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OBSIDIAN IN THE PREHISTORIC AEGEAN: TRADE AND USES

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Abstract

This paper studies the prehistoric use of obsidian quarries in the Aegean. Obsidian sources in the eastern Mediterranean have been traced on certain islands of the Aegean: Melos, Antiparos and Giali. Due to its hardness, this material was already being used by the end of the Upper Palaeolithic to produce blades with sharp edges to serve as knives, scrapers and razors, arrowheads and spears, axes, saws and mattocks. This naturally occurring glass was also used for ornamental purposes. During the Late and the Final Neolithic Period (ca. 5300-3200 B.C.), when the systematic habitation of the Cyclades developed, the transportation of obsidian was incorporated in the gradually developing trade networks of the Aegean. The material was much in demand in the early Bronze Age. During the later Bronze Age its use declined and by the classical period it seems to have been replaced by metal. Around 1100 B.C. the use of obsidian was discontinued because of the increasing popularity of metals. During the Roman period obsidian, was used in the manufacture of mosaics and decorative objects, such as mirrors.

Keywords*: obsidian, Aegean, Melos, blade, Giali, Phylakopi.*

Περίληψη

Ο οψιανός ή οψιδιανός που αναφέρεται για πρώτη φορά από τον Πλίνιο τον πρεσβύτερο (77 μ.Χ.), στο βιβλίο του «Naturalis historiae», αποτελεί ένα σημαντικό ημιπολύτιμο λίθο στην ιστορία της ανθρώπινης ανάπτυξης. Πρόκειται για σκληρό ηφαιστειακό πέτρωμα με υαλώδη μορφή και στιλπνό μαύρο χρώμα. Στον ελλαδικό χώρο κοιτάσματα οψιανού έχουν εντοπιστεί σε ορισμένα νησιά όπως: Μήλο, Αντίπαρο και Γυαλί. Εξαιτίας της σύστασης και της ανθεκτικότητάς του, ιδιαίτερα ο οψιανός της Μήλου, χρησιμοποιήθηκε ήδη από τα τέλη της Ανώτερης Παλαιολιθικής περιόδου (11η χιλιετία π.Χ.) για την κατασκευή λεπίδων με κοφτερές ακμές, που χρησίμευαν ως μαχαίρια, ξυράφια, βέλη, ακίδες κτλ. Τα πρωϊμότερα δείγματα εργαλείων και απορριμμάτων επεξεργασίας πυρήνων οψιανού βρέθηκαν στο σπήλαιο Φράγχθι, στην Αργολίδα. Έτσι, τα ευρήματα αυτά αποτέλεσαν την αρχαιότερη μαρτυρία για την ναυσιπλοΐα στην Ανατολική Μεσόγειο και για την ανθρώπινη παρουσία στη Μήλο και τις Κυκλάδες γενικότερα, ήδη από το τέλος της Παλαιολιθικής περιόδου. Κατά την Ύστερη Νεολιθική Περίοδο (περίπου 5300-3200 π.Χ.), όταν αναπτύχθηκε η συστηματική κατοίκηση των Κυκλάδων, η μεταφορά οψιανού ενσωματώθηκε σταδιακά στα αναπτυσσόμενα εμπορικά δίκτυα του Αιγαίου. Η χρήση του στον Ελλαδικό χώρο χρονολογείται κυρίως μέχρι την Ύστερη εποχή του Χαλκού (1600-1200/1100 π.Χ.), όπου μειώθηκε λόγω της αυξανόμενης δημοτικότητας των μετάλλων, παρακμάζοντας τελείως κατά τους Κλασικούς χρόνους (5ος-4ος αι. π.Χ.). Τέλος, κατά τη Ρωμαϊκή εποχή ο οψιανός χρησιμοποιήθηκε σποραδικά στην κατασκευή ψηφιδωτών, καθώς και διακοσμητικών αντικειμένων, όπως καθρέφτες.

Λέξεις κλειδιά: *Οψιδιανός, Αιγαίο, Μήλος, Λεπίδα, Γυαλί, Φυλακωπή*

1. INTRODUCTION

Volcanic activity in the Aegean area gave rise to a valuable artifactual material, known as obsidian. Obsidian is a volcanic glass, formed when lava extruded from a volcano is cooled rapidly, often at the margins of a flow. For the first time in 77 A.D. Pliny the Elder, in his book 36 "*Historia Naturalis*, mention that "among the various forms of glass we may reckon Obsian glass, a substance very similar to the stone found by Obsius in Ethiopia (obsianus lapis) (*«In genere vitri et obsiana numerantur ad similitudinem lapidis, quem in Aethiopia invenit* ***Obsius****, nigerrimi coloris, aliquando et tralucidi, crassiore visu atque in speculis parietum pro imagine umbras reddente).*

Obsidian was first recognized by Colin Renfrew and his colleagues J.E. Dixon and J.R. Cann in the 1960s as a uniquely sensitive indicator of prehistoric trade, both because of the great desirability of this material before the use of metals, and also because the trace-elements it contains are usually diagnostic of individual sources (Cann and Renfrew, 1964; Renfrew Dixon and Cann, 1966; Renfrew Dixon and Cann, 1968; Cann, Dixon and Renfrew, 1969). The idea of obsidian as evidence of exchange and mobility was not new. In 1843 John Lloyd Stephens describes a ceramic vessel filled with obsidian points, and he concludes that, "as there are no volcanoes in Yucatan from which obsidian can be produced, the discovery of these proves intercourse with the volcanic regions of Mexico" (Stephens, 1843, 232).

Obsidian is a hard black or grey, volcanic material known as "glass mineral", however, it is not a true mineral since as a glass it is not crystalline. In addition, its composition, is too complex to comprise a single mineral. The basic chemical components of obsidian are silica dioxide (SiO_2, consisting of between 70 and 75%), aluminum oxide (Al_2O_3, with 10-15%), sodium oxide (Na_2O, with 3-5%), potassium oxide (K_2O, with 2-5%) and iron oxide (Fe_2O_3, constituting 1-5%) (Balkan- Atlı, 2008, 191).

Pure obsidian is usually dark or green in appearance (Moorey, 1994, 63-64), though the color varies, depending on the composition and circumstances of formation. Iron and magnesium typically give the obsidian a dark brown to black or red color, but may also be colorless. For instance, black color is related with magnetite. If obsidian is highly oxidized, then the glass may include hematite, which gives obsidian a reddish color. If volcanic glass contains iron, it tends to have a green color (Balkan-Atlı, 2008, 191).

2. SOURCES

Systematic exploration of the natural sources of obsidian in the Mediterranean began towards the end of the 19th century (Cann and Renfrew, 1964, 111). The global occurrence of substantial obsidian deposits is limited to Hawaii, Japan, Iceland, Hungary, Italy, Greece, Turkey, Armenia, Ethiopia, Mexico, Ecuador, Arizona and New Mexico (Balkan-Atlı, 2008, 191).

In the Mediterranean, deposits are evident only on islands, while in the Carpathians, central and eastern Anatolia, and Ethiopia they are found in inland mountainous areas (Karimali 2005, 182; Renfrew and Aspinall, 1990, 259–61; Robb and Farr, 2005, 35). A number of sources are known in the Western Mediterranean, namely the island of Sardinia, Lipari, Pantelleria and Monte Arci (Morley and Renfrew, 2010).

In the Aegean there are three sources of obsidian: Melos and Antiparos in the Cyclades, and Giali in the Dodecanese (Georgiades, 1956, 151; Moundrea-Agrafioti 2005, 51; Renfrew, 1972, 442; Renfrew and Aspinall, 1990, 259; Renfrew *et al*. 1965, 229–32). Despite the fact that obsidian only occurs naturally on the three islands mentioned above, it was the primary raw material employed to manufacture chipped stone tools in many Aegean prehistoric communities. Limited evidence exists for the latter two sources' exploitation for chipped stone tool production, to the extent that prehistoric communities on both Antiparos and Giali imported Melian obsidian for such purposes (Evans and Renfrew, 1968; Sampson, 1988).

2.1. Melos

The island of Melos is located in the western part of the Cyclades and belongs to the Aegean volcanic arc (Pichler and Kussmaul, 1972) that begins at the Gulf of Aegina, extends through Santorini, Kos, Nisyros and Yali and reaches as far as Turkey. Two sources of obsidian were identified on the island, in the north-east at “Sta Nychia” (=which mean Nails) (Fig. 1 – 3) and “Demenegaki”, near Komia on the east coast (Barber 1987, 113; Carter and Kilikoglou 2007, 115–16; Moundrea-Agrafioti, 2005, 51; Torrence, 1982, 193). A green obsidian - like glass also occurs at Mandrakia.

Fig. 1: “Sta Nychia”.

Fig. 2: “Sta Nychia”.

Fig. 3: Obsidian.

The ancient workings are entirely on the surface quarries rather than mines and are for the most part shallow and irregular. Some, however, on the eastern slope of Demenegaki have vertical faces, suggestive of a more organized industry. The quarries were rediscovered as early as 1836 by Fielder (Fielder 1841, 1369- 445), but the first archaeological survey was conducted by D. Mackenzie (Makenzie, 1897, 77. Bosanquet 1904, 216 – 218). In 1986 Torrence has undertaken a detailed study of the evidence for obsidian procurement on Melos. Her surveys of the obsidian sources of Demenegaki and "Sta Nychia" permitted the following estimates of the total output of these sources in terms of obsidian macrocores (Fig. 4): "Sta Nychia" (4, 895, 870) 800 tonnes and Demenegaki (3, 084, 338) 500 tonnes (Torrence, 1986).

Fig. 4: Obsidian Core from Melos

New studies are suggesting that in fact there were major regional and chronological distinctions in these sources' exploitation. For example, during the Neolithic Age, Demenegaki was the primary source exploited, with procurement shifting to "Sta Nychia" in the Bronze Age. At both sites the greatest proportion of rejected, incompleted artifacts are large blade cores or macrocores (Renfrew, 1972, pl. 26, fig.15.5, 15.6, 15.10).

2.2. Giali

Giali is a small volcanic island in the Dodecanese, located between the south coast of Kos and Nisyros and some 240 km to the east of Melos. The island owes its name to the fact that its obsidian is sometimes transparent and colorless as glass. Obsidian sources of Giali are found in the northern part of the island and are placed within perlitic strata (Sampson, 1984, 63; 1988, 10). Giali obsidian is not dark and clear (Buchholtz and Althaus, 1982), but it contains many white-grey perlitic spherulites (chalcedony crystals) (Fig. 5). This material is unsuitable for chipping tools, since Giali obsidian breaks easily and does not form good edges (Georgiades, 1956, 155; Evely, 1993, 119; Katsarou *et al.* 2002, 111; Moundrea – Agrafioti 1990, 406; Renfrew *et al.* 1965, 232). On the other hand, the presence of obsidian chips from Melos on the island of Giali implies that the Neolithic inhabitants imported the raw material from the Cyclades.

Fig. 5: Obsidian from Yiali.

The obsidian from Giali with the white spherulites, was used to make the small stone Middle Minoan I – Late Minoan II vases and other items found at the Minoan palace of Knossos, Mallia, Aghia Triada and Zakro in Crete (Barber, 1987, 113, 173; Carter and Kilikoglou, 2007, 124–6; Renfrew and Aspinall, 1990, 259; Renfrew *et al*. 1965, 239–31; Sampson, 1984, 69–72; Warren, 1969, 135–6).

The excavator, Sir Arthur Evans, originally ascribed it to a source on the island of Lipari on the basis of visual appearance (Evans, 1921, 87, 412). But scientific study, carried out later, demonstrated that the obsidian came not from Lipari, but from the island of Giali (Renfrew *et al* 1965, 235 – 237, 239 – 240; Evans, 1994, 5).

Giali obsidian has been recovered in many sites across the Dodecanese, while the Melian obsidian was also preferred in some of the islands, such as Patmos (Sampson 1987, 113), Pharmakonissi (Dreliosi 1994, 799), Astypalaia (Hope, Simpson and Lazenby 1973, 163, 165 – 167). But on most sites Giali and Melian obsidian coexist.

2.3. Antiparos

Antiparos is located at the heart of the Cyclades, 60 km northeast of Melos. The obsidian source at Antiparos was scarcely used. This is to be explained by the fact that Antiparian material is available in only small nodules - commonly less than 5 cm in length - inappropriate for producing blades (Cann *et al*. 1968, 105; Evely 1993, 119; Georgiades 1956,160; Moundrea-Agrafioti 2005, 51;). So according to many

scholars the obsidian source of Antiparos was insignificant (Renfrew and Aspinall, 1990, 259; Barber 1987, 113; Cosmopoulos 1991, 76; Karimali 2005, 182; Robb and Farr 2005, 35). The only site where it has been found in the form of artıfacts is the Late Neolithic settlement of Saliagos near Antiparos (Cann *et al*. 1968, 106; Evans and Renfrew 1968, 47, Fig. 68.4). On the other hand, the total lithic industry of Saliagos is composed of at least 95 per cent of Melian obsidian, in the form of waste flakes and blades. Moreover, the largest cores outside Melos have been found at Saliagos (Evans and Renfrew 1968, Fig. 60), discovered by N. Zaphiropoulos on the surface of the island.

On Antiparos an important find is a nodule in a grave at Apandima and Krassades cemeteries, dating to the Early Cycladic period (Renfrew *et al*. 1965, 239). Also, recent finds at Poros - Katsambas (Dimopoulou 1997, 433–4; Mantzanas 2000, 8) dated in Early Minoan I–Middle Minoan I, are raising question for the importance of this obsidian source.

3. USES

Obsidian is found on many prehistoric settlements in the Aegean area and was mostly used by the inhabitants of the Aegean for producing weapons and cutting tools. Before the introduction of metallurgy to the islands, obsidian was used for blades and tools and was widely exported to surrounding regions. Since at first metal tools were very rare, obsidian continued to be used as a more available alternative throughout the Early Bronze Age. Its attractive black color, its resistance along with its ideal flaking or knapping qualities make it very suitable for tool production, especially blades with sharp edges to serve as hammers, knives, scrapers and razors, arrowheads and spears, axes and saws.

The techniques used for flaking stone are well known: direct percussion, indirect percussion, using an intermediate object, and pressure flaking. The latter method - a technology probably introduced as part of the “Neolithic package” from Anatolia (Pèrles 1988, 483; Demoule and Pèrles 1993, 364) - seems to have been the most frequently used, as it was the only one needed to make bifacial long blades. After flaking, the resultant blades and flakes were retouched, in order to be transformed into tools. Retouching was done also by percussion or by pressure. In the case of the first method, the piece was hit with a hammer made of stone, bone or horn and flakes were detached from its edges until the designed shape was obtained. In the second case, the

mason used a punch made of bone or horn and the pressure of his chest and detached flakes both from the edges and the center of the piece.

The earliest use of obsidian identified as coming from Melos, has been traced back to Upper Palaeolithic levels at Franchthi cave in Argolid (Peloponnesus) around 160 km from Melos by sea (Jacobsen 1969; Aspinall, Feather and Renfrew 1972). In the Upper Mesolithic significant quantities of large fish bones appear in faunal assemblage. But there is no evidence of the Mesolithic period in any part of Melos. According to Pèrles (Pèrles 1990a, 46 – 47), obsidian becomes abundant soon after. Sometime before 7000 B.C., fishing became important, and at this period obsidian was obtained from the Cycladic island of Melos (Renfrew 1972, 63 – 64). In Franchthi cave the layers containing the obsidian were interlaced with remains of tuna fish; so, it has been assumed that fishermen catching tuna in Melos island, discovered obsidian. According to the evidence mentioned above, the Melian sources of "Sta Nychia" (fig.1-3) and Demenegaki are known to have been exploited from as early as the eleventh millennium B.C. (Pèrles 1979, 83; Pèrles 1987, 142 – 45).

From the earliest Neolithic Greece (Milojcic, Boessneck and Hopf, 1962, pls. 18 - 19) Melian obsidian was used on a more widespread basis, known from the aceramic levels at Knossos in Crete and a number of mainland sites, particularly in Thessaly, where obsidian commonly formed at least 50% of the chipped stone assemblage (Pèrles 1989, 1990a; Evans 1994). Furthermore, a few chipped arrowheads of obsidian, discovered in the prehistoric villages of Dimini and Sesklo in Thessaly, seem to belong to the Neolithic Age (Evans and Renfrew 1968, 46).

Fragments of obsidian were found in large quantities in the Late Neolithic Settlement and Cemetery of Kephala in Kea island (Coleman 1977). Also, there is one piece (no. 51) of a wide blade, a type that is common in Melos (Renfrew, Cann and Dixon, 1965, 232). The working tools are classified, according to their function, into six categories: blades (paralleled sided or irregular), flake tools, scrapers, pointed tools, used cores, other used pieces. Some of the tools of obsidian were deposited in graves (Coleman 1977, 6).

In the geometric town of Zagora in the island of Andros, ten flakes artifacts of Melian obsidian, were found during the 1969 excavation (Runnels, 1988, 245 - 249), which fall into the following types: flat, prismatic bladelet core, scraper, blade fragments, flakes, irregular etc.

Melian obsidian (fig. 6) can be found all over the Aegean as far north as Macedonia and Thrace, from Kephallinia in the Ionian islands, and in most western Anatolian sites, such as Aphrodisias (Leurquin, 1986) or Beycesultan (Lloyd and Mellaart, 1962), proving that obsidian industry plays a role in Early Bronze Age. Even though the other sources on the periphery of the Aegean world were known to exist, it was commonly believed that the obsidian was Melian.

Fig. 6: Obsidian from Melos.

The quite large amount of roughly 60 to 70% of tools made of obsidian is constant throughout the excavated settlement phases, from the Neolithic to the Early Bronze Age. There is no evidence of a declining obsidian industry in the Early Bronze Age despite the obviously available metal resources. During the Bronze Age, the increasing use of bronze implements went hand in hand with an increasing use of obsidian.

Throughout this period, obsidian razors, sometimes accompanied by cores, forms part of the funeral furniture of many graves in the Southern and Central Cyclades. They have been found in Amorgos, Anaphi, Antiparos, Ios, Naxos (Doumas, 1977, 100 – 101; Renfrew, 1984a, 47 – 48; Papathanassopoulos, 1962, 132 – 137, pl. 66 -70), Paros (Tsountas, 1898, 156 – 157), Siphnos and Syros (Tsountas, 1899). This burial habit makes its “first” appearance in the Ionian islands (Dörpfeld, 1927; Heurtley, 1934 – 35) and in South Thessaly (WeiBhaar, 1979) and appears to have been enacted on a more widespread basis in late Early Bronze Age.

From the beginning of the Early Bronze Age, obsidian was a regular component of Cycladic grave assemblages (Doumas, 1977, Pl. LI), present only in the form of non-cortical, pressure-flaked prismatic blades (Carter, 1994). The social norm in the Early Bronze Age I (EBI) was to inter only single pieces, but in late Early Bronze Age this practice changed and among the grave findings the archaeologists often found a set of blades. An important example is the site of Agrilia on Epano Kouphonisi (Zapheiropoulou, 1970, 1984), which is the largest late EBI cemetery in the Cyclades, where half of the 72 tombs contained obsidian blades.

Obsidian remained in occasional use even after the beginning of the Iron Age. Flakes have been found in a "geometric" tomb at Eleusis, the so-called tomb of Isis (Tsountas, 1898, 107), and in another at Praisos in Crete. So, obsidian may have been used for ritual reasons after iron had taken its place in ordinary use. The social norm was the inclusion of one blade per inhumation, along with occasional multiple – blade assemblages. In marble working, obsidian blades or flakes might have been used to cut incisions into the sculptures in order to complete their finer details. The material was occasionally found in classical deposits as a secondary material of prehistoric origin. According to Pliny (XXXVI.197), obsidian was used for mirrors and statues.

Obsidian was also valued as a decorative item; for example, small vessels, statuettes and mirrors could be formed from nodules of the glassy rock. In a Roman mosaic excavated by members of the British School on the west side of the ancient town of Melos, in Tramithia, obsidian was found to have been used with excellent effect for the black tessellate (Bosanquet, 1898, 63 – 76).

4. DISCUSSION

The nature of Bronze Age obsidian exchange was first discussed at the turn of the 20th century by the British excavators of the site at Phylakopi on Melos (Fig. 7-8). An important starting point is the excavation and analysis of Phylakopi's "obsidian workshop" (Fig. 8) (Atkinson *et al* 1904). Phylakopi is the largest Bronze Age site on Melos, some 7 km east and 8 km west of the obsidian quarries of "Sta Nychia" (Fig. 1-3) and Demenegaki, respectively. The "obsidian workshop" was discovered within the fortification walls of the settlement's western end (Atkinson et al 1904, pl. 1; Bosanquet 1904, 218; Torrence, 1986, 148). According to Mackenzie (the director of the excavations) "already by the time of the early First City the possession of this material

and the working of it formed the chief source of prosperity at Phylakopi" (Mackenzie 1904, 244-45). Mackenzie believed this huge deposit to be the waste from a workshop manufacturing obsidian blades, which were then traded to communities of the Greek mainland, Crete and the northern Aegean. Mackenzie was also of the opinion that the knapping-floors at “Sta Nychia” and Demenegaki were generated by workers "from the great emporium at Phylakopi", describing the quarries as "dependent stations" of the "prehistoric capital of Melos" (Mackenzie, 1904, 245). On the other hand, Bosanquet provided the specific discussion of Phylakopi's obsidian, with conclusions different to those of his director (Bosanquet 1904). Both scholars did agree that as obsidian was being exploited prior to Cycladic colonisation (Bosanquet, 1904, 228-29), the quarries during the Neolithic "were probably at first independent stations exploited directly from without", with Phylakopi's role in the raw material's exchange only emerging much later (Mackenzie 1904, 246-48). It was on the nature of this role that Bosanquet proposed a quite different interpretation, arguing that Phylakopi's importance was based, "not on natural wealth but on geographical conditions" (Bosanquet, 1904, 218-20, 231). Bosanquet also argued that the “obsidian workshop” was generated by tool production for local consumption, as opposed to the manufacture of blades for Aegean consumption (Bosanquet, 1904, 219-20). So, both scholars reasoned that the growth and decline of this large settlement was due to the fluctuations in the profits derived from control of the obsidian outcrops at “Sta Nychia” and “Demenegaki”. But careful study of the deposits showed that there was very little obsidian present when the duration of the occupation was considered and the later stages of production were largely unrepresented. These lines of evidence seemed to indicate that there was direct access to Melos quarries or purchase of core from the inhabitants of Phylakopi. On the other hand, Colin Renfrew prefers the model of the “direct access” to the quarries, especially during the period when Melos was uninhabited (Renfrew, 1972, 442 - 443). For the period when Melos (Phylakopi) was inhabited, we have the combination of direct access and down the line exchange, though Melians didn’t lose all the control over the quarries (Renfrew, 1972, 449). Colin Renfrew, on later discussions, distinguishes between different “organizational zones”, basically sites that can be defined as a “supply zone” where materials were found, and a “contact zone” where items were exchanged (Oka, Kusimba, 2008, 8).

Later it was the work of Torrence that brought all the above theories together (Torrence 1981, 1982, 1986). Her study also involved fieldwork at the obsidian quarries at Melos and Phylakopi where she excavated a small part of the “obsidian workshop” (Torrence 1986, 149). Torrence finally concluded that there was no evidence for the presence of specialists producing artifacts for commercial sale in the site of Phylakopi (Torrence

1986, 162). The procurement of obsidian was not organized on a commercial basis, but the extraction of obsidian from the quarries had been undertaken in a very unsystematic manner (Torrence, 1986, 181 -186).

Fig. 7: Phylakopi.

Fig. 8: "Obsidian Workshop".

The presence of obsidian in the Upper Palaeolithic levels of the Franchthi Cave in the Argolid, provides indirect evidence for the earliest maritime travel in the Aegean (Cherry, 1985, 15, Fig. 2-2). Moreover, there is no evidence for the Cyclades being permanently occupied until the Late Neolithic (Evans and Renfrew, 1968) and possibly none on Melos until the Final Neolithic (Cherry and Torrence, 1982), so it has important ramifications for how the raw material was procured and distributed.

The Late Neolithic period witnessed changes in many levels such as - the increase in maritime activity, including the colonisation of the Cyclades, which arguably led to a greater circulation of obsidian (Torrence, 1986, 13-15, 135-36; Perlès, 1989, 13). For example, obsidian was far more plentiful in Late Neolithic Corinth, compared to the Early Neolithic – Middle Neolithic levels where chert implements were 6 times as common as those of obsidian (Lavezzi, 1978, 407, 425-26). More people in southern Aegean society were then able to gain and work obsidian, with regions such as Attica and Euboea witnessing the innovation of obsidian blade - manufactured by indirect percussion, a less skillful mode of production than pressure - flaking, the technique it replaced largely (Perlès, 1989, 12-13).

The earliest lithic industries of the Cyclades are comparable to those of Attica, Euboea and the Argolid (Evans and Renfrew, 1968; Perlès, 1981, 1990). As mentioned above, at the Cycladic Late Neolithic site of Saliagos near Antiparos, the chipped stone assemblage was dominated by obsidian, where a flake- and (indirect percussion) blade - based industry existed in tandem. Blades continued to be manufactured by indirect percussion during the Final Neolithic, as represented by the assemblage from Kephala

on Kea (Coleman, 1977, Fig. 1.5), with pressure-flaking making its first appearance in the Cyclades in "sub-Neolithic" Ayia Irini and the Early Bronze I levels of Phylakopi (Cherry and Torrence, 1982, 20).

Gathering all the theories about the quarries at "Sta Nychia and Demenegaki on Melos island, we may conclude that: many scholars accept that there was open access to obsidian from both quarries at least from the Upper Paleolithic until the foundation of Phylakopi in Early Cycladic Period (EC) III. Since then, until the Late Bronze Age (LBA) there was some kind of control over the sources by Phylakopi (Mantzanas, 2000, 4, 19). Renfrew and Torrence (Renfrew, 1972, 442–3; Renfrew *et al*. 1965, 241–2; Torrence, 1982, 197; 1984, 61–2; 1986, 170–1) favour a model of continuity for the same manner of acquiring obsidian as in the Neolithic.

All the obsidian used in the Aegean is proved to have come from the island of Melos. It is of great interest that Early Neolithic sites such as Nea Nikomedeia in Macedonia, Soufli and Sesklo in Thessaly and Knossos in Crete, were all obtaining obsidian from Melos by about 6000 B.C. This open access to material during the Neolithic and the Early Bronze Age (EBA) - was achieved either through special voyages or as one function of a trip where other activities were performed, with a down-the-line reciprocal exchange taking place (Perlès, 1992, 145; Torrence 1982, 220; 1986, 103–5, 135–6, 216).

5. CONCLUSIONS

Trade is part of the human evolution and human behavior (Mauss, 1990, 71-78, Oka, Kusimba, 2008, 3), since it paves the way for innovation and progress through social interaction. People learn new ideas and new techniques from other people. During the Late and the Final Neolithic (ca. 5300-3200 BC), when the systematic habitation of the Cyclades developed, the transportation of obsidian changed and was incorporated in the gradually developing trade networks of the Aegean. The exchange of obsidian reached its peak during the Final Neolithic and the Early Helladic period. 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.

Obsidian was much in demand in the Early Bronze Age (EBA). During the later Bronze Age its use declined and by the Classical period it seems to have been displaced by metal.

The trade of obsidian played an important role in the economy of the Bronze Age and was connected with the development of navigation in the Aegean toward the beginning of the 3rd millennium B.C. Long distance trade and the control of this organization required a central political organization (Hirth, 1996, 207).

Melian obsidian is by far the most abundant item of exchange in the Aegean Neolithic, being found on all Neolithic sites within the region (Perlès, 1992). Beyond the direct access theory, the trade of the Melian obsidian is confirmed by the presence of parallel exchange networks through which other types of obsidian circulated in the Aegean. The more complex circulation of Melian obsidian, along with the direct access, allowed the formation of different exchange networks, often acting in parallel across the Aegean.

Beyond all the sources of obsidian in the Aegean (Giali, Antiparos etc.), Melian is by far the most common material, controlling the monopoly in the Neolithic periods.

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7. REFERENCES

Aspinall, A., Feather, S.W. and Renfrew, C., 1972. *Neutron Activation Analysis of Aegean Obsidian*, Nature, Vol. 237, June 9, 333- 334.

Atkinson, T.D., Bosanquet, R.C., Edgar, C.C., Evans, E.J., Hogarth, D.G., Makenzie, D., Smith, C. and Welch, F.B. 1904. *Excavations at Phylakopi in Melos* (Society for the Promotion of Hellenic Studies, Supplementary Paper no. 4). London, Macmillan.

Balkan-Atlı, N., 2008. Prehistoric Obsidian Mining in Göllü Dağ (Central Anatolia), in Unsal, Ancient Mining in Anatolia and Eastern Mediterranean, edited by Paşamehmetoğlu & Özbal, 191-208, Atılım Üniversitesi.

Barber, R.L.N. 1987. *The Cyclades in the Bronze Age*, London: Duckworth, 113–119. DOI: 505812.

Bosanquet, R.C.1898. Excavations of the British School at Melos. "The Hall of the Mystae". *Journal of Hellenic Studies* 18, 60 – 80.

Bosanquet, R.C. 1904. *The Obsidian Trade* in Excavation at Phylakopi in Melos, edited by T. D. Atkinson, R. C. Bosanquet, C. C. Edgar, A. J. Evans, D.G. Hogarth, D. Mackenzie, C. Smith, and F. B. Welch, 216 – 232. Society for the Promotion of Hellenic Studies, Supplementary Paper vol. 4. London, Macmillan.

Buchholtz, H.G. and Althaus, E. 1982. *Nisyros, Giali, Kos*. Ein Vorbericht über ärchaologisch – mineralogische Forschungen auf griechischen Inseln. (Archäologische Obsidian forschungen, 1). Mainz: Philipp von Zabern.

Cann, J.R. and Renfrew, C. 1964. The characterization of obsidian and its application to the Mediterranean region, *Proceedings of the Prehistoric Society* XXX, 111– 33. DOI: 10.1017/S0079497X00015097.

Cann. J.R., Dixon, J.E. and Renfrew C. 1968. Appendix iv. The sources of the Saliagos obsidian. In Evans, J.D. and Renfrew, C., *Excavations at Saliagos near Antiparos* (London, BSA Supplementary Vol. No. 5), 105–7.

Cann, J.R., Dixon, J.E. and Renfrew, C. 1969. Obsidian analysis and the obsidian trade, in D. Brothwell and E. Higgs (eds.) *Science and Archaeology*, London, Thames and Hudson, 578-591.

Carter, T. 1994. Southern Aegean fashion victims: an overlooked aspect of Early Bronze Age burial practices, edited by N. Ashton and A. David, 127 – 44, Stories in Stone. Lithics Society Occasional Paper 4, London.

Carter, T. and Kilikoglou, V. 2007. From Reactor to Royalty: Aegean and Anatolian Obsidians from Quartier Mu, Malia (Crete). Journal of

Mediterranean Archaeology 20.1. 115 – 145. Doi: 10.1558 //jimea. 2007.v 20i1. 115 116.

Cherry, J.F. 1985. Islands out of the stream: Isolation and Interaction in the Early East Mediterranean Insular Prehistory, in Knapp and Stech (eds.), 12 -29.

Cherry, J.F. and Torrence, R. 1982. *The Earliest Prehistory of Melos*, edited by C. Renfrew and M. Wagstaff, 24 – 34.

Coleman, J.E. 1977. *Kephala, A Late Neolithic Settlement and Cemetery*, Keos. Vol. 1, American School of Classical Studies, Princeton, N.J.

Cosmopoulos, M.B. 1991. The Early Bronze 2 in the Aegean (Jonsered, Studies in Mediterranean Archaeology 97).

Demoule, J.-R. and Perlès, C. 1993. "The Greek Neolithic: A New Review," *Journal of World Prehistory* 7, 355- 416.

Dimopoulou, N. 1997. Workshops and craftsmen in the harbour-town of Knossos at Poros-Katsambas. Craftsmen, Craftswomen and Craftsmanship in the Aegean Bronze Age, edited by R. Laffineur and P.P. Betancourt, 433–8, Liège, Aegaeum 16.

Dörpfeld, W. 1927. Alt-Ithaka. Ein Beitrag Zur Homer-Frage. Otto Zeller, Osnabrück.

Doumas, Chr. 1977. *Early Bronze Age Burial Habits in the Cyclades*. Studies in Mediterranean Archaeology, vol.48. Göteborg: Paul Aströms Förlag.

Dreliosi, A. 1994. Leros - Drumons. *Archaiologikon Deltion* 49, Chronikα, 798.

Evans, A. 1921. *The Palace of Minos*, Vol. I. London.

Evans, J.D. and Renfrew, C. 1968. *Excavation at Saliagos near Antiparos*, The British School of Archaeology at Athens. Supplementary Volume 5. London: Thames and Hudson, 46 – 63.

Evans, J.D. 1994. The early millennia: continuity and change in a farming settlement, in D. Evely, H. Hughes-Brock and N. Momigliano (eds), *Knossos a Labyrinth of History: Papers Presented in Honour of Sinclair Hood*. London: 1-20.

Evely, R. D. G. 1993. *Minoan Crafts: Tools and Techniques – An Introduction*. Göteborg, Studies in Mediterranean Archaeology 92.

Fiedler, K.G. 1841. Reise durch alle Teile des königreiches Griechenland in Auftrag der königl. griechischen Regierung in den Jahren 1834 bis 1837, 2 vols., Leipzig.

Georgiades, A. N. 1956. Erevna epi ton ellinikon opsidianon. Praktika tis Akadimias Athinon - Sinedria tis 8 Martiou 1956.

Hirth, K. G. 1996. Political Economy and Archaeology: Perspectives on Exchange and Production, *Journal of Archaeological research*, 4(3), 203-239.

Heurtley, W.A. 1934-35. Excavations in Ithaca, IT, Annual of the British School at Athens XXV, 1- 45.

Hope Simpson, R. and Lazenby, J.F. 1973. Notes from the Dodecanese iii. *Annual of the British School at Athens* 68, 127–79.

Jacobsen T.W. 1969. Excavations at Porto Cheli and Vicinity, Preliminary Report, II: The Franchthi Cave, 1967 – 1968", Hesperia 38, 343 – 381.

Karimali, E. 2005. Lithic technologies and use. Edited by E. Blake and A.B. Knapp, 180- 214, *The Archaeology of Mediterranean Prehistory*. Oxford. DOI: 10.1002/9780470773536.ch8.

Katsarou, S., Sampson, A. and Dimou, E. 2002. Obsidian as temper in the Neolithic pottery from Yali, Greece. In Kilikoglou, *Modern Trends in Scientific Studies on Ancient Ceramics*, edited by V. A. Hein and Y. Maniatis, 111–20. Oxford, BAR International Series 1011.

Lavezzi, J. C. 1978. Prehistoric investigations at Corinth, *Hesperia* 47, 402-51.

Leurquin. L J.L., 1986. Chipped Stone. Chipped Stone Analysis 1975–1982. In Prehistoric Aphrodisias. An Account of the Excavations and Artifact Studie. Edited by M. Joukowsky, 240–285. Archaeologia Transatlantic 3. Providence: Brown University, Center for Old World Archaeology and Art.

Lloyd, S. and Mellaart, J. 1962. Beycesultan I. The Chalcolithic and Early Bronze Age Layers. Ankara: British institute of Archaeology at Ankara.

Mackenzie D. 1897. Ancient Sites in Melos, BSA 3, 71 – 88. DOI: 10.1017/S0068245400000769

Mackenzie, D. 1897b. Excavations of the British School at Melos: the site of the "Three Churches", Journal *of Hellenic Studies* 17, 122 – 133.

Mackenzie D. 1904. The successive settlements at Phylakopi in their Aegeo-Cretan relations. In T.D. Atkinson, R.C. Bosanquet, C.C. Edgar, A.J. Evans, D.G. Hogarth, D. Mackenzie, C. Smith and F.B. Welch (eds), Excavations at Phylakopi in Melos. Society for the Promotion of Hellenic Studies, Supplementary Volume 4, Macmillan, London: 238-72.

Mantzanas, C. 2000. Tropoi prosktisis kai katatmisis piritikon petromaton kata tin Proimi Xalkokratia. *Archeologikon Deltion* 55, Meletes, 1 - 22.

Mauss, M. 1990. The Gift: The Form and Reasons for Exchange in Archaic Societies. New York, London: W.W. Norton.

Moorey, P.R.S. 1994. *Ancient Mesopotamian Materials and Industries*. Oxford: Clarendon Press.

Morley, I. and Renfrew, C. 2010. *The Archaeology of Measurement: Comprehening Heaven, Earth and Time in Ancient Societies*, Cambridge: Cambridge University Press.

Moundrea-Agrafioti, A. 1990. Akrotiri, the chipped stone industry, reduction techniques and tools of the LCI phase. *Thera and the Aegean World III. Vol. I, Archaeology*, edited by D.A. Hardy, 390- 406, London.

Moundrea-Agrafioti, A. 2005. Ta ergaleia apo laxevmeno litho kata tin epohi tou Halkou, to telos mias techonologikis paradosis. Archaiologia kai Texnes 94, 49 - 57.

Oka, R. Kusimba, C. 2008. "The Archaeology of Trading Systems, Part 1: Towards a New Trade Synthesis," Journal of Archaeological Research 16(4), 1-5

Papathanasopoulos, G.A. 1962. Kykladika Naxou. *Archaiologikon Deltion,* 17 (A). 104 – 151.

Perlès, C. 1979. Des navigateurs méditerranéens il y a 10 000 ans. *La Recherche* 10, 82- 83.

Perlès, C. 1987. Les industries lithiques taillées de Franchthi (Argolide, Gréce). Tome I. Présentation générale et industries paléolithiques. Excavations at the Franchthi Cave, Fascicle 3. Indiana University Press, Bloomington and Indianapolis.

Perlès C. 1988. New ways with an old problem. Chipped stone assemblages as an index of cultural discontinuity in early Greek prehistory, in E. French and K. Wardle (eds), Problems in Greek Prehistory. Bristol Classical Press, Bristol, 477-88.

Perlès, C. 1989. From Stone Procurement to Neolithic Society in Greece. David Skomp distinguished lectures in Anthropology, February 1989. Indiana University, Bloomington.

Perlès, C. 1990. L'outillage en pierre taillée néolithique en Grèce: Approvisionnement et exploitation des matières premières. *Bulletin de Correspondance Hellénique*, CVIV, 1- 42.

Perlès, C. 1992. Systems of exchange and organization of production in Neolithic Greece. *Journal of Mediterranean Archaeology*, 5 (2), 115 – 164.

Pichler, H. and Kussmaul, S. 1972. The calc – alkaline volcanic rocks of the Santorini group (Aegean Sea, Greece) *N.Jb.Miner. Abh.*, 116, 268 – 307.

Renfrew, C.1972. The Emergence of Civilization. The Cyclades and the Aegean in the Third Millennium B.C. London: Metheum. DOI:10.1017/S0003598X00053941.

Renfrew C. 1984a. From Pelos to Syros: Kapros grave D and the Kampos group, in J.A. MacGillivray and R.L.N. Barber (eds), The Prehistoric Cyclades. Edinburgh, 41- 53.

Renfrew, C., Cann. J. R., Dixon J.E. 1965. Obsidian in the Aegean, The Annual of the British School at Athens, 60, 225-247.

Renfrew, C., Dixon. J.E. and Cann, J.R, 1966. Obsidian and Early Cultural Contact in the Near East. *Proceedings of the Prehistoric Society*, 32, 30-72.

Renfrew, C., Dixon, J.E. and Cann, J.R. 1968. Further analysis of Near Eastern obsidians, Proceedings of the Prehistoric Society 34, 319-31.

Renfrew, C. and Aspinall, A. 1990. Aegean Obsidian and Francthi Cave. In C. Perlès. *Les Industries Lithiques Taillées de Francthi (Argolide, Grèce), 2 : Les Industries Mésolithique et du Neolithique Initial* (Excavations at Franchthi Cave, Greece, Fascicle 5), 257 – 270. Bloomington: Indiana University Press.

Robb, J.E and Farr, R.H. 2005. Substance in motion, Neolithic Mediterranean "trade". In Blake, E. and Knapp, A.B. (eds.), *The Archaeology of the Mediterranean Prehistory*. Oxford, 24 - 45. DOI: 10.1002/9780470773536.ch2.

Runnels, C. 1988. The flaked Obsidian Artifacts, in Zagora 2, Excavation of a Geometric Town on the Island of Andros, edited by A. Cambitoglou, A.Birchall, J.J. Coulton, J.R. Green. Athens.

Sampson, A. 1984. The Neolithic of Dodekanese and the Aegean Neolithic Culture. *British School of Athens* 79, 239 - 249. DOI: 10.1017/S0068245400019948.

Sampson, A. 1987: Paleolithiki Periodos sta Dwdekanisa (Athens).

Sampson, A. 1988. *The Neolithic Settlement of Giali, Nisyros*. Athens: Euboiki Archaiophilos Etaireia.

Stephens, J. Ll., 1843. Incidents of Travel in Yucatan.

Torrence, R. 1981. Obsidian in the Aegean: Towards a Methodology for the Study of Prehistoric Exchange. University of New Mexico.

Torrence, R. 1982. *The Obsidian Quarries and their use*, in An Island Polity: The Archaeology of Exploitation in Melos, edited by C. Renfrew and M. Wagstaff, 193 – 221. Cambridge – New York, Cambridge University Press.

Torrence, R. 1984. Monopoly or direct access? Industrial organization at the Melos obsidian quarries. In J. Ericson and B. Purdy (eds.). Prehistoric Quarries and Lithic Production, Cambridge: Cambridge University Press, 49 – 64. DOI: 10.1017/CBO9780511753244.006.

Torrence, R. 1986. Production and Exchange of Stone Tools. Prehistoric obsidian in the Aegean. Cambridge: Cambridge University Press.

Tsountas, Ch. 1898. Kykladika I. *Ephimeris Archaiologiki*, 137.

Tsountas, Ch. 1899. Kykladika II. *Ephimeris Archaiologiki*, 730.

Warren, P. 1969. *The Minoan Stone Vases*. Cambridge: Cambridge University Press.

Wießhaar, H-J. 1979. Ausgraben auf der Pevkakia-Magula and der Beginn der Frühen Bronzezeit in Griechenland, *Archäologisches Korrespondenzblatt*, 9: 385-92.

Zapheiropoulou, Ph. 1970. Archaiotites kai mnimeia Kykladon. Chronika. *Archaiologikon Deltion* 25(B'2), 423– 430.

Zapheiropoulou Ph. 1984. The chronology of the Kampos group, in J.A. MacGillivray and R.L.N. Barber (eds), The Prehistoric Cyclades. Edinburgh: 31-40.