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Archaeometric investigations on the sarcophagus no. 1993/74 in the Diachronic Museum of Larissa, Thessaly, Central Greece: I. Characterization and provenance of the marble

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ABSTRACT

An exceptional marble sarcophagus was found in Larissa (Thessaly, Central Greece) and is kept in the Diachronic Museum of Larisa (inv. no. 1993/74). The marble consists mainly of calcite (>99%) with traces of white mica (muscovite or phlogopite), apatite and quartz. It exhibits a granular heteroblastic texture, with straight to curved grain boarders. The maximum grain size of the calcite crystals is 2.5 mm. The C-O isotopic results of two marble samples are similar ($\delta^{18}O$=-0.82‰, $\delta^{13}C$=+2.06‰ and $\delta^{18}O$= -0.66‰, $\delta^{13}C$=+2.02‰). Combining all these data with that of other marble-producing areas of the Aegean Region, it is concluded that the marble used for the sarcophagus is from Paros Island.

Keywords: Marble; Provenance; Isotopes; Paros Island; Larissa; Thessaly; Greece.

INTRODUCTION

An exceptional and unique sarcophagus made of marble was discovered by chance in 1993, during the course of municipal works in N. Douka street, at the south-eastern part of modern Larissa city, Thessaly, Central Greece (Diachronic Museum of Larissa, inv. no. 1993/74). It belongs to the so-called "architectural type". The case is preserved intact and measures: 2.29-2.33 m long x 0.86-0.89 m wide x 0.83 m high, externally (Figure 1). Its pedimental lid is preserved in a fragmentary state, consisting as it does of a variety of large and small fragments. The sarcophagus dates to the Late Classical Period-early 4th century BC (Katakouta and Palioungas, 2020).

Along its upper and lower edges the case bears plain mouldings with painted decoration: a Lesbian cymatium on the lower moulding, with erect ivy leaves in blue on a red background, and an Ionic cymatium on the upper moulding with alternating blue and red leaves on a yellow background. A band of painted decoration also runs around the vertical face of the lid, consisting of a meander and abacus ornaments in red and black on a yellow background (Katakouta and Palioungas, 2020).

Marble is a common rock in Thessaly. It is incorporated in the Palaeozoic-M. Triassic basal sequence, along with schists and gneisses, and in the Late Jurassic-Early Cretaceous thick-bedded lithological units of Pelagonian zone (Koutsovitis, 2017; Pentedeka et al., 2019). Moreover, recrystallized limestone (locally dolomitic) is associated with the Late Cretaceous to Eocene meta-sedimentary rocks that overly unconformably the Pelagonian zone.

This study focuses on the mineralogical, petrographic and isotopic characterization and the potential source of the marble used for the manufacture of the sarcophagus from Larissa. Provenance studies of marble artifacts used in antiquity are very important for preservation, restoration and reconstruction purposes and for determining the ancient trade patterns, the distance of transportations and the networks of exchange and communication in various periods.

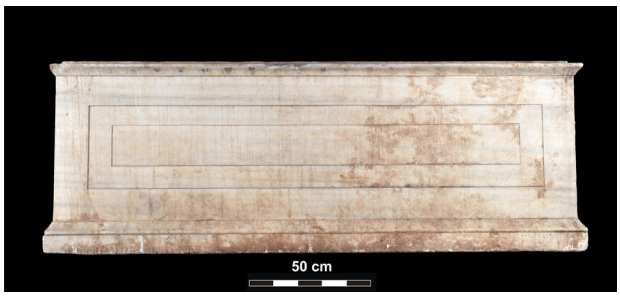

Figure 1. The Late Classical Period (early 4th century BC) marble sarcophagus found in Larissa. Diachronic Museum of Larissa, inv. no. 1993/74. Photograph by G. Dallas.

SAMPLING AND METHODS OF ANALYSES

A small marble sample, with a cylindrical shape (0.051 m long and 0.033 m in diameter), was obtained with a drilling in a broken corner of the sarcophagus case, under the permission of the Greek Ministry of Culture.

A thin section was prepared for mineralogical and petrographic study, which was conducted under transmitted light polarizing microscope at the Department of Mineralogy, Petrology and Economic Geology of the School of Geology in the Aristotle University of Thessaloniki (AUTH). Microscopy was applied for the determination of the mineralogical composition, including accessory minerals, and the textures of the mineral constituents, with particular reference to calcite.

Powder of the sample was processed by X-ray diffraction (XRD) in order to identify the possible presence of minor minerals and dolomite, in addition to calcite, and their relative abundances in the sample. The XRD analysis was carried at the Department of Mineralogy, Petrology, Economic Geology (AUTH) with a PHILIPS PW1710 diffractometer (Ni-filtered CuKα/Ni: 40 kV, 0.01° 2θ, 3-63°, 0.02° 2θ/sec).

Finally, the marble sample (approximately 5 g) was analyzed for the carbon and oxygen isotopic ratios at the ISO Analytical Laboratory, Cheshire, United Kingdom. Two analyses were obtained from two different parts of the marble sample in order to avoid possible surface impurities. The O- and C-isotope ratios are referred to the standard VDPB (*Belemnitella Americana* from the Cretaceous Pee Dee Formation, South Carolina).

RESULTS

Macroscopically the marble has a white color and is semi-transparent under the sunlight. It is a medium-grained marble with visible calcite crystals. Based on the XRD and the patterns of optical microscopy (Figure 2 a,b), the sample consists of calcite (more than 99%) with traces of white mica (muscovite or phlogopite), apatite and quartz. Dolomite was not detected. It is therefore characterized as a calcitic marble.

The marble from the sarcophagus exhibits a granular heteroblastic texture (Figure 2a), which indicates that it consists of calcite grains with small and large sizes. The small grains, up to 0.4 mm in length, coexist with larger crystals ranging from 0.5 to 1.8 mm in length and only rarely their size is up to 2.5 mm. The large grains are countered by small grains that fill the interspaces among the large crystals. This is typical of marbles from Penteli, Thessaly, Paros, Naxos and Thasos (Capedri et al., 2004). The shape of the grain boarders (GBS) is straight to curved, and rarely sutured to dentate (Figure 2b). Under microscope, the large calcite crystals often show lamellar twinning and triple-grain junctions of the crystals,

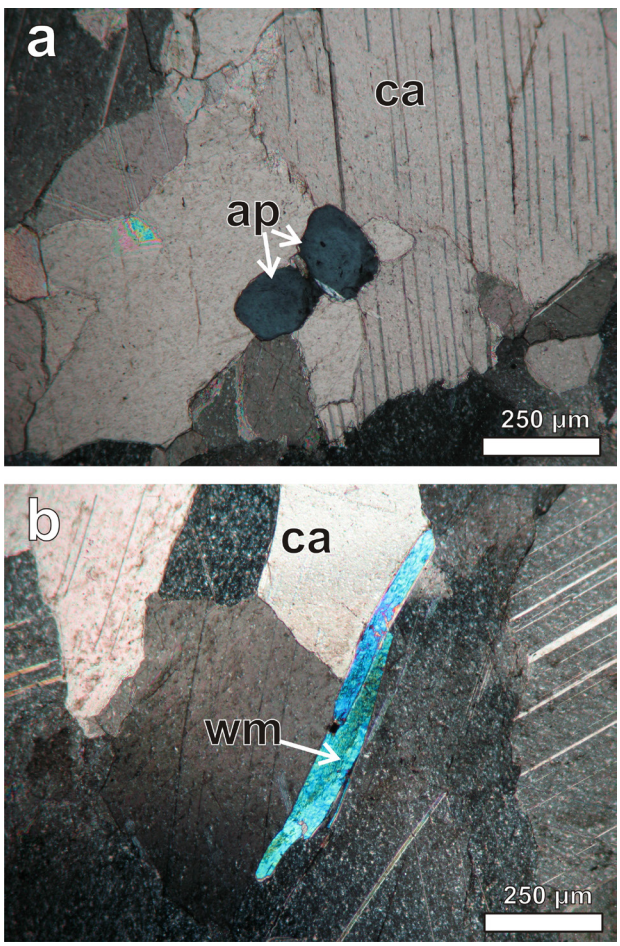

Figure 2. Photomicrographs of the marble from the sarcophagus under cross polarized light (N+). The calcite crystals show lamellar twinning. (a) Heteroblastic texture of the marble and apatite (ap) grains in the calcite (ca); (b) White mica (wm) with calcite (ca) grains exhibiting straight GBS and triple-grain junctions at about 120° angles.

meeting at about 120° angles (Figure 2b). The MGS of calcite in the studied marble is 2.5 mm, which is typical of the medium-grained marbles from different localities around Aegean, including Penteli, Thasos, Cyclades (Paros and Tinos islands) and Thessaly (Gorgoni et al., 2002; Capedri et al., 2004).

The accessory minerals of the marble include small flakes of white mica (probably muscovite or phlogopite) with a length up to 0.5 mm and rounded quartz and apatite grains with a maximum size of 200 μm (Figure 2 a,b). Opaque minerals are not observed.

The C-O isotopic results of the marble sample from the sarcophagus (LS1: $\delta^{18}O$=-0.82‰, $\delta^{13}C$=+2.06‰; LS2: $\delta^{18}O$=-0.66‰, $\delta^{13}C$=+2.02‰) are plotted in the diagram of Figure 3. It is apparent that these values have a consistent signature and in the diagram $\delta^{18}O$ versus $\delta^{13}C$ they plot in a very restricted field.

DISCUSSION

The determination of the white marble sources used for the manufacture of the sarcophagus no. 1993/74 from Larissa is based on an extended data base with published and unpublished data of C- and O-isotopic results from 90 different ancient white-marble quarrying sites in the Eastern Mediterranean region. The majority of these quarries are concentrated around the Aegean Region. The data base includes marble quarries from Greece, Asia Minor in Turkey, Italy and North Macedonia, with a total of more than 1.200 isotopic analyses. The isotopic data were obtained from Craig and Craig (1972), Herz (1988, 1992), Asgari and Matthews (1995), Pentia et al. (2002), Bruno et al. (2002), Lazzarini and Antonelli (2003), Capedri et al. (2004), Attanasio et al. (2006) and Antonelli and Lazzarini (2015). The isotopic results of this study were compared with this data base. Both analyses plot only into the fields of the marbles from Alyki in Thasos Island, from Paros Island in Cyclades, from Proconnesus Island in Marmara Sea and from Carrara in Italy (Figure 3). It is apparent that all the other possible sources are excluded and the provenance of the marble has to be concentrated in only those four ancient quarrying sites.

Among the four possible marble sources, Carrara is excluded because the marble is homoblastic and the MGS ranges from 0.2 to 1.5 mm, with an average of 0.8 mm (Capedri et al., 2004), and therefore it does not meet the requirements. The marble from Proconnesus is also excluded because it contains almost always dolomite, at percentages ranging from 3% to 20% (Attanasio et al., 2008). The marble from Alyki in Thasos Island contains

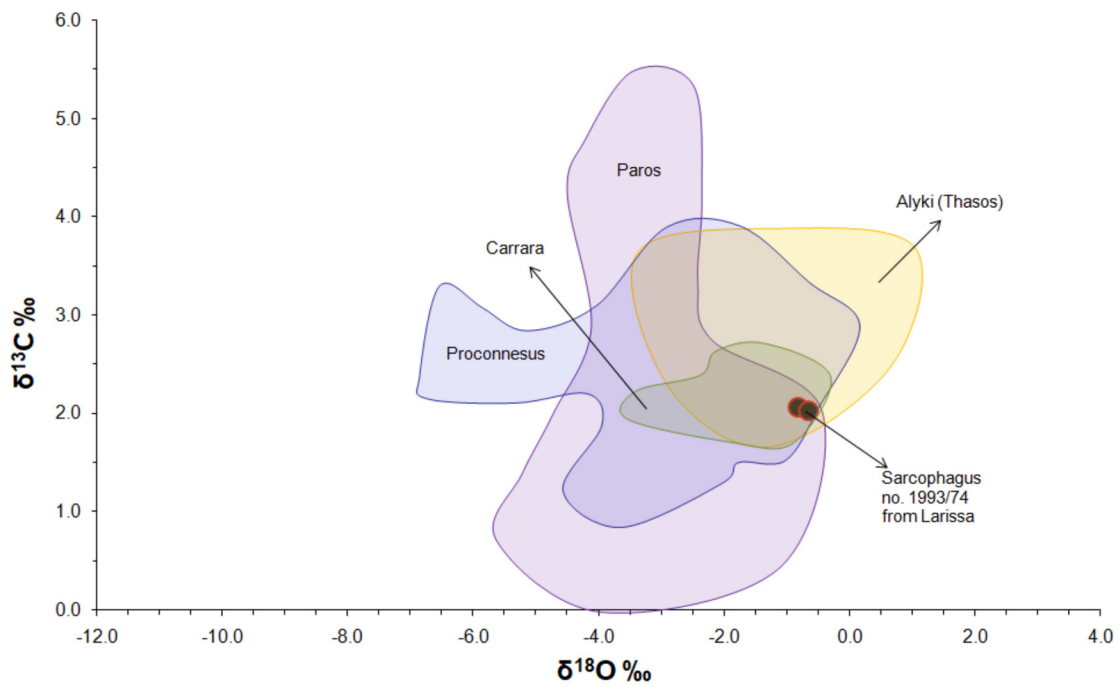

Figure 3. $\delta^{18}O$-$\delta^{13}C$ diagram for the marble sample of the sarcophagus from Larissa. Reference isotopic fields of the marbles from the ancient quarries around Aegean are also shown: Alyki (Thasos Island), Paros Island, Proconnesus Island and Carrara. Isotopic data from Craig and Craig (1972); Herz (1988); Asgari and Matthews (1995); Bruno et al. (2002); Pentia et al. (2002); Capedri et al. (2004); Attanasio et al. (2006, 2008); Antonelli and Lazzarini (2015).

various accessory minerals such as epidote, titanite, albite, quartz, white mica and graphite, in tiny amounts (Bruno et al., 2002; Capedri et al., 2004; Attanasio et al., 2006; Antonelli and Lazzarini, 2015). The crystal boundaries from Alyki marble are curved to sutured and the MGS ranges from 2.4 to 5.0 mm but mostly is between 3.1 and 4.5 mm (Attanasio et al., 2006; Antonelli and Lazzarini, 2015). These features do not resemble with the characteristics of the marble from the studied sarcophagus.

The most comparable marble with the studied sarcophagus is Paros marble. Both marbles include mainly calcite with apatite, quartz and white mica as accessories (Capedri et al., 2004). Paros marble has a medium grained (MGS=1.3-1.8 mm and rarely up to 2.3 mm) heteroblastic texture with linear to slightly sutured grain boundaries, similar with the studied sample.

It is evident therefore that the source of the marble which was used in the construction of the sarcophagus from Larissa, is most probable from Cyclades and more particularly from Paros island. Carrara, Proconnesus and Alyki of Thasos are excluded because their characteristics vary from the Paros marbles and the studied sarcophagus sample. For the same reason, the local marble from Thessaly (for ancient quarrying see Melfos, 2013) is also excluded.

CONCLUSIONS

Combining all the presented data it is concluded that the raw material of the white marble used in the construction of the sarcophagus no. 1993/74 from Larissa, comes from Paros Island. This is well documented from the isotopic signatures, the mineralogical composition and the fact that Paros was a marble producing island during the Classical period.

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