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ORIGINAL PAPER

Characterization of stone artifacts from the Middle and Late Neolithic to the Chalcolithic deposits of Drakaina Cave, Kephalonia, Ionian Islands: a mineralogical-geochemical approach for determination of local and "exotic" raw materials and their sources

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Abstract
This work presents the results of the mineralogical, petrographic, and geochemical study carried out on representative samples from the large assemblage of the Neolithic stone artifacts found in Drakaina Cave, at Kephalonia island, western Greece. The aim of this study is the determination of the raw materials used for the manufacture of lithic/stone implements, as well as their possible sources. Of the artifacts under study, the chipped stone tools were manufactured on cherts from local sources, while the ground stone edged tools on gabbro and the discoid stone beads on talc, both imported in the Ionian Islands. Geochemical analyses indicate that the most probable source for the gabbro artifacts is the Pindos Mountains. Limestones and sandstones, used by the Neolithic stone workers for the production of various ground stone tools, such as grinding slabs, grinders, abraders, polishers and hammer stones, were acquired exclusively from local sources, as they are the predominant rock types of the island. The raw material for the manufacture of a zoomorphic vessel of white marble was most probably originated from Naxos, an island of the Cyclades complex in the south Aegean Sea.

Keywords Neolithic stone artifacts · Lithic tools · Raw materials · Provenance study

Introduction

An essential part of the interdisciplinary archeological investigation is the provenance study of stone artifacts. Identification of raw materials and their sources is of significant importance in order to approach and understand the knowledge and the experience of prehistoric communities on material practices and exploitation of the natural resources in dynamic landscapes (Stratouli 2005). Early farmers manufactured their tools using minerals and rocks, procured through various ways, like the direct exploitation of local resources, e.g., stream and river sediments, rock outcrops and quarries, or via indirect methods, such as the participation in various social and exchange networks (Melfos et al. 2001; Melfos and Stratouli 2002; D'Amico 2005; Perlès et al. 2011; Gluhak and Rosenberg 2013; Richter et al. 2013; Andreeva et al. 2014; Melfos and Stratouli 2016; Bekiaris et al. 2017). Provenance studies based on detailed petrographic and geochemical analyses can provide a useful indicator for the movements and contacts of prehistoric people as well as for the technological processes (Melfos and Stratouli 2002; Lerner et al. 2007; Sario 2013; Melfos and Stratouli 2016).

Kephalonia island is one of the best places for studying the use of mineral resources during prehistory; furthermore, due to the monotonous geological context (Fig. 1), it is fairly easy to distinguish the local from the "exotic" raw materials (Stratouli and Melfos 2008; Stratouli et al. 2014; Melfos and

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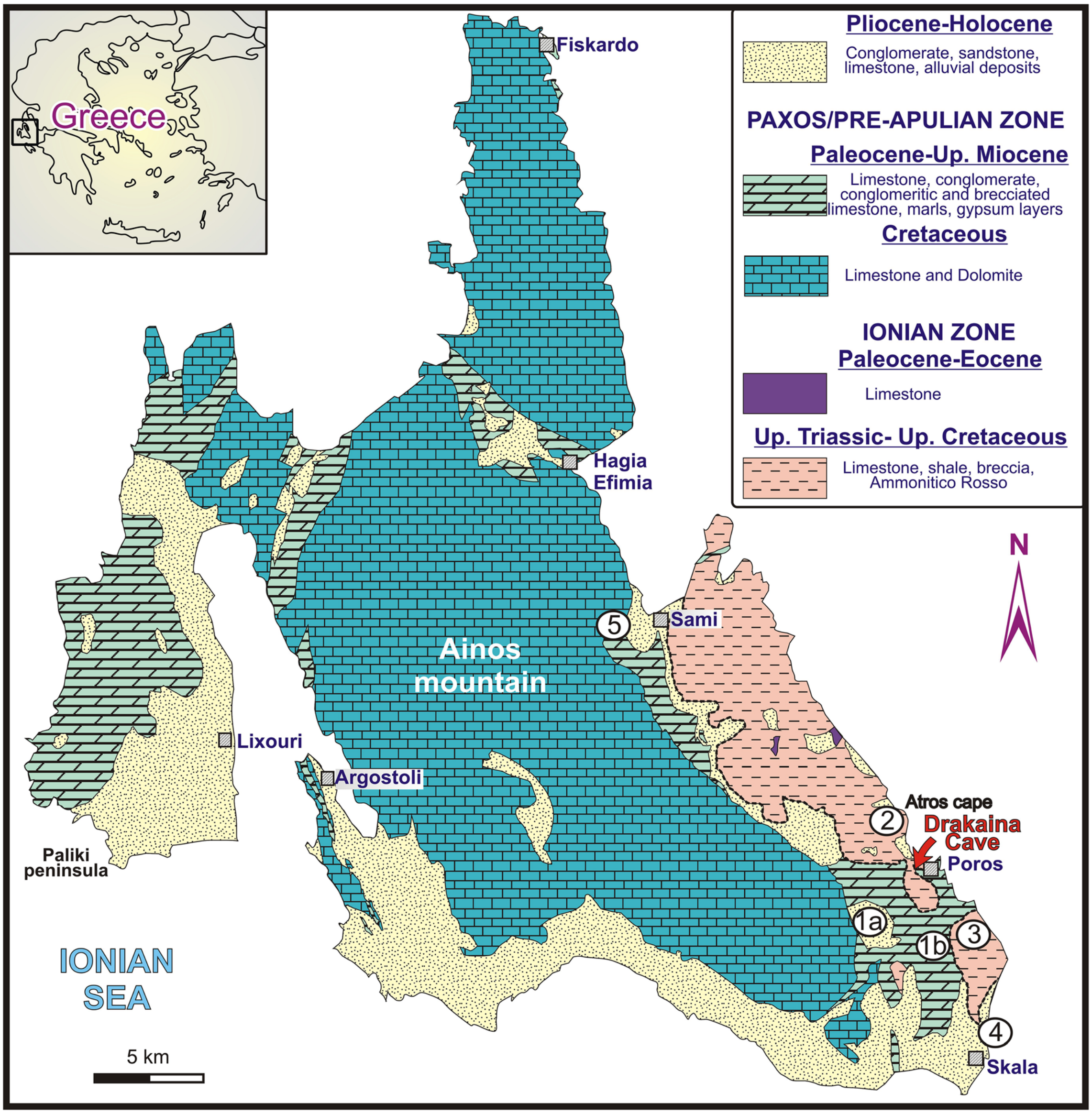


Fig. 1 Simplified geological map of Kephalonia (modified after British Petroleum Co et al. 1985; Lekkas et al. 2001). Drakaina Cave and the sampled geological occurrences of cherts (1–5) are also displayed. 1a Kampitsata; 1b Anninata; 2 Atros cape; 3 Megali Rachi hill; 4 Skala; 5 Sami

Stratouli 2016). Kephalonia is located in the Ionian sea of Western Greece and was inhabited since the Middle Palaeolithic or even the Lower Palaeolithic period (Cubuk 1976; Kavvadias 1984; Foss 2002; Tourloukis 2010; Runnels 2014). According to Kavvadias (1984), Foss (2002) and Runnels (2014, and references therein) stone tools from that period have been found at Fiskardo, Skala, Mounta, Agios Gergios, Poros, Argostoli, Spilaio, and Sami (Fig. 1), produced by chert of possible local origin.

There are not any direct dating results on these findings, but Runnels (2014) suggests that Fiskardo tools may be older than 100 kyr. Furthermore, according to Cubuk (1976) the stone pebble “industry” found at Skala could be dated in the Lower Palaeolithic. Foss (2002) studied various prehistoric sites at Kephalonia and concluded that the used lithic resources in prehistory have been exploited during the following three periods: the late Middle Palaeolithic, the Late and the Final Neolithic and the early Bronze age.

The paper focuses on the study of representative samples from the large number of lithic implements from the Middle, the Late Neolithic and the Chalcolithic (ca. 5600–3700 cal BC) deposits of Drakaina Cave. It is a small limestone cavity along the Vochynas gorge within the area of Poros, a village on the SE littoral of Kephalonia (Fig. 1); Drakaina has provided important information on the exploitation of the resources, in particular the range of lithic raw materials used for specific purposes by its Neolithic occupants (Stratouli and Melfos 2008; Stratouli et al. 2014; Melfos and

Stratouli 2016). The study aims at the determination of the raw materials used for the manufacture of the stone tools, their mineralogical and geochemical properties as well as their possible sources. This allows for significant conclusions concerning the specific rock types used by the Neolithic people in the area of Drakaina Cave ca. 7500–5700 years ago, the locations for the raw material procurement, the distances of transportation and the networks of exchange and communication among different communities.

Archeological background

Drakaina Cave, lying at an altitude of ca. 70 m, is situated on the steep cliffs of the Vochynas gorge, close to the south-eastern coast of Kephalonia and within the area of the village of Poros (Tab. 1, Fig. 2). At this time, Drakaina forms an open shallow cavity with a sheltered area of ca. 90 m^2. A dispersal of a number of limestone blocks on the terrace in front of the cave as well as within its fill is evidence for several episodes of roof collapse (Fig. 3). The gorge connects the inner part of the island, in particular the proximate Tzannata Basin, rich in varied micro-environments and resources, with the nearby littoral, which opposes the adjacent mainland. Excavations at Drakaina Cave were carried out over an area of ca. 48 m^2 by the Ephorate of Palaeoanthropology-Speleology of the Greek Ministry of Culture, mostly under the directionship of Dr. Georgia Stratouli on the topic of the prehistoric deposits of the cave, between 1992–1996, 1999–2002, and 2004–2005 (Fig. 3).

The use of the cave covers two distinct chronological periods, separated by a long void (Fig. 4).The uppermost part of the site sequence comprises archeological layers (ca. 0.20–0.40 m thick), dated from the late seventh to the early second century BC, when the site served as a shrine dedicated mainly to the Nymphs (Chatziotou and Stratouli 2000). The cultural layers dated to the prehistoric period have been dated to two main phases: a transitional Middle/Late Neolithic and a Late Neolithic I phase, that is Drakaina I (ca. 5600–4900/4800 cal BC), and a Late Neolithic II phase (or Chalcolithic/CH, including the Final Neolithic), that is Drakaina II (ca. 4900/4800–3700 cal BC). Several aspects of the Late Neolithic I and the Late Neolithic II cultural record of the cave, along with the importance of the Drakaina's location, point to the outstanding role of the cave during that period as a locus of social activity, in particular of social gatherings, periodically hosted in Drakaina Cave (Stratouli and Metaxas 2017, 2018).

One of the peculiarities found in the Neolithic sequence of the cave is a succession of several hard whitish-looking surfaces, dated mostly to the Drakaina II phase (Fig. 4). Through micromorphological analysis they were identified as lime plastered floors (Karkanas and Stratouli 2008). These stable constructions occurred at intervals and showed a remarkable consistency in materials and techniques over a time span of almost a millennium. In addition, the occupational deposits of the cave exhibit in situ preserved remains of hearths, as well as material of several raked-out fire installations mixed with burnt food remains.

Besides the unusual and remarkable practice for cave sites of setting a series of lime plastered floors, there is evidence for consumption on-site of various foodstuffs (Stratouli et al. 2014). It is notable that cereals and legumes reached the cave already processed and ready for consumption, while the bones of domesticates are dominated by selected body parts of high nutritional yield (Stratouli et al. 2014).

Moreover, the Neolithic deposits of Drakaina contained a plethora of pottery: this includes a variety of wares, such as black burnished, incised (Fig. 5), urfirnis, and dark-on-light, along with parts from at least seven zoomorphic four-legged rhyta, all characteristic of the Drakaina I occupation phase; the late vessel type is considered as having been used in a ritual context (Mlekuž 2007). A number of *c.* ten very fragmented pithoid vessels with plastic decoration as well as polychrome (Fig. 6) and crusted wares occur at Drakaina II phase. Worth mentioning is the high fragmentation of the LN pottery at Drakaina, evidenced mainly for the decorated wares, which is pointing to practices of deliberate breakage and/or partially on-site deposition.

Other categories of material were represented in abundance in the Neolithic deposits of Drakaina Cave as well, such as ca. 550 chipped stone formal tools and more than 10,500 knapping by-products of the chert manufacture. A striking feature of the cave's chipped stone assemblage is the large number of at least 213 projectile points (Fig. 7); they have been indicative of recurrent social gatherings in Drakaina with symbolic or ritual implications.

Further, notable is the sizable assemblage of ca. 440 ground stone implements; they were used for various tasks, like food preparation, pigment processing (Fig. 8) and chert knapping. It seems likely, their life cycle ended with the completion of certain activities at the site (Bekiaris 2010), in similar ways as evident in other categories of material, such as pottery, chipped tools and ornaments, e.g., a large number of beads made of both, local molluscs and imported talc.

To be considered are the *Spondylus gaederopus* bracelets found in Drakaina. Eight fragments, dated to the early Late Neolithic I phase, belong to between four and six bracelets, which could be locally made. They were burned and discarded as part of a single event, since all fragments were found in the same layer and trench.

Imported artifacts (or their rocks) include gabbro and dolerite celts (Stratouli and Melfos 2008), most probably from Pindos Mountains (Greek mainland), a large number of talc beads, possibly from the Pindos Mountains as well, a fragment of a zoomorphic vessel made of marble, a small amount

Table 1 Summary information on the Drakaina Cave archeological site, the artifacts identification, the raw materials, and the geological samples. SEM = scanning electron microscope; ICP/OES = inductively coupled plasma optical emission Spectrometry; ICP/MS = inductively coupled plasma mass spectrometry; XRD = X-ray diffraction. The coordinates from sampling sites have been collected from Google Earth

Archeological samples

Archeological site of Drakaina Cave, coordinates: 38° 08′ 57″ N, 20° 46′ 14″ E

No.	Sample ID	Type of artifact	Material characterization	Methods of analyses applied
1	KEF 5120	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
2	KEF 4331	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
3	KEF 5119	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
4	KEF 5110	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
5	KEF 4333	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
6	KEF 4329	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
7	KEF 23	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
8	KEF 1724	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
9	KEF 5114	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
10	KEF 4332	Chipped stone tool	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
11	KEF 5118-8	Cutting-edged stone tool	Diabase/dolerite	Optical microscopy, ICP/OES, ICP/MS
12	KEF 5120-18	Cutting-edged stone tool	Gabbro	Optical microscopy, ICP/OES, ICP/MS
13	Kef 5114-5a	Discoid bead	Talc	XRD, ICP/OES, ICP/MS
14	Kef 5114-5b	Discoid bead	Talc	XRD, ICP/OES, ICP/MS
15	Kef 5114-5c	Discoid bead	Talc	XRD, ICP/OES, ICP/MS
16	Kef 5114-5d	Discoid bead	Talc	XRD, ICP/OES, ICP/MS
17	KEF 2526	Ground stone tool for polishing tasks	Limestone	Optical microscopy, XRD
18	KEF 5245-2	Ground stone tool for polishing tasks	Limestone	Optical microscopy, XRD
19	KEF 5312	Ground stone tool for polishing tasks	Limestone	Optical microscopy, XRD
20	KEF 4329-4	Ground stone tool for grinding tasks	Limestone	Optical microscopy, XRD
21	KEF 4333-3	Ground stone tool for grinding tasks	Limestone	Optical microscopy, XRD
22	KEF 4332-1	Grinding/abrasive tool	Sandstone	Optical microscopy, XRD
23	KEF 5117	Grinding/abrasive tool	Sandstone	Optical microscopy, XRD
24	KEF 5311-b	Grinding/abrasive tool	Sandstone	Optical microscopy, XRD
25	KEF 5311-c	Grinding/abrasive tool	Sandstone	Optical microscopy, XRD
26	KEF 2530	Zoomorphic vessel	Marble	O-C isotopes, XRD

Geological samples

No.	**Sample ID**	**Location**	**Coordinates**	**Material characterization**	**Methods of analyses applied**
1	KEF 1	Atros mountain	38° 09′ 03″ N 20° 45′ 57″ E	Limestone	Optical microscopy, XRD
2	KEF 2	Kapmitsata	38° 08′ 10″ N 20° 43′ 57″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
3	KEF 2a	Kapmitsata	38° 08′ 10″ N 20° 43′ 57″ E	Sandstone	Optical microscopy, XRD
4	KEF 3	Anninata	38° 06′ 42″ N 20° 46′ 55″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
5	KEF 4	Megali Rachi hill	38° 06′ 20″ N 20° 46′ 55″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
6	KEF 5	Skala	38° 04′ 53″ N 20° 47′ 54″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
7	KEF 6a	Cape Atros	38° 10′ 37″ N 20° 45′ 20″ E	Limestone	Optical microscopy, XRD
8	KEF 6	Cape Atros	38° 10′ 37″ N 20° 45′ 19″ E	Chert	Optical microscopy, XRD
9	KEF 7	Cape Atros	38° 11′ 09″ N 20° 44′ 49″ E	Limestone	Optical microscopy, XRD
10	KEF 8a	Vochynas gorge	38° 08′ 53″ N 20° 46′ 03″ E	Sandstone	Optical microscopy, XRD
11	KEF 8b	Vochynas gorge	38°08′53” N 20°46′03″ E	Limestone	Optical microscopy, XRD

Table 1 (continued)

12	KEF 11	Agrapidia	38° 08′ 02″ N 20° 47′ 27″ E	Sandstone	Optical microscopy, XRD
13	KEF 15	Skala	38° 05′ 07″ N 20° 48′ 03″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
14	KEF 15B	Skala	38° 05′ 07″ N 20° 48′ 03″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
15	KEF 15G	Skala	38° 05′ 07″ N 20° 48′ 03″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
16	KEF 15BR	Skala	38° 05′ 07″ N 20° 48′03″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
17	KEF 15R	Skala	38° 05′ 07″ N 20°48′03″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
18	KEF 15Y	Skala	38° 05′ 07″ N 20° 48′ 03″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
19	KEF 18B	Sami	38° 13′ 51″ N 20° 37′ 58″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
20	KEF 18Y	Sami	38° 13′ 51″ N 20° 37′ 58″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
21	KEF 18R	Sami	38° 13′ 51″ N 20° 37′ 58″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS
22	KEF 18BR	Sami	38° 13′ 51″ N 20° 37′ 58″ E	Chert	Optical microscopy, SEM, ICP/OES, ICP/MS

of obsidian artifacts from the island of Melos in the Cyclades too, and two gypsum beads from the neighboring Zakynthos island (Ionian Sea). Few of the analyzed pottery samples are most likely imported as well. In contrast, all chert artifacts subjected to petrographic and rare earth element (REE) analyses seem to be from local sources (Melfos and Stratouli 2016).

In the present work, we focus on the study of the stone tools, which include the chipped stone artifacts made of chert, the cutting-edged stone tools made of gabbro, the discoid beads made of talc, the ground stone tools made of limestone, the grinding/abrasive tools made of sandstone and a zoomorphic vessel made of white marble.

Geological setting

The rocks of the Kephalonia Island belong to the Ionian and the Paxos/Pre-Apulian geotectonic zones of the external Hellenides (British Petroleum Co et al. 1985; Lekkas et al. 2001; Van Hinsbergen et al. 2006). They mainly consist of limestones (Fig. 1) of various ages, which were deposited at

Fig. 2 Satellite image of Kephalonia Island and its environs and view of the Poros village with the gorge of Vochynas and the location of Drakaina Cave (photo taken from the east)

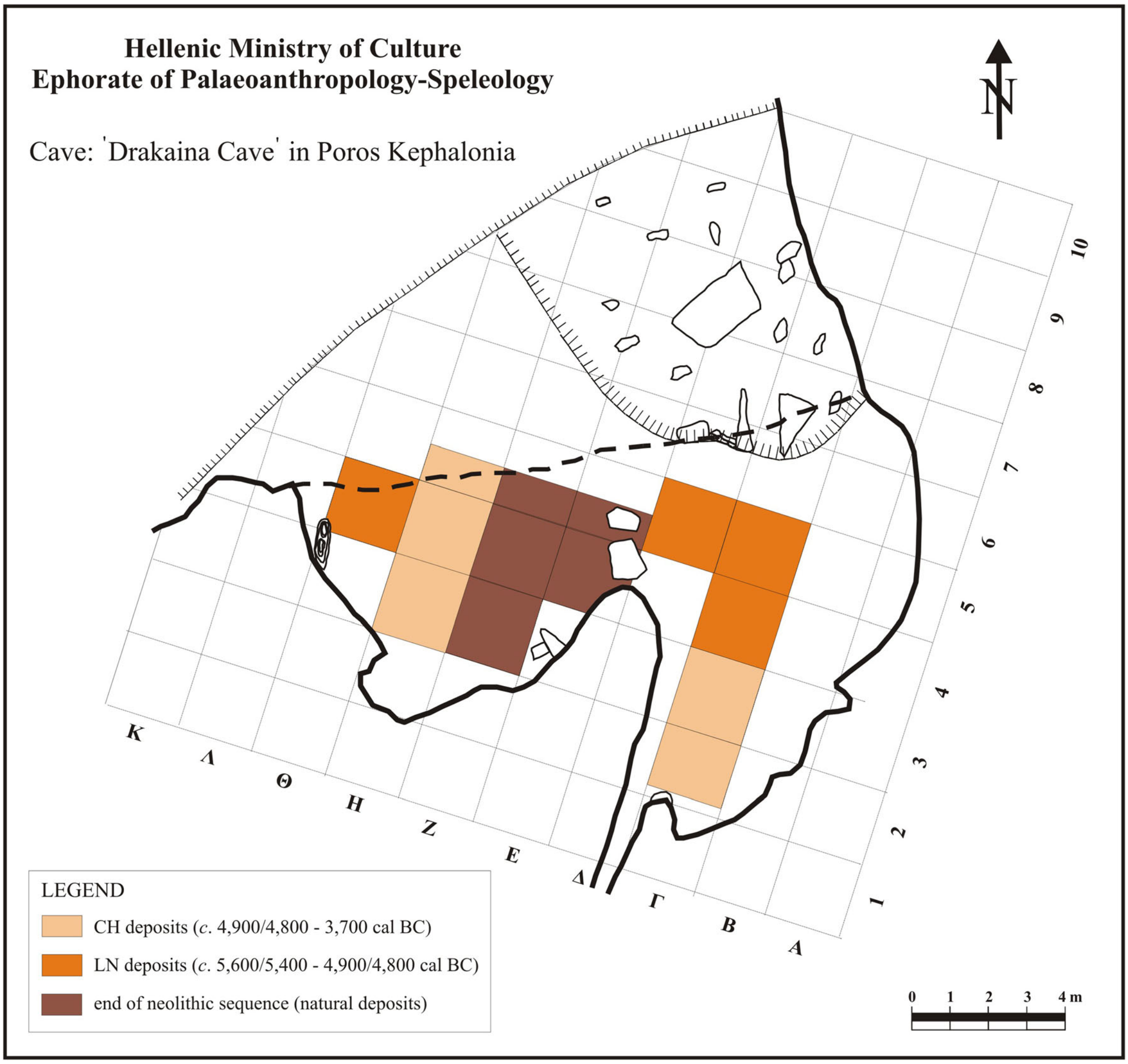


Fig. 3 Plan of the shallow Drakaina Cave (after the topographer Theodoros G. Chatzitheodorou) with the excavation grid and the neolithic deposits revealed to date in each excavated trench

the margin of the Apulian platform. Between Cretaceous and Oligocene a major rearrangement of various small plates in relation to the Tethys ocean was caused by the Alpine orogeny. The subsequent intensive earth crust movements influenced the rocks and the sediments of the whole Tethys region. The emergence of the Ionian Islands, including Kephalonia, resulted from gradual tectonic movements, which still are very active (Van Hinsbergen et al. 2006).

The rocks of the Ionian Zone occur at the southeastern part of Kephalonia and consist of Mesozoic to Paleogene carbonates, mainly calcitic and dolomitic limestones (Fig. 1). This series is overlain by shales, calcareous sandstones and breccias with an Oligocene to late Miocene age (34 to 7.5 Ma ago). The Paxos/Pre-Apulian Zone extends on the major part of Kephalonia and is composed of pelagic to reefal limestones of early Cretaceous to late Miocene age. Intercalations of dolomites, marls and conglomerates also occur. The rocks of the Ionian Zone were overthrust on the Paxos/Pre-Apulian Zone along the Ionian thrust, which is a major tectonic feature transecting most of the Ionian Islands.

The sedimentary characteristics and the microfacies in the rocks of Kephalonia demonstrate shallow or pelagic marine depositional environments. According to Van der Land et al. (2004) and Hagmaier et al. (2005) the low-Mg calcite ooid formations show a restricted lagoonal/high energy paleoenvironment during late Cretaceous. Hagmaier et al. (2005) also reported megabreccias of redeposited platform-margin limestone blocks within hemipelagic mudstones during Eocene. The porous to massive limestones rich in fossils of late Miocene age, found at the Paliki peninsula, represent a marine tropical to subtropical environment (Georgiadou-Dikeoulia 1965; Symeonidis and Schultz 1968; Pomoni-Papaioannou et al. 2000). They consist of fine-grained pelagic calcitic carbonates with well-sorted beds rich in planktonic

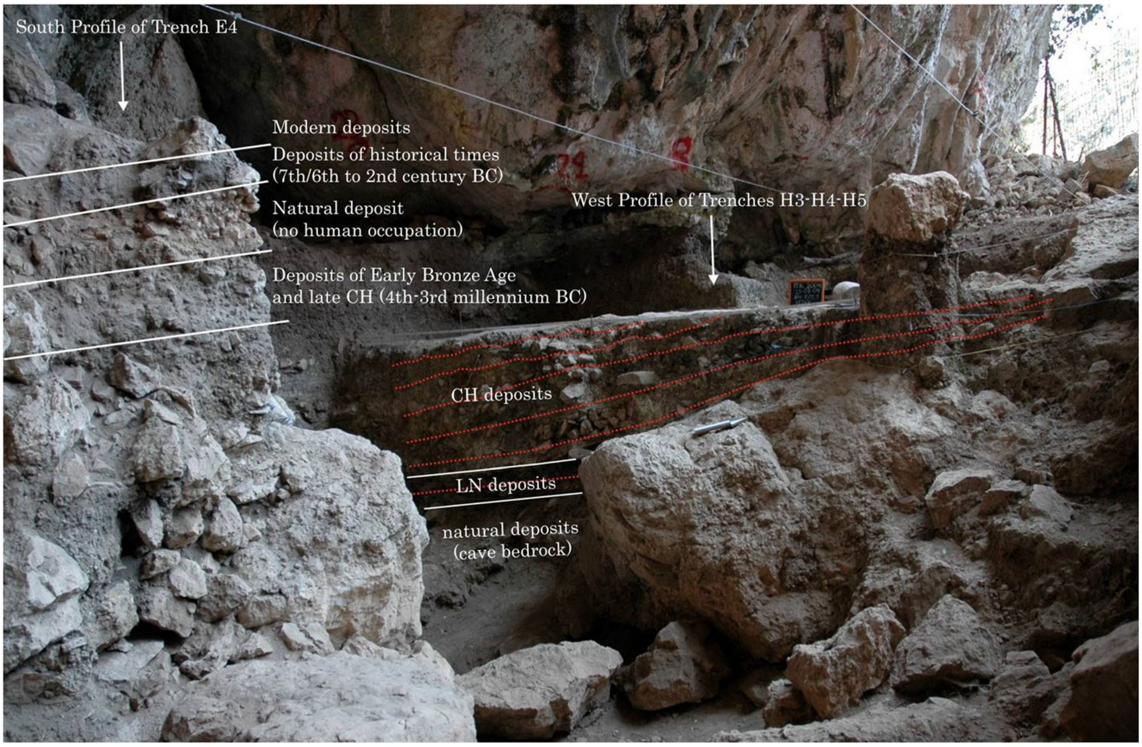


Fig. 4 View of the central and the western part of Drakaina Cave with the stratigraphic sequence from the natural bedrock to modern times, projected on the south profile of trench E4 and on the west profile of trenches H3-H4-H5. The red dotted lines indicate the approximate level of preserved lime plaster floors occurring within the neolithic sequence (LN = Late Neolithic I deposits; CH=Chalcolithic = Late Neolithic II deposits)

Foraminifera (*Globigerinidae*). Pomoni-Papaioannou et al. (2000) imply that Terrigenous material is absent or occurs scarcely.

The middle to late Jurassic limestones often include radiolarian cherts forming beds and nodules of various colors, mainly grayish to reddish. These cherts are related to the pelagic deposits found in the tectonic units of Mediterranean orogenic belts, such as the Tethys ocean (Aiello et al. 2008).

The Mesozoic to Miocene limestones of both geotectonic zones in Kephalonia Island are overlain by Pliocene to Pleistocene sediments and alluvial deposits and consist mainly of marls, sandstones, conglomerates, travertines, limestones and gypsum (Georgiadou-Dikeoulia 1965; Symeonidis and Schultz 1968; British Petroleum Co et al. 1985; Lekkas et al. 2001; Triantaphyllou 2001). The sediments extend mostly in the western and the southern parts of Kephalonia (Fig. 1),

Fig. 5 Drakaina Cave. A fragmented bowl with incised decoration from LN I layers

Fig. 6 Drakaina Cave. Two highly fragmented open vessels with polychrome decoration from LN II layers

Fig. 7 Drakaina Cave. Various types of chert projectile points from LN I and LN II layers

including the Paliki peninsula and a narrow zone (10–15 km wide) across the sea shore from Argostoli to Poros. Two different deposition mechanisms of these sediments have been proposed by Van Hinsbergen et al. (2006). The sediments of southern and south-western Kephalonia were formed due to a rapid uplift in early Pliocene, which led to emergence and erosion of the pre-existed formations. In contrast the sediments of the Paliki peninsula at the north-western part were deposited due to the Pleistocene uplifting.

Kephalonia probably was attached to the neighboring islands of Zakynthos and Ithaki during parts of the Late Pleistocene, but remained insular and detached from the Greek mainland. Between Middle Paleolithic and Mesolithic (125,000 to 8000 before present) the sea level varied between 120 to 80 m below present level (Ferentinos et al. 2012) and as a consequence the land of Kephalonia was larger than it is today. Fossil shorelines, produced by ancient seismic movements, are identified by notches in the whole island, especially along the coast of Fiskardo peninsula (Evelpidou et al. 2016). They formed from complicated tectonic episodes, including past uplift and later subsidence at the same sites, and were affected by the global sea-level rise of the Holocene.

Fig. 8 Drakaina Cave. Ground stones coated with red pigment

Materials and methods

Twenty-six representative stone artifacts and twenty-two geological samples from various rock types of Kephalonia were selected for a petrographic and geochemical investigation (Table 1). The sampling was carried out during the excavations periods of 2003 to 2005, after the special authorization provided by the Hellenic Ministry of Culture. Thin and polished sections of the samples were studied for their mineralogical composition, the textural features and the general characteristics of the rocks, by optical microscopy using a Leitz Laborlux 11 POL S microscope at the School of Geology of the Aristotle University of Thessaloniki. Selected samples were also investigated with a scanning electron microscope (SEM) at the Faculty of Sciences of the Aristotle University of Thessaloniki. The SEM study was carried out with a JEOL, JSM-840A scanning microscope, connected with an energy-dispersive spectrometer (EDS) (LINK, AN 10/55S).

The mineralogical composition of powders of the rock samples was assessed by X-ray diffraction (XRD) at the Department of Mineralogy, Petrology and Economic Geology of the Aristotle University of Thessaloniki, using a Phillips type X-ray diffractometer. A goniometer system and a Cu anode tube ($\lambda = 1.540$ Å) were used, operating at 40 kV/30 mA, with a scanning angle of 2θ between 3 and 63° with count rate of 10^3/s and at a scanning speed of 17 min.

The samples were analyzed by means of inductively coupled plasma optical emission spectrometry (ICP/OES) to determine their major elements, and by inductively coupled plasma mass spectrometry (ICP/MS) for the determination of their trace element and rare earth element (REE) or Lanthanides content at the "Activation Laboratories Ltd" in Ontario, Canada. The geochemical signatures of the immobile elements, including the REE, characterize the formation of each rock and remain stable throughout the geological evolution such as weathering, hydrothermal alteration, diagenesis, and metamorphism. This is the reason why these elements are the most useful of all trace elements and their use has important applications to petrology and to provenance studies of archeological materials. Therefore, determination of the sources of the raw materials at the studied stone artifacts of Drakaina Cave was possible from the geochemical abundances of certain trace elements and REE.

Oxygen and carbon isotopic analyses of one marble sample were carried out at the Department of Geology of the Royal Holloway University of London. The oxygen and carbon isotope ratios (δ^{18}O and δ^{13}C) are referred to the standard VPDB (Vienna Belemnitella Americana from the Cretaceous Pee Dee Formation, South Carolina).

Results

Chipped stone artifacts made of chert

A total of over 550 chert tools and approximately 12,000 pieces of debitage, indicative of on-site knapping (Fig. 9), were unearthed during the excavations so far, demonstrating that Drakaina Cave was an important manufacturing site for chipped stone tools for a long period, at least between the sixth millennium and the beginning of the 4th millennium cal BC. These artifacts include arrows, blades, bladelets, scrapers, as well as cores, fragments and flakes, and were made of chert with various colors (Stratouli et al. 2014; Melfos and Stratouli 2016).

Fig. 9 Tools made of chert with various colors from the LN Iand LN II layers of Drakaina Cave

A broad classification, on the basis of their color, revealed five wide categories: gray, black, brown, red, and yellow cherts (Melfos and Stratouli 2016). Geological investigations in the eastern part of Kephalonia showed that in some sites, including Atros cape (Fig. 1), high quality large cherts are found in the limestones forming nodules and layers (Fig. 10a) with a length which exceeds 3 m. The chert colors are similar with the archeological cherts from Drakaina Cave, varying from gray and black to brown and red.

Furthermore, the Pliocene-Holocene sediments and the alluvial deposits in Kephalonia contain small slices (< 10 cm) of chert gravels, which had been naturally reworked with the whole sedimentary succession, and now they outcrop within the conglomerates and breccias (Fig. 10b). The color variation remains the same with the primary chert nodules in limestones, demonstrating gray, black, red, brown, and yellow tints. Several sites with chert gravels have been observed in the south-eastern region of Kephalonia, and especially in the areas of Aninata, Megali Rachi hill, and Skala (south of Poros), Kampitsata (west of Poros) and Sami in the northeast (Fig. 1). All these occurrences could have been exploited by the neolithic people at least 7500–5500 years ago.

The mineralogical composition of the five chert types (i.e., yellow, gray, black, brown, and red) from the artifacts (10 samples) and the geological occurrences (15 samples) is similar and consists of microcrystalline quartz with traces of calcite, pyrite and iron oxides and hydroxides (Table 2). All the samples contain also microfossils and organic material in various concentrations (Melfos and Stratouli 2016).

Microcrystalline quartz appears in tiny grains with a diameter of ≤ 1 μm and only in some cases their size exceeds 10 μm (Fig. 11a). Under microscope quartz is colorless, regardless of its macroscopic color. However, in places the iron oxides and hydroxides provide a dark, pale-brown or red color (Fig. 11b). In addition, the gray color is attributed mainly to the organic matter present (Fig. 11c), the amount of which apparently increases from the semi-transparent to whitish gray cherts. Calcite is always present in black cherts, in the form of fossil remnants or as veinlets, which were formed during diagenesis (Fig. 11d). Calcite was also observed in the other chert types, but only rarely, possibly demonstrating remnants of calcareous fossils.

Pyrite is found mainly in the form of tiny disseminated euhedral crystals or spheroids, with a size < 10 μm, especially in brown and red cherts (Fig. 11e). The presence of pyrite spheroids is indicative of biogenic sedimentary environments during pyrite formation and the spherical form is attributed either to a replacement of organic globules by pyrite or to nucleation and growth of initial iron monosulfide

Fig. 10 Geological occurrences of cherts in Kephalonia. **a** Chert nodule within the bedded limestone of Atros cape. **b** Chert gravel within the Pliocene-Holocene sediments at the area of Kampitsata

microcrystals through a rapid bacterial sulfate reduction of highly metabolizable organic matter during early diagenesis (Rickard 1970; Xiao et al. 2010). Iron oxides and hydroxides (Fig. 11b), mostly goethite, occur in yellow, brown and red cherts and not in gray and black cherts. They are the oxidation product of pyrite and are more frequent in the red than the yellow and brown cherts.

The fossils are mainly *Radiolaria* (Fig. 11f, g), but fragments of *Foraminifera*, *Porifera*, *Lamellibranchiata*, and *Echinodermata* are also observed. These fossils are well preserved and represent a marine pelagic depositional environment (Horowitz and Potter 1971; Flügel 1982). The *Radiolaria* are rounded, although in some cases they appear elongated (Fig. 11f). Similar radiolarian cherts have been described by Dimitriadis and Skourtopoulou (2001) from neolithic sites in northern Greece, and especially from Makrygialos, Dispilio and Megalo Nisi Galanis. They suggested that the raw materials originated from the broader area of the sites, since radiolarian cherts are common rock types in western and north-western Greece.

Yellow cherts, including the so-called honey-flint, were identified among the neolithic chipped stone artifacts (Melfos and Stratouli 2016). They consist mainly of microcrystalline quartz (grain size < 10 μm) with minor calcite, which is attributed to deformed fossils, and iron hydroxides (Table 2). This chert type contains characteristic fossils, such as *Ammonites* and planktonic *Foraminifera* most typically *Globotruncana* (Fig. 11h). These fossils were common during Late Cretaceous and were deposited at an open-sea continental slope to pelagic environment. The studied sample of such yellow chert found in the neolithic layers of Drakaina Cave is possibly identical with the so-called honey flint, which was described by Perlès (1992, 1994) and Perlès and Vitelli (1999) and is considered as one of the most excellent quality materials for flaking. Numerous chert gravels, including yellow cherts, were observed during a geo-archeological survey in the area of Skala (Fig. 1), with evidence of use possibly since the prehistoric times. These cherts are microscopically identical with the yellow chert implements found in Drakaina Cave and have the same mineralogical composition with them.

Melfos and Stratouli (2016) recently showed through a detailed geochemical study that the raw materials of a representative cluster of chipped stone artifacts from the archeological collection of Drakaina Cave is made of local cherts, from Kephalonia island. Using trace elements correlation and REE spider diagrams, they discriminated specific sites, e.g., Sami, Skala, Megali Rachi, Anninata, and Kampitsata (Fig. 1), where the raw materials were acquired for the construction of neolithic chert artifacts.

To strengthen the interpretation of Melfos and Stratouli (2016), we furthermore use here normalized multi-element spider diagrams, which were constructed for the same sample group (10 artifacts and 15 geological samples). Spider diagrams are line chart plots of the abundances of a set of elements, mainly geochemically immobile elements, in an analyzed sample relative to their abundance in some standard. For the cherts, which are siliceous, sedimentary, very fine grained materials, specific geochemical discrimination variation diagrams do not exist. So, as in other cases (Gauthier et al. 2012; McKay et al. 2013), to create the spider diagrams for the Kephalonia cherts, nine selected major and trace elements were used (Tables 3 and 4) and their concentrations were

Table 2 Microscopic characteristics of the different chert types from Drakaina Cave and from the natural occurrences in E and SE Kephalonia

Chert type-color	Quartz grains size	Minor minerals	Fossils contained	Organic material
Gray Black	< 10–30 μm	Calcite	*Radiolaria* *Porifera* *Lamellibranchiata Echinodermata*	Yes
Brown Red	< 1 μm	Calcite, pyrite, Fe-hydroxides		
Yellow	< 10 μm	Calcite, Fe-hydroxides	*Planktonic Foraminifera: Globotruncana*	No

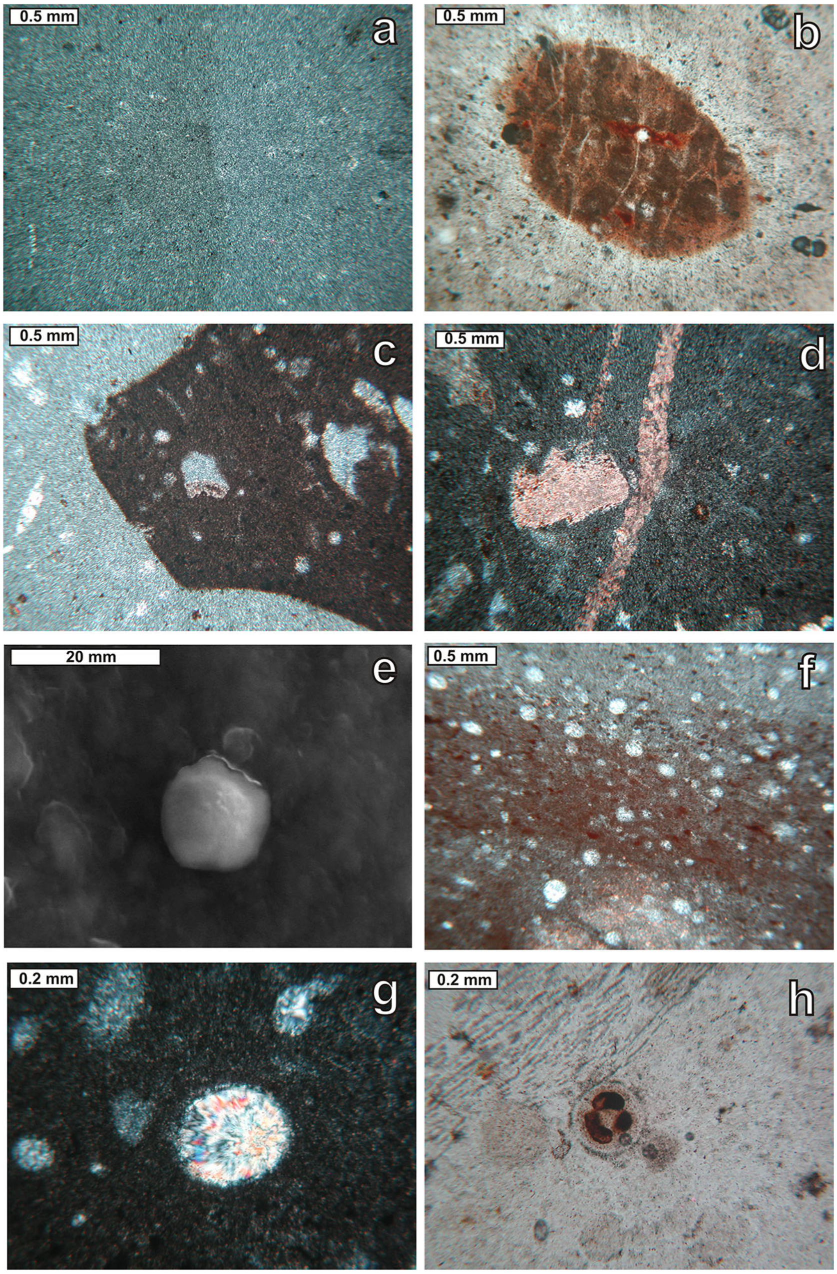


Fig. 11 Photomicrographs showing the typical textures of geological (**a**–**g**) and archeological (**h**) cherts from Kephalonia island and Drakaina Cave, respectively. **a**–**d**, **f**–**h** Thin sections, **e** SEM; **a**–**d**, **f**–**g** +N, **h** //N. **a** Micro-crystalline quartz (KEF 2). **b** Brown-colored micro-crystalline quartz containing iron hydroxides (KEF 5). **c** Organic material (dark color) within microcrystalline quartz (light color) (KEF 2). **d** Calcite in the form of fossil remnants and veinlets formed during sediment diagenesis (KEF 3). **e** Pyrite micro-spheroid within microcrystalline quartz (KEF5, SEM). **f.** *Radiolaria*, sometimes elongated, in microcrystalline quartz (KEF 5). **g** *Radiolaria* consisting of chalcedony within organic material (dark color) (KEF 2). **h** Planktonic *Foraminifera* in the yellow-type chert (KEF 4333)

normalized to average continental upper crust (McLennan 2001). Chemical elements used in the diagrams are presented in order of increasing ionic potential (Fig. 12).

In Fig. 12, we observe that there is an overlap of the multi-element spider diagram patterns for specific archeological cherts with particular geological sources. Three artifacts (KEF 23, KEF 5114, KEF 5120) overlap with geological cherts from Kampitsata (KEF 2), from Anninata (KEF 3) and from Megali Rachi hill (KEF 4), respectively (Fig. 12a). Two archeological samples (KEF 4332, KEF 5519) and two geological from Skala (KEF 5, KEF 15BR) with positive Ba anomalies overlap quite well (Fig. 12b). The six samples which do not show positive but slight negative anomaly of Ba (Fig. 12b), include three artifacts (KEF 1724, KEF 4333, KEF 5110) and three geological cherts (KEF 15R, KEF 15Y, KEF 15Br) also from Skala area. Finally, the artifacts KEF 4329 and KEF 4331 demonstrate similar multi-element patterns to geological samples (KEF 18R, KEF 18B) from Sami (Fig. 12c). Consequently, the results of the multi-element spider diagrams support the consideration of Melfos and Stratouli (2016) about the local sources of the raw materials from Kampitsata, Anninata, Megali Rachi hill, Skala, and Sami (Table 5).

Table 3 Major (wt%) and trace (ppm) elements of the different chert types from the natural occurrences in eastern and south-eastern Kephalonia. Fe_2O_3 = Fe total, LOI = loss of ignition, bd = below detection

Sample	KEF2	KEF3	KEF4	KEF5	KEF6	KEF15	KEF15B	KEF15G	KEF15R	KEF15Y	KEF15BR	KEF18Y	KEF18R	KEF18B	KEF18BR
Color	Gray	Black	Brown	Red	Yellow	Yellow	Black	Gray	Red	Yellow	Brown	Yellow	Red	Black	Brown
wt%															
SiO_2	97.45	95.44	97.01	96.71	98.10	97.21	97.80	98.30	98.10	95.70	98.20	98.30	97.80	95.70	98.10
Al_2O_3	0.17	0.08	0.44	0.35	0.36	0.52	0.29	0.22	0.28	0.23	0.13	0.12	0.25	bd	0.10
Fe_2O_3	0.05	0.07	0.08	0.22	0.12	0.15	0.17	0.08	0.20	0.12	0.05	0.06	0.13	0.07	0.05
MnO	0.01	bd	bd	bd	bd	0.02	bd	bd	bd	bd	bd	bd	bd	bd	bd
MgO	0.04	0.04	0.04	0.12	0.01	0.03	0.02	0.02	0.04	0.02	0.01	0.01	0.01	0.11	bd
CaO	0.18	0.96	0.06	0.40	0.15	0.03	0.22	0.22	0.15	0.27	0.01	0.02	0.05	0.09	0.04
Na_2O	0.22	0.18	0.26	0.23	0.08	0.15	0.08	0.07	0.08	0.08	0.07	0.07	0.07	0.07	0.06
K_2O	0.08	0.03	0.18	0.07	0.11	0.18	0.06	0.07	0.08	0.07	0.03	0.04	0.06	0.06	0.04
TiO_2	bd	0.01	0.02	0.01	0.01	bd	0.01	0.01	0.02	0.01	0.01	bd	0.01	0.01	bd
P_2O_5	0.02	0.02	0.03	0.04	bd	0.02	0.05	bd	0.02	0.05	bd	bd	0.06	0.06	0.02
LOI	2.17	3.01	1.91	1.87	1.66	1.32	1.12	1.46	1.56	2.25	1.38	1.88	1.76	1.87	1.66
Total	100.39	99.84	100.03	100.02	100.60	99.63	99.82	100.45	100.53	98.80	99.89	100.50	100.20	98.04	100.07
ppm															
Sc	bd	bd	bd	2	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
Cu	bd	bd	18	18	13	20	10	7	9	8	5	5	9	8	8
Zn	bd	bd	bd	41	7	bd	bd	bd	5	bd	bd	bd	bd	bd	bd
Ga	bd	bd	bd	bd	1.2	1.0	0.8	1.0	1.0	1.1	0.6	0.9	0.9	0.9	0.8
Rb	bd	bd	3.2	2.5	2.1	5.0	1.8	1.1	2.0	1.3	0.6	0.4	1.6	0.7	0.4
Sr	8.1	9.4	7.1	5.0	5.5	7.0	6.8	6.4	17.5	12.7	5.1	5.5	18.6	80.4	6.1
Y	1.7	bd	7.6	8.1	3.6	bd	6.2	27.7	9.5	4.5	5.5	85.8	53.2	8.9	61.0
Zr	13.00	5.00	7.00	5.00	0.52	1.13	0.90	1.02	4.32	3.21	1.45	1.12	0.97	10.00	1.47
Nb	1.1	bd	bd	bd	0.2	bd	0.2	bd	0.5	0.2	bd	bd	0.2	0.4	bd
Sn	4	bd	3	2	1	3	1	1	1	1	bd	bd	bd	1	bd
Ba	57	55	224	34	13.8	6	19.8	12.9	7.8	8.7	3.1	6.5	57.4	382	6.4
Hf	0.2	bd	0.2	bd	11.5	bd	19.8	23.2	99.5	72.2	33.0	24.6	22.3	47.7	32.4
Th	0.14	0.12	0.39	0.38	0.42	0.20	0.32	0.21	0.32	0.27	0.11	0.08	0.22	0.21	0.12
U	1.43	0.92	0.29	0.12	0.21	0.50	0.60	1.76	0.73	0.33	0.19	0.47	0.66	0.78	0.71
La	3.30	0.60	7.38	5.37	2.20	0.80	5.20	24.20	7.10	2.40	3.90	23.50	15.80	4.40	19.50
Ce	0.86	0.51	2.62	3.77	2.4	1	2.8	4.7	3.9	2.4	1.7	4.8	4.1	3.4	3.5
Pr	0.64	0.15	2.16	1.69	0.28	0.19	1.33	6.15	1.35	0.30	0.65	7.25	3.80	0.80	4.85
Nd	2.4	0.6	9.0	7.2	1.3	0.8	5.7	25.9	6.0	1.6	2.9	35.5	19.2	3.9	23.8
Sm	0.45	0.14	2.03	1.64	0.25	0.20	1.06	5.23	1.01	0.24	0.58	8.48	4.61	0.73	5.10
Eu	0.10	bd	0.46	0.41	0.06	bd	0.27	1.27	0.34	0.06	0.14	2.28	1.30	0.23	1.40

Table 3 (continued)

Sample	KEF2	KEF3	KEF4	KEF5	KEF6	KEF15	KEF15B	KEF15G	KEF15R	KEF15Y	KEF15BR	KEF18Y	KEF18R	KEF18B	KEF18BR
Gd	0.48	0.10	2.03	1.79	0.34	0.20	1.12	5.45	1.38	0.26	0.56	10.20	5.83	0.94	6.43
Tb	bd	bd	0.29	0.26	0.01	bd	0.13	0.77	0.16	bd	0.05	1.64	0.92	0.09	0.99
Dy	0.30	0.11	1.45	1.35	0.20	0.20	0.78	4.45	1.07	0.20	0.49	9.80	5.88	0.82	5.83
Ho	bd	bd	0.26	0.25	0.01	bd	0.12	0.83	0.20	0.02	0.06	2.22	1.35	0.17	1.36
Er	0.14	bd	0.69	0.65	0.11	0.10	0.39	2.20	0.62	0.12	0.23	6.13	3.87	0.53	3.69
Tm	bd	bd	0.10	0.09	bd	bd	0.02	0.27	0.06	bd	bd	0.83	0.51	0.04	0.48
Yb	0.12	bd	0.56	0.50	0.13	bd	0.30	1.63	0.48	0.10	0.19	5.16	3.16	0.39	2.76
Lu	bd	bd	0.09	0.08	bd	bd	0.02	0.21	0.04	bd	bd	0.77	0.50	0.04	0.43

Cutting-edged stone tools made of gabbro

Edged tools, also known as celts, are implements with an acute edge on one of their ends, acquired through deliberate modification. They were the stone portions of originally hafted tools, and have been used in cutting activities, such as tree-felling, wood-working, deforestation, digging, butchery etc. In contrast to most Greek Neolithic sites (e.g. Stratouli 2002; Stroulia 2010, 2014; Tsoraki 2011), the edged tools category in Drakaina is rather vague, comprising only six specimens, among thousands of stone artifacts. Their limited number is probably related to the character of the site and the activities hosted at the Cave as considered by Stratouli et al. (2014).

The celts share the same macroscopic characteristics with a green to dark-green color and a fine- to medium-grained massive texture, without any cracks or discontinuities, demonstrating a high density and hardness (Fig. 13a). Small slices of two representative tools (KEF 5118, KEF 5120) were obtained for a microscopic and a geochemical analysis. Examination under optical microscope showed that the sample KEF 5118 is a fine-grained rock and the sample KEF 5120 is a medium-grained rock. They both have a similar mineralogical composition, consisting of plagioclase, clinopyroxene, and magnetite, which are the primary minerals (Fig. 13b, c). Actinolite, chlorite, serpentine, and talc comprise the secondary alteration phases, which have replaced the primary minerals through geological processes (Stratouli and Melfos 2008).

The mineralogical composition and the textural features demonstrate that the medium-grained rock is gabbro and the fine-grained rock is diabase/dolerite. In Greece, these rocks are found in large outcrops, along oceanic-continental suture zones, and occur in the so-called Vardar and Pindos-Vourinos oceanic lithosphere remnants, as well in Evia and in the Othris Mountain. Minor occurrences are found in western Attica, in Argolid, in the Evros region, in Lesbos island and in the islands of Crete-Karpathos-Rhodes forming a continuous dismembered chain. However, the geological context of western Greek mainland and the Ionian sea, including Kephalonia island, does not favor the occurrence of ophiolites and therefore gabbro and diabase/dolerite do not occur in these regions.

Based on their chemical composition the studied samples are characterized as boninitic gabbros. Stratouli and Melfos (2008) have previously shown, taking into consideration the REE patterns, that the raw materials of both cutting-edged tools were procured either from Grevena area of Pindos mountain (Moura and Aspropotamos locations) or from Argolid of the Peloponnese (Fig. 14). All the other possible sources among the Greek ophiolite occurrences were excluded since their REE patterns did not show any similarities with the patterns of the Drakaina's tools.

In the present study, we furthermore investigate if there is a possibility to distinguish the exact source by using normalized multi-element diagrams, known as spider diagrams, in which

Table 4 Major (wt%) and trace (ppm) elements of the different chert types from the chipped-stone implements in Drakaina Cave. Fe_2O_3 = Fe total, LOI = loss of ignition, bd = below detection

Sample	KEF1724	KEF23	KEF4329	KEF4331	KEF4332	KEF4333	KEF5110	KEF5114	KEF5119	KEF5120
Color	Gray	Gray	Yellow	Red	Black	Yellow	Brown	Black	Brown	Red
wt%										
SiO_2	98.40	96.34	95.70	97.20	97.70	96.36	97.30	96.48	96.99	96.31
Al_2O_3	0.11	0.18	0.15	0.23	0.20	0.61	0.28	0.39	0.41	0.26
Fe_2O_3	0.07	0.07	0.07	0.21	0.11	0.11	0.13	0.10	0.17	0.13
MnO	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
MgO	0.02	0.03	0.11	0.06	0.01	0.08	0.03	0.06	0.10	0.03
CaO	0.10	0.25	0.09	0.07	0.35	0.25	0.50	0.10	0.34	0.86
Na_2O	0.07	0.19	0.07	0.07	0.19	0.36	0.09	0.24	0.22	0.21
K_2O	0.05	0.06	0.06	0.06	0.06	0.09	0.08	0.11	0.08	0.05
TiO_2	0.01	0.01	0.01	0.01	bd	0.02	0.01	0.01	0.01	bdl
P_2O_5	bdl	0.02	0.06	0.06	0.10	0.03	0.12	0.02	0.04	0.04
LOI	1.37	2.69	2.87	1.82	1.97	2.17	2.07	2.13	1.35	2.57
Total	100.20	99.84	99.19	99.79	100.69	100.08	100.61	99.64	99.71	100.46
ppm										
Sc (ppm)	bd	bd	bd	8	bd	bd	bd	bd	bd	bd
Cu	7	bd	15	bd	bd	59	42	14	bd	bd
Zn	bd	bd	bd	1	bd	122	7	bd	bd	bd
Ga	1.0	bd	1.5	1.1	bd	1.2	1.0	bd	bd	bd
Rb	0.5	bd	3.3	49.5	3.7	5.4	1.5	3.2	3.0	bd
Sr	12.5	7.0	6.5	8.5	9.8	5.0	11.0	7.1	7.0	10.0
Y	3.1	3.0	8.8	53.8	5.7	1.8	22.5	7.0	8.1	bd
Zr	3.78	9.00	2.01	1.49	1.21	0.76	2.20	7.00	5.00	4.00
Nb	bd	1.1	1.4	0.3	bd	bd	0.2	bd	bd	bd
Sn	bd	3	0.5	0.5	bd	2	bd	2	bd	bd
Ba	11	45	109	220	67	10	13	174	57	50
Hf	86.2	0.2	11.4	21.2	15.4	0.2	49.1	0.2	bd	bd
Th	0.09	0.18	0.34	0.21	0.21	1.08	0.24	0.34	0.40	0.15
U	0.97	1.50	0.66	0.72	0.55	2.00	0.25	0.30	0.15	0.77
La	1.80	3.19	4.20	16.20	5.10	0.67	7.10	5.96	5.25	0.55
Ce	1.50	0.80	3.3	4.5	2.7	1.83	3.60	3.80	3.68	0.49
Pr	0.19	0.62	bd	bd	bd	0.20	1.01	2.34	1.62	0.14
Nd	0.9	2.2	3.6	19.9	5.6	0.8	4.8	7.3	7.2	0.6
Sm	0.15	0.44	0.66	4.68	1.00	0.22	0.88	1.73	1.60	0.13
Eu	0.04	0.10	0.18	1.50	0.23	bd	0.29	0.43	0.38	bd
Gd	0.18	0.41	0.90	6.01	1.09	0.23	1.14	1.91	1.75	0.09
Tb	bd	bd	0.08	0.99	0.11	bd	0.14	0.24	0.23	bd
Dy	0.17	0.26	0.74	5.94	0.74	0.34	1.00	1.38	1.30	0.10
Ho	bd	bd	bd	bd	bd	bd	0.22	0.30	0.21	bd
Er	0.06	0.13	0.49	3.89	0.31	0.21	0.70	0.66	0.60	bd
Tm	bd	bd	bd	bd	bd	bd	0.07	0.32	0.08	bd
Yb	0.05	0.10	0.33	3.23	0.20	0.20	0.53	0.51	0.44	bd
Lu	bd	bd	0.03	0.60	0.01	bd	0.06	0.10	0.07	bd

the abundances of a range of elements (Tab. 5) are compared with a reference source. The elements are ordered with increasing compatibility from left to right. Spider diagrams are considered to be the best discriminators of subtle differences in source rocks and the data are normalized relative to a candidate reservoir. The diagram of Fig. 15 is based upon the MORB standard of Pearce (1983) and shows a differentiation of the Argolid gabbro sample. In contrast, the geochemical data of the tools from Drakaina Cave reveal almost identical patterns with those from Moura-Aspropotamos location of Pindos mountain. Thus, there is clear evidence that Pindos is the most possible provenance of the raw materials of the two ground stone celts found in Drakaina Cave (Fig. 15).

Discoid beads made of talc

During the excavations in Drakaina Cave, a large number (> 140) of small discoid beads were unearthed. The majority has a light- to dark-green color. They are very soft, with a hardness of about 1 on the Mohs scale. Four of these beads, studied with a SEM, have overall diameter from 4.0 to 5.0 mm, while the diameter of their hole varies between 1.5 and 2.0 mm (Fig. 13d). The beads have either rounded or quite straight edges demonstrating probably two different techniques of construction. The rounded edge is possibly attributed to the beads, which were produced separately, whereas the straight edge is observed in those beads, which were manufactured as an elongated long circular stone object with a hole in the middle and then it was cut in small separate beads.

The XRD analyses showed that the four beads are made of pure talc, which is a very soft mineral of low hardness (1.0 to 1.5 on the Mohs scale), consisting of hydrated magnesium silicate. Talc varies in color from green to gray, or from white to silver, and is characterized by a greasy to pearly luster. Due to its low hardness, talc can be easily handled.

Chemical analyses of the four studied beads revealed an almost identical chemical composition, which is evidence that the raw materials were probably from the same source (Stratouli and Melfos 2008). Talc is originally found in ophiolites with dunite, harzburgite, gabbro, diabase/dolerite, and serpentinite and thus it is highly probable that in addition to gabbro/diabase tools, the talc beads were also transported to the island of Kephalonia from Pindos Mountains through the same transportation or exchange networks.

Ground stone tools made of limestone

A large number of ground stone objects made of limestone (Fig. 16a, b) have been found during the excavations in Drakaina Cave. This group consists of 218 implements, mostly handheld tools, employed in abrasive, polishing and percussive tasks (Stratouli et al. 2014). Their shapes and forms with the water-rolled faces and the curvilinear appearances suggest that they are cobbles and pebbles collected from seashores and riverbeds and were used as tools without receiving any kind of deliberate modification prior or during their use and thus they are considered the products of an expedient technology (Stroulia 2010).

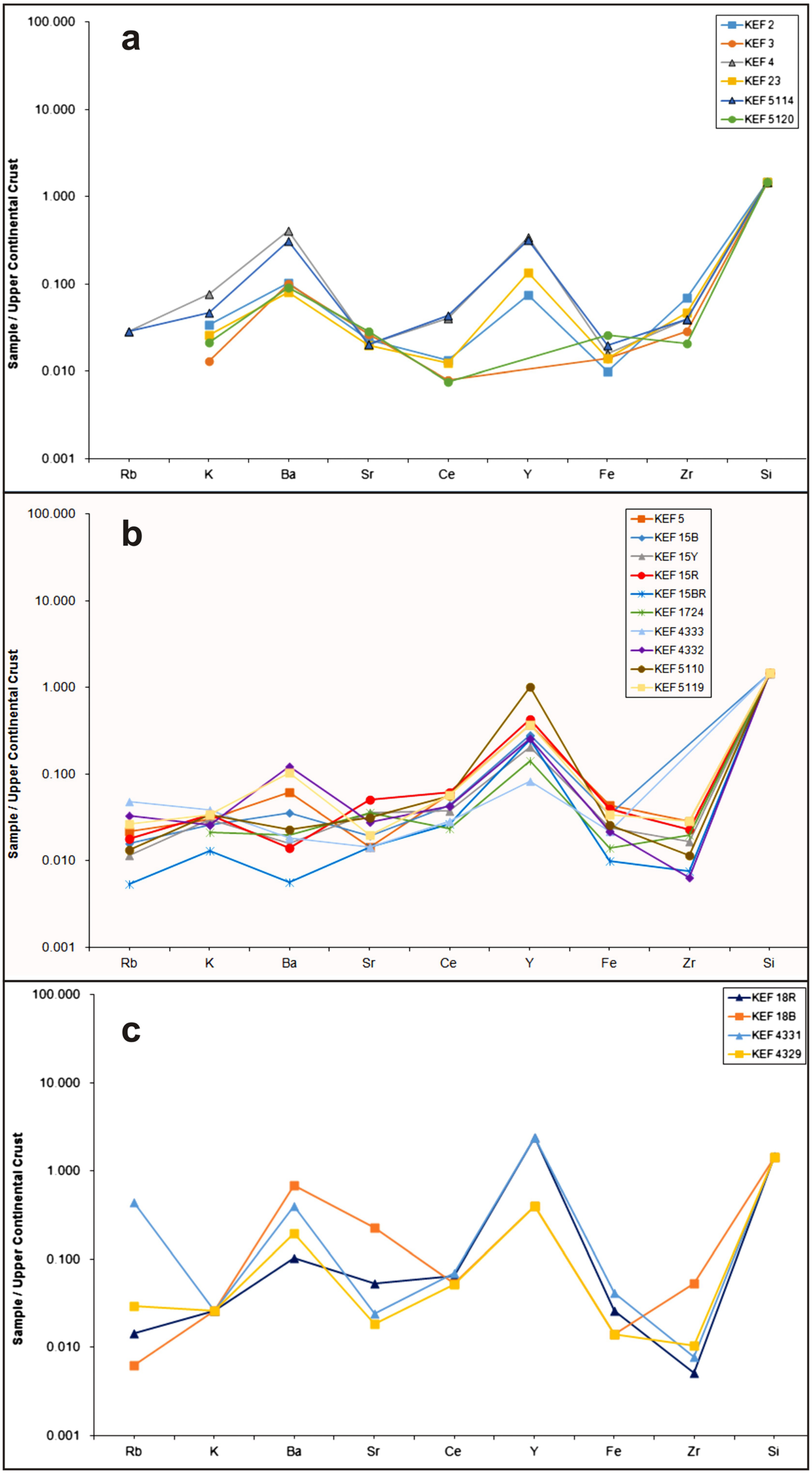
Limestones are sedimentary rocks composed of carbonates, mainly calcite. When dolomite is present, the rocks are called dolomitic limestones. Limestones can be formed in the sea through an inorganic or organic route. In the first case, limestones form by direct precipitation of calcium carbonate from a saturated solution caused either by an increase in temperature or by evaporation. In the second case, they usually contain fossils of plants and animals. The rock is formed as fossils gradually assimilate, and depending on their resistance to diagenesis, persist to occur cemented within the rock.

Five representative limestone implements from the archeological finds of Drakaina Cave were studied in order to determine their mineralogical and petrographic composition and to confirm the characteristics of the different limestone raw materials for specific uses. Three of the artifacts were used mainly for polishing tasks and the other two were classified as passive and active tools used mainly for grinding tasks (Stratouli et al. 2014). The three polishing implements have a white color and form pebbles with a length ranging from 4.0 to 8.0 cm. Their raw material is characterized as a micritic limestone since they are dominated by fine-grained calcite grains, mainly less than 50 μm. Small white mica flakes are rarely observed within the limestone. The color under the microscope is dark, due to the extended presence of organic material (solidified bitumen) (Fig. 17a). The limestones contain fossils, such as *Bivalves*, G*astropods*, and, on rare occasions, *Radiolaria* (Fig. 17b).

Due to their homogeneous, compact, and fine-grained structure, these limestones are appropriate for altering the surfaces of other objects (i.e., clay, stone, wood, bone or leather items), often giving them a shiny appearance, through abrasive and polishing mechanisms (Adams 2002). Many limestone tools exhibit abrasive use-wear on their faces and some on their sides. The wear marks comprise namely of flattened faces, often accompanied by the development of sheen and the presence of scratches and scars, indicating the implement's kinetics, while in use.

The two passive/active tools used for grinding tasks have a coarse grained texture and their raw material is characterized as fossiliferous limestone, on the basis of the classification by Boynton (1980), because it contains numerous fossil fragments. Mineralogically the limestone consists mainly of calcite intermixed with subordinate quartz. Calcite fills the well-preserved fossils, whereas the cementing material is dominated by carbonate-rich organic material, which has a hazy black color under the microscope. *Nummulites*, G*astropods*, *Echinodermata*, *Algaes*, *Lamellibranchiata*, and *Bryozoa* are the most common fossils observed within these limestones (Fig. 17c–f). Their length sometimes reaches 5 mm and they are apparently recrystallized.

The presence of sizable fossils probably favored the preference of this limestone variety compared to other types of grinding/abrasive tools, such as abraders and grinding slabs.


a
KEF 2
KEF 3
KEF 4
KEF 23
KEF 5114
KEF 5120
b
KEF 5
KEF 15B
KEF 15Y
KEF 15R
KEF 15BR
KEF 1724
KEF 4333
KEF 4332
KEF 5110
KEF 5119
c
KEF 18R
KEF 18B
KEF 4331
KEF 4329
Sample / Upper Continental Crust
100.000
10.000
1.000
0.100
0.010
0.001
Rb
K
Ba
Sr
Ce
Y
Fe
Zr
Si

◀ **Fig. 12** Upper continental crust normalized spider diagrams for archeological and geological chert samples. **a** Three archeological (KEF 23, KEF 5114, KEF 5120) and three geological chert samples (KEF 2: Kampitsata, KEF 3: Anninata, KEF 4: Megali Rachi hill); **b** Two archeological (KEF 4332, KEF 5519) and two geological samples (KEF 5, KEF 15BR), exhibiting positive Ba anomalies, and three artifacts (Kef 1724, Kef 4333, Kef 5110) and three geological cherts (Kef 15R, Kef 15Y, Kef 15Br) which show slightly negative Ba anomalies. All the geological samples are from Skala area; c. Two archeological (KEF 4329, KEF 4331) and two geological chert samples from Sami (KEF 18R, KEF 18B)

The hard and compact fossils would make excellent abrasive agents, while their resistance would increase the efficiency of the implements, especially for the shaping and reduction of other artifacts through direct abrasion. Moreover, the compacted fossils and the recrystallized matrix of these limestones would also make them suitable for grinding and pulverizing materials.

Limestones are widespread in Kephalonia, demonstrating an age of Upper Triassic to Miocene, and cover the largest part of the island (Fig. 1). Furthermore, the geological survey revealed that the local alluvial Pliocene to Holocene sediments contain a large number of limestone gravels. Two main types of limestone were observed in the rocks, especially at the slopes of Mount Atros, which extends north to north-west of Drakaina Cave, and in the alluvial sediments. The two types are represented by a micritic limestone consisting of only calcite, and by a fossiliferous limestone with coarse grained calcite and traces of quartz containing large fossil fragments. This confirms that the natural limestone exposures are identical with the studied implements and we can therefore conclude of a local origin for the limestones used in the ground stone assemblage of Drakaina Cave.

Grinding/abrasive tools made of sandstone

Sandstone is another type of rock that had been extensively used in Drakaina Cave for the production of ground stone tools (Fig. 16c, d). This raw material is represented by 212 specimens, mainly grinding/abrasive tools (i.e. grinding slabs and grinders) and at lower rates for percussive tools and multiple-use tools (Stratouli et al. 2014). The macroscopic examination of the sandstone ground tools found in the neolithic layers of Drakaina Cave are distinguished in three major types, based on their color variations: red, brown and green. Four representative implements from all color types were collected for microscopic study and X-ray diffraction analyses.

Sandstone is a clastic sedimentary rock in which at least 50% of the grains are 1/16 mm to 2 mm in size. It generally consists of quartz, feldspar, mica, calcite, or dolomite and very small lithic polymineralic fragments. All these minerals are cemented with clay, silica, carbonate or iron oxide. Sometimes sandstone has great durability, due to the compaction and cementation rate, making it suitable for structural uses. Various minerals, such as iron oxides and

Table 5 Major (wt%) and trace (ppm) elements of two polished edged tools from Drakaina Cave, Kephalonia. Fe_2O_3 = Fe total, bd = below detection

Sample	KEF 5118-8	KEF 5120-18
wt%		
SiO_2	49.47	53.71
Al_2O_3	12.48	13.05
Fe_2O_3	7.48	7.85
MnO	0.15	0.15
MgO	11.96	9.02
CaO	9.90	9.72
Na_2O	0.69	1.02
K_2O	0.14	0.07
TiO_2	0.23	0.28
P_2O_5	0.03	0.03
LOI	6.88	5.82
Total	99.41	100.72
ppm		
V	207	230
Cr	972	475
Co	41	34
Ni	177	95
Cu	16	43
Zn	31	39
Ga	10	11
Ge	0.7	bd
As	bd	bd
Rb	2	2
Sr	52	55
Y	6.2	6.9
Zr	14	13
Nb	4.7	2.5
Mo	bd	bd
Ag	bd	bd
In	bd	bd
Sn	bd	bd
Sb	bd	bd
Cs	bd	bd
Ba	43	27
La	0.90	0.95
Ce	2.09	2.20
Pr	0.25	0.29
Nd	1.35	1.53
Sm	0.44	0.50
Eu	0.18	0.22
Gd	0.69	0.79
Tb	0.14	0.16
Dy	1.01	1.16

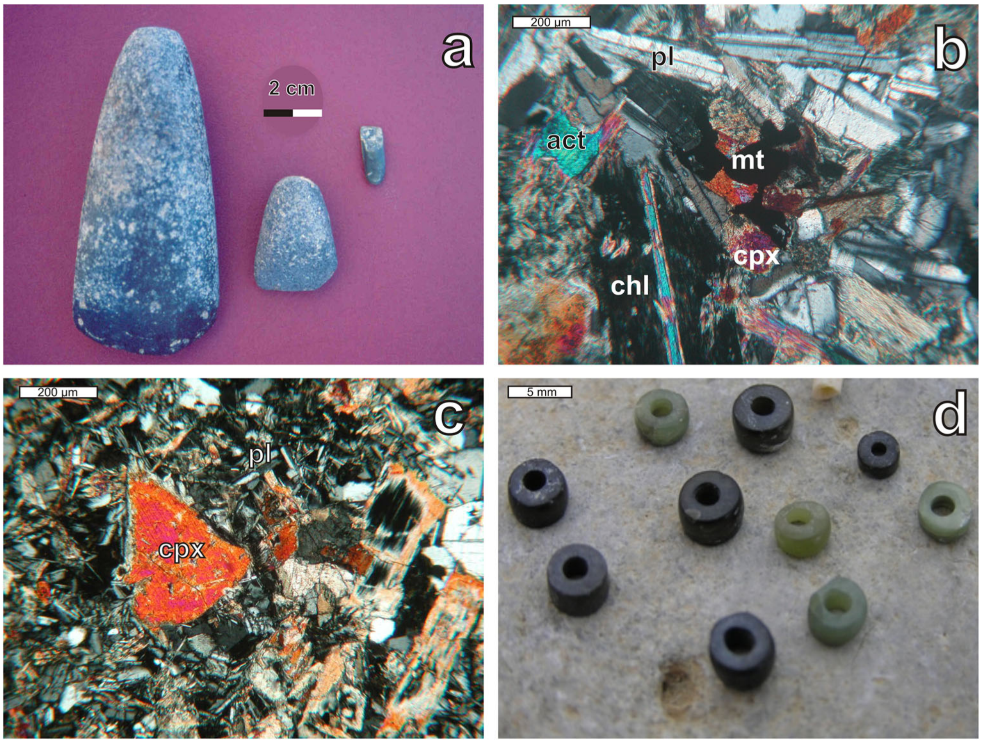


Fig. 13 **a** Polished edged tools made of gabbro/dolerite, Drakaina Cave. **b** Photomicrograph showing typical example of the mineral composition of the tool made of dolerite (KEF 5118-8) in Drakaina Cave, thin section, +N. **c** Photomicrograph showing typical example of the mineral composition of the tool made of gabbro (KEF 5120-18) in Drakaina Cave, thin section, +N. **d** Perforated, ring-shaped beads with straight or rounded edges. *pl* plagioclase, *act* actinolite, *cpx* clinopyroxene, *chl* chlorite, *mt* magnetite

carbonates, which leached into the layered sand beds, give to sandstones rich and varied colors.

Mineralogical examination of the red-colored sandstones revealed that they consist mainly of calcite and quartz. Calcite is the predominant mineral and constitutes a significant proportion (ca. 90%) of the clastic grains (Fig. 18a, b). According to Moorhouse (1985) such rocks may be classified as "calcarenites," whereas the term "calcareous sandstones" may be also used. Most of the calcite grains have an anhedral subangular shape and their size reaches up to 1 mm. Quartz grains are angular (Fig. 18a, b) and display undulose extinction. They constitute approximately 10% of the clastic grains and their size ranges from 0.1 mm to 0.5 mm. The fossils, which are occasionally found among the clastic grains of the red sandstones, are frequently broken and only a few are well preserved (Fig. 18b). Mineralogically, they consist of calcite and are represented by *Foraminifera*, *Lamellibranchiata*, *Echinodermata*, *Nummulites*, and *Algae*. The red sandstones are cemented with calcite and occasionally with iron hydroxides or oxides, possibly goethite or hematite. Iron oxides are opaque or slightly translucent and are ascribed to diagenetic redistribution of iron derived from the decomposition of iron-bearing detrital minerals. In such cases the primary textures have been destroyed and the oxidation gives a distinctive red tint to the rock.

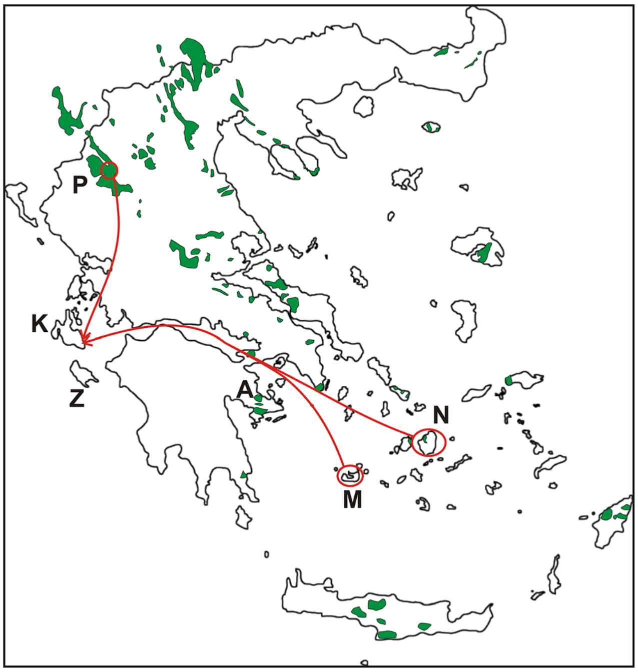


Fig. 14 Sketch map showing the distribution of the ophiolites (green colored) in the Aegean and the provenance of the raw materials for imported stone implements in Drakaina Cave. *K* Kephalonia island, *Z* Zakynthos island, *A* Argolid, *M* Melos island, *N* Naxos island, *P* Pindos

Calcite, dolomite and quartz are the major minerals of the brown sandstones (Fig. 18c). The textural features of the brown sandstones are almost identical with those of the red sandstones. Quartz represents ~ 20% of the clastic grains and its size varies between 0.1 and 1.0 mm. In many cases, it has a microgranular polycrystalline texture (Fig. 18c) demonstrating its chert derivation. Due to the high amount of the carbonates (calcite and dolomite), this rock may be classified as calcarenite-dolarenite (Moorhouse 1985). Fragments of shells

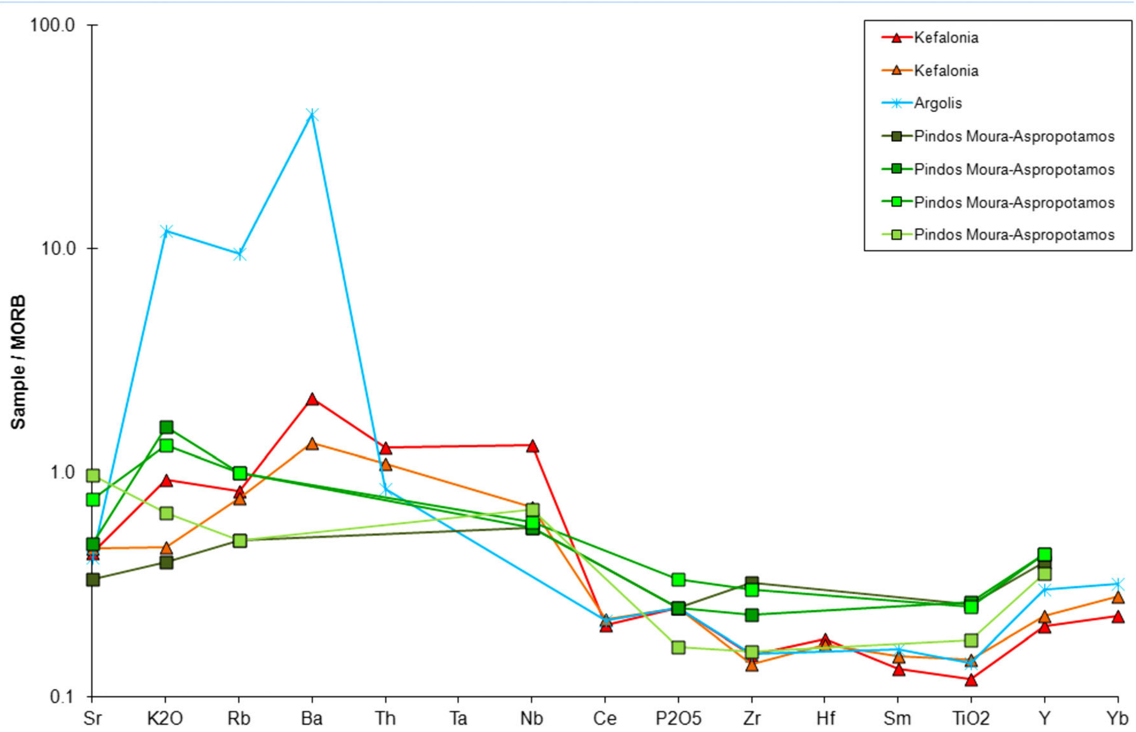
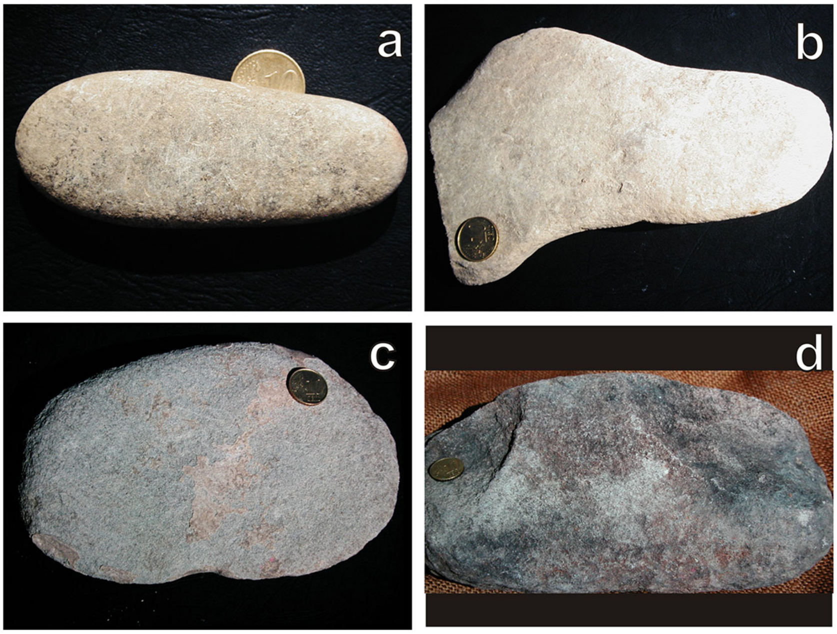


Fig. 15 MORB normalized multi element spider diagrams of the two polished edged tools from Drakaina Cave (KEF 5118-8, KEF 5120-18; data taken from Table 4), compared with four samples from Pindos Moura-Asporpotamos area (data from Kostopoulos 1988) and one sample from Argolid area (data from Pe-Piper and Piper 2002)

and other fossils, such as *Foraminifera*, *Lamellibranchiata*, *Echinodermata*, and G*astropods*, are common in the brown sandstones.

The green sandstones consist mainly of calcite with minor quartz and dolomite as well as traces of chlorite and muscovite. The constituent minerals exhibit a good sorting within the beds of the rock and their distribution is homogeneous. The grain size of the calcite clastic grains reaches 0.1 mm (Fig. 18d). Quartz comprises approximately 10% of the clastic grains, whereas chlorite and muscovite sum up to 5%. The fossils are mainly pelagic and are represented by *Foraminifera*, *Lamellibranchiata*, and G*astropods.*

Fig. 16 Ground stone implements from Drakaina Cave. **a**, **b** Implements made of limestone with water-rolled faces, for abrasive, polishing and percussive tasks. **c**, **d** Implements made of sandstone with water rolled faces, for grinding/abrasive and percussive uses



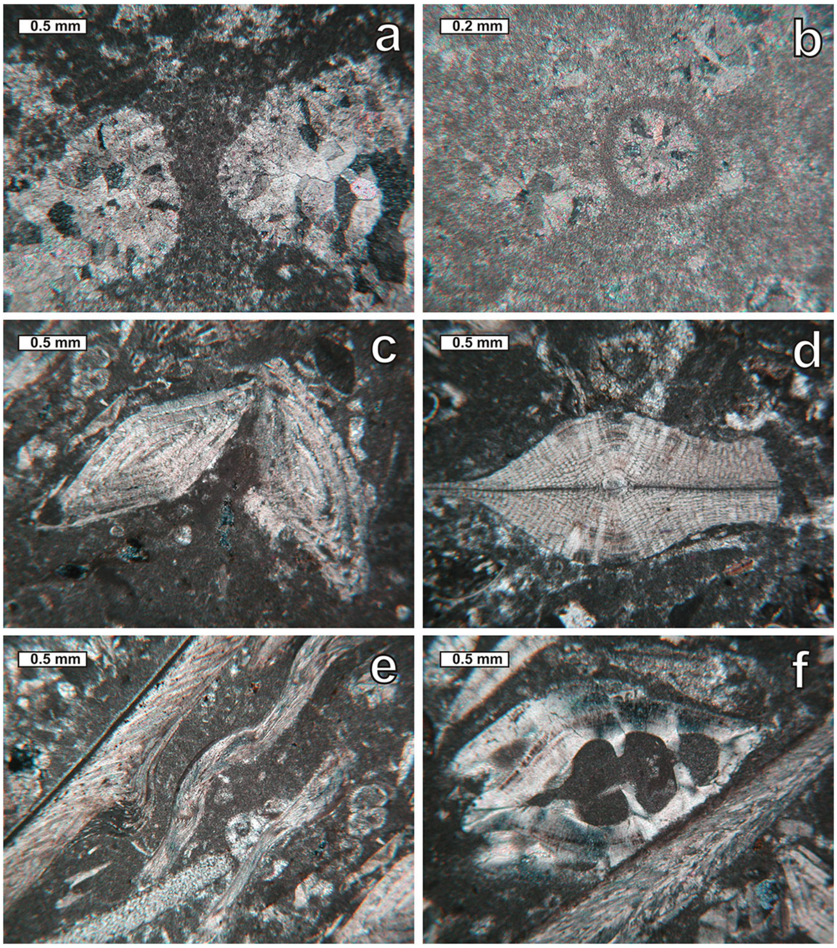


Fig. 17 Photomicrographs showing the typical textures of geological (**a**–**d**) and archeological (**e**–**f**) limestones from Kephalonia island and Drakaina Cave, respectively. Thin sections, +N. **a** Calcite and recrystallized fossils, within organic material (KEF 1). **b** Calcite and a R*adiolaria* within fine grained calcite and organic material. **c** *Nummulites* within organic material (dark color) (KEF 6). **d** Fossil within organic material (dark color) (KEF 6). **e**, **f** Fossils and fragments of fossils within organic material (KEF 5245-2)

Extensive areas in Kephalonia island, especially in the western and southern regions (Fig. 1), are covered by sedimentary rocks of Pliocene to Pleistocene age, consisting mainly of sandstones, conglomerates, marls, limestones, and travertines (British Petroleum Co et al. 1985). Relatively large sandstone slabs, in the form of boulders, up to 50 cm long, are found within the sedimentary sequences or within the alluvial deposits of the rivers and gorges in the area adjacent to Drakaina Cave. Field observations around Drakaina Cave showed that the main sandstone types, based on their colors, are the same with the types observed in the neolithic ground stone tools: red, brown, and green sandstones.

The vast majority of the sandstones in Neolithic Drakaina, as well as in other Greek Neolithic sites (e.g., Bekiaris 2007, 2018; Tsoraki 2007; Stroulia 2010) were used in the manufacture of grinding implements. It is well documented in the literature (Runnels 1985; Stroulia 2010; Melfos et al. 2014) that because of its granular texture, sandstone was a suitable and favored raw material for manufacturing grinding slabs and grinders during the Neolithic. In the case of Kephalonia, the anhedral angular quartz grains, which occur within the local sandstones in a percentage of about 10 to 20%, made this raw material suitable for grinding tasks, such as the preparation of foodstuffs. According to Stratouli et al. (2014) several works were performed with the grinding tools in Drakaina Cave, including food preparation (meat, fish, corps, and herbs), wood shaping, bone and shell ornaments manufacture, as well as pigments and salt processing. However, they support that crops were mainly processed out of the cave and so the grinding stones were not extensively used for preparation of fine-grained flour.

The mineralogical composition of three geological samples is almost identical with the studied implements. The red sandstone contains mainly calcite with minor quartz and traces of dolomite, chlorite and mica, as well as several fossils. The size of the calcite and quartz angular clastic grains reaches up to 10 mm and the cement material is mainly carbonate impregnated with iron oxides and hydroxides. The brown sandstones contain clastic grains up to 1.2 mm in size, made of calcite, dolomite and quartz, as well as few fossils. The main mineral of the green sandstones is calcite with minor quartz, dolomite, and chlorite, and sometimes it contains fragments of fossils. The size of the clastic grains reaches 0.4 mm.

Comparing the mineralogical composition and the texture of the sandstone implements with the geological samples, we come to the conclusion that the raw materials were collected

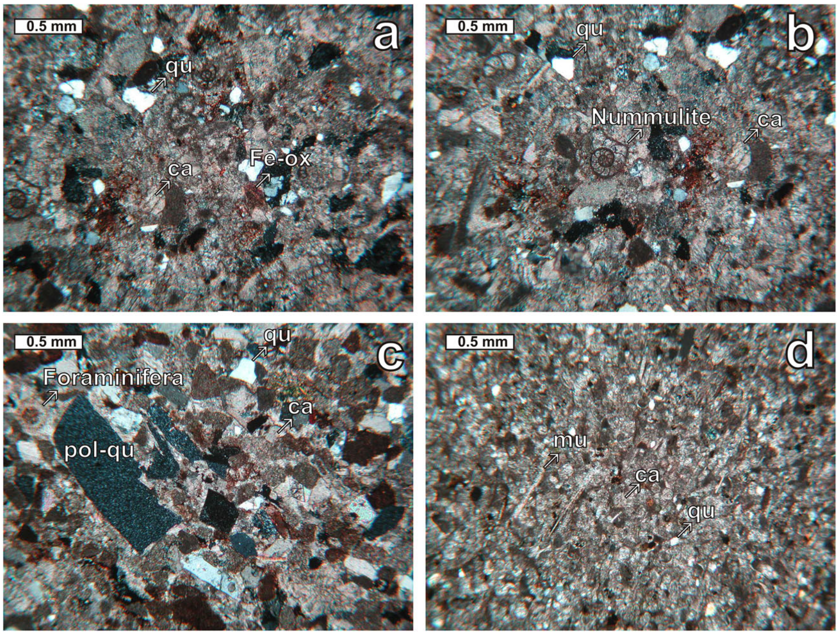


Fig. 18 Photomicrographs showing the typical textures of geological (**a**, **c**) and archeological (**b**, **d**) sandstones from Kephalonia island and Drakaina Cave, respectively. Thin sections, +N. **a** Red sandstone: calcite (ca) and quartz (qu) clastic grains within carbonate cemented by calcite and Fe-oxide (Fe-ox) (KEF 7). **b** Red sandstone: a fossil (*Nummulite*) within calcite (ca) and quartz (qu) grains (KEF 5311-5c); c. Brown sandstone: microgranular polycrystalline quartz (pol-qu), single quartz (qu), and calcite (ca) clastic grains and a fossil (*Foraminifera*) (KEF 8). **d** Green sandstone: small calcite and quartz grains and rarely muscovite (mu) (KEF 5117)

from the neighboring area of Drakaina Cave as there were sufficient resources of this rock.

A zoomorphic vessel made of white marble

White marble, an attractive and brilliant rock, was strongly related to the social, religious and economic life of people in ancient times. The use of white marble as a raw material during the Neolithic is evident in several objects, including anthropomorphic figurines, various tools and vessels, which were found in Cyclades, Crete, mainland Greece (e.g., Francthi Cave, Sesklo, Dimini, Larisa and Lakonia), as well as Egypt and Western Anatolia (Evans and Renfrew 1968; Renfrew and Peacey 1968; Herz 1992; Devetzi 1996; Maniatis et al. 2009; Ifantidis 2011; Stratouli et al. 2014). Since such artifacts were rare during the Neolithic period, it is suggested that most of them were used for special purposes and were regarded as objects of social prestige (Bailey 2005).

Knowledge of exact sources of the raw materials used for the manufacture of marble artifacts in antiquity is very valuable. It allows important conclusions concerning distances of transportation and networks of exchange and communication as well as direct or indirect trade patterns between different ancient communities. Various analytical methods are applied for the provenance determination of ancient white marble objects. They mainly include mineralogical study, petrographic analysis, and stable isotopes (^{18}O and ^{13}C) (Craig and Craig 1972; Manfra et al. 1975; Herz 1987, 1988, 1992; Capedri and Venturelli 2004; Attanasio et al. 2006).

The suitability of these techniques is based on the development of extensive data bases from known ancient marble sources and the statistical treatment of the measured parameters. An important additional requirement is a small amount of sample. In particular, isotopic ratios of C and O provide usable signatures for determining the provenance of marbles. Isotopic analysis involves measuring of the $^{13}C/^{12}C$ and $^{18}O/^{16}O$ ratios in samples, and the results are expressed in terms of the deviation from a conventional standard, the Pee Dee Belemnite (PDB) international standard, a carbonate fossil from South Carolina. This deviation, called δ, is expressed as $\delta^{13}C$ and $\delta^{18}O$ in parts per thousand (‰ or per mil) and forms the isotopic signature. The values exhibit a relatively restricted range in each quarry area or limited parts of a geological formation (Craig and Craig 1972; Herz 1987). $\delta^{13}C$ and $\delta^{18}O$ values may be a good indicator of the formation environment of the carbonate in the studied marble samples.

A special find, probably the leg of a zoomorphic vessel (Fig. 19), made of white marble was uncovered in a late Neolithic layer of Drakaina. Macroscopically, its color is white-gray and it is semi-transparent. Its provenance is very interesting since white marble is not known to occur in either the Ionian islands or the western coast of the Greek mainland.

Due to the tiny slice of the sample (ca. 1 g), which was obtained from a fractured part of the marble find under discussion, it was not possible to prepare a thin section for

Fig. 19 The zoomorphic leg of a white marble vessel (KEF 2530) from the LN I layers of Drakaina Cave

microscopic examination. The marble sample (approximately 5 mg) was analyzed to determine its carbon and oxygen isotopic ratios. In addition, an XRD study was carried out in order to identify the mineralogical composition (in particular to distinguish calcite from dolomite) and their relative abundances in the sample. On the basis of the XRD pattern (Fig. 20a), the marble consists mainly of calcite with minor dolomite. The isotopic results showed that the $\delta^{13}C$ value of the marble object is + 3.44‰ and the $\delta^{18}O$ − 11.15‰ (Tab. 6, Fig. 20b).

According to Baker et al. (1989) and Ganor et al. (1991), such a carbon and oxygen isotope composition reflects an initial marine sediment signature. Veizer and Hoefs (1976) consider that carbonates with $\delta^{13}C$ values around 0 ± 4‰, represent a marine environment of deposition. An oxygen isotopic ratio lower than − 1.00‰ in marine carbonates, is caused either by exchange with fluids after deposition of the carbonate or by deposition of carbonates in the marine environment at increased temperatures (De Groot et al. 1996). In the case of fluid exchange, metamorphism affects isotopic ratios and causes $\delta^{18}O$ decrease depending on the temperatures reached.

The provenance determination of the white marble vessel from Drakaina Cave is based on an extended data base, which contains published and unpublished data from over 100 different ancient white-marble quarrying sites in the Eastern Mediterranean region, including Greece, Asia Minor in Turkey and Italy, with a total of more than 1200 isotopic analyses. The isotopic data were obtained from Craig and Craig (1972), Herz and Vitaliano (1983), Herz (1987, 1988, 1992), Germann et al. (1988), Lazzarini et al. (1995), Asgari and Matthews (1995), Moens et al. (1996), Hermann et al. (2000), Bruno et al. (2000), Pentia et al. (2000), Gorgoni et al. (2002), Lazzarini and Antonelli (2003), Capedri et al. (2004), Melfos (2004), Attanasio et al. (2006), Melfos et al. (2010), Antonelli and Lazzarini (2015), and Melfos (unpublished data).

The isotopic results of the studied vessel were compared with this data base. In the binary diagram of $\delta^{13}C$ versus $\delta^{18}O$, the marble plots only into the fields of the Naxos marble in the Aegean Sea, and of the Sardes marble in Asia Minor (Table 6, Fig. 20b). The large overlapping of the isotopic data fields from different localities renders $\delta^{13}C$-$\delta^{18}O$ plots often ineffective in discriminating the marble sources. It is therefore evident that other methods should be applied for a more specific determination of the provenance. Mineralogical composition could help in distinguishing the two different sources, e.g., Naxos from Sardes. Naxos crystalline white marble is a typical calcite carbonate and contains also dolomite, quartz, muscovite, epidote, zircon, sphene, plagioclase as accessories, in various proportions (Roos et al. 1988). The marble of Sardes consists also of calcite with plagioclase, serpentine and sphene as accessories (Antonelli and Lazzarini 2015). The presence of very small quantities of dolomite in the Neolithic marble artifact from Drakaina Cave indicates that Naxos is a possible source of its raw material (Fig. 20b).

Discussion

The present study revealed that the prehistoric inhabitants of Drakaina Cave in Kephalonia island had an excellent knowledge of the natural resources of their land and that they chose the available raw materials for specific purposes and uses. The majority of the used raw stones derived from local sources on the island. Their choice was based on the quality and properties of the minerals and rocks. For the manufacture of the stone tools, the neolithic users collected lithic raw materials from the adjacent areas within a distance not exceeding 10 km. The chipped stone artifacts were manufactured on cherts from the rich local sources in the neighboring areas of Drakaina Cave, such as Kampitsata, Anninata, Megali Rachi hill, Skala, and Sami (Fig. 1). Limestones and sandstones, from local sources too, were used to manufacture abrasion, percussion and grinding tools. Both raw material types are available in the broader area of Drakaina Cave, in the form of gravels, up to 50 cm long, within the sedimentary sequences and the alluvial deposits of the rivers and gorges. Besides, limestone is extensively present since it is the predominant rock type on

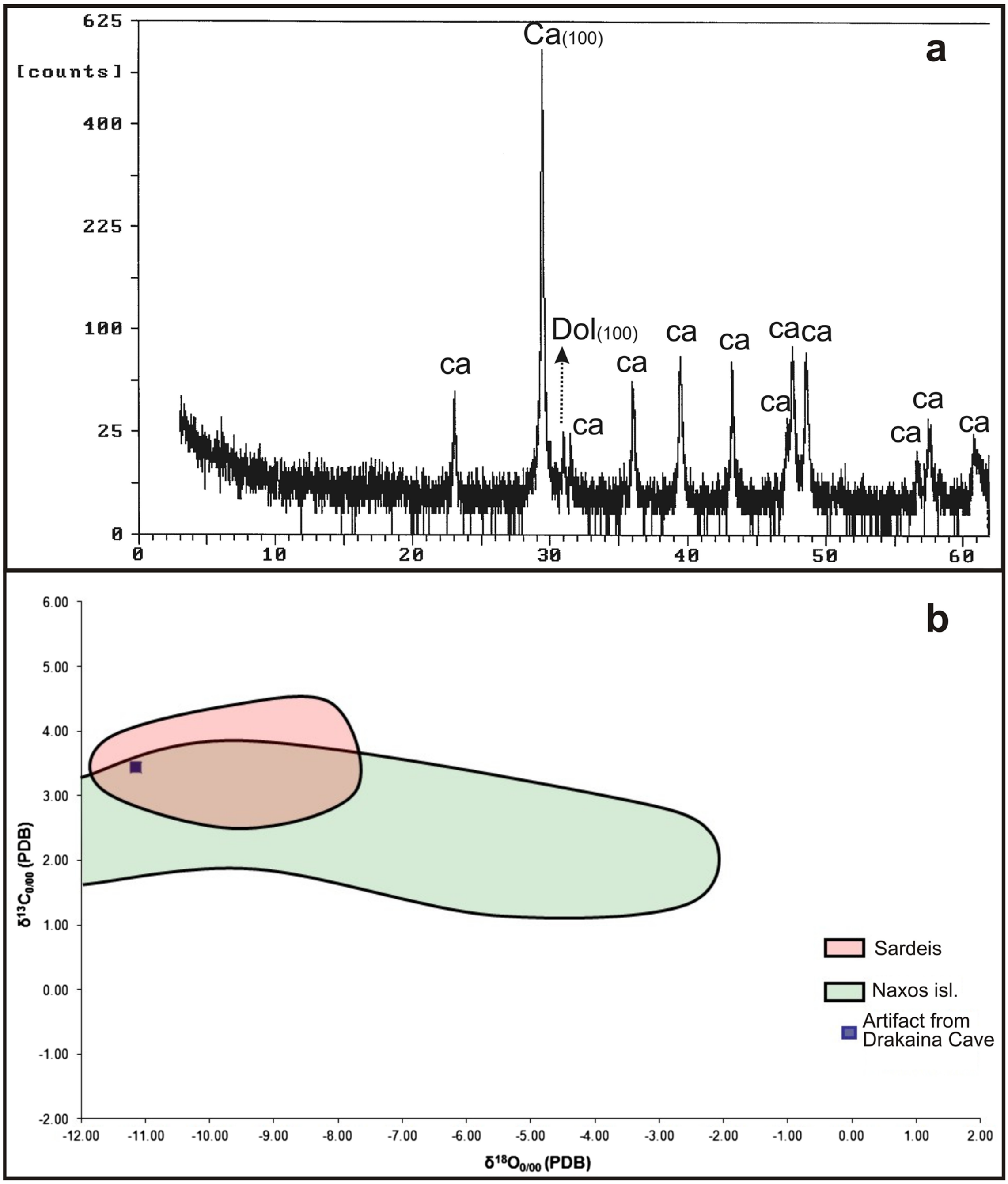


Fig. 20 **a** XRD pattern of the leg of a zoomorphic white marble vessel from Drakaina Cave. Ca = calcite, Dol = dolomite. **b** δ^{13}C-δ^{18}O isotopic plot of the white marble artifact from Drakaina Cave and the reference fields from Naxos island and Sardes (data taken from Herz 1987, Germann et al. 1988, Herz and Doumas 1990, Gorgoni et al. 2002, Capedri et al. 2004)

Kephalonia island (Fig. 1). This is evidence for the availability of a dynamic "lithic" landscape, which was full of high quality raw material resources (Stratouli et al. 2014).

The commonest implement in Drakaina Cave was manufactured by chert of Kephalonia, including the so-called honey flint. It is evident by the patterns of Fig. 12 that the archeological and the geological cherts are not totally homogeneous, but the observed minor heterogeneity is typical for siliceous sediments, even in an outcrop scale (see Gauthier et al. 2012). The overall patterns are similar, demonstrating that the archeological samples have strong chemical affinities with the geological samples collected from Kephalonia. The multi-element normalized spider diagram patterns for the archeological and geological cherts exhibit depletion in respect to the upper continental crust, because all the elements are plotted below 1. They also display positive anomalies of Ba (apart of 6 samples), Y and Sr with respect to the other elements.

Table 6 Mineralogical and O-C isotopic compositions of white marbles from the zoomorphic vessel found in Drakaina Cave, and the ancient marble quarries in Naxos Island and in ancient Sardes of Minor Asia

Locality	Mineralogical composition	C-O isotopes (referred to the standard VPDB)	References
Drakaina Cave	Calcite, dolomite	δ^{18}O: − 11.15‰ δ^{13}C: 3.44 ‰	This study
Naxos island	Calcite, dolomite, quartz, muscovite, epidote, zircon, sphene, plagioclase	δ^{18}O: − 13.8 to − 2.2‰ δ^{13}C: 0.3 to 3.8 ‰	Herz (1987), Roos et al. (1988), Germann et al. (1988), Herz and Doumas (1990), Gorgoni et al. (2002), Capedri et al. (2004), Attanasio et al. (2006)
Sardes	Calcite, plagioclase, serpentine and sphene	δ^{18}O: − 11.4 to − 3.2‰ δ^{13}C: 0.1 to 4.5 ‰	Antonelli and Lazzarini (2015)

Local chert is characterized by very good properties and was easily accessible (Melfos and Stratouli 2016). That was probably the major factor in the choice of this material, which was transported into the cave either through direct collection from the sources or through exchange processes with other Neolithic communities of the island. However, both methods for acquiring the local chert raw materials are not excluded. It is very probable that the users of the cave transported the chert raw materials from the sources in central and southeastern Kephalonia to the cave through marine roads, due to the vicinity of Drakaina Cave to the seaside.

A long term debate about the provenance of the honey flint in the Neolithic sites of Balkans has shown numerous potential sources including western Greece, Albania, Bulgaria or Romania (Kardulias 1992). According to Perlès (1992, 1994) and Perlès and Vitelli (1999), honey flint is an ideal chert raw material for knapping. The yellow chert from the geological outcrops of Kephalonia and the archeological material of Drakaina Cave, resembles in color and quality with honey flint described before in Franchthi Cave, Thessaly and elsewhere. We suggest therefore that Kephalonia island was possibly one of the sources of the honey flint, and most probable the Skala area in southeastern Kephalonia (Marinatos 1960; Matzanas 2000; Melfos and Stratouli 2016).

Only a very restricted number of special implements was made of exotic raw materials. The studied cutting-edged tools and the discoid beads are made of gabbro and talc, respectively. Both raw materials were a product of import into the Ionian islands. Our study provides evidence on the provenance of the gabbro artifacts, indicating that the most possible source of origin was the ophiolite complex of Pindos (Fig. 14). We suggest that the studied discoid beads made of talc were also transported through the same transportation route from Pindos, because talc is also a mineral associated with ophiolites.

The raw material used for the manufacture of a white marble zoomorphic vessel probably originated from the Cycladic island of Naxos in the south Aegean Sea (Fig. 14). Similar studies for prehistoric marble artifacts in the Mediterranean region are very scant in the literature. Herz (1992) has shown that among five marble vessels from the Neolithic layers of Francthi Cave in Argolid, two are from Naxos island. Naxos and Paros islands were the main sources of marble during the Neolithic and Early Bronze Age around the Aegean (Herz and Doumas 1990; Herz 1992; Maniatis et al. 2009; Tambakopoulos and Maniatis 2012). Combining all the presented data it is concluded that the raw material of the white marble vessel found in Drakaina Cave comes from Naxos. This is well documented from the isotopic signatures, the mineralogical composition and the fact Naxos was a marble-producing island during the Neolithic period and the Early Bronze Age.

In addition to these implements, Stratouli and Metaxas (2018) mention that a small number of artifacts made of obsidian originated from Melos in the Cyclades, whereas two beads of gypsum were from the neighboring island of Zakynthos (Fig. 14).

It is obvious that these exotic implements were imported to the island of Kephalonia through various networks of exchange and communication. Artifacts made of raw materials chain exchange, like gabbro, talc, marble, obsidian, and gypsum, were a kind of prestige to hold them. The origin of raw materials over an extensive area implies the existence of long distance networks. They suggest that there were various trade routes from the Greek mainland (Pindos) and the Aegean islands (Naxos, Melos) to the Ionian islands (Fig. 14). Marine trade was common from the Mesolithic times in the Aegean and the Ionian Sea (Reingruber 2011; Sampson et al. 2016). The imported implements indicate that Kephalonia was involved in regional exchange networks during the Middle Neolithic to the Chalcolithic.

Conclusions

The dynamic "lithic" landscape of Kephalonia served to the prehistoric people of Drakaina Cave with natural resources ca.

7500–5700 years ago. The inhabitants collected the proper minerals and rocks for specific purposes and uses, based on their quality and properties, from an area within a distance not exceeding 10 km. The chipped stone artifacts were made of local high quality cherts, including the so-called honey flint. Chert forms nodules and layers in the limestones or gravels in the recent sediments, which could be very easily collected and transported to the neolithic site. In the same way, the abrasion, percussion, and grinding tools were manufactured by gravels of limestones and sandstones, which are abundant in the sediments of the broader area of Drakaina Cave. However a few artifacts for special uses were made of exotic raw materials. The cutting-edged tools and discoid beads were produced by gabbro and talc, respectively, and their source was the ophiolite complex of Pindos. The white marble for the manufacture of a zoomorphic vessel probably originated from the Cycladic island of Naxos in the south Aegean Sea. These exotic implements were imported to the island of Kephalonia through complicated networks of exchange and communication.

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