Obsidian from the Final Neolithic site of Pangali in Western Greece

Development of exchange patterns in the Aegean

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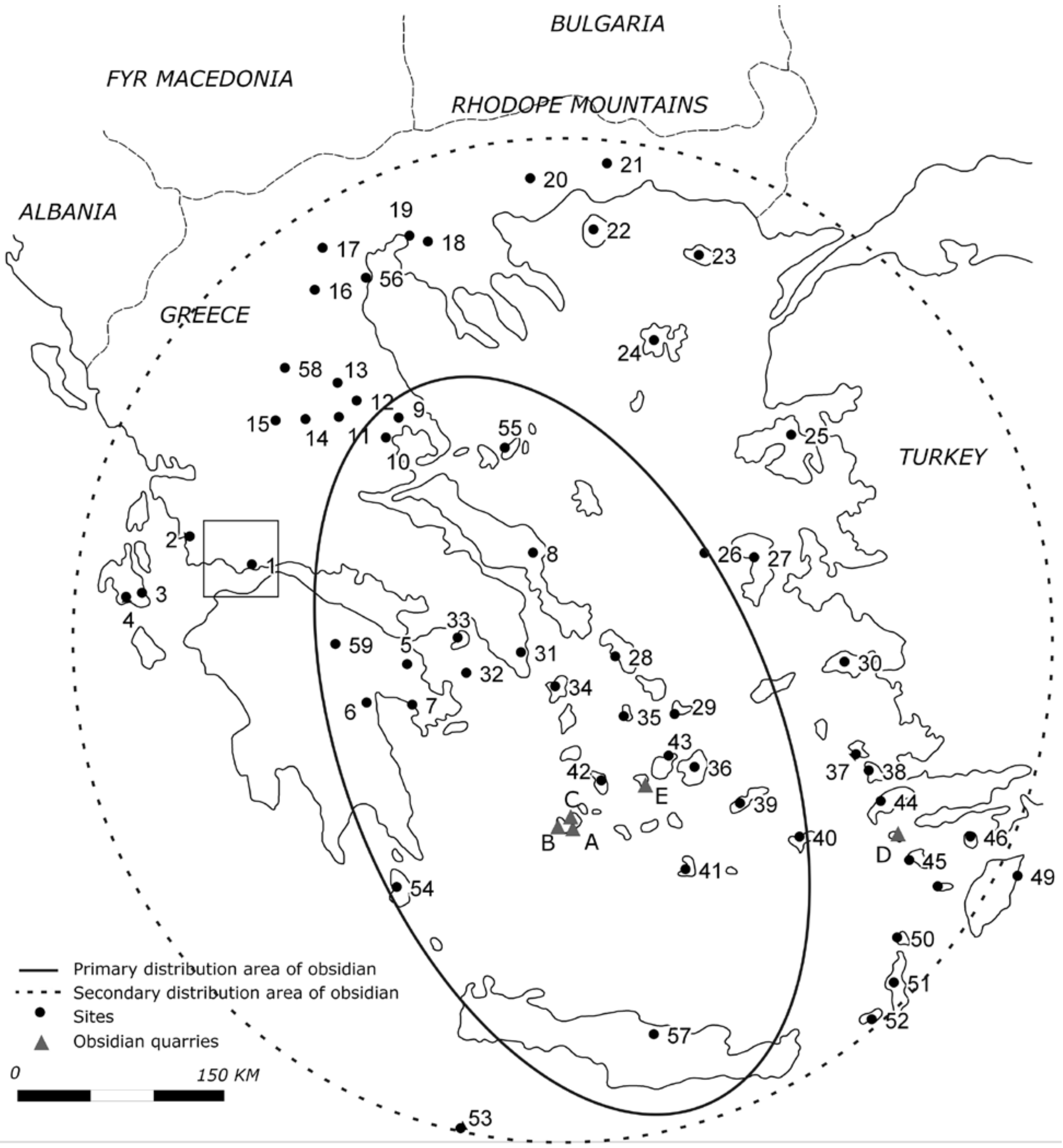
Abstract

Obsidian is found on many prehistoric settlements in the Aegean area; and most of it has been procured from Melos. Few assessments have been made in order to evaluate the amount of obsidian exchanged in different periods, but it is a general assumption that the exchange of obsidian reached its peak during the Final Neolithic and the Early Helladic. During this particular transition, the settlement pattern changes in the Aegean area and many sites move closer to the sea. Furthermore, the different islands are colonized. Pangali is one of these settlements where it is possible to observe and test different theories and hypotheses concerning the role of lithic specialization, exchange mechanisms and trading routes. The exchange of obsidian could have stimulated the development of some established transportation routes which grew important when copper and other exotic good were traded during the following Early Bronze Age. These facts could be one of the main reasons why some of these Final Neolithic sites developed into important Bronze Age settlements.

The aim of this paper is to present the chipped stone material from Pangali in Aetolia, one of the excavated Final Neolithic sites in Western Greece (figures 1 & 2). A special emphasis will be put on the obsidian assemblage and the technological and typological analysis of this material to compare this assemblage with other contemporary sites from the Aegean area. Many changes occur during the Final Neolithic, the main part of the Aegean islands is colonized and the settlement pattern changes from many inland sites to coastal orientated sites. Finally, the emergence of metallurgy is observed. These alterations are interpreted as the beginning of a more stratified society bringing with it many changes to ideology, power, gender and size of settlements. Accordingly, the analysis of the chipped stone material from Pangali and other Final Neolithic sites includes some new perspectives and some re-evaluation of the technological specialization, exchange patterns and development of transportation routes during the Final Neolithic in the Aegean region.

Pangali – excavation methods, stratigraphy and radiocarbon dates

The site of Pangali is situated on the eastern slopes of Mount Varassova in a rock shelter near a small natural bay, a very typical location com-



1. Pangali
2. Hagios Nikolaos
3. Kaphallenia - site 53
4. Kaphallenia - Mounta - site 15
5. Berbati
6. Lerna
7. Franchthi
8. Skoteini - Tharrounia
9. Dimini
10. Pevkakia Magula
11. Argissa Magula
12. Otzaki Magula
13. Ag. Sofia
14. Zarko
15. Prodromos
16. Servia
17. Nea Nikomedeia
18. Vasilika
19. Thermi
20. Sitagroi
21. Paradeisos
22. Kastri
23. Swnothraki
24. Lemnos
25. Lesbos
26. Psara
27. Chios
28. Andros
29. Ftelia - Mykonos
30. Samos
31. Kitsos
32. Aegina
33. Salamis
34. Kefala - Keos
35. Syros
36. Zas Cave - Naxos
37. Leros
38. Kalymnos
39. Amorgos
40. Astypalia
41. Thera
42. Siphnos
43. Saliagos
44. Kos
45. Tilos
46. Symi
47. Alimnia
48. Chalki
49. Kalythies Cave
50. Saria
51. Karpathos
52. Kasos
53. Gavdos
54. Kythera
55. Youra
56. Makriyalos
57. Knossos
58. Theopetra
59. Kastria

A. Demenegaki - Melos
B. Sta Nychia - Melos
C. Mandrakia
D. Giali
E. Antiparos

Figure 1. Map with selected Late and Final Neolithic sites in the Aegean, and the Aegean obsidian sources with the primary and secondary distribution areas indicated. Partly after Renfrew 1972; Torrence 1986; Broodbank 1999; Runnels & Murray 2001. Graphic: L. Sørensen, K. Langsted & N.A. Møller.

Figure 2. The site Pangali with the upper and lower terraces to the left and Mt. Varassova to the right. Patras and the Gulf of Patras are visible in the background. Photo: L. Sørensen.

pared to other coastal orientated sites from this period (figure 2; Broodbank 1999). The site was located during an intensive survey of the area conducted in 1995 by a Greek and Danish excavation project (Dietz & Moschos 2006). In 1996 a 2x2 m trial trench was excavated to investigate the nature of occupation. The soil was dry sieved in a four mm mesh in order to obtain even the smallest finds. The deposit was approximately 60 cm thick and the surface was clear of rocks and larger vegetation. Three levels of occupation were recovered during excavation, relating to a single cultural phase. In the deepest level, a hearth was found immediately above bedrock. It measured approximately 1.5 m in diameter, and consisted of hard, burned earth with small pieces of clay and charcoal. A vast quantity of potsherds (60 kg), lithics, bones, bone tools, sea shells and land snails as well as some spindle whorls and a fragment of a figurine were recovered from the excavation (Mavridis 2006:117ff). This paper will concentrate on the analysis of the chipped stone material. In the analysis from Pangali, the entirety of the lithic and bone assemblages from the survey in 1995 are analysed together with the assemblage from the 1996 excavation, because there were no differences in the material (Sørensen 2006:140). The pottery and lithic assemblage were typologically dated to an early phase of the Final Neolithic (Ib), approximately 4,600 – 4,200 BC, which has been confirmed by two radiocarbon dates from the hearth.[1]

The dates places the chipped stone industry of Pangali with other contemporary Late and Final Neolithic sites such as Dimini (Moundrea-Agrafioti 1981), Lerna (Kozłowski *et al.* 1996:295ff), Saliagos (Evans & Renfrew 1968), Ftelia (Galanidou 2002:317ff), Kitsos (Perlès 1981:129ff), Skoteini Perlès 1993:448ff), Kastria (Karampatsoli 1997:485ff) and Franchthi (Perlès 2004). The obsidian blade production in particular has many similarities among these sites. Some obsidian material has also been registered from surveys at other sites in Western Greece, such as Hagios Nikolaos (Benton 1947:170ff) and Kephellonia – site 53 (Randsborg 2002) (figure 1). However, Pangali is the first site in Western Greece, where a detailed lithic analysis has been conducted.

Local and exotic raw material studies

During the surveys and the excavation of Pangali a total of 1300 pieces weighing approximately 3.5 kg were recovered. Both in weight and numbers, radiolarite predominates followed by flint, obsidian and marble (figure 3). Radiolarite is dark red and represents 59% of the material. The flint assemblage from Pangali consists of 18% of the whole assemblage. Most of the flint types are of local origin, but there was a light yellow fine grained core, which was imported from the regions of Epirus and Southern Albania (Perlès 1992a:124f; Tringham 2003:84ff). Most of the radiolarite and flint was procured locally at the beach

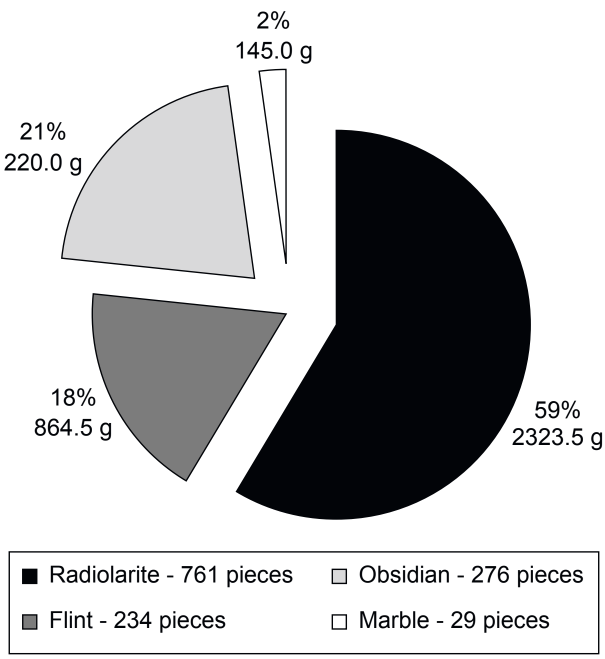


Figure 3. The frequency and weight of the different raw materials at Pangali. Graphic: L. Sørensen & C. Casati.

or in the nearby riverbeds of the Evinos River. This indicates that these raw materials were probably procured within a radius of, at the most, five km. from the site. The final local material was marble constituting 2% of the total assemblage. Marble was found on the site and was the most local outcrop, but also of low quality. Nevertheless it was used for a crude flake production, which indicates a need for and shortage of raw materials. In contrast, the exotic raw material obsidian is considered to be the best material for producing cutting tools. The obsidian assemblage at Pangali is the largest from hitherto published sites in Western Greece and consists of 276 pieces or 21% of the total assemblage (figure 3).

Provenance of the obsidian

A grey shiny type dominates the fine grained obsidian from Pangali followed by a black shiny type. The obsidian found at Pangali could theoretically derive from two possible areas as the site is situated within sailing distance from both the Cycladic and the Italian obsidian sources (Torrence 1986; Tykot 1996:39ff). In order to determine the origin of obsidian in prehistoric contexts, several studies, especially of the Aegean obsidian, have been carried out (Renfrew *et al.* 1965; Torrence 1986:95). One of the best methods used to determine the place of origin is spectroscopic analysis for trace elements (Optical Emission Spectroscopy, OES). The first distinction of Aegean obsidian was based on the content of barium and zirconium in the obsidian and gave a means of distinguishing Aegean from Anatolian obsidian. These methods of determining provenance resulted in the identification of five obsidian sources in the Aegean area. Three sources are located on the island of Melos (Demenegaki, Sta Nycia & Mandrakia). The remaining two are found on Antiparos and Giali (figure 1). The obsidian from Pangali evidently derives from Melos, but it is difficult to determine from which particular source on Melos the obsidian comes, as the greyish and the black obsidians, dominating the Pangali assemblage, are both found in Demenegaki and Sta Nychia.[2] Future studies of obsidian's source provenance might be able to clarify this problem. Finally, by using provenance analysis it is possible to reconstruct direct and indirect movements of people during Aegean prehistory, opening up the discussion of various types of exchange and of the creation of several trading routes due to the continuous demand for this excellent cutting material.

The obsidian procurement strategy during Aegean prehistory

Some of the earliest remains of Melian obsidian were found in Upper Paleolithic and Mesolithic context in the Franchthi Cave (Perlès 1987). The two other obsidian sources on Antiparos and Giali are regarded as secondary sources in the Neolithic (figure 1). Obsidian is found all over Greece and as far west as Kephallénia and far north as Corfu and Macedonia (Randsborg 2002:81ff; Perlès 1990a:24ff). The distribution of Melian obsidian has been divided into a primary and a secondary zone (figure 1). The primary zone consists of sites where the chipped stone material is dominated by obsidian and the secondary zone indicates an area where Melian obsidian occurs in limited number (Renfrew 1972:443ff; Torrence 1986:94ff; Perlès 1990a:24ff). The obsidian from Pangali has been weighed at 220 g (figure 3), which is very little compared to the amount of obsidian from contemporary sites, which lie near Melos such as Ftelia on Mykonos (75 km) or Saliagos near Antiparos (60 km). This could indicate a possible fall-off pattern based on distance and the amount of obsidian procured at each site. One large core from Ftelia ranging in length from approximately 13 cm to 6.3 cm contains the same amount of obsidian as the whole amount found at Pangali (Galanidou 2002:330). A comparison of the weights of obsidian assemblages from different Neolithic sites would of course require these sites to have been sufficiently excavated. Few assessments have been made in order to evaluate the amount of obsidian exchanged in different periods, but it is a general assumption that the exchange of obsidian reached its peak during the Final Neolithic and Early Bronze Age (Runnels 1985:359ff; Perlès 1992a:115ff; Demoule & Perlès 1993:393). In the Middle and Late Bronze Age obsidian exchange declined, and during the later Geometric, Archaic, Classical, Hellenistic and Roman periods obsidian was rarely observed (Torrence 1986:100ff; Kardulias 1999:61ff; Parkinson 1999:73ff; Karimali 2005:192ff). This data gives us some means to observe and test different theories and hypotheses concerning exchange mechanisms during the Final Neolithic and Early Bronze Age and to interpret whether the obsidian was procured directly or indirectly.

Current discussions on different views on procurement strategies

In the last few years there have been some important discussions on procurement strategies within the Aegean region (Renfrew 1972; Torrence 1982:197ff; 1986; Perlès 1990a; Kardulias 1992). The main focus has been on trying to answer the question of whether or not lithic production was controlled by specialists during the Neolithic and Early Bronze Age. This discussion began with the publication of the Early Helladic site of Phylakopi on Melos. Supposedly, the wealth of this site was closely connected to the control and possible monopoly over the obsidian sources seen in the high level of lithic craftsmanship (Mackenzie 1904:245). The same argument was posed by Mylonas (1959:143), who suggested that Cycladic obsidian traders had settled at the Early Helladic site of Aghios Kosmas in Attica, a centre of lithic production and trade to neighbours from the inland settlements. Renfrew (1972:473ff) argues against the important nature of Aegean obsidian exchange, mainly because the quantity of obsidian consumed declined after the end of the Early Helladic II due to the adoption of metal. He concludes that the obsidian trade may never have been very significant economically during the Early Bronze Age. Furthermore, Renfrew argues that the prehistoric exchange is different from today and that obsidian would not have been profitable, because it was not a valuable enough resource (Renfrew 1972:473ff). The examination of the Melian quarries made by Torrence (1982, 1986), revealed no evidence of boundary lines, structures or port facilities, which confirmed the results of Renfrew's work. Torrence (1982:197ff) concludes, that the quarrying activities seem to have been conducted in an opportunistic and unorganised fashion. Runnels (1983:419) reached same results and concluded that ships from the mainland had access to the obsidian, but it was an activity on a small scale, with subsequent exchange taking place from many coastal sites to the inland sites. Torrence also suggests, that the exploitation of obsidian from Melos was random, expedient and unorganised, which required a simple technology (Torrence 1984:62). However, Perlès argues against Torrence on this matter and states, that the mainland lithic specialists regulated the acquisition of Melian obsidian in the Early and Middle Neolithic (Perlès 1990a; 1990b). Accordingly, Perlès agrees that a direct access was probable for sites in the primary zone, close to Melos. However the quantity and regularity of worked obsidian found on the inland sites in the secondary areas of Thessaly and Macedonia were probably the result of an indirect procurement strategy controlled by specialists. Perlès (1992a:128) proposed in another article that, during the Late and Final Neolithic, off-site core preparation and workshops were probably common in the regions surrounding Melos, such as the Cyclades, Attica and Euboea. These workshops probably supplied Thessaly and Macedonia with prepared cores. Accordingly, the coastal sites in the eastern Peloponnese and in Thessaly could have obtained obsidian from Melos directly, but it is highly unlikely that the inland sites had direct access to obsidian. On the other hand, it is also highly unlikely that people in the Neolithic or the Bronze Age would travel 500 km, just to acquire some obsidian. It seems more reasonable to interpret the exchange of obsidian as embedded and connected to other activities, such as the exchange of other goods and the creation or maintenance of social contacts (Kardulias 1999:68). The main flaw in Perlès argument is the paucity of Neolithic and Early Bronze Age lithic assemblages from synchronic coastal sites in Thessaly and Macedonia (Perlès 1990a:30f). These sites form the key argument in her hypothesis, which states that the obsidian was procured in a controlled manner, contradicting Torrence's view of an uncontrolled procurement strategy. In this particular discussion, the chipped stone material from Pangali might be able to shed some new light and perspectives on this current debate, mainly because Pangali is a coastal site, which lies far away from the Melian source and therefore is in a parallel position to the coastal sites from Thessaly and Macedonia. There is also the question of middlemen who could have been engaged in the distribution of obsidian artefacts – from specialists and middlemen to consumers. By analysing the chipped stone material from Pangali, it should be possible to determine if the obsidian assemblage represents the waste from a specialized activity or if it is a result of an everyday household production. In order to answer these questions, it is necessary to analyse the lithic assemblage in a more detailed manner by using the concept of the *chaîne opératoire*.

The *chaîne opératoire* and lithic reduction

In the study of a lithic assemblage, the *chaîne opératoire* approach provides detailed and quantifiable data on successive processes, from the procurement of raw material until the artefact is discarded, and including all stages of manufacture and use of the different components.[3] The method has many advantages when analysing a local material, because the local material is generally present in all the stages of production including raw material procurement, core production and exploitation, tool production, tool maintenance and final discard (Inizan *et al.* 1999:14ff). The problems in using a *chaîne opératoire* analysis occur when dealing with exotic raw materials such as obsidian, because while the artefacts are moving they are changing value and hands. Changing hands especially causes the conceptual context to change according to the flint knappers' knowledge and skills. This change again influences the methods and techniques of knapping and the mode of production (Conneller 2006:38ff). When analysing the exotic material in the *chaîne opératoire*, artefacts with cortex, larger flakes and larger cores are generally absent, because they indicate the earlier stages of raw material acquisition, test knapping and core reduction (figure 4). According to Perlès (1992b:223), it is necessary to take into account the uncertainties of the *chaîne opératoire* when dealing with different subsystems and conceptual schemes, especially where certain parts of the operational chain are missing, which often occurs when analysing an obsidian assemblage. The following three phases in the *chaîne opératoire* will be the main focus of the lithic analysis of Pangali: *Phase 1*: The procurement and test knapping of the raw material, where larger flakes or blades with cortex are removed from the core. *Phase 2*: The primary and secondary production sequence, including core preparation and the manufacture of blades. *Phase 3*: The modification, resharpening, recycling and discarding of tools (figure 4).

The debitage from Pangali gives us important information regarding the production strategies, especially for the differences between local and exotic raw materials. In many publications the chipped stone assemblage analysis is concentrated on the obsidian assemblage making comparative studies difficult for the radiolarite, flint and marble assemblages. However, it is necessary to analyse the different raw materials in separate groups, because the conceptual scheme, the goal of project of the production and the actual *chaîne opératoire* are often not the same. Furthermore, limitations to the quality of the raw materials often set technical limits concerning what is possible to produce from that particular material.

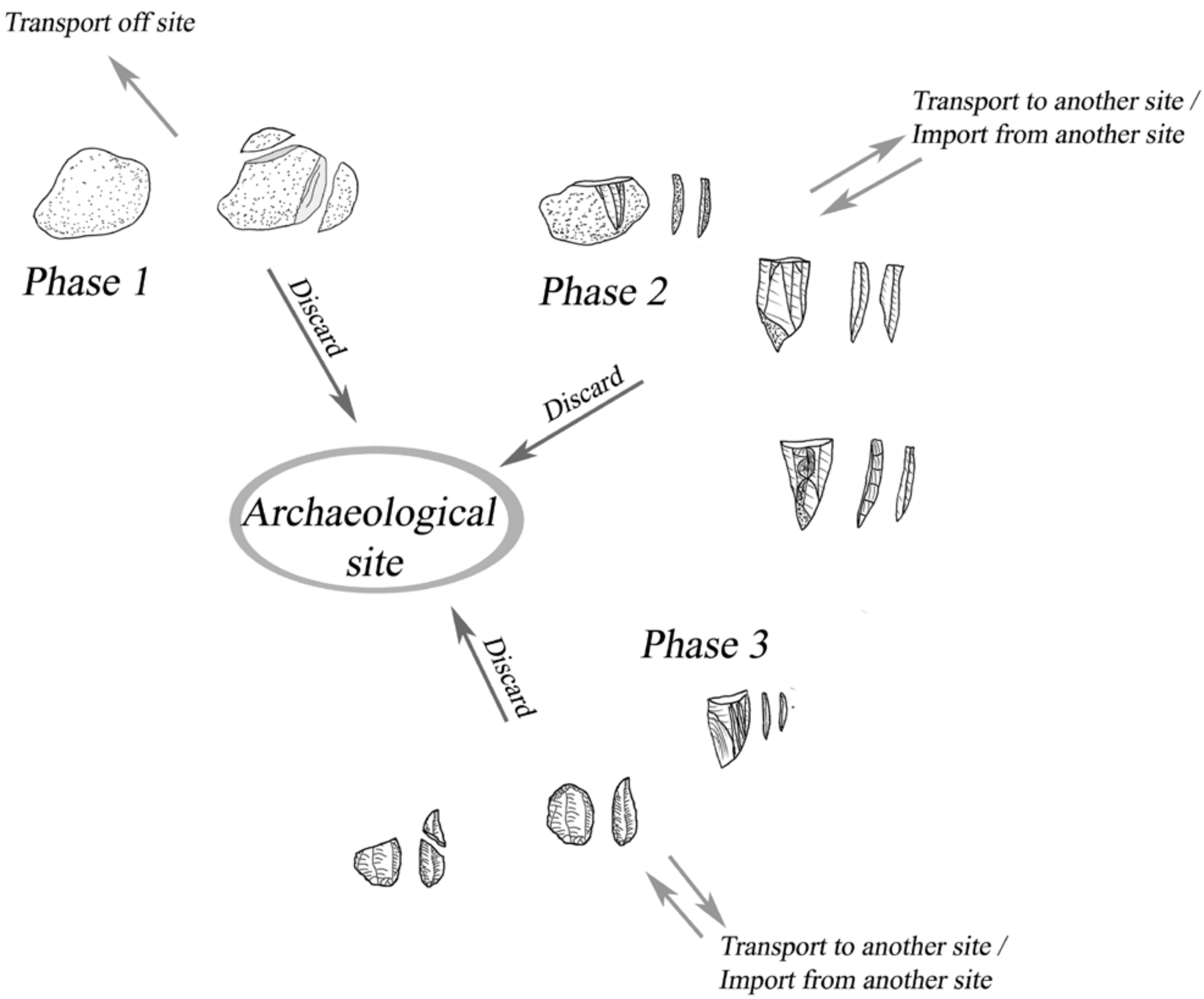
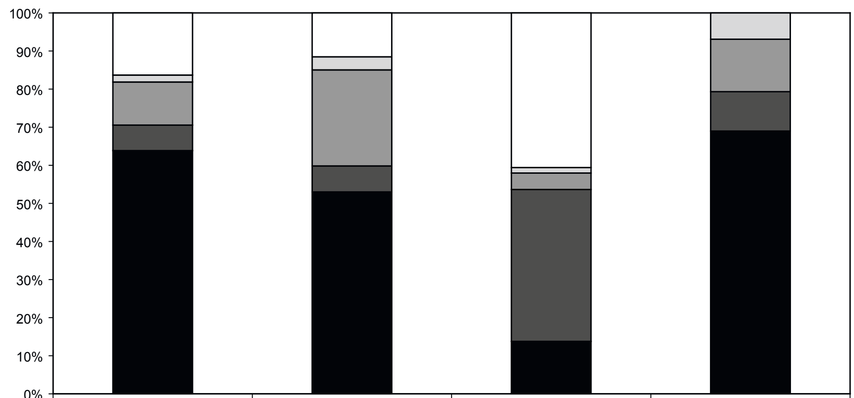


Figure 4. Schematic illustration of a generalized reduction sequence, including the three main phases in the chaîne opératoire outlined in the article. Graphic: L. Sørensen & K. Langsted.

The local assemblage

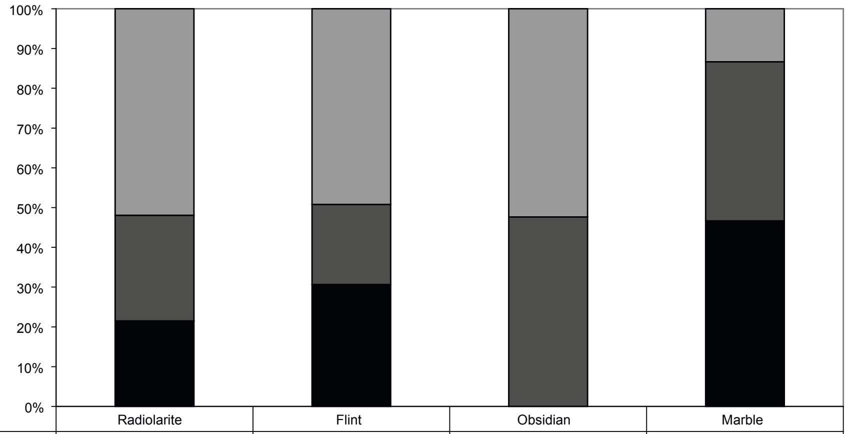
The radiolarite, flint and marble assemblages are dominated by small or larger flakes, which are covered with cortex (figure 5). All the phases in the *chaîne opératoire* are present, which indicates a local production (figure 6). The quality of the marble raw material is very coarse, so the use of marble could indicate a shortage of other raw materials at Pangali. Alternatively, the assemblage could be interpreted as a testing material used for knapping practice by less skilled flint knappers. Many of the cores of radiolarite and flint were totally exhausted even if they were procured locally (Sørensen 2006). The radiolarite and flint assemblages are dominated by normal everyday tools such as scrapers, retouched pieces and points (figure 7). Often, local flint was used for the production of flakes and blades of low quality. This has been observed on sites far away from high quality raw material sources, generally when the obsidian material is not dominant such as in Makriyalos and Sitagroi in Northern Greece (figure 1; Skourtopoulou 1999:123; Tringham 2003:81ff). However, almost every Late or Final Neolithic site in Greece has crude flake production of a local raw material of flint, chert, jasper, quartz or radiolarite, e.g. Saliagos (Evans & Renfrew 1968:47ff), Kitsos (Perlès 1981:135ff), Skoteini Cave (Perlès 1993:452ff), Lerna (Kozłowski *et al.* 1996:297ff) and Kastria Cave (Karampatsoli 1997:550).

The observed knapping technique of the radiolarite and flint assemblage is dominated by hard and soft direct technique (figure 8). These two techniques were mastered by most people in the Neolithic. It is very common to see raw materials from local areas worked primarily by these knapping techniques. The surprise in the radiolarite and flint assemblage was the observation of a few blades, knapped by pressure flaking (Sørensen 2006). Normally, pressure flaking is observed on blades from the obsidian assemblage, but at Pangali there seem to have been inhabitants who had the technical skills to master the pressure flaking on local raw materials. This observation is rather unusual, because pressure flaking was hardly a daily task for farmers, but a task carried out by highly specialized flint knappers. The fact that this demanding technique was practiced on local materials indicates that there were specialized flint knappers among the local inhabitants of Pangali. The last technique registered in the local raw material assemblage was invasive, parallel retouch produced by delicate pressure flaking which is found on some arrowheads. These facts indicate that the local habitants of Pangali mastered this particular technique and that the manufacture of points and preparation for hunting purposes was one of the many activities on the site (Sørensen 2006). The social role of hunting within these Late and Final Neolithic societies has only been discussed briefly (Hamilakis 2003:239ff). Howe-



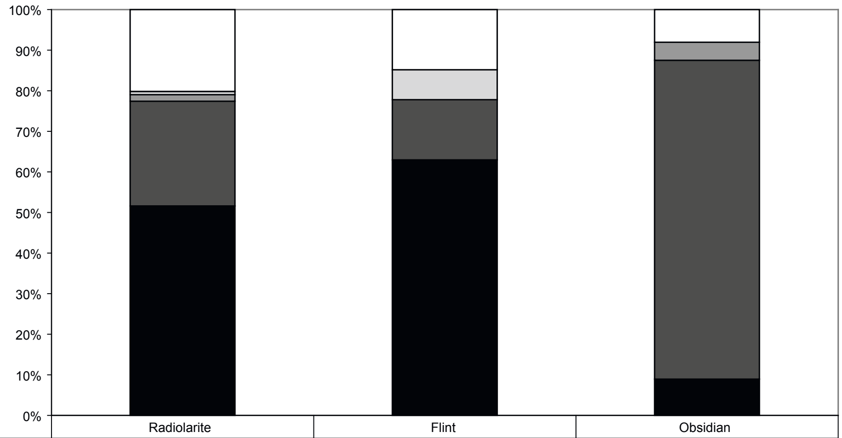
	Radiolarite	Flint	Obsidian	Marble
Tools	124	27	112	0
Cores	14	8	4	2
Technical Pieces	86	59	12	4
Production - Blades	51	16	110	3
Debitage - Flakes	486	124	38	20

Figure 5. The different production strategies on Pangali according to each raw material. Graphic: L. Sørensen & C. Casati.



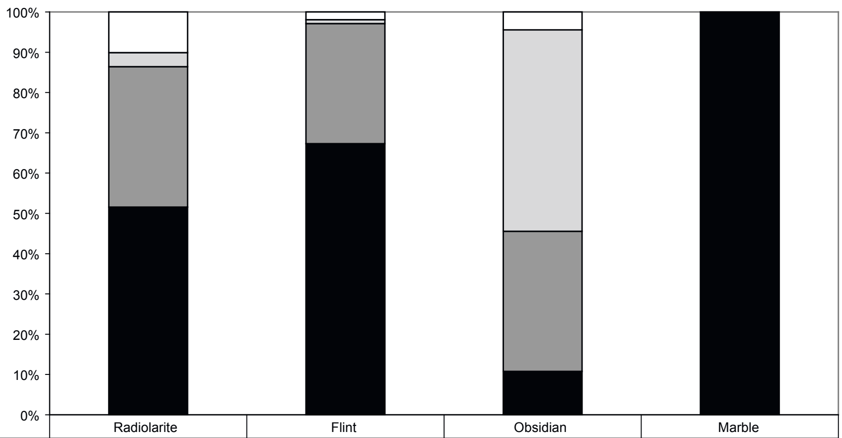
	Radiolarite	Flint	Obsidian	Marble
Maintenance & Use Phase (3)	174	61	123	2
Production Phase (2)	89	25	112	6
Preliminary Phase (1)	72	38	0	7

Figure 6. The different phases in the chaîne opératoire on Pangali. Graphic: L. Sørensen & C. Casati.



	Radiolarite	Flint	Obsidian
Points	25	4	9
Perforators	1	2	
Burins	2		5
Retouched Blades	32	4	88
Scrapers	64	17	10

Figure 7. The different tool types identified on Pangali. Graphic: L. Sørensen & C. Casati.



	Radiolarite	Flint	Obsidian	Marble
Pressure Percussion	29	2	7	0
Pressure Flaking	10	1	79	0
Soft Percussion	100	31	55	0
Hard Percussion	148	70	17	13

Figure 8. Flint technological observations from Pangali. Graphic: L. Sørensen & C. Casati.

ver, it is clear that hunting as a social practice indicates a changed perception of authority, status and gender, which are very similar to social trends within Early Bronze Age societies.

The obsidian assemblage and exchange

The obsidian assemblage from Pangali showed some very different results from those of the local raw materials. Firstly, the percentage of small and larger obsidian flakes is only 14%, whereas this group constituted over 50% of the local raw material assemblage. The second difference was the high proportion of blades, 40% (110 pieces), which proves a concentrated use of obsidian blades compared to blades of local raw materials (figure 5, 6, 7, 8). However, 96 of the obsidian blades were broken into several pieces, either deliberately or during the pressure flaking. Only 14 of the blades were complete, and the average size of the blades was 4-5 cm long and 1-1.5 cm wide (Sørensen 2006). Those are quite small blades compared with obsidian blades from other sites, like Saliagos (Evans & Renfrew 1968:48ff), Kitsos (Perlès 1981:149ff), Skoteini Cave (Perlès 1993:453ff) or Lerna (Kozłowski *et al.* 1996:350), which vary from 8-10 cm to smaller ones around 3-4 cm. The size of the blades could have something to do with the different size of the cores in the primary or secondary distribution areas (figure 1). In the Pangali assemblage the majority of the obsidian blades were fragmented, perhaps because they could be used as tools with particular hafting, such as sickles, which required the blades to be broken into smaller pieces approximately 2-3 cm in length and 1-2 cm in width. The fragmented blades represent one of the most deliberate choices made on Pangali: the tendency to break obsidian blades into fragments – so instead of one blade they get two blade fragments from one blade. This behaviour is also observed on other sites, mostly far away from Melos (Perlès 1981:210; 1993:475; Kozłowski *et al.* 1996:327; Karampatsoli 1997:487ff; Skourtopoulou 1999:123; Tringham 2003:81ff). Many of the obsidian blades are perfect and have probably been made by the best flint knappers, as little technical debitage with hinge fractures, crested blades or plunging terminations have been observed. The technical pieces in the obsidian assemblage make up only 4%, which was very low compared with those of the local raw materials (figure 5). The near total absence of cortical material and preparation pieces indicates that obsidian was brought to the site in the form of initiated cores or ready made blades produced outside the habitation zone or at another site. All the blades were probably produced by highly specialized knappers (figure 8). This interpretation is not new and has been suggested for a number of Late and Final Neolithic assemblages in Kitsos (Perlès 1981:131), Skoteini Cave (Perlès 1993:295), Lerna (Kozłowski *et al.* 1996:331), Kastria (Karampatsoli 1997:550) and Makriyalos (Skourtopoulou 1999:123).

Recently, Carter (2005:303ff) has argued that the presence of pressure flaking or craft specialization during the Aegean Bronze Age has been overstated, with the acquisition of technical knowledge and raw material being a more complex issue than envisaged previously. Using experimental lithic technology, he argues that pressure flaking was employed in a number of different ways to make obsidian blades. For example long blades made by specialists have been registered in Early Cycladic burials, but simple pressure flaking was used in a straightforward fashion by "common" people who used a natural crest to open the core with no other preparation. Between these two technological extremes lay the vast majority of the Aegean obsidian material. Carter might have a point, because some blades made by pressure flaking in the local radiolarite material were observed at Pangali. However, observations of the obsidian blades at Pangali prove an almost null rate of conceptual or gestural errors (Sørensen 2006). These facts indicate an introduction of obsidian into the site as pre-formed blades, cores or partly exploited cores made by external specialized knappers, because the technical debitage, such as flakes with cortex and crested blades, is underrepresented in the material (figures 5, 6). Even the cores, three exhausted pieces, are very rare in the assemblage indicating that there is no firm evidence of on-site production of obsidian.

This makes the obsidian cores extremely rare and far fewer what would be expected from the blade production. It is probable that some of the cores were taken away to another site for further exploitation or that the obsidian blades might have been imported to the site as finished blades made by specialists. The same scarcity of cores and technical pieces is observed in Franchthi (Perlès 1973:80), the Keos assemblage in the Asea Valley Survey (Carter 2003:130f), Kitsos (Perlès 1981:131), Skoteini Cave (Perlès 1993:295), Lerna (Kozłowski *et al.* 1996:331), Kastria (Karampatsoli 1997:550) and Makriyalos (Skourtopoulou 1999:123). The rarity of the cores remains a puzzle, and the most obvious reason for this particular phenomenon could have something to do with the distance to the raw material source and the large distribution area of the obsidian exchange (figure 1). The pattern corresponds to what Renfrew terms down-the line exchange (Renfrew 1972:465ff). This hypothesis is supported by analysing the amount of cores, and, in particular, the larger size of obsidian cores at Saliagos and Ftelia, compared to other sites in Greece. Many of the sites near Melos such as Saliagos or Ftelia had systematic blade production and procured obsidian directly, whereas many of the sites on the mainland probably did not have any obsidian blade production and procured obsidian indirectly.

This variability in imported artefacts could have something to do with the distance to Melos, but it could also be explained by differences in natural topography (mountain versus coastal sites) or in the site function (cave versus habitation site). There are also differences in the state of the obsidian, which has been exchanged between the inland and coastal sites. The Late Neolithic inland site Dimini had semi-prepared cores and the Late Neolithic coastal site of Agia Sofia had prepared cores. These differences are explained by the distance from the coast to the inland and thus highlight the importance of communication and transport between the sea sites and inland sites (Karimali 2000:20). The consequence of an indirect obsidian procurement strategy could be an occasional shortage of obsidian. Interestingly enough, it also indicates the beginning of an exchange route between Melos to some of the Cycladic islands and more distant areas such as the coast of Epirus, western Peloponnese, Thessaly or Macedonia in connection with probable seasonal tasks or specialized trips (figure 1).

Technological observations in the obsidian assemblage

The obsidian assemblage is dominated by pressure flaking with traces noted on 50% of pieces, mainly the blades (figure 8). Pressure flaking requires a long apprenticeship and regular practice. Even if the detachment of a blade is not difficult in itself, strict control of the core and the reduction sequence are very important. The second-most used technique at 35% is direct percussion with a soft hammer; it is also observed on the blades. Only 11% of the material has been knapped with a hard hammer and direct percussion technique, indicating that the inhabitants of the site have knapped the obsidian cores. Some of the larger blades have been reworked into points by delicate pressure flaking; these make up 4% of the technological observations on the flint (figure 8). The low variability in the obsidian blade technology on Pangali implies that blade production was carried out by very few flint knappers, the opposite situation to the material from Keos where many flint knappers have been identified (Torrence 1991:173ff). Another important observation is the fact that 96% of the obsidian assemblage was not covered by cortex, an amount far larger than the local raw materials (figure 5). These percentages have great importance for the interpreted *chaîne opératoire* phases present in the obsidian assemblage. The initial phases in the obsidian *chaîne opératoire* are totally absent, whereas unretouched blades are distributed in phase 2 and finished or reworked tools are placed in phase 3 (figure 6). At contemporary settlements in Southern Greece, 100 km from Melos, another *chaîne opératoire* has been observed in which all the phases are present such as at Saliagos (Evans & Renfrew 1968:46ff) or Ftelia (Galanidou 2002:317ff). At contemporary sites further away from Melos, such as Kitsos (Perlès 1981:80ff), Franchthi (Perlès 1990b:2ff) and Lerna

(Kozłowski *et al.* 1996:331ff), the primary decortification pieces are rare but every stage of the lithic reduction is present. This does not seem to be the case at Pangali or at other sites situated at great distance from Melos (Tringham 2003:82f; Perlès 1990a:24ff).

The obsidian at Pangali appears to have been indirectly procured from Melos in the form of slightly decortified nodules, preformed cores or larger flakes. When the obsidian reached Pangali it had already gone through many hands (figure 9). In general, the blade production at

Figure 9. Generalized reduction sequences for the obsidian assemblage indicating the different stages of obsidian exchange. Graphic: L. Sørensen & K. Langsted.

Pangali could be interpreted as a specialized skill, made by middlemen, because pressure flaking also occurs in the local material. Although it is rare, it proves the fact that the locals at Pangali also mastered the technically difficult skill of producing straight blades. This observation is quite rare, putting the flint knappers at Pangali in a special position. Maybe the flint knappers at Pangali had a specialized production of obsidian blades or perhaps they redistributed already finished blades or pre-made cores and exchanged these goods onwards to other sites. To prove that an actual production centre was located at Pangali is, at present, difficult. It is necessary to excavate more of the site. However, it is clear that Pangali is one of the sites which reflects the major changes in settlement pattern during the Late and Final Neolithic. These changes had an impact on the distribution of obsidian artefacts.

Settlement patterns and economic changes during the Late and Final Neolithic

During the Late and Final Neolithic, the growth of mainly small sites on the island has been linked to the development of Aegean trade and metalworking. According to Runnels and van Andel (1988:83ff), the expansion of this trade led to a denser population and a more dispersed settlement pattern spreading into marginal agricultural areas, such as caves in coastal areas. At the same time the smaller Aegean islands such as Paros, Saliagos, Naxos, Samos and Rhodes began to be settled (figure 1). The colonization of the Cycladic islands in the Late and Final Neolithic made it possible to shift obsidian procurement patterns from indirect to more or less direct procurement, which would explain the greater availability of obsidian in southern Greece (Perles 1990a:24ff; 1992b:223). This is the case for southern Greece, but when we look at the *chaîne opératoire* analysis of the obsidian procurement from Pangali, it becomes eminently clear, that we are dealing with an indirect procurement strategy. Here the preformed cores and finished blanks were imported to the site (figures 5, 6, 9). However, the procurement strategy of the obsidian involved long-distance travelling, especially through the use of sea routes as well as the beginning of long-distance exchange. These phenomena indicate the beginning of boundaries, as well as overall strategies for production, reproduction and legitimation of authority linked to the perception of space, status and gender identities. These changes were mainly generated by the increasing trade and control of exotic goods like copper.

Exchange theories of exotic goods in the Late and Final Neolithic

The control of copper in particular is the starting point of wealth and power at certain sites, which developed into urban centres during the Early Bronze Age. However, when we look at the metal finds from Late and Final Neolithic Greece, they are few compared to the large amount of finds from Bulgaria and the Balkans. When we compare the metallurgy of Greece to that of the Balkans it must be concluded that the Balkans were far more metallurgically advanced than Greece (Zachos & Douzougli 1999:959ff). The rarity and quality of metal finds, particularly in cave sites in southern Greece, suggests that they were high status artefacts traded far from their production centres. So far, two potential centres are known from southern Greece, Lavrion and Siphnos, which are key locations in the exchange systems in the Final Neolithic (Perlés 1992a). The many new settlements in the Late and Final Neolithic created a larger demand for utilitarian materials (obsidian, emery and andesite) as well as exotic objects such as copper. The main copper production area appears to have been the Cyclades, from where the different goods were distributed to the Aegean area (Perlès 1992a:131ff). Pangali is located in the secondary distribution area of both copper and obsidian sources and so far no metal find has been found at Pangali. However, a fair amount of obsidian which was procured indirectly was found at Pangali. This interpretation could indicate some sort of reciprocity or exchange between Melos and other mainland sites (figure 9; Perlés 1990a:30ff). When obsidian reached the mainland, Renfrew believes, it was passed on by balanced reciprocity with a "down the line" exchange (Renfrew 1972:465ff, Fig 42). In this kind of exchange, the obsidian is first procured from the source. After the inhabitants returned to their settlement, a portion of the raw material was used and the remaining was exchanged by balanced reciprocity to friends and relatives in neighbouring settlements. This process is then repeated with the next settlement; and, as a result, the quantity of obsidian declines exponentially in relation to distance from the source (Torrence 1986:105ff). The curve for down the line exchange would include a supply zone (Phase 1) sector for distance from the source next to a fairly steep sloping area, the contact zone (Phase 2). There is however one problem with this model: When sea transport is involved in the transportation of goods, the predicted fall-off pattern will be distorted. Sometimes it even excludes down-the-line exchange (Perlès 1992a). Other fall-off patterns for obsidian exchange are freelance exchange and directional exchange. These types of exchange involve chiefly central place market exchange with middlemen as traders. In this case, the fall-off curve would be distorted by peaks, which represents centres as in the directional trade model (Renfrew 1975: fig. 11-14).

The procurement pattern of the obsidian has been interpreted to comprise three zones before reaching Pangali. Zone 1 is a direct supply zone, within the primary distribution area at the Cyclades and coastal sites. At these sites the obsidian is present in large amounts and comprises over 95% of the lithic assemblage. Zone 2 is an intermediate zone, within the primary distribution area at Thessaly, western Peloponnese, where the obsidian is exchanged indirectly through middlemen as semi-finished products in relatively large amounts, with no real fall-off effect as the distance from the source increases. Zone 3 is characterized by indirect supply in the secondary distribution area and in more distant places such as western Macedonia, Western Greece or isolated inland sites where obsidian is found in very small quantities, as illustrated by an absolute fall-off curve[4] (figures 9-10, and table 1). Pangali is situated just outside the primary distribution area; therefore, evidence from this site can contribute to the, currently under analysed, picture of obsidian procurement patterns in Western Greece. There are pos-

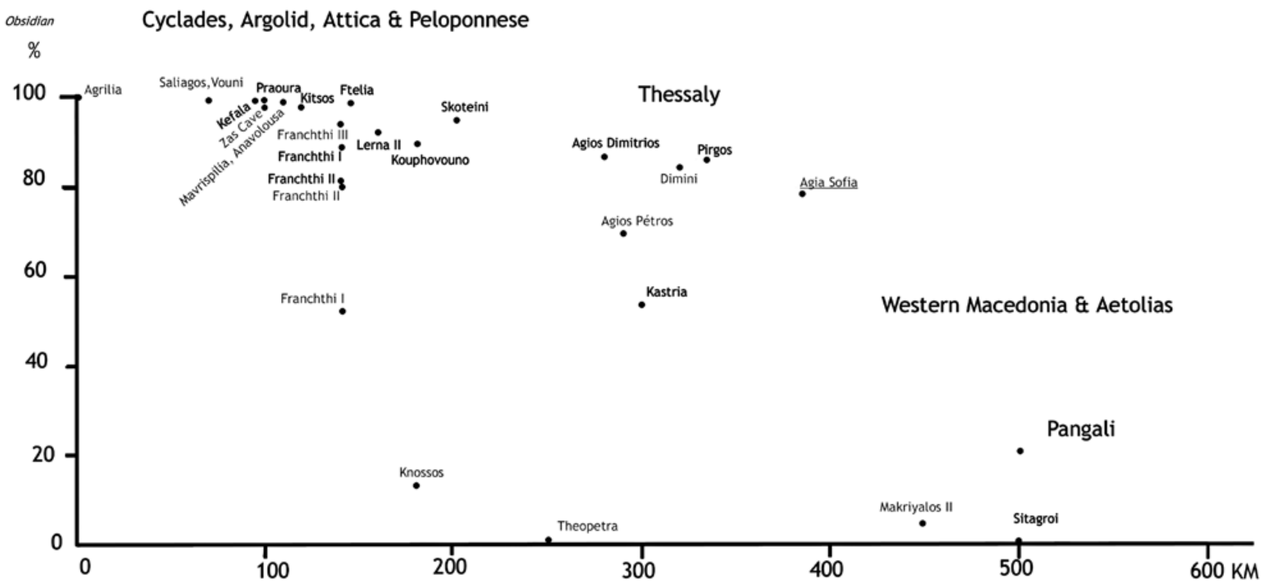


Figure 10. Selected Late and Final Neolithic sites with the percentage of obsidian found at each compared with the distance to Melos, indicating two different fall-off patterns: 1) down the line exchange and 2) directional trade. Sites in grey scale are dated to the Late Neolithic, and sites in black scale are dated to the Final Neolithic. The approximate distance from Melos to the different sites is calculated to be the shortest distance from Melos in all cases. Graphic: K. Langsted & L. Sørensen.

Region	Site	Phase	Approximate distance to Melos	Amount of obsidian	Proportion of cortex on the obsidian	Amount of reduction on the cores	References
Western Macedonia	Sitagroi	LN/FN	500 km	1%	non	No cores	Tringham 2003:81ff
	Nea Nicome-deia	LN	460 km	Represented but rare	-	-	Rodden 1962
	Makriyalos II	LN	450 km	5%	non	E/F	Skourtopoulou 1999:122ff
	Mégalonissi	FN	450 km	Well represented but not dominant	-	-	Fotiadis 1987
	Galanis	FN	450 km	Well represented but not dominant	-	-	Perlès 1990a
	Servia	LN	440 km	Represented but not dominant	-	-	Ridley & Wardle 1979; Watson 1984
Aetolias	Pangali	FN	480 km	21%	1%	E/F	Sørensen 2006
	Hagios Niko-laos	LN	480 km	Non dominant	-	-	Benton 1947
Kephellonia	Site 53	LN/FN	450 km	Non dominant	-	E/F	Randsborg 2002
Thessaly	Theopetra	LN	500 km	1%	Non	E/F	Kyparissi-Apostolika 1999:148
	Agia Sofia	LN	380 km	79%	2%	D/E	Milojcic et al. 1976; Perlès 1990a
	Pirgos	LN/FN	330 km	86%	-	-	Perlès 1990a
	Dimini	LN	320 km	84.5%	5%	C/D	Moundrea-Agrafioti 1981
	Agios Pétros	LN	290 km	69%	9%	-	Moundrea-Agrafioti 1981; Efstratiou 1985
Central Greece	Antre Corycien	LN	260 km	Well represented but not dominant	-	-	Perlès 1981
	Élatée	LN	230 km	Dominant	-	-	Weinberg 1962
	Étreusis	LN	200 km	Dominant	-	-	Perlès 1990a
Tharrounia	Skoteini	LN/FN	200 km	95%	> 5%	C/D	Perlès 1993:451ff
Peloponnese/ Argolid	Agios Dimitrios	FN	280 km	87%	7%	-	Perlès 1990a
	Kastria	LN/FN	300 km	54%	> 5%	D/E	Sampson 1997:550
	Asea	LN/FN	200 km	Dominant	-	-	Holmberg 1944
	Corinth	LN	180 km	Dominant	-	-	Lavezzi 1978; Perlès 1990a
	Kouphovouno	LN/FN	180 km	> 90%	Rare	-	Renard 1989
	Lerna II	LN/FN	180 km	92%	Rare	D	Kozłowski et al. 1996:324ff
	Franchthi – I	LN	140 km	52%	17%	A/B	Perlès 1990a
	Franchthi – II	LN	140 km	81%	16.5%	A/B	Perlès 1990a
	Franchthi – III	LN	140 km	94%	17.5%	B	Perlès 1990a
	Franchthi – I	FN	140 km	89%	3%	D	Perlès 1990a
	Franchthi – II	FN	140 km	80%	21%	D	Perlès 1990a
Attica	Néa Makri	LN	150 km	Dominant	-	-	Perlès 1990a
	Kitsos	LN/FN	120 km	97.5%	6%	B/C	Perlès 1990a
Cyclades	Knossos	LN	180 km	13%	-	-	Evans 1964; Perlès 1990a
	Ftelia	LN/FN	125 km	99%	Rare	B/C	Galanidou 2002:318ff
	Mavrispilia	LN	110 km	99%	19%		Belmont & Renfrew 1984; Torrence 1986; Perlès 1990a
	Anavolousa	LN	110 km	99%	7%		Belmont & Renfrew 1984; Torrence 1986; Perlès 1990a
	Praoura	FN	100 km	99%	-	-	Coleman 1977; Perlès 1990a
	Zas Cave	LN	100 km	98%	Present	D/E	Zachos 1999:158
	Kefala	FN	95 km	99%		A	Coleman 1977; Perlès 1990a
	Saliagos	LN	70 km	99%	-	A/B	Evans & Renfrew 1968; Torrence 1986; Perlès 1990a
	Vouni	LN	70 km	99%	-	-	Evans & Renfrew 1968; Perlès 1990a
	Agrilia	LN	Melos	100%	-	A	Perlès 1990a

Table 1. The amount of obsidian found at selected Late and Final Neolithic sites in Greece. Partly after Perlés 1990a, table 4. A: Raw nodules. B: Preliminary preparation of the core. C: Core with removed cortex and primary blades. D: Pre-formed core. E: Blade or flake cores. F: Exhausted cores. The approximate distance from Melos to the different sites are all calculated to be the shortest distance from Melos.

sibly three kinds of models which would apply to the obsidian assemblage at Pangali: namely, down the line, free-lance and directional exchange. It is at present impossible to predict he fall-off pattern for the Pangali assemblage, because only a part of the site has been excavated, though a tendency towards a down the line or directional trade is most likely (table 1 and figure 10). The continuous demand for obsidian during the Neolithic probably created the development of exchange patterns over both sea and land routes.

The development of routes and exchange patterns

The development of exchange patterns has a great impact on how we observe and interpret a certain route. These studies are all dependent on reliable provenance analyses used to determine the prehistoric quarries. It is only possible to investigate where the different production stages took place in the landscape when the quarries are known. Organised exchange should follow certain routines, as described above, and involve a transportation of goods along a defined route. Furthermore, it is important that this sort of exchange is completely organized on certain settlements, where these exchanges happen again and again. A route is a social phenomenon, which exists as an institution through several historical processes and creates a pattern for later travel. To begin a voyage to a particular place or area requires complex knowledge about strategic choices, which the traveller must make (Giddens 1984). In a culture without written resources this knowledge is not stored in archives, but can only be maintained by repeated travel along the route (Sindbæk 2001:49ff). On many of these routes a certain settlement was probably chosen because of the advantages of the local landscape, such as proximity to a natural harbour, river, plain or valley. The repeated use of certain routes and settlements in the landscape could create historical, symbolic and mythological values for these people as they moved within the Aegean landscape. Many of these Aegean routes are illustrated in Agouridis (1997:10), who charts one of the possible sea routes from Melos to the Argolid region and through the Corinthian Gulf or around Peloponnese to the Western part of Greece (figures 1, 9, 10; table 1). These could be some of the routes from which the inhabitants of Pangali could have received their exotic objects.

Abandonment of Pangali – moving to the next harbour

Pangali was abandoned during the Final Neolithic, but the route must have been fixed and known during this period, which could be one of the reasons why a major Early Helladic settlement was founded one kilometre further east from Pangali (Dietz & Moschos 2006:38ff). The site is located at the next natural harbour near fertile plains suitable for farming. In the layers belonging to the later part of Early Helladic I, there was recorded a small obsidian assemblage indicating that this material was still exchanged at this particular place in the Early Bronze Age (Dietz & Moschos 2006:110ff). The Chalkis assemblage is much more limited and dominated by obsidian flakes and fragmented blades. No cores are found in the assemblage; however, 19 flakes, 16 blades and five crested blades were recorded. It has been discussed whether the presence or absence of crested blades may be taken as indicators of on-site modification of cores or large blanks into blade cores, as opposed to the importation of prepared cores from elsewhere as Renfrew (1972:449) suggests. If the crested blades are restricted to a few sites, the production of blades would occur at a limited number of locations, which can be seen as a positive argument for a model proposing the regulation of obsidian importation from large production centres (Kardulias 1999:68f). The obsidian assemblage from Chalkis reflects, in my opinion, a much wider distribution of crested blades, indicating unrestricted access through a decentralized system of exchange in the primary distribution zone. Yet, for the secondary distribution zone there are still places where the obsidian is centralized on a regional level in a continuation of the Neolithic system. During the Final Neolithic, many sites are abandoned; however, there are also several cases of Late and Final Neolithic sites which evolved into important Early Bronze Age settlements (figure 1; Demakopoulou 1996:192). This settlement strategy proves, in principle, that there are actually no really differences in obsidian distribution and in exchange patterns between the Neolithic and Early Bronze Age. However, obsidian production systems seems to have been consolidated at some larger production places during the Early Bronze Age, and these locales then emerged as new regional centres of specialisation, such as Phylakopi, Mallia and Knossos (Parkinson 1999:76ff). Systematic production is controlled by an obsidian pressure flaking technique, which reached a high level of sophistication in terms of standardized procedure and resulting mass product (Karimali 2005:192). Furthermore, during the Early Bronze Age obsidian blades do not only have utilitarian uses, but also symbolic value as longer, pressure flaked blades are recorded in several Early Helladic, Cycladic and Minoan burials (Carter 1994:127ff).

Concluding remarks and perspectives

So far, Pangali is one of the only Final Neolithic sites in Western Greece with a large research potential. The site was settled during the Final Neolithic phase LN Ib ca. 4,600 – 4,200 Cal. BC. It has many topographical advantages as an observation point as it lies near a natural harbour with a view to the Gulf of Patras. Furthermore, the site had access to fresh water resources from Mount Varassova and, finally, the site lies on a known transportation route where obsidian and other goods could have been exchanged from the coastal area to the inland regions on the river Evinos. The finds from Pangali proved to have many similarities to other Final Neolithic sites. The pottery assemblage was dominated by coarse ware although some fine ware was also registered. The lithic assemblage was dominated by local raw materials, but imported obsidian was present in the assemblage, indicating extensive local contacts with other cultural groups in the area. The obsidian was probably imported to the site from Melos through middlemen as proven by the *chaîne opératoire* analysis. The production of obsidian blades on the site has not yet been confirmed due to a lack of manufacture debitage or other evidence. However, it is highly likely that obsidian production did take place in the region near the site. This interpretation supports Perlès (1990a; 1990b) hypothesis that mainland specialists regulated the acquisition of Melian obsidian in the secondary distribution zone where it had arrived thanks to several middlemen. It is, at present, not clear what role these middlemen played in the material reduction and fall-off patterns. The highly skilled production of arrowheads on the site, confirmed by the many performs, could indicate that Pangali indeed was settled by these middlemen. These arrowheads are commonly associated with the larger Final Neolithic sites where specialized obsidian production is also observed. At Pangali there was also a crude flake and blade production using local raw materials, an argument against the theory of Pangali being settled by specialists. However, crude flake production has also been observed on some sites dominated by obsidian. The archaeological material at Pangali gives only a small insight into the lithic and bone assemblage. The study of the pottery, lithic and bone assemblages is an ongoing process which could benefit from a future excavation as many new questions have been raised by this material. Pangali has many similarities with other Final Neolithic sites with regards to its topographical position, seasonal habitation, lithic assemblages, imported artefacts, tool manufacture and bone assemblage. Do we face the same problems when it comes to the interpretation and function of these other sites? I would argue that these sites were inhabited by part-time farmers who also practiced herding, hunting and trading commodities, including obsidian, in exchange for social contacts and other local goods. The demand for obsidian at Pangali and other Final Neolithic sites in Western Greece led to an increased development of land and sea routes. Moreover, the development of fixed avenues of transportation and the increasing exchange of obsidian led to an established route which became important when metal and other exotic goods was traded during the following Early Bronze Age periods. Obsidian exchange in particular may have stimulated traffic along an already known sea route which later societies could benefit from.

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Notes

1. Pangali – shell: AAR-9670; 6005±50BP; 4460-4340 Cal. BC; Calibrated curve Marine04. Pangali – charcoal: AAR-9671; 5530±50BP; 4450-4330 Cal. BC; Calibrated curve IntCal04 (Heinemeier 2006:196f).

2. I would like to thank Dr. V. Kilikoglou from the Laboratory of Archaeometry, N.C.S.R. "Demokritos", who investigated the obsidian from Pangali.

3. The debitage is divided into different groups. The first debitage grouping consists of the large assemblage of small and large flakes. In the second group are different kinds of blades, microblades and fragments of blades. The third group comprises the technical pieces that include hinge flakes, plunging pieces, primary blades or flakes with cortex and single or double crested blades. The fourth group includes cores, and the last group different kinds of tools. The different assemblages are also registered according to the amount of cortex on each artefact, because the cortex indicates which phases are present in the *chaîne opératoire* (figures 5, 6 and 9).

4. The distance from Melos to Pangali could, of course, vary; however, the sea transportation took place along the coastline, which makes the distance considerably higher than open sea journeys (Agouridis 1997:5ff). Some of the sites, like Franchthi I, Knossos, Theopetra and Kastria, are showing a rather strange result on the curve, which can be explained. Firstly, at Franchthi and Knossos the amount of obsidian is not high in the beginning of the Late Neolithic (phase LN I). Secondly, Kastria and Theopetra are both inland sites and the amount of obsidian is therefore low at these two sites.

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