BLACK SCULPTURAL MATERIALS FROM VILLA ADRIANA: STUDY OF PROVENANCE

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Abstract
This contribution reports the archaeometric study of four black fragmented pieces and one small red pedestal stored in the reserves of Villa Adriana, Tivoli. They were petrographically studied to know the lithology, before any isotopic comparison was performed. C and O stable isotopes and EPR similarity to the available databases helped to assign the provenance. *Lapis basanites,* Black Göktepe and Ain el Kasir in Tunicia were the most likely raw materials.

Keywords
Villa Adriana, sculpture, provenance study, quarry, black stone, Göktepe, *lapis basanites.*

Introduction

This paper is a complementary study of the previous one dedicated to white sculpture in Villa Adriana (Lapuente *et al.* 2012). The archaeological context, methodology and techniques applied are extensively described in the other paper.

The present archaeometric contribution investigates the stone provenance of four black fragmented pieces and one small red pedestal (Fig. 1). A sequential approach was used, taking into account petrography and cathodomicrofacies as the first step, combined with the C and O stable isotopes whenever necessary to further discrimination. One sample was subjected to EPR analysis[1] to verify black Göktepe.

Although thin section studies do not always assure an adequate determination of provenance, they should always be made first, to determine the geological nature of the rock, thereby avoiding any confusion between different black lithologies and bypassing unnecessary comparisons. An additional problem arises, in many cases, with recrystallized carbonate rocks whose boundary between an advanced diagenetized limestone and a marble of low metamorphic grade, is not always easy to establish. Description under the petrographic microscope followed criteria of classical classifications and references (Flügel 2004). Both isotopes and EPR results were compared to the available databases.

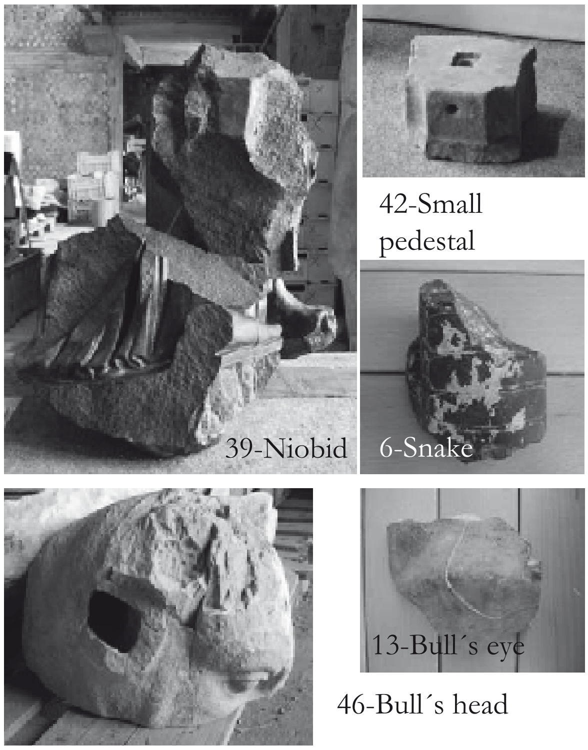

Fig 1. Fragmented pieces under study.

Results and discussion

Results are described by lithology (Table 1). Different options are discussed in detail with regard to provenance.

Red marble (Sample TI-VA 42)

Red marble quarries used in antiquity, rosso antico, have not been identified in many places. Two principal regions of the Mediterranean area supplied this precious stone; Peloponnesus, in Greece and Caria in Turkey. The small red pedestal under study was archaeometrically compared to three types, the *marmor Taenarium* from Cape Tainaron, currently known as Cape Matapan on the Mani Peninsula, in Southern Peloponnesus, and the Iasos and Aphrodisias red marbles in south-western Anatolia (Gorgoni *et al.* 2002; Lazzarini 2007).

The pedestal is a red marble (Fig. 2a) with crystalloblastic fabric, sometimes lepidoblastic when small mi-

1. The authors are deeply grateful to Dr Attanasio for all the facilities and help offered to one of us (H. Royo) during his stay at the Roman Laboratories.

cas are developed. Calcite grains are slightly heteroblastic with a preferred orientation by syntectonic crystallisation. The maximum grain size is 1mm, while the average is 0.4 mm. Hematite is finely dispersed along the boundaries of calcites but it also concentrates in small nodules (Fig. 3a). This feature seems to be typical of Iasos marble (Gorgoni *et al.* 2002) and also the MGS agrees with the *Iassense uniforme* (Lazzarini 2007). Quartz, plagioclase and opaque iron ores are accessory minerals. CL microfacies shows a bright intensity with an orange colour and heterogeneous distribution, with small shades associated to accessories and to zones where the hematite is concentrated inside the calcite crystals.

Isotopic signature (δ^{18}O:-2,66; δ^{13}C:2,52) matches those from the Mani and Iasos area fields (Fig. 4) offered by Gorgoni *et al.* (2002). However, in Fig. 5, these data are plotted on the diagram by Lazzarini (2007) where they are drawn outside the global isotopic diagram of the Mani quarries and, on the contrary, inside the *marmor Iassense* field, close to another red artefact analized by Lazzarini (2007)[2]. Taking into account petrography and isotopes, Iasos is currently the most convincing source, but it should later be coupled with new additional archaeometric results emerging from recently discovered quarries in Anatolian (Bruno *et al.* 2012).

Black stones

The use of the classical nomenclature such as *lapis basanites,* nero antico, bigio antico or bigio morato based on visual examination is known to cause confusion. Recent databases have helped enormously in the study of locating the origin of black stones, but have highlighted a number of errors previously made due to the inexactness and ambiguity of their use in the literature (Attanasio *et al.* 2009; Yavuz *et al.* 2009; Brilli *et al.* 2010; Lazzarini, 2010).To avoid any misunderstanding, the best solution is to describe the stones under the petrographic microscope.

In this study, black stones of different very fine grained lithologies were sampled. As these were very dark in colour from grey to greenish or deep black, they could easily be mistaken on the basis of ocular examination (Fig. 2b, c, d, e). This difficulty is even greater if we consider that the oxidation of the organic carbonaceous matter at the exposed surfaces tends to turn from black to grey (Lazzarini 2007). Table 1 compiles archaeological information and analytical results.

Metagreywackes (Samples TI-VA 6, 39)

There are two very dark greenish black pieces of very fine grained sandstone (Fig. 2b, c) whose petrographic features reveal its metagreywacke lithology with no foliation (Fig. 3b). Detrital angular grains smaller than 0,4mm, are composed of quartz, plagioclase, quartz-feldspar rock fragments, opaques and muscovite. Interstitial matrix is abundant with chlorite, sericite and some epidote replacing the original detrital clay matrix. Minor calcite and iron oxide cements are also present. Under CL some colours appear: blue K-feldspar, green plagioclase, orange calcite and purple quartz. These petrographic characteristics are well matched to those described by Brown and Harrell (1995) like the metagreywacke from Mons Basanites (Wadi Hammamat, Eastern Desert of Egypt) which was sporadically worked from the Early Dynastic period through Roman times[3]. Other names are *lapis basanites* and "bekhen" the ornamental stone highly prized by the ancient Egyptians.

One of these samples was a fragmented snake (TI-VA 6) and the other a fragment of Niobid (TI-VA 39). Worthy of note are the details on the carving of the draped robes which manifest the artistic quality on this very hard stone (Fig. 1). This provenance confirms the requirement of the previous petrographic examination, especially when other Niobids from Villa Adriana were archaeometrically assigned to Nero Göktepe (Attanasio *et al.* 2009).

Black limestone (Sample TI-VA 13)

The sample under consideration (a bull´s eye) is a compact black stone (Fig. 2d) with rare white veins. Under the microscope it is a clayey fossiliferous limestone, with a groundmass composed of iron oxide micrite matrix and clay minerals enriched in organic matter. Depending on the amount of bioclasts present, it varies from a matrix-supported (wackestone) to a grain-supported fabric (packstone), after Dunham (1962). It can also be classified as a sparse biomicrite, after Folk (1959, 1962), as the only allochems (skeletal grains) do not exceed 50%. Revised Dunham classifications by Embry and Klovan (1971) and Wright (1992), retain the same name (wackestone to packstone) as the grains are smaller than 2mm and it preserves its depositional fabric. Grains are well sorted bioclastics, planktonic foraminifera, most of them Globigerinids, which exhibit their typical globular, uniserial, biserial and triserial multichambered sections. Their wall structures were obliterated by diagenesis and the intraparticle porosity was filled by sparite which is also present in the microveins. There are no siliciclastic grains but some remains of unidentified bivalves can be observed. Under CL there is nothing worthy of note, except for its non visible luminescent behaviour (Fig. 3c).

To date, few high quality black limestones have been quarried and traded across the Mediterranean area, to reach Rome itself. The studied fragment was compared to the recently published databases previously cited. Consideration was also given to certain data that was provided a few years ago and whose lithology and rel-

2. Isiac Priest, inv. 117, Archaeological Nacional Museum Venezia. See Table 6, in Lazzarini (2007, 89).

3. It seems that the use of this Egyptian stone ceased in the 2nd century and was replaced by black stone from Caria (Attanasio *et al.* 2009, 339).

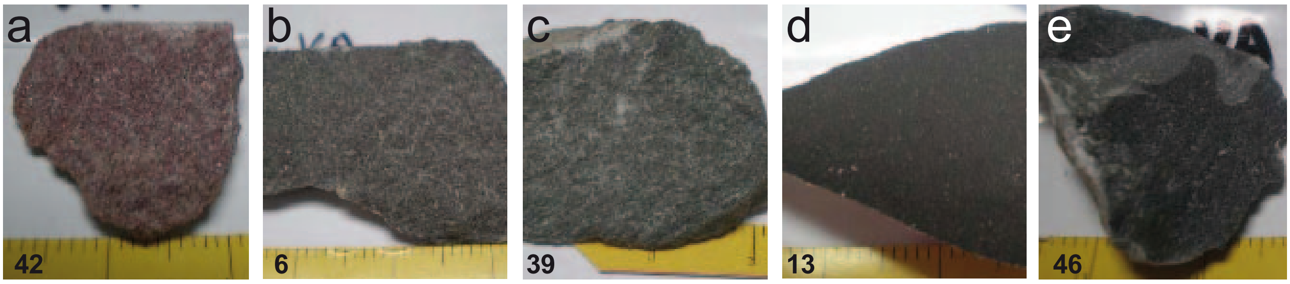

Fig 2. Fresh surface of archaeological coloured samples (TI-VA number). (a) Red *Iassense* (b) (c) Metagreywackes *(lapis basanites),* (d) Black limestone probably from Ain el Ksir (Tunisia), (e) Black Göktepe (Turkey).

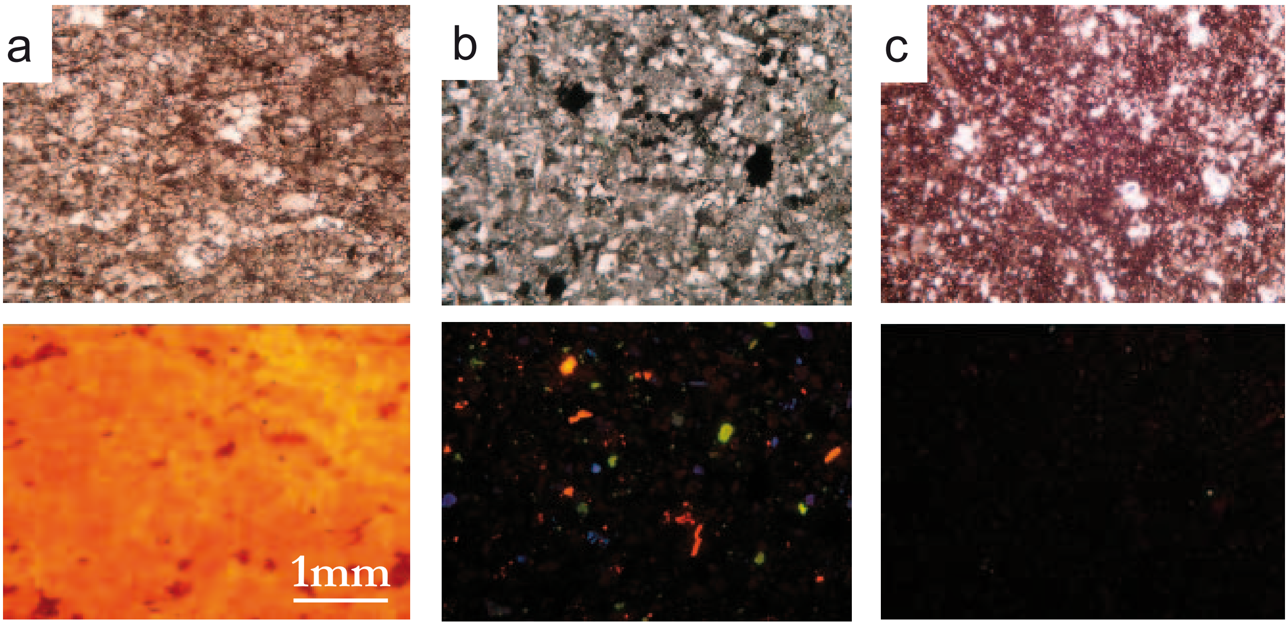

Fig 3. Photomicrographs in plane-polarised light and CLmicrofacies: (a) Red *Iassense,* (b) Metagreywacke (*lapis basanites)*, (c) Black limestone, sparse biomicrite or wackstone, possible Ain el Ksir (Tunis).

Provenance	Petrographic and CL features	Our ref. (TI-VA)	Store Inventory Ref.		Archaeological description	δ18O	δ13C	EPR Int	EPR W
BLACK STONES									
Wadi Hammamat (Egypt)	Metagrauwacke *lapis basanites* Detrital angular grains <0,4mm Diagenetized-metamorphic matrix Non foliation CL: blue (Kfs), green (Pl), orange (Cc), purple (Qtz)	6 39	XXVIII XIV	988 841	Snake Niobide				
Ain el Ksir ? (Tunisia)	Black limestone (wacke-packstone) Non visible CL	13	XXVI	40424	Bull´s eye	-4,06	-1,68		
Göktepe (Turkey)	Very fine grained calcite, organic matter, “ghost” recrystallized microfauna, mosaic patches Iron oxides and clay minerals Lamination non pervasive Sparstone to laminated bituminous argillaceous limestone Non visible CL	46	XIII	134	Bull´s head	-3,83	3,87	0,0245	0,5402
RED STONE									
Iasos (Turkey)	Calcite heteroblastic MGS:1mm Hematite finely dispersed, small nodules Bright intensity heterogeneous CL	42	XIV	27105	Pedestal	-2,66	2,52		

Table 1. Coloured sculptures from Villa Adriana.

evance were definitely known in terms of being widely marketed (Fornaseri *et al.* 1995; Bruno and Pallante 2002; Agus *et al.* 2006).

Regarding petrography, this sample can be compared to the black limestone from quarries exploited in proconsular Africa, modern Tunisia, reported by Agus *et al.* (2006) and Brilli *et al.* (2010). In fact, the black stone shows the typical open-marine pelagic features common in the Tunisian Bou Dabbous Formation of the Lower Eocene, contrasted with those studied by Tlig *et al.* (2010). It was compared to those from the Tunisian quarries of Djebel Oust, Djebel Azaeiza, Ain el Ksir, and even Thala (though it seems to be of modern exploitation, Brilli *et al.* 2010), and the black limestone of Chios, in the Caria region (Lazzarini 2007; Brilli *et al.* 2010). From the petrographic data of 54 samples from Tunisia and 13 from Chios, the quarry which has similar microfacies is that of Ain El Ksir[4].This quarry is located near Chemtou (ancient Simitthus) and is famous for the exploitation of giallo antico, which was widely used for the pavements of Villa Adriana, together with the pavonazzetto type (Salvatori *et al.* 1988).

Other options of possible provenance have been taken into account after the availability of data; a black fossiliferous limestone from Doliana, along with some recristallized limestones from Mani[5], both areas in Peloponnesus, (Bruno and Pallante, 2002). Fornaseri *et al.* (1995) compiled an extensive number of black limestones, (some of which are already mentioned above), in order to compare them with the *Lapis Niger* in the Comitium of the Roman Forum, which was found to be a variety of the so-called Palombino limestone from the Tolfa district, close to Rome. As some Palombino microfacies reported there, are comparable to those under review here, they have also been included in the isotope study[6]. Finally, some authors stress the importance of Teos black limestone[7] in the Roman world, a reason for which one sample reported by Fornaseri *et al.* (1995) is also included here.

Fig. 6 shows the isotopic signature of the TI-VA 13 sample (δ^{18}O:-4,06; δ^{13}C:-1,68) along with those from the quarries mentioned above and some archaeological artefacts in black biomicrites provided by Lazzarini (2007). Five of these sculptures were undoubtedly carved in limestone from the Tunisian Ain el Ksir, but the other two samples from the Altar of Jugurtha[8] remain unknown, though they probably came from an undiscovered quarry in Tunisia (Lazzarini 2007). The isotopic values of our sample are plotted outside the fields of the quarries in question, but are relatively close to the Ain el Ksir and Chios samples. From these options, Chios should be rejected because its microfacies does not match at all. Compared to these Tunisian samples, ours is depleted 0,93‰ in carbon, and 1,09‰ higher in oxygen. These anomalies could be related to the analytical procedure for the acid treatment of samples due to the organic matter present in the sample, since it is difficult to argue other causes, either because the stone could be affected weatherwise, or in another way, through water-rock interaction with a hydrothermal fluid. In this regard, the first option seems unlikely since in the case of superficial weathering, it is known that carbon values change only slightly but that oxygen becomes more negative (Herz 1987). The second could be valid in terms of slightly increasing oxygen values, but both possibilities should be excluded through lack of microscopic evidence of mineralogical disturbance.

Unrelated to these considerations, other settings can be added such as quarry sampling not having been extensive enough and the stones exploited presenting a wider range of isotopic values. In this respect, it is worth not-

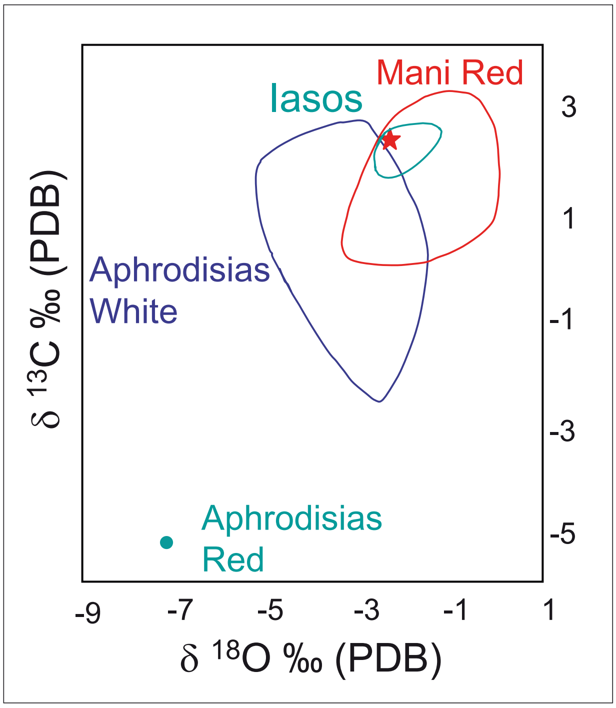

Fig 4. Isotopic diagram of rosso antico compared to the global area of quarries in South Peloponnesos and Carian marbles, after Gorgoni *et al.* (2002).

4. Table 1 of petrographic data (Brilli *et al.* 2010), although all of its 8 samples were classified as grainstones, this might be due to a typing error, since the microphotograh given as nero of Ain El Ksir (Sample CHM 6) seems to show the presence of abundant micritic depositional matrix.

5. These are Mounatanistika, Alika and Kyparissos recrystallized limestones which have been included to compare isotopes, though they are quite different from the petrographical point of view. They have however been taken into account as they were listed in the Yavuz *et al.* (2009) database.

6. Hydrothermally altered simples have deliberately been discarded whose values of δ^{13}C are below -12.

7. Although to date no archaeometric database is available.

8. Numbers 2750 and 3517 from the Capitoline Museums.

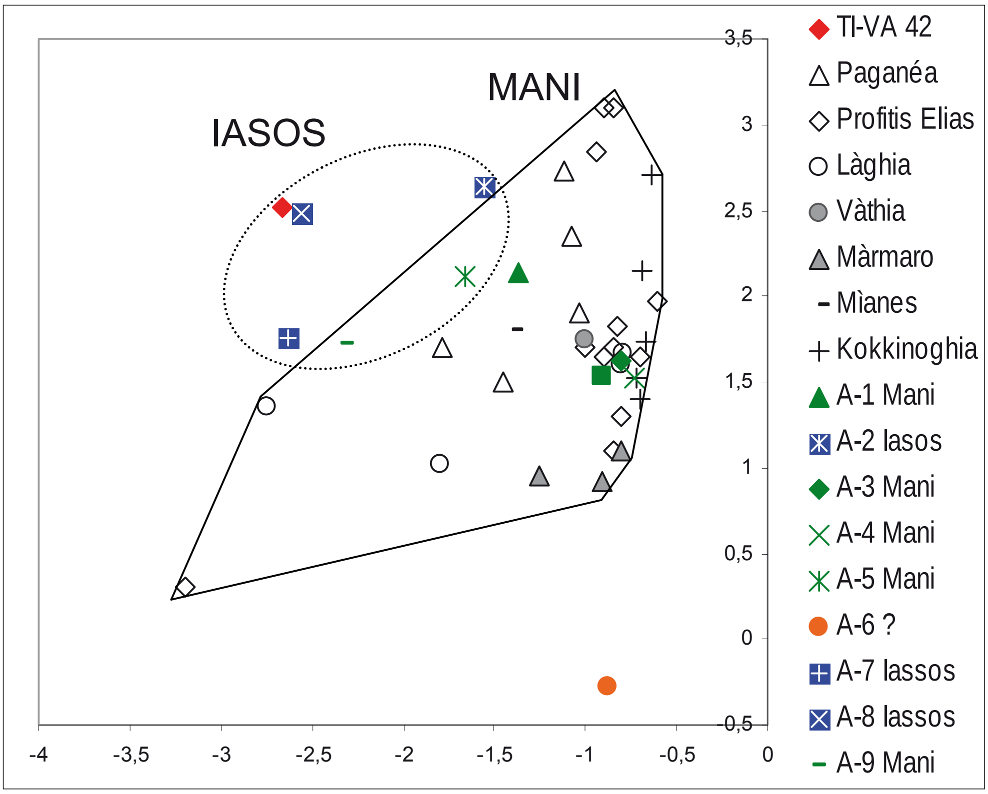

Fig 5. Isotopic diagram of Iasos rosso antico compared with the quarries of Mani Peninsula and different archaeological artefacts (A-) after Lazzarini (2007, chapt. 5, Table 6). The pedestal (TI-VA 42) is close to the values of sample 8 (Isiac priest, Archaeological National Museum Venezia).

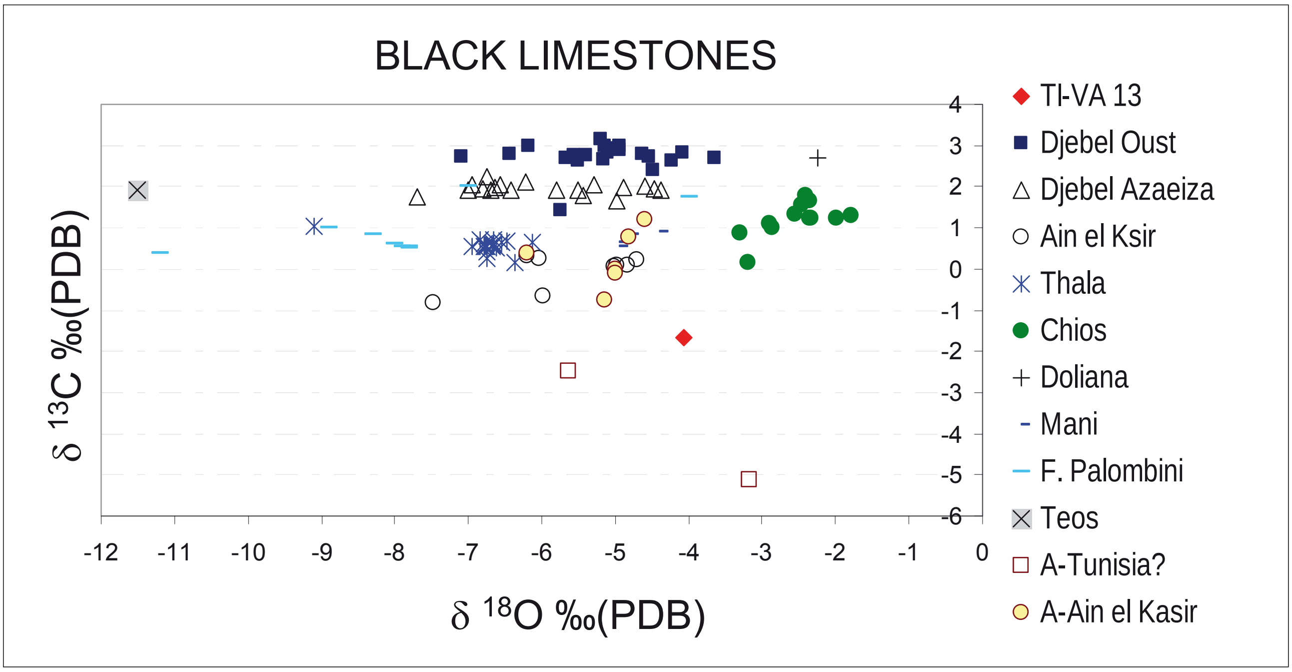

Fig 6. Isotopic signature of TI-VA 13 black limestone compared with the available quarry data from Brilli *et al.* (2010), Lazzarini (2007), Bruno and Pallante (2002) and Fornaseri *et al.* (1995). Archaeological samples (A-) in black biomicrites, analyzed by Lazzarini (2007), are included.

ing that the two archaeological pieces cited by Lazzarini (2007) also show a wide dispersion, relatively close to the values found here. Fortunately, petrographic features with no peloids in our sample, keep it apart from the Altar samples. In conclusion, after all available black database, Ain el Ksir is the most probable origin.

Black bituminous argillaceous limestone (TI-VA 46)

A bull´s head carved in very fine black stone (Fig. 1), with no apparent vein, was analysed under the petrographic microscope, revealing its bituminous carbonate nature

FIG 7. Different petrographic images of the same sample (TI-VA 46) attributed to Black Göktepe.

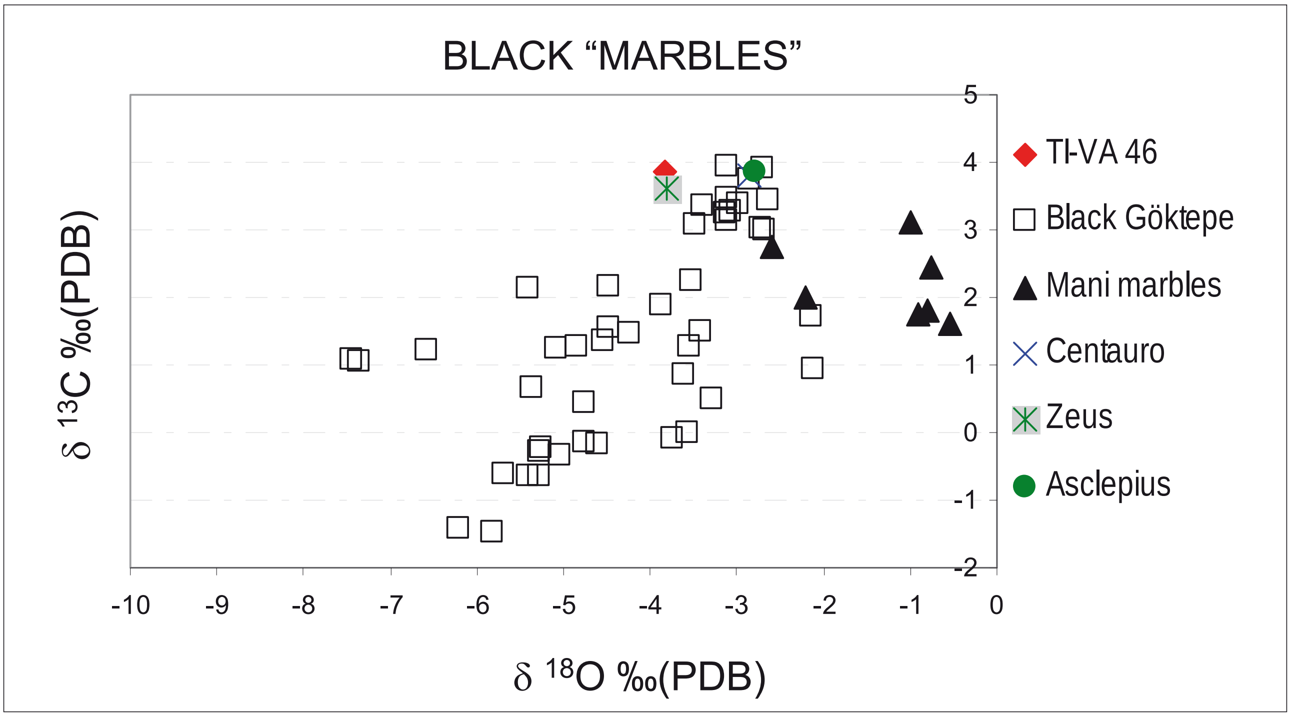

FIG 8. Isotopic signature of TI-VA 46 black stone compared with the available quarry data from Yavuz *et al.*(2009); Attanasio *et al.* (2009); Bruno and Pallante (2002). Data of archaeological pieces from Attanasio *et al.* (2009) are included.

affected by diagenetic recrystallization processes. It is composed of extremely fine grained calcite, with patches where calcite is very fine grained and of mosaic texture. Zones where calcites are recrystallized, could be observed as a diagenetized limestone with an obliterate texture which should be classified as a sparstone (Wright 1992). The general microscopic view (Fig. 7) offers an assemblage of microcalcites with the appearance of have been foliated, but this arrangement resulting from the flattening of organic matter, iron oxides and argillaceous mudstone; impurities all irregularly distributed in dark planar laminations sometimes crinkled, but clearly sedimentary microstructures (Flügel 2004). This distinctive feature, only visible microscopically, is not a pervasive foliation (typical from regional metamorphism). Moreover, freshly cut, the stone shows a high degree of compactness (Fig. 2e). The patches where calcite displays a better mosaic texture are irregular, almost lenticular, sometimes showing a "ghostly" effect of recrystallized microfauna with a typical prismatic structure of carbonates. Subperpendiculars to the general orientation are small microveins filled with coarser calcite crystals which are not evident by visual examination. Being partially patchy, grain size is quite different in each zone, so it is not worth characterizing the standard measurements, as with white marbles. The finer calcites are 20 μm long, but constitute the majority of the matrix. Mosaic patches are no more than 5 mm long in which calcites are quite uniform in size (100 μm). The calcites of prismatic texture are the biggest, ranging from 250 to 750 μm. Finally, in the microveins, calcite reaches 120 μm. Scraping the sample emits a distinctive fetid odour. Apart from its non visible luminescent behaviour, there is no comment to make on the CLmicrofacies.

To date, few recrystallized limestone (some of them regarded as black marble) quarries have been considered important in antiquity. The analyzed sample has been compared to recently published data (Bruno and Pallante, 2002; Attanasio *et al.* 2009; Yavuz *et al.* 2009).

Petrographycally the black marbles from Mani Peninsula, in Southern Peloponnesus, are all characterised by a heteroblastic, mortar fabric with variable amounts of quartz, white mica, K-feldspar, apatite, ore minerals and graphite (Bruno and Pallante 2002) whose textural photomicrographs do not match the description of the sample under consideration. The geological notes of the black Göktepe[9] offered by Yavuz *et al.* (2009) and Attanasio *et al.* (2009) reveal the character of low grade metamorphic calcitic marble with well defined foliation, granoblastic texture and an average grain size of 0.086 ± 0.032 mm, even the sulphur odor upon scraping. These features could be consonant with those from our sample, moreover from the view of the unique photomicrograph published. An EPR analyses was obtained with the values of intensity (0,0245) and linewidth (0,5402) which reinforce this provenance as intensity in the Black Göktepe ranges from 0,0205 to 0,1110 and linewidth is also matched (Attanasio *et al.* 2009).

Unfortunately, the fragmented sculpture studied showed no visible white to yellowish vein which seems to be a recurrent element of the black Göktepe. However many other black sculptures without this attribute have been attributed to Göktepe, after analytical tests (Attanasio *et al.* 2009).

The scatterplot of Fig. 8 illustrates the isotopic signature ($\delta^{18}O$: -3,83; $\delta^{13}C$: 3,87) of the sample (TI-VA 46) along with the isotopic distribution of Mani marbles (Bruno and Pallante, 2002) and Göktepe black marbles from district 1 and 2 (Attanasio *et al.* 2009; Yavuz *et al.* 2009). Signatures from three emblematic archaeological sculptures recently assigned to nero Goktepe have also been drawn (data from Bruno and Pallante 2002; Lazzarini 2007; Yavuz *et al.* 2009) together with those from the list of black Göktepe artefacts, some of them originally from Villa Adriana, published by Attanasio *et al.* (2009).

Isotopic values agree with Göktepe provenance and are very similar to those of the Zeus sculpture from Anzio, held at the Capitoline Museums (inv. 655) and a Dacian prisioner (inv. 779) at the Conservatory Palace, in Rome.

Conclusions

The analytical results confirm that different black stones were used for sculpturing proposes at Villa Adriana, though their chronology is not available since they were collected from the fragmented collections stored in its reserves (León and Nogales 2008, 2010).

Though only four samples on black stones were analyzed, it is significant that three different sources provide the material. In other words, *lapis basanites* o metagreywacke from Egyptian Mons Basanites (Wadi Hammamat) coexist with Turkish Black Göktepe and Tunisian Black Limestone, probably from the quarry of Ain el Ksir, near where the giallo antico was exploited. Iasos (Turkey) is currently the most convincing source for the small red pedestal.

This study is a new example of how knowing petrographic data before any additional technique applied, is essential to avoid unnecessary comparison.

These results emphasize the importance of Göktepe marble at Hadrian age in agreement with the significant number of sculptures of Villa Adriana recently assigned to the black Göktepe quarries (Attanasio *et al.* 2009).

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