional formula, which also gives them a local flavor.

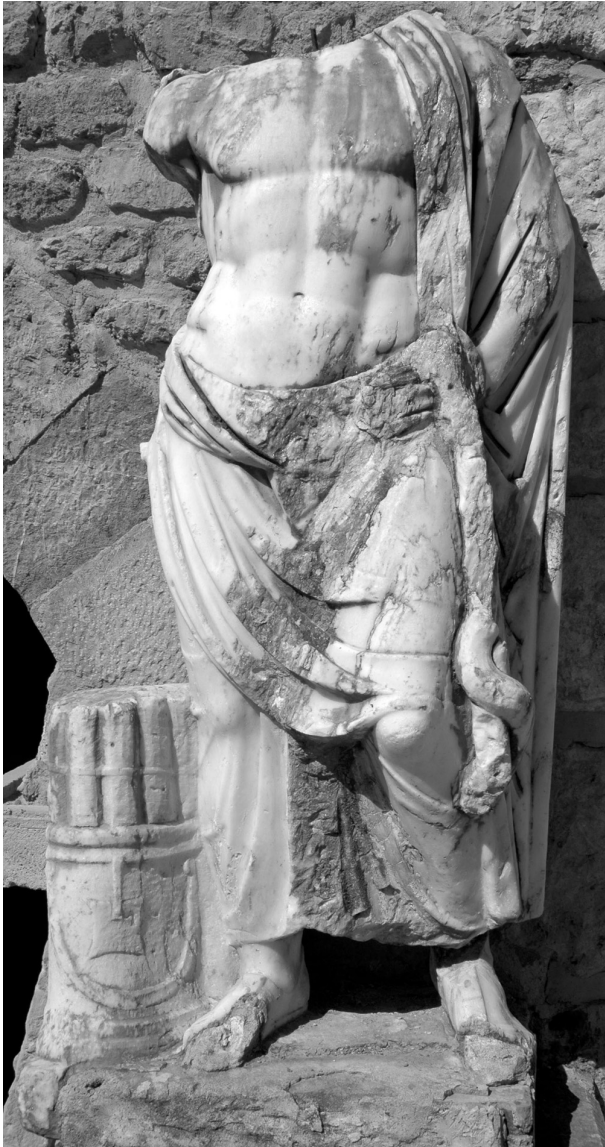


Fig. 10. Aesculapius, USF 9397, Guelma Museum. Conspicuous foliation on shoulder and overfold of mantle confirms that the marble comes from Mt. Pentelikon.

A beautiful statuette of Neptune, USF9401, has isotopic ratios compatible with both Filfila and Paros, but its optical characteristics particularly favor the latter. Previous observers have also identified it as “Cycladic marble”.

Although this sampling is relatively limited, it is tempting to offer some generalizations about the roles or lack thereof for different sources of marble identified at Guelma. Mahouna marble was used for relief sculpture, while Aegean marble appears only in three-dimensional sculpture (that is, statuary and busts). To some degree there is a hierarchy of quality: Aegean marble appears to have been used for good- to medium-quality statues, Filfila marble for medium- to poor-quality. In the case of the artistically unconvincing sculptures, the quality of the marble from Filfila was also poor. Often no separate typologies are apparent in statues made of marble from the various sources. Very similar togati could be produced in both Filfila and “imported” mar-



Fig. 11. Portrait head, USF9394, of togatus, USF9393, Guelma Museum. Detail of intrusive vein, probably marble from Mt. Filfila.

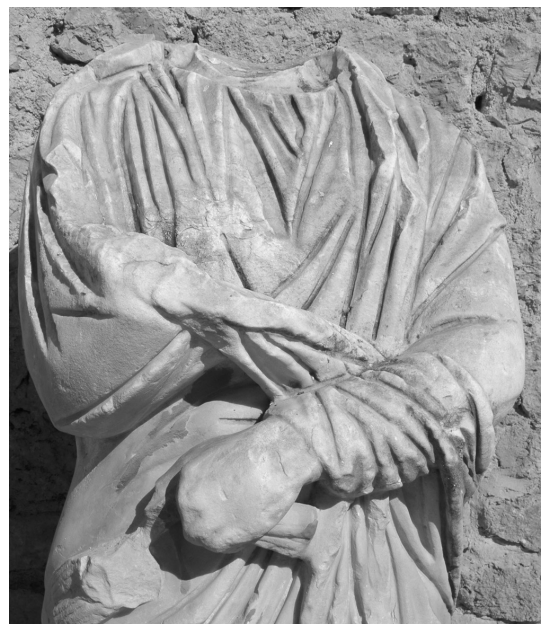


Fig. 12. Ceres/Pudicitia, USF9402, Guelma Museum. Soft grayish zones confirm that the marble comes from Mt. Filfila.

bles. The same is true for the statues of Aesculapius, all three of which belong to the “Tunis type” (HOLTZMANN 1984, 884-885, cat. 276-280). Even if migrant artists had been involved, prevailing conventions in the Guelma area apparently dictated the compositional types. Provincial and cosmopolitan work appears in marble from each source. Many of these statues are made of thin, flat slabs irrespective of the marble source. One type of cuirassed statue, however, seems to be the work of a cosmopolitan workshop active in Tunisia and Italy that favored Thasian marble.

Conclusions

The variability of marble from Mt. Filfila in both analytical and macroscopic terms makes the identification of the sources of marble used for sculpture in eastern Aige-



Fig. 13. Aesculapius, USF10835, Guelma Museum. Soft grayish zones confirm that the marble comes from Mt. Filfila.

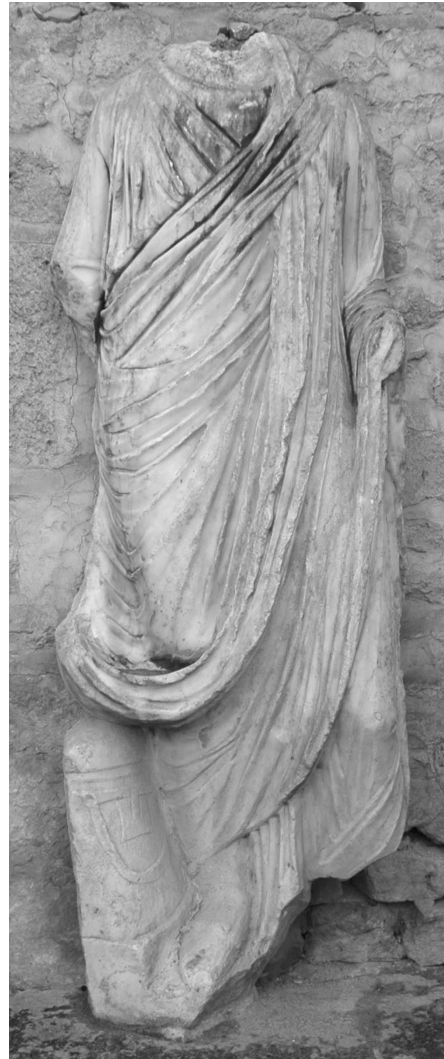


Fig. 14. Dignitary wearing toga, USF10854, Guelma Museum. Probably marble from Mt. Filfila.

ria unusually difficult. EPR is of limited value in distinguishing Filfila from other marbles. Nonetheless, scientific techniques (in this case, EPR, CL, XRD, and analysis of stable isotopes of carbon and oxygen) in combination with macroscopic observation make it possible to identify both local and Aegean sources for sculptural marble at sites in the neighborhood of Guelma with varying levels of confidence. In some cases, it is possible to arrive at virtually unambiguous identifications largely on the basis of isotopic ratios. More often, considerable weight must be placed on optical characteristics of the marble to make an attribution. In any case, it is clear that the primary local source for fine sculpture – both statues and portrait heads – was Mt. Filfila. Relief sculpture but no statuary was carved in the travertine of Mt. Mahouna, and we found no figural sculpture of any kind in the marble of Cap de Garde. The marbles imported from the Aegean came from Mt. Pentelikon, Paros, and Thasos, and possibly Afyon as well. No figural sculpture of Carrara or Göktepe mar-

ble was recognized. The marble of eight of the sculptures was attributed to Algerian and twelve to Aegean sources. This preliminary study also suggests that both good and poor quality statuary could be produced in the marble of Filfila, while imported marble statues tended to range from good to superior. While marble came from the Aegean, the cases of the Jupiter of the Capitoline type USF9398 or the armored torso USF9387 indicates that often the orientation of sculptural workshops was towards Rome. The bald “Isiac priest” type, USF9392, suggests a possible orientation toward Athens.

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