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Characterisation of the white marble of two unpublished ancient Roman quarries on the Islands of Fourni and Skyros (Greece)

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ABSTRACT. — Most outcrops of good quality crystalline marble of the Mediterranean countries were exploited in Roman times for the production of blocks to be used for statuary and architectural elements. Hence, a wide variety of marble was employed and is now found in archaeological excavations. The precise determination of the provenance of a marble object is of great archaeological importance, and is obtained in most cases by the petrographic study of a thin section with analysis of the C and O stable isotopes. Despite of the fact that it is highly developed, the already existing petrographic and isotopic data base of the most important marbles used in antiquity is still insufficient because of the incomplete knowledge and study of all ancient quarries. The contribution of this research is to add new data on two unpublished small Roman quarries discovered on the Greek islands of Fourni and Skyros. The marbles quarried there are very pure and characterised by a low-grade metamorphism which produced a limited recrystallization on the marine limestone protoliths. The fabrics are quite distinctive; the marble from Fourni shows a strong lineation and traces of metamorphic stress while that of Skyros is characterised by a polygonal mosaic equilibrium-fabric. The isotopic data for the Fourni marbles vary from $\delta^{13}C_{PDB}$ = 3.8 to 4.9, and $\delta^{18}O_{PDB}$ = –2.7 to –3.9. The Skyros marble vary from $\delta^{13}C_{PDB}$ = 0.6 to 1.9, and $\delta^{18}O_{PDB}$ = –4.2 to –7.1. These data have been compared with those of similar marbles used in antiquity.

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RIASSUNTO. — La maggior parte degli affioramenti mediterranei di marmi cristallini di buona qualità vennero sfruttati in età romana come siti estrattivi di blocchi da utilizzare per statuaria ed elementi architettonici. Da questo fatto deriva la grande varietà di marmi che vengono trovati in scavi archeologici. La precisa determinazione della provenienza del marmo di un manufatto riveste una grande importanza archeologica, ed è attualmente ottenuta nella maggior parte dei casi mediante l'accoppiamento dello studio petrografico di sezioni sottili con l'analisi degli isotopi stabili del C e dell'O.

Nonostante la banca dati petrografica e isotopica dei più importanti marmi usati in antico sia molto sviluppata, essa è da considerare ancora insufficiente a causa della non completa conoscenza e studio di tutte le cave mediterranee antiche.

Il presente contributo consiste nell'incremento di tale banca con nuovi dati relativi a due piccole cave romane inedite scoperte nelle isole greche di Fourni e Skyros.

I marmi ivi estratti sono bianchi, molto puri e caratterizzati da un metamorfismo di basso grado che produsse una limitata ricristallizzazione dei due protoliti costituiti da calcari marini.

Le loro strutture sono risultate piuttosto

caratteristiche: quello di Fourni mostra una forte lineazione e tracce di stress metamorfico, mentre il marmo di Skyros evidenzia una struttura poligonale di equilibrio con numerosi punti tripli. I dati isotopici del marmo di Fourni variano da 3,8 a 4,9 di $\delta^{13}C_{PDB}$ e da –2,7 a –3,9 di $\delta^{18}O_{PDB}$.

Quelli del marmo di Skyros da 0,6 a 1,9 di $\delta^{13}C_{PDB}$ e da –4,2 a –7,1 di $\delta^{18}O_{PDB}$.

Questi dati sono stati confrontati con quelli di marmi simili usati in antico.

KEY WORDS: *Marble, ancient quarries, Fourni, Skyros, petrography, isotopes.*

INTRODUCTION

In recent years there has been considerable interest on the part of specialists working in several archaeometric laboratories around the world in the characterisation of the crystalline marbles used in ancient monuments and works of art. The main goal has been to create a reference data base which could enable the provenance of a marble artefact of historic and artistic value to be identified through simple and affordable scientific analyses. The importance of such an identification for archaeologists, architects and art historians, is based on the possibility of attributing an object to its producing atelier; on the indirect reconstruction of commercial connections and the paths of maritime or terrestrial routes; on the collection of data useful for the authentication of the artefact and, finally, on the finding of sources of the same marble for substitutions, restorations and copies. Many museums such as the Metropolitan Museum of Art (New York), the British Museum (London), the Louvre (Paris), the Musei Capitolini (Rome), the Ny Karlsberg Glyptotek (Copenhagen), and the AntikenMuseum Basel, have therefore started extensive campaigns of laboratory analyses for the identification of the marble forming the most important masterpieces in their collections.

At present there exists no single scientific methodology that guarantees the positive provenancing of a marble sample of unknown origin, and there has been very little research in the field of non-destructive methods (Careri *et al.*, 1992), which ideally should be preferred to those needing the removal of a sample. Instead, the combination of two (e.g. ESR and C and O-isotopes-analysis) or multiple, (e.g. trace elements, isotopic and petrographic analysis) destructive methods is currently used. Of all the above-mentioned combinations, the one which is most used, and most advanced in terms of developed data base is the petrographic study of thin sections and C and O isotopic analysis (Gorgoni *et al.*, in press). As regards these two databases, and in general those existing for all the other methods, it should be specified that they are all limited to the most important marbles exploited in antiquity, such as the Greek (Pentelic, Parian, Naxian, Thasian, Lesbian) the Microasiatic (Proconnesian, Dokymaean, Aphrodisian), and the Lunense (Carrara) marbles. Some data also exist on secondary qualities such as those from ancient Iberia and Gallia, etc., but they are not sufficient to cover all the possible sources of an ancient marble artefact. In classical times in fact, most outcrops of crystalline marbles, especially the good quality ones (compact, with homogeneous fabric and white colour, and possibly a fine grain-size), were exploited all around the Mediterranean, and travelled especially as blocks or half-worked pieces. Marbles with such good properties are quite common in the places cited above, and in many other localities of Asia Minor, Greece and North-Africa. Many of these have never been studied archaeometrically, thus making the source identification of a marble object often very difficult.

The lack of a complete scientific data base of reference for all the ancient Mediterranean marble quarries undoubtedly underlies this difficulty.

It is with the intention of expanding the petrographic and isotopic data base of the white marbles used in antiquity that the results of our analyses of the marbles of two small unpublished Roman quarries recently discovered on the Greek islands of Fourni and Skyros (fig. 1) are here presented, together with other information of archaeological and historical interest.

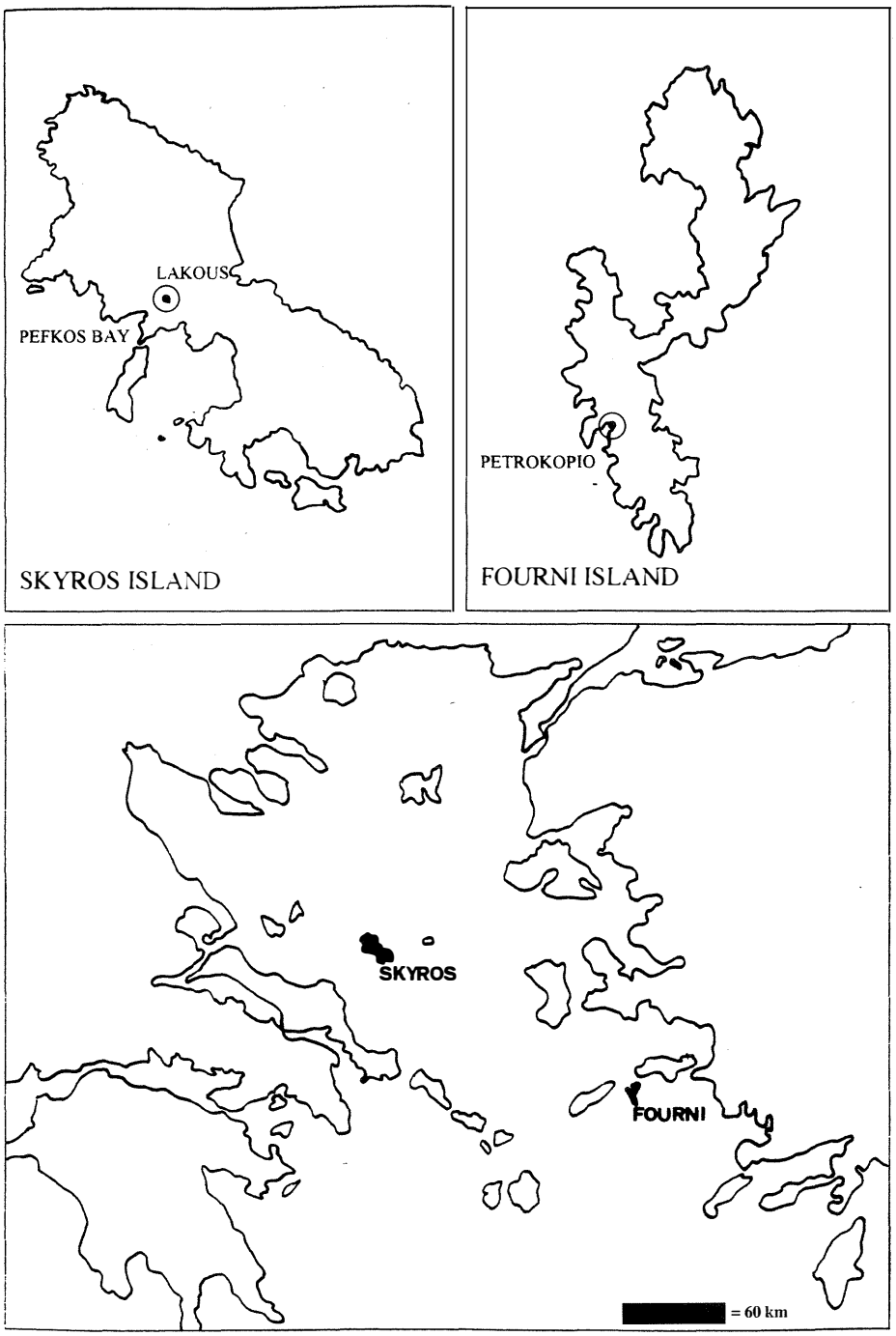

Fig. 1 – Map with the locations of the ancient Roman quarries on the Island of Fourni and Skyros.

THE MARBLE OF FOURNI: RESULTS AND DISCUSSION

Fourni is a very small Island (30 km^2) in the Eastern Aegean Sea between the larger islands of Samos and Ikaria (fig. 1). Given its favourable position it has been frequented and inhabited since very ancient times. It is quite certain that in classical times it was under the dominion of the Samians, and then of the Romans, but nothing is left that dates from these periods. Very little is also known of its geology, and it still has no detailed geological map.

Geologically the island of Fourni belongs to the Pelagonian zone and is formed by terrains dating to the Trias (limestones-epimetamorphites) (Georgalas, 1924; Koehne, 1937). The main formations are mostly made of metamorphic rocks such as marbles, calcschists, chlorito-and-micaschists, and phyllites. The marbles are present in the NE and SW areas of the island (Jacobshagen, 1986), and are most probably related to the larger marble-outcrops of the islands of Ikaria and Samos, and of Mount Mykale in Turkey. The latter two were exploited by the Greeks since archaic times, as demonstrated for example by the kouroi (statues of naked youths) in the Archaeological Museum of Pitagorio (Samos) and by all the architectural elements of the temple of Athena Polias still visible at the ancient town of Priene. The marble of Samos has never been studied archaeometrically; that of Priene was investigated petrographycally and for its Ca/Sr ratio (Lazzarini *et al.*, 1980).

Nothing is known about the marble of Fourni: there are no ancient sources or modern studies on it, its use and characteristics. An ancient quarry was worked into the outcrop around the bay of Petrokopiò in the SW of the island, very close to the sea. The quarry is partly filled by collapsed material. The preserved part is small, being some 25 m long, with a front of 10 m maximum height with numerous and nicely preserved cutting marks (fig. 2) of the types left by a «heavy pick» (Waelkens, 1992). These, the presence of many unfinished and half-finished squared blocks, column-shafts, sarcophagi, with dimensions related to the Roman foot (29.6 cm), together with Roman potsherds scattered on the surface of the quarry area, are evidence of a Roman exploitation of this quarry. Most of the unfinished artefacts are gathered near the sea (fig. 3) where they were transported to be ready for a shipment that never took place. Measurements of some of the pieces (in cm) are as follows:

– 3 fragments of column shafts and drums (fig. 3): 1) length = 90, diameter = 105; 2) 90 × 185; 3) 187 × 85. The second, and largest of these drums, may have been prepared for the cutting of «rotae» (disks) for flooring.

– squared blocks (fig. 3): 102 × 332 × 71; 98 × 127 × 75; 120 × 120 × 120; L-shaped block: thickness = 62 × 150 (long side) × 210 (short side) × 90 (two ends of the L)

– sarcophagus (fig. 4): length = 336, height = 100, width = 130.

Considering their half-finished state, these are more or less multiples of 30 cm.

Point chisels and quarry picks were used to square the pieces on site in order to avoid any excess load. This is also demonstrated by the presence of several deposits of debris still containing small blocks and column shafts (fig. 5) at various stages of shaping. Quite remarkable is the presence of an unfinished sarcophagus which features an area in relief at the centre of the coffin prepared for an eventual inscription. Also to be noted is the presence on the site of a «gournià», a sort of small carved box made of marble which was filled with water and used for tempering the iron tools. Buried in the water in front of the quarry there are also several squared blocks and other half-finished pieces testifying to the lower sea level in ancient times.

The marble quarried at Petrokopiò is of good quality, showing a white colour mass (Munsell Neutral Scale = 9) (Munsell, 1967) with frequent stripes of a milky-white (M. N. S. = 9.5), or yellowish colour, and rarer gray spots (M.N.S. = 8.5). Its compactness and very fine grain-size must have made it easy to work, sculpt and polish.

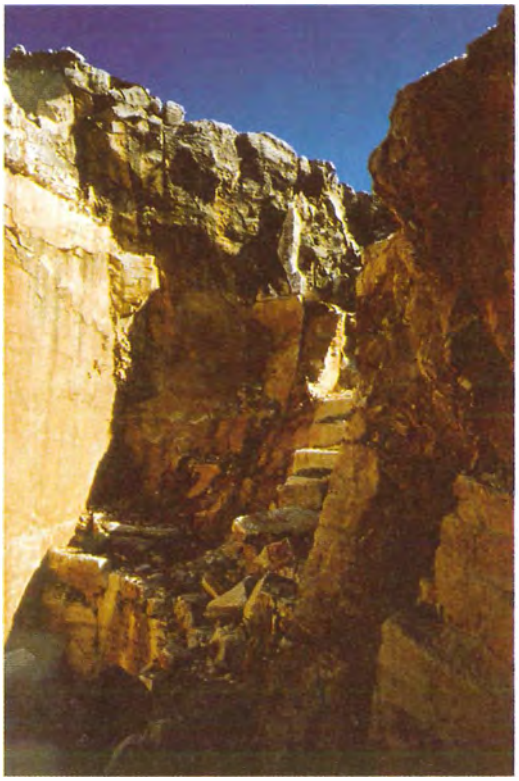

Fig. 2 – The ancient front of the quarry at Fourni with marks of the heavy pick to the right.

Fig. 3 – The quarry yard by the sea with accumulated ancient shaped marble blocks.

Fig. 4 – Fourni: the unfinished Roman sarcophagus.

Fig. 5 – Foruni: detail of quarry-debris including small squared blocks and shaped columns.

This marble has never been studied scientifically and is not included among the Cycladic and other Greek marbles so far studied archaeometrically (Herz, 1992, Gorgoni *et al.*, in press).

Considering the quite limited size of the quarry and the homogeneity of the marble, 6 small samples were taken from different areas, and 1 (sample F7) from an ancient block. These samples were then subjected to petrographic

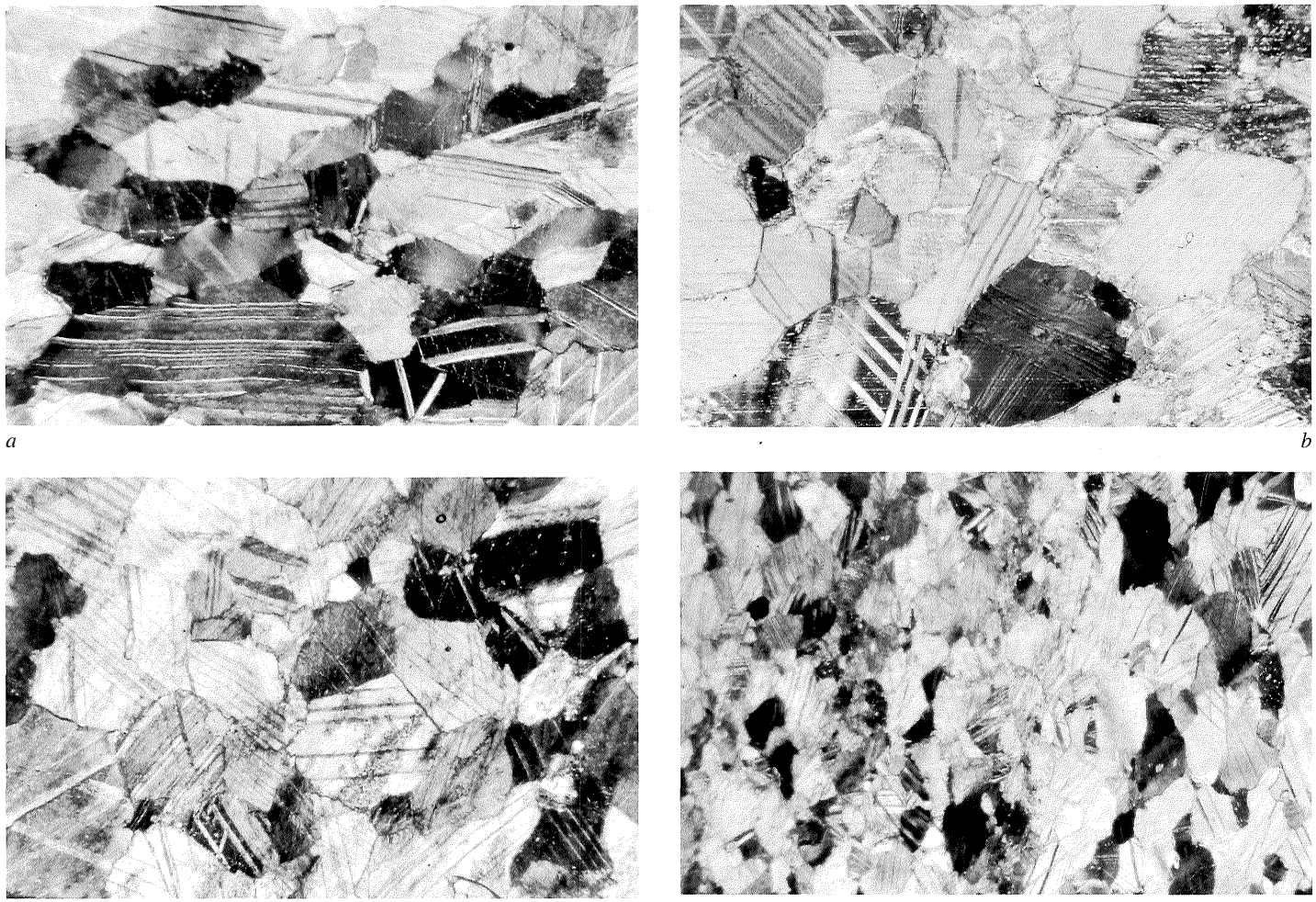

Fig. 6 – Photomicrographs (N +, 40 ×) of thin sections of the marble of Fourni showing: *a*) the fabric parallel to the E-W lineation; *b*) the fabric perpendicularly to the lineation; *c*) a weak deformation in the polysynthetic twinning and a quartz crystal; *d*) a zone with fine grain size and a N-S oriented fabric.

analysis in thin section, X-Ray diffraction and 5 of them to isotopic analysis (McCrea, 1950). The results obtained are summarized in table 1.

Under the microscope the marble shows a heteroblastic, sometimes homeoblastic lineated fabric (Table 1) formed by frequently iso-oriented calcite crystals (fig. 6*a*) accompanied by small trains of K-mica (sericite) and concentrated veins formed by black particles of carbonaceous matter. The calcite crystals feature mainly curved boundaries, with rarer straight ones (fig. 6*b*) sometimes forming triple points. The frequent deformation on the traces of polysynthetic twining are indicative of some metamorphic stress (fig. 6*c*). The average grain size (determined by measuring a large number of crystal' diameters) is around 0.6 mm, also because of the frequent presence of zones with very fine grain (fig. 6*d*); the MGS (Maximum Grain Size), an important fingerprinting parameter (Moens *et al.*, 1988) varies from 0.75 to 2.10 mm. The relative (internal) amount

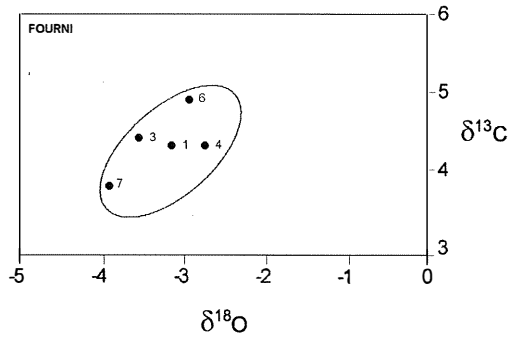

Fig. 7 – The isotopic signature of the marble of Fourni.

of accessory minerals is also reported in Table 1. They comprise quartz (sometimes hydioblastic and including small needles of rutile), K-mica in tiny needles, pyrite and frequently associated small limonitic masses. Three samples (nos. 2, 5 and 7) gave traces of dolomite by X-Ray diffraction. The isotopic

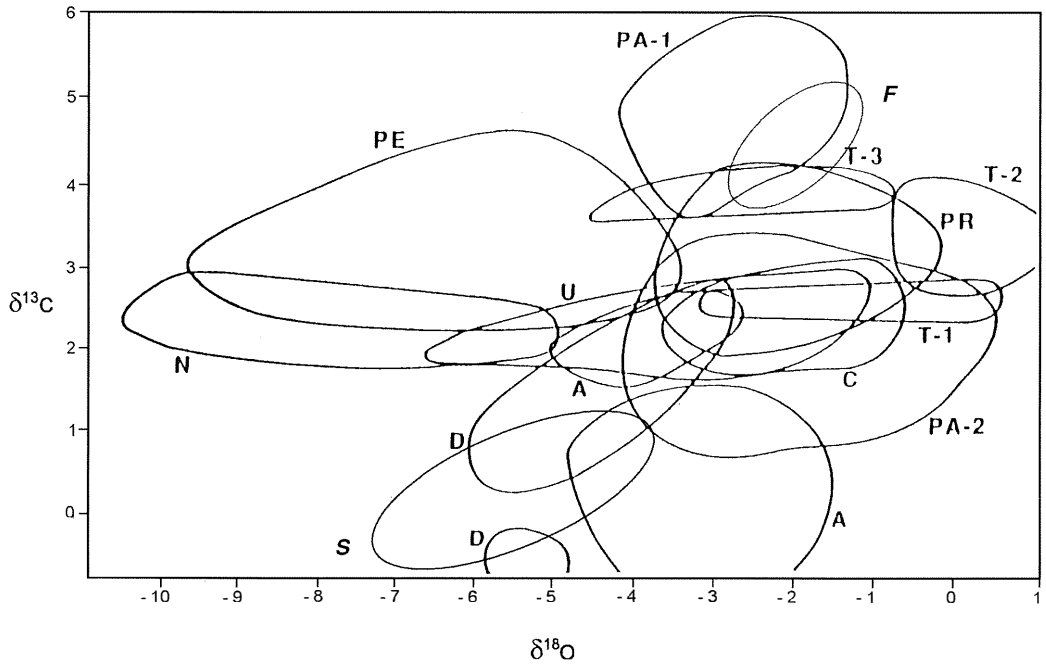

Fig. 8 – Fourni (*F*) and Skyros (*S*) $\delta^{13}C$ *vs* $\delta^{18}O$ variation ranges. Fields of the most important marbles used in antiquity are plotted for compìarison. N = Naxos; PE = Mount Penteli; S = Skyros; D = Dokymeion; A = Aphrodisias; U = Usak; PA-1 = Paros Stephani; PA-2 = Paros Lakkoi; C = Carrara; T-1/3 = Thasos; F = Fourni; PR = Marmara.

TABLE 1

Petrographic and isotopic data of the white marbles from Fourni and Skyros (Greece).

QUARRY	Sample	C.I.	Qz	M	C	O.M.	D	A.g.s.	M.g.s.	C.c.b.	F		$\delta^{13}C$	$\delta^{18}O$
FOURNI	Fl	9	±	+	++	±		0.68	2.10	CURVED	HE	STRONGLY LINEATED WITH DEF.TWINS	4.3	-3.1
"	F2	9		±	++	±	±	0.66	1.31	"	HE	"		
"	F3	9		+	++	±		0.60	0.75	CURVED-STRAIGHT	HE/HO	STRONGLY LINEATED WITH LEVEL FINE GR.	4.4	-3,5
"	F4	9	±	±	+	±		/	1.22	CURVED-STRAIGHT	HE/HO	"	4.3	-2.7
"	F5	9	±	±	+++		±	0.61	1.14	CURVED	HE/HO	"		
"	F6	8.5	±	±	+++			0.44	0.82	"	HE	WEAKLY LINEATED WITH DEF. TWINS	4.9	-2.9
"	F7	9		±	+++	+	±	0.55	1.20	"	HE	STRONGLY "	3.8	-3.9
SKYROS	P1	9		±	+		+	/	0.48	CURVED	HE/HO	WITH FINE-GRAINED LEVELS	0.6	-7.1
"	S1	9				±	+	/	1.60	"	HE/HO	"		
"	P2	9.5			+			0.14	1.76	CURVED-STRAIGHT	HO	POLYGONAL, WITH TRIPLE POINTS		
"	P3	8.5			±			0.16	1.98	STRAIGHT TO CURVED	HO	"		
"	P4	9.5		±	++	±		0.12	0.41	"	HO/HE	POLYGONAL WITH FINE-GR. AREAS	1.9	-4.2
"	P5	9.5		++	+++			0.16	3.20	"	HO	"	1.6	-4.6
"	P6	9.5			±			0.15	0.26	"	HO	POLYGONAL WITH TRIPLE POINTS	1.4	-4.8
"	P7	8.0			+			0.18	0.52	CURVED	HO	POLYGONAL WITH WEAK LINEATION		
"	P8	9.5			+	±		0.12	0.56	CURVED TO STRAIGHT	HO	POLYGONAL WITH TRIPLE POINTS	1.4	-4.9
"	P9	9.5			+			0.14	0.32	"	HO	"		
"	P10	9.0			+			0.14	0.31	STRAIGHT TO CURVED	HO	"		

C.I. = colour index according to Munsell, 1967; Qz = quartz; M = Potassic Mica; C = carbonaceous matter or graphite; O.M. opaque minerals; D = dolomite (detected by x-ray diffraction method); A.g.s. = average grain size (mm^2); M.g.s. - maximum grain size (mm^2); C.c.b. = calcite crystal boundaries; F = fabric; HE = hteroblastic; HO = homeoblastic; ± trace; + = present; ++ = abundant; +++ = very abundant.

results expressed in the PDB standard (Table 1) show a variation of $\delta^{13}C$ from 3.8 to 4.9, and of $\delta^{18}O$ from –2.7 to –3.9 (fig. 7).

This marble should be considered as a product of localized low-grade (low-T, high-P) regional metamorphic processes which took place on pure marine limestones in the «green-schist» facies. Comparing the petrographic and isotopic data of the Fourni marble with similar fine-grained marbles used in antiquity (fig. 8), namely those from the ancient town of Docimium (Iscehisar, province of Afyon, Turkey), from the island of Paros (Central Aegean Sea, Greece), Mount Penteli (Athens, Greece), and from Luni (Carrara, Italy), one may remark that:

– petrographically the marble of Fourni is quite distinct from all the other cited ones: its lineated fabric makes it distinguishable from those of Docimium, Paros and Luni. Pentelic marble is quite similar to ours, but it has a larger average grain size (around 0.9 mm) and a much higher amount of accessory minerals, namely k-mica and chlorite. The marble of Priene is always of grey colour, with a coarser grain size and a larger M.G.S.

– isotopically it may be confused only with the marbles from Thasos (Thasos-3) and Paros-Stefani (Paros-1).

In conclusion, combining the petrographic and isotopic data, the marble of Fourni is well separated from all the similar important marbles of antiquity considered above.

THE MARBLE OF SKYROS: RESULTS AND DISCUSSION

Skyros is one of the several Islands belonging to the Sporades archipelago situated in the North-Western Aegean Sea (fig. 1). It is quite small (210 km^2), and hilly, but well situated geographically on the route from the Eastern and Northern Aegean to the Island of Euboea and Attica. It was inhabited from proto-historic times (Sapouna-Sakellaraki, 1998) and became a flourishing place in Greek times. The Roman consul Sulla conquered it in 86 B.C., and not long after the island became very productive for Rome. The Augustan period marked the start of the exploitation of a beautiful polychrome carbonate breccia which is commonly called Marmor Scyrium or «Scyreticum», and «Breccia di Settebasi» (Lazzarini, 1999). The former name appears on a fragment of the famous edict on the price of various goods issued by the emperor Diocletian in 301 (Gnoli, 1988), where the marble is listed at the rather cheap cost of 40 denarii (silver coins) per cubic foot. The low price may be explained by the fall in the cost of marble that occurred in Rome in the IV c. following the considerable stockpiling of marbles at the «statio marmorum» (marble-yard) of Ostia and the beginning of the decadence of the capital. Another possible explanation is that this price did not relate to the breccia (which in theory should have been more expensive, at least 150 «denarii», like other decorative stones such as the very similar «Marmor Lucullaeum», which anyway was no longer available at the time of the edict), but to the white marble that will be described here. White and gray marbles, like the Proconnesian and the Lesbian are in fact listed at 40 and 50 «denarii» respectively. Their low price, like that of the Skyros marble was justified by the availability of large quantities and by the location of their quarries close to the sea, which made transportation and shipment to all Mediterranean destinations very easy. Strabo (IX, 5, 16) also offers evidence of the different costs of white and coloured marbles by indirectly stressing the importance of the latter. Finally, we may consider the white Skyrian marble as a cheap substitute for more prestigious white, similarly fine-grained Greek marbles like the Parian and Pentelic.

As in the case of the Fourni marble, we know nothing about the history of the use, diffusion, etc., of the marble from Skyros, except that it was used locally from archaic times for statuary (examples are in the archaeological museum of Skyros), and in the classical period for architectural elements as in the temple dedicated to Apollo at Chora (Defner, 1923). Judging by the size of existing ancient quarries,

and by the artefacts left on the island, the use in Roman times increased considerably, probably leading to exportation.

The geology of the island of Skyros is quite complex, as is immediately evident from the study of the geological map published by IGME, the Hellenic Geological and Metallogenic Institute, (Jacobshagen and Matarangas, 1972). The outcropping formations range from igneous rocks (peridotites, dunites, andesites, dacites, spilites and tuffs) of the Lower Tertiary, to sedimentary rocks (limestones, marls, sandstones, flysch, etc.) dating from the Permian-Carboniferous to the Neogene, to the volumetrically dominant metamorphic rocks (gneiss, phyllites, schists of various types, calcite-dolomite-marbles, serpentinites, ophicalcites) dating from the Middle Triassic to the Upper Cretaceous. According to Melentis (1973), the island belongs to the Pelagonian zone of the Hellenides, more precisely to the Eohellenic Tectonic Nappe, and roughly consists of a basement formed by gneiss and mica-schists, overlain by a phyllite series. The marbles lie in structural conformity above the phyllites. The Upper Cretaceous limestones generally overlie the basement and the marbles transgressively, both locally penetrated by ultrabasic intrusions and serpentinites, while small bodies of andesite intruded into the limestones in few places.

The calcite-dolomite marble occupies a very large part of the island and has an estimated thickness of 1000 m. It dates to the Middle Triassic-Jurassic (?) and includes fine-grained to coarse marbles, mostly thick bedded, with colours varying from pure white to dark gray, and polychrome meta-breccias. The latter were extensively quarried in Roman times in various parts of the island (Aghios Panteleimon, Treis Boukes, Kourisies: Lazzarini, 1999) and on small islets like Balaxa, Rinia and Skiropoula (Defner, 1923; Dworakowska, 1972), and have already been the subject of an archaeometric study (Lazzarini and Turi, 1999).

Of the limestones, only a small portion has been transformed into a marble and/or has the necessary characteristics to be used as dimension material, namely the marble outcropping in the area to the North of the Bay of Pefkos (fig. 1). In this area numerous quarries were open in Roman times, mostly for the exploitation of the breccia, but also for the production of a beautiful white, fine-grained marble used locally for columns and other architectural elements, table pedestals, tubs, some of which, as mentioned above, were very likely exported: this should be proved by archaeometric analysis. Unfortunately the ancient quarries have been extensively destroyed in recent years by the intensive modern extractive activity carried out since the early 1900s. There exist several small ancient quarries from which a nice pure-white, fine-grained marble was extracted in Roman times in the area called Bounò (= mount) and on the islet of Kolouri, both to the NW of Agh. Panteleimon. The main extractive area was that still called Kolones from the Roman columns found there, where Defner visited several ancient quarries in 1923, some of which contained cisterns and traces of aqueducts and settlements. The largest of these quarries is in a place called Lakous. It is unfortunately still productive and is therefore undergoing the complete destruction of the ancient traces of exploitation. The quarry is situated on Mount Dekatria, at about 260 m above sea level and forms a sort of amphitheatre open to the E-NE. It is quite large, being some 150 m long with a front of 20-30 m high (fig. 9). It yields a beautiful white marble in the lower levels, with occasional thin yellow veins and grey spots, and a more homogeneous white-greyish marble in the upper ones. These colours are connected to concentrated fine particles of limonite and carbonaceous matter respectively. By 1997 only some parts of the quarry (to the extreme lower left, fig. 10) still retained the typical chevron-like quarry marks of ancient exploitation left by the use of a Roman heavy pick, the rest being much modified by modern cutting of the marble with diamond wire and explosives. During recent operations to clear the quarry area of the ancient debris, a large number of Roman

Fig. 9 – The ancient quarry of Lakous at Skyros with evidence, in the foreground, of modern exploitation.

Fig. 10 – The left part of the quarry with the best preserved traces of Roman exploitation.

Fig. 11 – An ancient column left at the quarry.

Fig. 12 – The deposit of ancient blocks at the marble workshop.

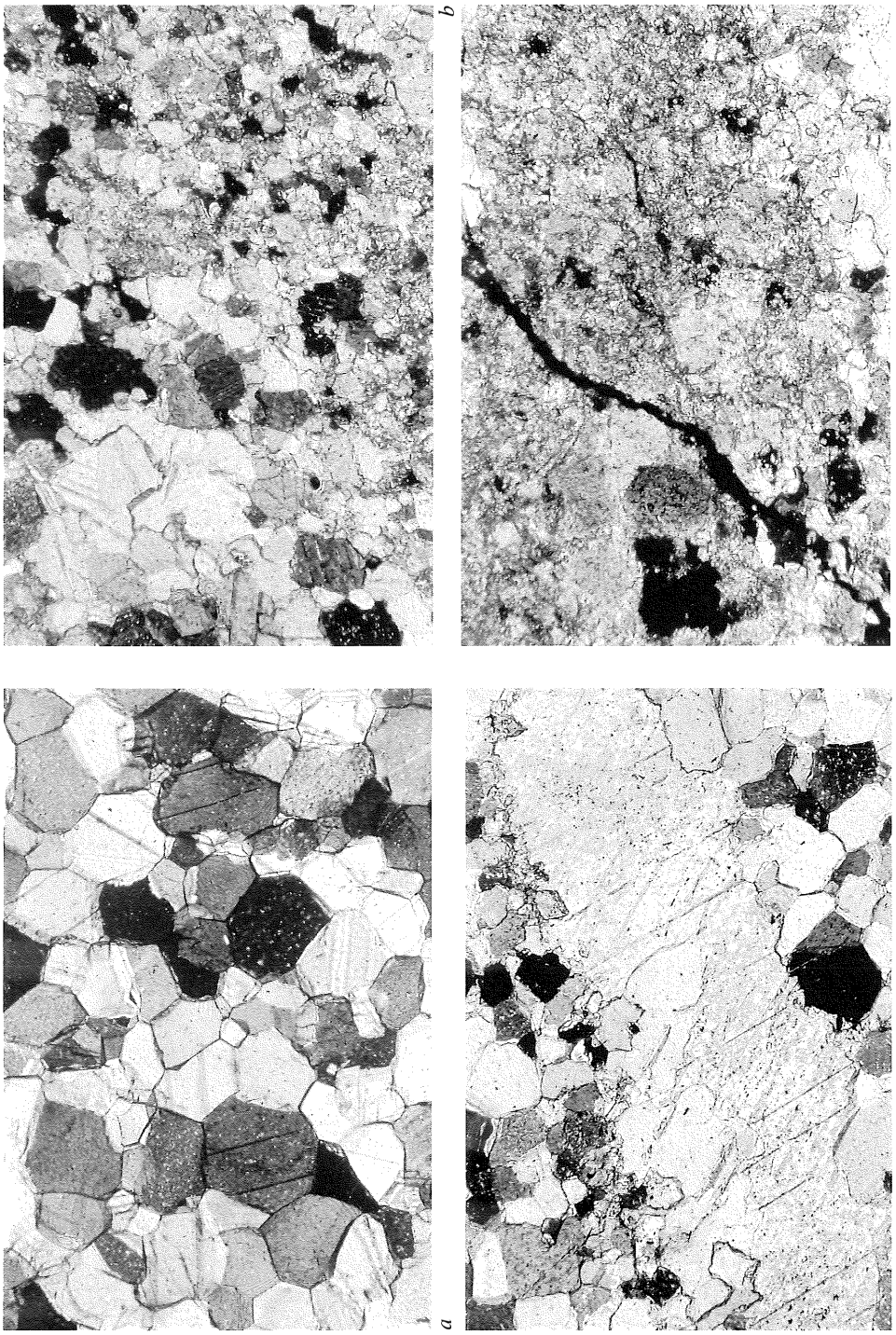

Fig. 13 – Photomicrographs (N +, 80 ×) of thin sections of the marble of Skyros showing: *a*) a perfect homeoblastic polygonal fabric with abundant triple points; *b*) a zone with very fine grain size; *c*) a porphyroblast of calcite; *d*) a weakly recrystallised zone with relics of the protolith still showing a stylolith with stylo-cumulated carbonaceous particles.

squared blocks were found: a few of them (two small columns and some squared blocks) were still lying on the site (fig. 11), others had been cut into slabs in past years, and some had accumulated in the yards of the marble workshop of the quarry owner (fig. 12), together with a few blocks of breccia. Some blocks show the typical stepped shape of blocks prepared for the cutting of slabs. The dimensions of some of these blocks (considered as whole pieces), of other rectangular ones, and of a fragmentary column, are:

78 × 104 × 255; 80 × 95 × 220; 80 × 90 × 220; 80 × 90 × 280; 89 × 96 × 251; 64 × 69 × 170; 62 × 74 × 155; 71 × 80 × 182; 90 × 111 × 211; 92 × 109 × 208; column: 128 × 52 (d.).

A lot of breccia and marble was quarried after the First World War by the British company Marmor Limited, and intense exploitation continued for several decades: since the island had specialised stonecutters it also served as a worksite and deposit for blocks of other stones (like the ophicalcite of Tinos) to be shipped for the Greek and international market. The port of Pefkos, very close to the quarrying area of Agh. Panteleimon, was where the marble was shipped from in Roman and recent times; many squared blocks are still accumulated there: their dimensions are indicative of the period of extraction.

A total of 10 samples were taken from different parts of the quarry of Lakous and from the ancient debris and blocks: they were subjected to the same analyses as above.

The results of the petrographic and isotopic analyses are collected in Table 1. In general the marble of Skyros is very compact and homogeneously pure-white (M.N.S. = 9.5), but sometimes it shows thin yellow or pinkish veins, and grey spots (M.N.S. = 8/8.5). The average grain size is very small (around 0.15 mm); the M.G.S. varies from 0.26 to 3.20 mm. The fabric is mostly homeoblastic, of polygonal type with abundant triple points formed by calcite crystals with straight boundaries (fig. 13*a*). Sometimes present are

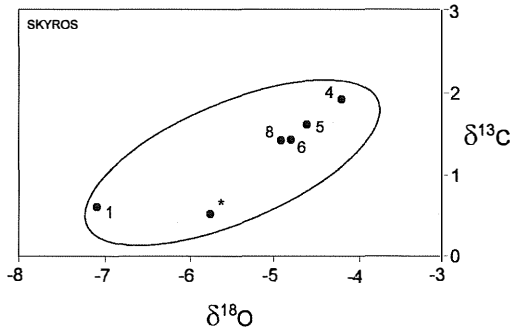

Fig. 14 – The isotopic signature of the marble of Skyros (* from literature, Lazzarini and Turi, 1999).

zones with very fine grain size (fig. 13*b*), and rare, isolated porphyroblasts of calcite (fig. 13*c*) often showing slightly bent polysynthetic twins. Apart from traces of K-mica, iron ore minerals (mostly limonite and hematite) and carbonaceous particles (fig. 13*d*), this marble is remarkably pure calcite (only two samples showed the presence of dolomite). The isotopic analysis of 5 samples gave $\delta^{13}C$ ranging from 0.6 to 1.9, and $\delta^{18}O$ from –4.2 and –7.1. To these isotopic data may be added two other published analyses (Lazzarini and Turi, 1999) relating to a sample of white marble from a unknown modern quarry of Skyros ($\delta^{13}C$ = 0.50, $\delta^{18}O$ = –5.75), and to a sample of grey marble taken from an outcrop close to the Bay of Achilles ($\delta^{13}C$ = 1.0, $\delta^{18}O$ = –11.8).

Like that of Fourni, the Skyrian marble should be considered the product of a low grade metamorphism mainly producing a weak recrystallisation of calcite.

Comparing these results with the same selection of similar marbles used in antiquity and cited above for Fourni, (Table 1, fig. 8) it is noticeable that:

– petrographically, the white marble from Skyros is unique for its very regular equilibrium- polygonal fabric and very fine grain size. This fabric makes it easily distinguishable from the marbles of Docimium, Paros, Mount Penteli and that of Fourni, while it may sometimes be confused with that of Luni, but its finer grain size and larger M.G.S.

are quite distinctive also with respect to this last material

– isotopically, the field of Skyrian marble partly overlaps those of the marbles from Docimium, Aphrodisias, Naxos and Usak (fig. 8).

Again, as for the marble of Fourni, by combining the petrographic and isotopic data one can easily distinguish the white marble of Skyros from all the marbles mentioned above.

In conclusion, we are confident that the characterisation of the marble of the two quarries of Petrokopiò (Fourni) and Lakous (Skyros) will make it possible not only to identify these marbles among the white ones used in the Eastern Aegean area, but also to determine whether marble was exported from these two islands.

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