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Characterization of the siliceous rocks at Stélida, an early prehistoric lithic quarry (Northwest Naxos, Greece), by petrography and geochemistry: A first step towards chert sourcing

Nikolaos Skarpelis [a], Tristan Carter [b,*], Daniel A. Contreras [c], Danica D. Mihailović [d]

[a] Department of Economic Geology and Geochemistry, National and Kapodistrian University of Athens, Greece
[b] Department of Anthropology, CNH 524, McMaster University, 1280 Main Street West, Hamilton, ON L8S 4L9, Canada
[c] Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE), Aix-Marseille Université, CNRS, IRD, Avignon Université, France/Groupement de recherche en économie quantitative d'Aix-Marseille (GREQAM), Aix-Marseille Université, France
[d] University of Belgrade, Faculty of Philosophy, Department of Archaeology, Čika Ljubina 18-20, 11000 Belgrade, Serbia

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ABSTRACT

This article presents the results of a combined petrographic and geochemical characterization study of raw materials from the early prehistoric chert source of Stélida, on Naxos (Cyclades, Greece). The project represents the first step in a larger provenience studies programme dedicated to documenting which communities exploited this source during the Lower Palaeolithic to Mesolithic (≥250,000–9000 BP). Field- and lab-based studies conclude that the cherts originated by pervasive silicification of the upper part of a clastic sedimentary sequence by hydrothermal fluids moving along a detachment fault separating them from the underlying Naxos granodioritic intrusive. Quartz is the dominant mineral, while zircon, anatase, hematite and barite are accessories. Petrographic features that are considered characteristic of the Stélida raw materials (e.g. colour and lustre, massive microcrystalline texture, abundant cavities, quartz crystals projecting into cavities and thin quartz veinlets cross-cutting bedding planes) are described. The cherts are strongly depleted in trace and Rare Earth elements. The petrographic and geochemical study of any stone tool made of chert showing similar macro- and microtextures, mineralogical features, and geochemical signature indicates a potential Stélida origin.

1. Introduction: insular lithic resources of the Mediterranean

Insular lithic resources – primarily for making chipped stone tools - played a significant role for prehistoric Mediterranean communities, particularly from the Neolithic when most of these islands were colonized (cf. Cherry, 1981; Farr, 2006). The best-known raw materials are the volcanic products of the region, particularly the obsidian sources on Sardinia, Pantellaria, Lipari, Melos, Antiparos, and Giali, for which there is an extensive literature detailing their geochemical characterization and history of exploitation (e.g. Carter, 2009; Costa, 2007; Renfrew et al., 1965; Williams-Thorpe, 1995). Less well-known island resources whose raw materials tended to have more local spheres of circulation include flint/chert on Corsica (Chiari et al., 2000), Sardinia (Bressy et al., 2008), Sicily (Robb and Farr, 2005: 28), Crete (Brandl, 2010), and Cyprus (Manning et al., 2010).

While most of these insular sources' primary period of exploitation began with the advent of farming, there is some evidence for pre-Neolithic exploitation. The best-known example of this was the procurement of Melian obsidian by hunter-gatherers on the Greek mainland in the 11th millennium cal BC (Upper Palaeolithic), which at the time of discovery represented the earliest – indirect – evidence for seafaring in the northern hemisphere (Renfrew and Aspinall, 1990). The received wisdom at the time was that any ventures into the Mediterranean by hunter-gatherers were limited in scale and distance, representing seasonal fishing/foraging ventures, rather than island colonization (Cherry, 1981). More recent work has produced more robust evidence for pre-Neolithic (Late Pleistocene-Early Holocene) insular settlement in the Mediterranean (Broodbank, 2013: 148–156), including Epi-Palaeolithic sites on Lemnos (Efstratiou et al., 2014) and Cyprus (Simmons, 1999), plus a few Mesolithic habitations in Corsica/Sardinia (a single island at the time [Costa, 2004]) and the Aegean islands (Sampson, 2014; Strasser et al., 2015). More radical claims have also been made for earlier Lower-Middle Palaeolithic activity in the Aegean (Runnels, 2014), though these claims have until recently rested almost entirely on surface finds (though see Strasser et al., 2011).

Little attention has been paid to the particulars of the non-obsidian raw materials within the chipped stone assemblages of Palaeolithic and Mesolithic sites of the Aegean Basin, despite the fact that chert(s) and quartzes were the predominant conchoidally fracturing materials

* Corresponding author.
E-mail addresses: skarpelis@geol.uoa.gr (N. Skarpelis), stringy@mcmaster.ca (T. Carter), danielalexandercontreras@gmail.com (D.A. Contreras), danicamih@yahoo.com (D.D. Mihailović).

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used by these hunter-gatherer populations (Table 1). The chert source of Stélida on Naxos (Cyclades [Figs. 1–2]) offers direct evidence of long-term exploitation of chert, and raises the question of whether chert was a widely-available and locally-exploited resource in the pre-Neolithic Aegean Basin, or instead an exotic, valued, and traded material as obsidian would later come to be. In part this question is purely geologic: how abundant are cherts in the region? Unfortunately, given their limited appeal to economic geology and their relatively small extent, they have not been widely noted in geologic mapping efforts.

The question may also be addressed archaeologically, by examining the chert components of lithic assemblages at archaeological sites – but approaching the question from that direction necessitates the ability to discriminate between distinct geologic outcrops of chert. Here we explore the characterization of Stélida chert through petrographic and geochemical analyses, creating the basis for broader study of diversity within Stélida chert and between various Aegean cherts.

While sourcing studies are well-established in the Aegean with regard to obsidian (starting with Renfrew et al., 1965), there have been far fewer attempts to characterize other siliceous raw materials, despite the prevalent outcroppings of chert and other materials throughout the region (Bornovas and Rondoyanni, 1983; Creuzburg et al., 1977). This paper part-aims to redress this archaeometric imbalance. Employing a data-set of 12 geo-referenced source samples from Stélida, we identify both major and accessory minerals and macro- and micro-textural features. Analytically this involved macroscopic visual inspection, as well as inspection via a petrographic microscope and a Scanning Electron Microscope [SEM]. Major, trace, and Rare Earth Elements [REE] were then detailed by X-ray fluorescence spectrometry [XRF] and Inductively Coupled Plasma - Mass Spectrometry techniques [ICP-MS].

As detailed below, the exploitation of the Stélida chert source began in the Middle Pleistocene/Lower Palaeolithic, and continued – probably intermittently – until the Early Holocene/Mesolithic (Carter et al., 2014, 2016a). This paper briefly summarizes the history of archaeological investigation and the geology of the area, then presents a petrographic and geochemical characterization of the raw material. This study forms a component of the larger *Stélida Naxos Archaeological Project*, initiated by our team in 2013. The longer term aim of undertaking this characterization study is to be able to document the raw material's regional significance by tracking its distribution through space and time (the quantity of knapping debris at the site leads us to believe that the source had supra-Naxian significance).

2. Archaeology of Stélida

The chert source of Stélida comprises the majority of a hill rising 151 m above what today is the coast of north-west Naxos (Fig. 2). While Stélida was the focus of a geological study in the 1960s (Roesler, 1969), it was not until 1981 that the prehistoric exploitation of the raw materials was documented during an island-wide survey (Séfériadès, 1983). The associated archaeology comprised a large quantity of stone tool manufacturing debris, the date of which remained far from clear due to a lack of comparable material from the region. Tentative claims that Stélida was of Early Neolithic or Epi-Palaeolithic date were made (Séfériadès, 1983: 72–73), though this went against the accepted models at the time, which suggested that the Cyclades were uninhabited until the Late Neolithic, i.e. the 5th millennium cal BC (Cherry, 1981). That said, the archipelago was known to have been visited by (Greek) mainland populations from the Upper Palaeolithic onwards (11th millennium cal BC), as attested indirectly by the recovery of Cycladic (Melian) obsidian in late Pleistocene cultural layers at the Franchthi Cave in the Argolid (Renfrew and Aspinall, 1990). Stélida remained something of a chronological enigma until archaeologists of the Greek Ministry of Culture proclaimed the site to have been exploited during the Mesolithic, Upper- and Middle Palaeolithic, based on the techno-typological characteristics of finds from a series of small-scale rescue excavations over the past 15 years (Legaki, 2012, 2014).

In 2013, we initiated the *Stélida Naxos Archaeological Project* to undertake a detailed geo-archaeological characterization of the site (www.stelida.mcmaster.ca). The research was part-motivated by the fact that the archaeology is being lost at an alarming rate due to modern construction. In turn, recent claims for Middle Pleistocene – Early Holocene sites elsewhere in the Aegean islands provide Stélida with a broader evidential context for its Palaeolithic – Mesolithic activity (Runnels, 2014; Sampson, 2014). These data are reconfiguring our understanding of the Aegean Basin's early prehistory, and potentially challenging orthodoxies concerning early humans' maritime capabilities (for a counter-point see Leppard, 2014).

Over the first two seasons we undertook a pedestrian survey of the site, using a combination of transects and grids to systematically document approximately 40 ha of the undeveloped areas of Stélida, and parts of the promontory to the south. Standardised recovery methods using transects and grids led to the collection of 17,910 surface artefacts. Artefacts were found widely distributed across Stélida (Fig. 3), not only in those areas immediately surrounding the outcrops, but also on the flanks of the hill in widely varying densities. Aside from a handful of pottery sherds, obsidian flakes, and hammerstones, the finds comprised flaked chert artefacts (Figs. 4–7), of which a significant number had technological and typological traits associated with material from well-dated Lower – Upper Palaeolithic and Mesolithic sites in the region (Carter et al., 2014). We here provide a precis of the four main periods of activity documented at the chert source.

2.1. Mesolithic

The Mesolithic period is represented by artefacts whose form and techniques of production are in keeping with excavated material from Early Holocene sites elsewhere in the southern Aegean (see Kaczanowksa and Kozlowski, 2014), including the sites of Maroulas (Kythnos), Kerame 1 (Ikaria), and Franchthi Cave (Argolid) (Fig. 1). The material is microlithic (sub-2 cm) and largely flake-based, percussion-knapped from multi-directional cores; there is also a minority bladelet component (Fig. 4). Retouched pieces include those with linear retouch, notches, denticulates, piercer/borers ('spines'), and end-scrapers; true geometrics are rare (Carter et al., 2016a).

2.2. Upper Palaeolithic

The Upper Palaeolithic assemblage is comprised of percussion blade industries (Fig. 5); the technical and morphological characteristics of both cores and end-products suggest that there are at least two phases represented within this period at Stélida. Distinctive carinated end-scrapers/bladelet cores whose products have a distinctive twisted

Table 1
Relative proportions of major stone tool raw materials from excavated insular Mesolithic sites in the Aegean Basin.
(Data from Carter et al., in press; Kaczanowksa and Kozlowski, 2008; Sampson et al., 2010).

Site	Date	Obsidian	Chert/Flint	Quartz
Maroulas (Kythnos)	Mesolithic	31% ($n = 1911$)	11 ($n = 635$)	56% ($n = 3382$)
Kerame 1 (Ikaria)	Mesolithic	c. 40% (n = ?)	c. 47% (n = ?)	c. 3% (n = ?)
Cyclops Cave (Youra)	Mesolithic	8% ($n = 15$)	82% ($n = 147$)	2% ($n = 4$)
Livari (SW Crete)	Mesolithic	2% ($n = 4$)	98% ($n = 246$)	0.4% ($n = 1$)

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