# Neolithic society in Northern Greece: the evidence of ground stone artefacts

## Volume I

**Christina Tsoraki**

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Department of Archaeology,
University of Sheffield

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*to Ben*

# ABSTRACT

Analysis of ground stone technology from the Neolithic of Greece rarely goes beyond incomplete descriptive accounts to focus on the activities performed with these tools and the contexts of their use. Ground stone products are seen as mundane static objects devoid of meaning and lacking significance. The aim of this thesis is to move away from incomplete accounts of ground stone technology and static typologies. Drawing upon the concepts of the *chaîne opératoire* and 'object biographies' this thesis investigates ground stone technology as a social practice focusing on the life-cycle of artefacts from raw material selection to final deposition. The underlying premise is that a contextual approach can contribute to understanding the ways in which the production, consumption and discard of ground stone artefacts were structured within different forms and scales of social practice and the manner in which these differences articulated different meanings and social understandings. The aims of the thesis were materialised through the study of the rich ground stone assemblage from the LN settlement of Makriyalos, Greece.

The analysis of the *chaîne opératoire* of the Makriyalos ground stone assemblage revealed diverse technological choices expressed throughout the cycle of production and use. Established traditions existed according to which specific materials were considered to be appropriate for the production of different objects. Furthermore, detailed analysis suggests that the resulting objects were far from mundane artefacts but were instead active media for expressing choices informed by cultural understandings of appropriateness.

Building upon analysis of the *chaîne opératoire*, spatial analysis of the Makriyalos assemblage indicated distinct depositional patterns of different categories of ground stone within and between the two phases of Makriyalos. This analysis offers significant insights into the way(s) these implements were incorporated into the social life of Makriyalos. Ultimately, the thesis demonstrates that ground stone artefacts were actively employed in the creation and negotiation of varied and distinct identities (individual vs. communal) that could be transformed through different contexts of practice.

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# CHAPTER ONE

## *Introduction*

### 1.1. Why ground stone technology?

Going through publications of Greek prehistoric sites, one recurrent feature strikes the reader. The presentation of the portable material culture is restricted to long descriptions of pottery assemblages, while other bodies of material culture are presented briefly over a few pages and quite often are grouped together under the heading 'small finds'. This elusive term has come to represent a wide range of artefacts that escape the interest of archaeologists. This attitude stems from a long archaeological tradition, common worldwide, which wished to reconstruct chronological sequences. Pottery assemblages have been considered to be a very reliable chronological indicator in comparison to other sources of data (e.g., lithic tools). As a result, not much attention has been devoted to the collection of the latter during excavation, and little effort has been put into their post-excavation study (cf. Perlès 2001).

A body of material that has suffered and still suffers from this way of thinking is ground stone artefacts. Since the beginning of the 1980's, Runnels (1983) noted the significance of collecting, studying and publishing lithic artefacts. In 1995 Kardulias and Runnels noted the lack of systematic studies of ground stone arguing that '*nonflaked lithic artifacts are rarely collected in the course of excavations and even more rarely published in full*' (Kardulias and Runnels 1995: 109).

A decade later this suggestion still holds true as is demonstrated by the lack of fully published ground stone assemblages. Studies of Greek assemblages tend to focus on a few artefact categories and in particular on tool types such as axes and grinding slabs (cf. Moundrea-Agrafioti 1981; Runnels 1981), leaving aside other products of ground stone technology that are less common and remain less understood. Furthermore, the presentation of ground stone within publications is restricted to incomplete descriptive accounts (cf. Séfériadès 1992) limiting our understanding of the range of artefacts present on different archaeological sites and chronological periods and more importantly the contextual relations between ground stone and other classes of material culture are rarely investigated. This lack of systematic studies makes it difficult to establish a terminology to categorise ground stone objects consistently as has been the case in other regions of the world (e.g., Wright 1992a; Wright 1992b; Adams 2002) hindering thus meaningful comparisons between sites and regions, while at the same time it impedes our understanding of the character of this technological practice throughout prehistory.

This attitude to ground stone is linked to a widely-held belief that the meaning of these artefacts does not pose any problems for archaeologists to decipher as they represent utilitarian objects that relate to everyday mundane activities and accordingly attempts to explore the meaning(s) ground stone held for prehistoric societies are rarely made (cf. Mantzourani and Catapoti 2004). This attitude to ground stone technology, however, contradicts recent approaches to material culture that emphasise its dynamic role in shaping identities and facilitating social reproduction (e.g., Dobres and Hoffman 1994; Edmonds 1995; Dobres 2000). Ground stone technology and its products, therefore, have been greatly under-theorised and under-problematized.

It is exactly this lack of systematic studies that has prompted this writer to attempt to realise the potential of ground stone technology by investigating this technological practice from a different perspective. For these aims to be realised a holistic approach is necessary, encompassing a wide range of stone objects that can be attributed to what is traditionally defined as 'ground stone technology'. By this means the full range of ground stone artefacts that were used on a daily basis by the inhabitants of a settlement would be studied. Furthermore, understanding of the technological practice would require the full analysis of the life histories of ground stone artefacts - from procurement of raw material to manufacture, use, reuse and final deposition. In that sense, choices made throughout the production, use and deposition of these artefacts could be brought to light. Thus, following a biographical approach, the main aims of this thesis are:

1. To study the different episodes of ground stone tool biographies.
2. To explore how acts of production and consumption relevant to ground stone technology were organised within the level of the individual settlement.
3. To consider how ground stone technology facilitated social reproduction.
4. To explore the practical, social and symbolic significance of ground stone objects within Neolithic societies in Greece.
5. To study all the above using different scales of temporal (synchronic, diachronic) and spatial (domestic, communal) analysis.

## 1.2. Matters of definition

Before we proceed with this endeavour a definition of 'ground stone technology' is necessary. A broad definition of the term ground stone is 'any stone item that is primarily manufactured through mechanisms of abrasion, polish, or impaction, or is itself used to grind, abrade, polish, or impact' (Adams 2002: 1). Or 'any tools made by combinations of flaking, pecking, pounding, grinding, drilling and incising' (Wright 1992a: 53). It becomes immediately apparent by these definitions, however, that a wide range of techniques were employed in the production of ground stone artefacts and in some categories (e.g., expedient hammers) grinding may have not played any role in their formation and use. In that sense, the term 'ground stone' does not adequately describe the range of object categories the term encompasses and the processes involved in their production and use (Wright 1992a; Adams 2002; this is also true for the term 'nonflaked tools, e.g., Kardulias and Runnels 1995). Moreover, the widely-held distinction between products of ground stone technology and chipped stone artefacts based on manufacturing techniques alone seems less valid as flaking and grinding were employed in different stages of the production sequence of both categories of stone tools (e.g., flaking used in the initial shaping of axes and grinding slabs and abrading used to maintain platform edges in flaked stone technologies). Hence, grinding and flaking techniques were probably not regarded '*as mutually exclusive to prehistoric technologists as they are to lithic analysts*' (Adams 2002: 1).

More recently, in an attempt to deal with these issues entailed by the term 'ground stone', the term 'macro-lithic artefacts' was introduced (Risch 2002, 2008; Adams et al. in press). In this case, the size of artefacts is taken to be the decisive factor between 'ground stone' and 'chipped stone' technologies. Yet, this term is not without problems as cross-cutting categories still exist (e.g., small-sized axes and chisels ca. 2 cm long, see Chapter 5 or exceptionally long blades such as those found in the Varna cemetery ca. 40 cm long, Bailey 2000: 204). Moreover, size cannot be considered an adequate factor to distinguish between these technological traditions as it refers to a morphological characteristic that can change during the use-life of an object.

Therefore, the current terminology used to describe 'ground stone' and to distinguish its products from 'chipped stone technology' is problematic. What is clear, however, is that both 'ground stone' and 'chipped stone' represent traditions of working stone that co-existed in prehistoric societies and may have been practiced within the same contexts and potentially by the same actors. In that respect, the general terms 'stone tools/stone technology' are more appropriate. In this thesis, the term 'ground stone technology' was employed due to its long tradition of use in archaeology and to the fact that no other appropriate term has been suggested that would make it meaningful to use. In respect to the above, it would be preferable to conduct a holistic analysis, which included both chipped and ground stone material. In future work it is hoped that the full technological network can be studied in more detail within a collaborative analytical project involving the study of a wide range of technological practices.

## 1.3. Selection of material for analysis

To attempt a holistic analysis, focusing on life histories of objects, demanded access to a large and contextualised assemblage. Most excavated assemblages come from small-scale excavations offering limited contextual information, as is the case for the assemblages from Late Neolithic (LN) – Final Neolithic (FN) Tharrounia in Central Greece (Sugaya 1993), Early Neolithic (EN) – Middle Neolithic (MN) Achilleion in Thessaly (Winn and Shimabuku 1989) or Early Bronze Age (EBA) Mesimeriani

(Alisoy 2002a) and LN Dikili Tash (Séfériadès 1992) in Macedonia. Some of the largest published assemblages come from surface survey projects spanning from the Neolithic to historical times and so offer no chronological or intra-site contextual control, as for example the 304 ground stone artefacts recorded by the Argolid Survey Project (Kardulias and Runnels 1995).

In contrast to these sets of material, an assemblage of substantial size deriving from an excavation with a plethora of contextual information is that from the Neolithic settlement of Makriyalos, located in Macedonia, Northern Greece. Large-scale rescue excavation at Makriyalos between 1993 and 1999 exposed six hectares of this flat, extended settlement dated to the LN (Pappa and Besios 1999b; see also Chapter 2). The Makriyalos ground stone assemblage comprises 8842 objects in total and encompasses a wide range of artefactual categories, making it by far the biggest such assemblage in Greece.

Moreover, the study of the stratigraphy and architecture of the whole settlement is well advanced enabling a contextual analysis to be undertaken (Pappa 2008). Post-excavation work has shed light both on individual classes of material and on the spatial and temporal organisation of human activity at the site. Among the categories of data that have been studied are the human bones and burials (Triantaphyllou 2001), archaeobotanical remains (Valamoti 2004) and animal bones (Collins and Halstead 1999; Pappa *et al.* 2004; Halstead 2005). In addition, the pottery assemblage from both phases of the Late Neolithic occupation has been studied, covering different aspects of ceramic technology such as typology, provenance, residue analysis, and spatial distribution (Urem-Kotsou *et al.* 2002; Vlachos 2002; Hitsiou 2003; Urem-Kotsou 2006; Urem-Kotsou and Kotsakis 2007). Finally, preliminary results of studies of the bone and chipped stone tools have been published (Skourtopoulou 1999, 2006; Isaakidou 2003).

Makriyalos thus offers the largest and best-contextualised ground stone assemblage from Neolithic Greece, allowing the whole lithic sequence from raw material selection to manufacture and use to final discard to be followed, while the large size of the assemblage allows for identified patterns to be meaningfully studied.

## 1.4. The structure of this thesis

The thesis chapters are structured as follows:

**Chapter 2** provides information on the Greek Neolithic and the Neolithic settlement of Makriyalos setting the archaeological scene of this study. In this chapter a synopsis of research in the Greek Neolithic is provided with an emphasis placed on key issues such as settlement patterns, the nature of the social organisation (household/community) of Neolithic societies and their acts of production and consumption. Following the general account of the Neolithic in Greece a detailed presentation of LN Makriyalos will be presented.

**Chapter 3** focuses on the methodological avenues followed in this PhD thesis addressing both the theoretical concepts and the techniques of analysis that have informed the study of the ground stone assemblage from LN Makriyalos.

**Chapters 4 and 5** provide the technological backbone of this thesis. The *chaîne opératoire* of ground stone technology from raw material selection, to production, use and final deposition is considered. Emphasis is placed on the choices that informed the way ground stone technology was organised. Chapter 4 concentrates upon the selection of raw materials and stages of production, whilst Chapter 5 focuses upon patterns of consumption and discard.

**Chapter Six** utilises an in depth contextual and spatial analysis to explore the depositional practices that relate to ground stone and provide a meaningful and socially constituted setting in which the observations reached during the technological analysis can be placed.

**Chapter Seven** provides the final account of the key themes addressed throughout the thesis and the conclusions reached regarding the way(s) in which ground stone technology and its products were caught up in the lives of the Makriyalos community and relates these findings to our understanding of the Greek Neolithic as a whole.

# CHAPTER TWO

## The Greek Neolithic: Setting the Context

### 2.1. Introduction

The pioneering work of Tsountas in Thessaly between 1899 and 1906 that culminated in his seminal publication *Αι προϊστορικαί ακροπόλεις Διμηνίου καί Σέσκλου* (The Prehistoric Acropoleis of Dimini and Sesklo) in 1908, followed by the publications by Wace and Thompson for Thessaly (1912) and Heurtley for Macedonia (1939), established early on that the Neolithic period in Greece was characterised by a rich and distinctive portable material culture (e.g., fine pottery, stone tools, figurines, stamps) and architectural remains. Research on Neolithic communities throughout Greece has continued since, revealing important information on every aspect of Neolithic life (for a more detailed review of the history of Neolithic research in Greece, see Gallis 1996: 23-30; Andreou *et al.* 2001).

The Greek Neolithic, that lasted over three millennia, was divided initially into Early, Middle and Late Neolithic (EN, MN, LN), by Weinberg, following Evans' tripartite division of the Bronze Age, but more recently a fourth phase, the Final Neolithic (FN), has been added (Gallis 1996: 26, 30). The LN period is sub-divided into LN I (Pre-Dimini) dated to 5400/5300-5000 BC and LN II (Dimini) dated to 4900-4500 BC. This study adopts the broad chronological scheme based on calendrical dates suggested by Andreou *et al.* (2001; Table 2.1).

A complete synthesis of research conducted on the Greek Neolithic is beyond the scope of this thesis. Rather, my aim is to provide a context for the study of the Makriyalos ground stone assemblage and to focus on key issues that will be addressed by the current thesis.

## 2.2. Settlement patterns

The Greek Neolithic landscape was littered with compact 'tell' villages representing long-term settlements used on a year-round basis (sedentary) (Demoule and Perlès 1993: 363; Halstead 1994: 200; 1995: 14; see Halstead 2005 for a detailed account of evidence for sedentary settlements). These communities practiced an agropastoral economy as suggested by archaeozoological and archaeobotanical evidence characterised principally by domesticated seed crops and livestock. Cultivated crops included both hulled and free-threshing cereals and pulses (einkorn, emmer, new type glume wheat, bread/macaroni wheat, hulled and naked barley, common millet, lentil, pea, grass pea, chickpea, and bitter vetch), while from the early stages of the Neolithic period sheep, goats, pigs, cattle and dogs appear frequently (Demoule and Perlès 1993: 362-363; Halstead 1994: 200-201; Valamoti 2004). Subsistence, was arguably based primarily on cereal and pulse crops as sedentary villages required large amounts of food and 'mortality data for sheep, the commonest domestic animal, suggest management according to a relatively unproductive 'meat' strategy' (Halstead 1999: 77; 2007), a view consistent with evidence from human dental health and stable isotope analysis of bone collagen (Triantaphyllou 2001).

Most information about settlement patterns during this period derive from excavations conducted in the region of Thessaly. Recent work in Macedonia, however, has clearly demonstrated that the area was inhabited throughout the Neolithic and enriched our knowledge of settlement patterns in this part of Northern Greece (Demoule and Perlès 1993: 368, 370; Halstead 1994:198, 200; Gallis 1996; Grammenos 1996: 42; Kotsakis 1996; Pappa and Besios 1999b; Andreou *et al.* 2001; Besios and Adaktylou 2006; Kotsos and Urem-Kotsou forthcoming). EN and MN settlements were located in alluvial plains and low hills near water resources (Andreou *et al.* 2001). A large number of these settlements (e.g., Sesklo) continued to be used in the MN suggesting longevity of settlement occupation (Demoule and Perlès 1993: 368).

Settlement patterns change considerably during the LN and FN period. The LN evidenced settlement expansion, with many of the previously occupied settlements now abandoned, and new more dispersed sites being established in previously unoccupied areas, whereas during the FN there is a tendency for populations to concentrate in fewer settlements and not many new sites are created (Demoule and Perlès 1993: 389; Kotsakis 1996: 54). The LN period is well represented in areas outside Thessaly such as Macedonia and Thrace (Grammenos 1996: 42) where a similar increase in sites has been noted supporting the claim for a 'Late Neolithic expansion' (Andreou *et al.* 2001: 297) . During this period settlements are situated in agriculturally marginal areas not previously occupied (shift from hills to alluvial plains with a more regular spatial distribution which created more stress in land resources). This increased settlement density would necessitate new mechanisms to control 'economic and social conflicts' and promote social cohesion (Demoule and Perlès 1993: 393).

Since the dawn of Neolithic research in Greece, tell settlements of small dimensions (less than 2 ha) were taken to represent the typical Neolithic settlement. Successive rebuilding of structures on the same locale for generations and the use of mudbricks resulted over the centuries in the formation of tells (*magoules* in Thessaly, *toumbes* in Greek Macedonia) (Andreou and Kotsakis 1987: 63; Kotsakis 1996: 52; Halstead 1999), a practice which according to Halstead (1999: 87) reflects a deliberate cultural choice by individual households. Some of the tell sites exhibit long life histories, e.g., in Central Macedonia tells were used from the LN until the Iron Age (Andreou and Kotsakis 1987: 61). Recent research, however, has clearly demonstrated that other forms of habitational patterns, mainly in the form of flat, extended settlements, existed concurrently (Kotsakis 1999, 2006). To quote Kotsakis (1994: 129), 'Neolithic settlement is not synonymous with tell settlement.'

Flat, extended sites of a large size (0.2-0.5 sq. km) have been recognised in the Balkans and in Greece (Kotsakis 1994: 127; Whittle 1996; Bailey 2000). In Greece, such sites were first identified in the lower polis of Sesklo B in Thessaly, in Nea Makri, in central mainland Greece (Theocharis 1973). Recent work by the Greek Archaeological Service and the Aristotle University of Thessaloniki established the widespread occurrence of this type of settlement throughout the Neolithic in the region of Macedonia (e.g., Vasilika and Thermi near Thessaloniki), while more examples have also been brought to light in Thessaly (Andreou and Kotsakis 1994; Pappa and Besios 1999a; Andreou *et al.* 2001; Pappa 2007). The exceptional size and imperceptible height of such sites indicated 'a different formation process from that which had created the tells' (Kotsakis 1999: 67). The large size of these sites was initially taken to indicate large populations, but closer analysis has revealed episodes of abandonment and relocation of buildings in other areas of the settlement ('shifting pattern of habitation') (Andreou and Kotsakis 1987; Kotsakis 1994: 127-128). Furthermore, in contrast to tell settlements, flat, extended sites were not as densely occupied but instead empty areas flanked the buildings, which according to Andreou and Kotsakis (1994: 17-25) may have been used for cultivation. The most complete picture of the spatial organization of flat, extended settlements is provided by the large-scale systematic excavation of Makriyalos in Pieria (Pappa and Besios 1999b; 1999a and for a detailed account of Makriyalos see section 2.6). Thus, tell and flat, extended settlements represent two distinct types of spatial organisation that are linked to different formation processes (Kotsakis 1999; Andreou *et al.* 2001).

The spatial organization of settlements presents great diversity in terms of form, size, and construction methods (Halstead 2006: 10). The boundaries of both tell and flat, extended settlements were delineated either by walls (e.g., MN Sesklo, LN Dimini, FN Pevkakia) or by ditches (e.g., Agia Sofia, Achilleion, Arapi Magoula, Soufli, Otzaki Magoula, Argissa, Servia, Makriyalos and Nea Nicomedia), a practice that indicates an attempt to demarcate space rather than to provide a defensive system against possible enemies (Chourmouziadis 1993; Demoule and Perlès 1993: 390; Kotsakis 1996: 52; 1999).

Variations are also encountered in the internal organization of these settlements. Excavations have revealed free-standing rectilinear buildings of varied size but also adjoining constructions tightly clustered together (e.g., Sesklo) while in other settlements such as Stavroupoli in Macedonia domestic architecture is characterised by pit-dwellings in the form of circular semi-subterranean constructions with a post-frame superstructure (Halstead 2006; Kotsakis 2006). Construction methods and materials employed also show variability even within the limits of a single settlement (e.g., mudbricks and wattle-and-daub at both Sesklo and Otzaki). Stone foundations were used when stone was available (Servia, Sesklo, Lerna) (Andreou and Kotsakis 1987: 62; Demoule and Perlès 1993: 370; Kotsakis 2006).

## 2.3. Social organization

Following Flannery's model of Neolithic settlement organization, Halstead suggested that the rectangular buildings revealed in Greek Neolithic settlements housed a small social unit, namely the household, which in effect was seen as an independent production and consumption unit (Halstead 1995). Admittedly, the underlying principle of 'households' is divisive. The concept of 'household' is culturally and historically specific and its internal structure and organization can acquire a plurality of meanings and different forms among different societies (Souvatzi 2003), the 'household', however, may be linked to a network of activities, the repetitive nature of which within a settlement may be taken to indicate the subdivision of society in smaller components (for an ethnographic example see the Marakwet, Moore 1996: 116; see also Kotsakis 1999; Souvatzi 2003; Tomkins 2004; Nanoglou 2008).

Halstead's earlier work focused on the economic viability and the gradual isolation of the household during the course of the Neolithic (Halstead 1995, 1999). Briefly, he argued that a 'domestic mode of production' (DMP) would not have been viable since unpredictable factors over the years, such as illness (which would reduce manpower) or bad weather during critical periods in the agricultural cycle (e.g., harvest), would jeopardise agricultural production and thus the survival of individual households. In that respect households could not have survived in isolation; instead individual households would have tended to collaborate and share resources with neighbouring households, creating alliances and obligations that needed to be repaid in the future (Halstead 1995).

Archaeologically, the presence of cooking facilities outdoors between houses was taken to indicate the sharing of cooked food among neighbouring households which would have promoted social cohesion between neighbours. Similarly, stylistically homogenous fine 'table ware' encountered beyond the limits of a single settlement indicate the existence of a social network of alliances that covered a wider area linking neighbouring settlements (Halstead 1995, 1999). Hence, according to Halstead (1995) 'intracommunal sharing' and 'inter-community hospitality' would have been important elements in the social life of Neolithic societies ensuring the viability of individual households.

During the LN settlement expansion and the inhabitation of agriculturally marginal areas, increased risks of 'subsistence failure' (Halstead 1995: 17) would have resulted in greater instability of individual households. This seems to have caused a shift from *sharing* among neighbouring households to storing available resources for future use by individual households (*hoarding*). This is suggested archaeologically by the gradual architectural isolation of the household during the LN, when walled courtyards limited sharing between neighbours, and by evidence for increased storage capacity in the form of deep storage pits implying long-term storage of resources (Halstead 1995: 17). The increased storage capability of individual households suggests according to Tomkins 'a new sense of ownership and property', with individual households exerting control over their own produce (2004: 50). These changing attitudes towards the appropriation of available resources may have resulted in tensions between community collaboration and household independence (Halstead 1995).

Building practices on the whole suggest that Neolithic societies in Greece placed 'architectural and symbolic emphasis on 'houses'', a practice encountered also in neighbouring regions (Kotsakis 1999; Halstead 2004: 153). This emphasis was linked with expressions of household identity (Kotsakis 1999; Halstead 2006). In parallel to the emphasis placed on houses and the 'domestic' arena, 'notions of community' endured throughout the Neolithic but were renegotiated and situated within different contexts (Tomkins 2004). As seen previously, Neolithic settlement architecture was characterised by large scale constructions such as boundary walls and ditches in both tell and flat, extended settlements, the construction of which has been taken to represent communal acts aimed at creating and reinforcing community solidarity (Kotsakis 1999; Halstead 2006). Collective identity was also strengthened and social relations were redefined through episodes of 'formalized commensality' (Pappa *et al.* 2004: 41) as the large volume of material unearthed from Pit 212 at LN Makriyalos suggests (see also Section 2.5.3). In addition, the deposition of disarticulated human skeletal remains in ditches (e.g., Makriyalos I) was interpreted as an attempt to reinforce 'group identity' (Triantaphyllou 1999, 2001).

The synchronic expressions of household identity (especially through large imposing houses in tell settlements) and collective identity (e.g., through large-scale earthworks) seem to have defined the social setting of Greek Neolithic societies (Halstead 1994, 1995, 1999, 2006; Kotsakis 1994, 1999, 2006; Tomkins 2004, 2007; Nanoglou 2008). Moreover, the distinct building practices encountered in tell and flat, extended settlements were interpreted as evoking different elements: individuality in the former (through the successive rebuilding of individual houses) and communality in the latter case (through the relocation of houses in different areas of the settlement) (Kotsakis 2006). To quote Halstead (2006: 16) 'both house and village were architectural distinctions that were continuously negotiated and reinforced through the Neolithic, arguably representing a dynamic tension between the conflicting ideals of household self-sufficiency and communal interdependence'.

## 2.4. Systems of production, acts of consumption and exchange networks: ascribing value to material culture

The Greek Neolithic is characterised by a rich material culture, the study of which reveals the material conditions of social reproduction of Neolithic communities. Perlès (1992) has provided a synthetic analysis of production systems, consumption and exchange networks in the Greek Neolithic, based on the premise that the production, distribution and consumption of material culture are elements of one coherent system and as such are materialised in relation to each other (Perlès 1992: 119; Perlès and Vitelli 1999). Focussing on stone tools (mainly chipped stone), pottery and rare goods (e.g., ornaments, stone vases, figurines, metals), she argued that these artefact categories were products of different production systems and consequently formed the basis of distinct exchange networks (utilitarian, non-utilitarian and social/symbolic/ritual).

Perlès (1992) further suggested that production of different artefact categories was organised in contrasting ways. The production of ground stone tools 'seems to have tended towards the most efficient balance between means employed, labour time and functional purpose' (Perlès 1992: 134). Thus 'time-saving procedures' (Perlès 1992:

131, Table 5) were selected. She argues that, with a few exceptions, stone tools have a 'predominantly utilitarian character... used for common, everyday needs' (Perlès 1992: 143; Perlès and Vitelli 1999) and contrast with fine ware and rare artefacts such as ornaments and stone vases that carried a 'social' meaning (Perlès 1992: 144). Thus, of the three exchange systems she envisaged for the Greek Neolithic, ground stone tools were attributed to that for utilitarian products, 'mainly economic in purpose ... with minimal social constraints and implications ... free of symbolic connotations' (Perlès 1992: 149). With regards the nature of exchange, Perlès suggested that the acquisition of raw materials from distant sources for the production of stone tools reflected 'a response to a local shortage' (Perlès 1992: 147), whilst that for ornament manufacture was linked to ideas about value and prestige as distant materials are seen as adding value to the object themselves. Hence, a rigid distinction is drawn between the functional and symbolic values of objects.

Perlès' arguments for the production and use of stone tools and stone ornaments and vases (seen as contrasting technologies) within individual settlements, however, are mainly based on unsubstantiated assumptions. The limited number of contextualised studies for ground stone tools and stone vases for the Greek Neolithic restricts our understanding of how these technologies were organised and perceived within different settlements leaving thus Perlès suggestions for their contrasting role unsupported. In this respect, the 'use context', as Perlès rightly points out herself (1992: 143), is of great importance in the understanding of the meaning(s) different artefact categories held in Neolithic societies. In her discussion, however, Perlès approaches use-contexts in a simplistic manner that hides the particular material conditions encountered in different settlements creating a misrepresented sense of uniformity for the Greek Neolithic. Hence, generalised suggestions for the role different categories of material culture held in the Greek Neolithic as a whole inevitably masks diversity within and between Neolithic settlements and the array of meanings encapsulated in material culture. Therefore, we need to move away from generalised accounts to more contextualised studies that look into the specific conditions of individual sites and allow us to investigate how Neolithic societies constituted themselves through engagement with the material conditions of their daily lives. Only then can the use-contexts of these artefacts be assessed and contrasted more effectively and exchange patterns be more meaningfully understood.

Contrary to Perlès' generalised approach to Neolithic production acts and consumption events, recent studies have placed emphasis on smaller-scale analysis of the social units (household vs. community) that seem to have been stressed by Neolithic architecture. The interplay between these social units, central to discussion of settlement organization in the Greek Neolithic, has the potential to provide a framework within which the materialised relationships of Neolithic societies can be situated and meaningfully investigated.

Social contexts of production and consumption have mainly been addressed in relation to pottery (Tomkins 2004, 2007; Urem-Kotsou 2006; Urem-Kotsou and Kotsakis 2007), chipped stone (Skourtopoulou 2006) and animal consumption (Halstead 2006, 2007) and subsequently to food-related activities and commensal politics (Pappa *et al.* 2004). These context-specific studies have highlighted the organisation of production and consumption variously on the scale of the household or of the wider community. Through detailed multi-levelled studies it is suggested that values and meanings attributed to artefacts are not constant but can vary depending heavily on the contexts and wider practices surrounding their use (Bradley and Edmonds 1993; Robb and Farr 2005: 14-15). In addition, these studies have contradicted the suggestions made by Perlès regarding the value that different categories of products held within Neolithic communities and the nature of their circulation patterns (Tomkins 2004; Skourtopoulou 2006). For instance, Tomkins' study of the Neolithic pottery assemblage from Knossos demonstrated long-distance circulation of ceramic vessels since the EN, a circulation that was necessitated by 'qualitative and social' reasons 'rather than out of economic necessity' (Tomkins 2004: 48). Skourtopoulou's (2006: 70-73) contextualised study of the Makriyalos chipped stone technology suggested that chipped stone technology was actively incorporated into symbolic acts that were entangled with domestic practices. What is evident in recent accounts, therefore, is that material culture, whether pottery or stone tools, is seen as an integral part of a web of social relations through which artefacts acquire their meaning and value. Hence, distinctions made between 'utilitarian' and 'social/symbolic' categories of material culture (Perlès 1992) are misleading since 'terms such as "utilitarian", "pragmatic", and "prestigious" originate in our own experience of a capitalistic economy' (Robb and Farr 2005: 39).

## 2.5. The archaeology of Neolithic Makriyalos

The Neolithic settlement of Makriyalos represents a flat, extended settlement and its principal significance lies in the great extent of the excavations at the site that have vastly enhanced our understanding of the internal organization of this settlement type in Greece (Pappa and Besios 1999b: 271; Pappa 2007). The Neolithic settlement of Makriyalos is located on the coast of the prefecture of Pieria, in Macedonia, Northern Greece, close to the modern seaside village of Makriyalos (Figure 2.1; Pappa and Besios 1999b). Excavations took place in the 1990's and were conducted by the Ephorate of Prehistoric and Classical Antiquities of Thessaloniki prior to the construction of the national road and railway line (Besios and Pappa 1998c). The size of the settlement is estimated at 50 ha, 12% of which has undergone detailed investigation by means of excavation (Besios and Pappa 1997: 216). Two spatially distinct phase of LN habitation have been identified: Makriyalos I (MK I henceforth) is dated to the earlier part of the LN period (5400-5000 cal. BC) and Makriyalos II (MK II) dated to the later LN (4900-4500 cal. BC) (Pappa and Besios 1999a; Pappa 2007: 273). MK I and MK II habitation are sited on opposite slopes of a gentle hill and there is only a slight spatial overlap of the two phases, which has facilitated detailed study of the architectural remains of both phases (Plate 2.1 & Figure 2.2; Pappa and Besios 1999a, 1999b; Pappa 2007).

### 2.5.1. Makriyalos I. The ditch system

The MK I settlement is sited on the south and south-west slope of a natural hill. Two parallel ditches (Ditch A and Ditch B) enclosed an area estimated at *c.* 28 ha, while a third ditch (Ditch Γ) has been identified inside the enclosed area. It has not been possible to establish the route of Ditch Γ nor its relation to other features of this phase, but it may represent an internal partition. In total 230m of the identified MK I ditches were investigated extensively (Pappa and Besios 1999a:181; Figure 2.2).

Excavations in Ditch A revealed two construction phases. The first phase comprised a chain of pits that underwent continuous episodes of renewal by 'cleaning out the old pits or by digging new pits in nearly the same place and always on the same line' (Plate 2.2; Besios and Pappa 1998c; Pappa and Besios 1999b: 112). A second phase was identified in places in which 'the ditch was re-dug as a continuous V-shaped channel' (Plate 2.3; Besios and Pappa 1997: 216; Pappa and Besios 1999b: 112). In places mudbrick or stone walls seem to have been built on the outer side of the ditch (Besios and Pappa 1998a; Pappa and Besios 1999b). Generally speaking, Ditch A represents a massive earthwork whose maximum depth reaches 4m and maximum width 4.5m. The fill of Ditch A comprises different layers that relate to different phases of construction, use, and final abandonment (Besios and Pappa 1998c: 18). Frequently, the sides of the ditch collapsed (e.g., due to rain), filling the ditch. This required frequent re-digging of the ditch, at a significant cost in time and energy. Some of the layers of the ditch fill were rich in ceramics, bone, shell, chipped and ground stone artefacts, and burnt seeds (Besios and Pappa 1997: 217; Besios and Pappa 1998b: 139). More interestingly, perhaps, Ditch A represents the main burial ground during this habitation phase as a large number of primary and secondary burials have been unearthed from this context (Triantaphyllou 1999, 2001).

The outer ditch enclosing the phase I settlement, Ditch B, located 10m away from Ditch A, represents a simpler construction with a continuous V-shaped channel resembling that of the second construction phase of Ditch A (Pappa and Besios 1999b: 112). The dimensions of Ditch B are smaller and the depth reaches 1,50m (Besios and Pappa 1997: 217). In contrast to Ditch A, the fill of Ditch B is uniform in character and rather empty of finds and the excavators suggested that the ditch was filled by its collapsed sides (Besios and Pappa 1998b: 139; Besios and Pappa 1998c: 18-19; Pappa and Besios 1999b: 112).

Ditch Γ, located almost in the centre of the enclosed area, bears great similarities to Ditch A. Like Ditch A, Ditch Γ has two construction phases: an initial phase of interlinked/intersecting pits (*chain of pits*), followed by a second phase in which the ditch was re-dug as a continuous V-shaped channel (Plate 2.4; Pappa *et al.* 2000). It was established stratigraphically that the chronological distance between the two phases was not great and no significant difference was attested in the finds from this context. In addition, the ditch was reinforced by a wall with stone foundation and mudbrick superstructure built on one of its sides (Pappa *et al.* 2000). Similar to Ditch A, Ditch Γ produced a fill rich in finds that included pottery sherds, bone tools, chipped stone and ground stone artefacts (Besios and Pappa 1998a; Besios and Pappa 1998b: 139; Pappa *et al.* 2000).

Interpretations of the significance of the ditch system for the Neolithic society of Makriyalos stress an array of functions. The role of the double ditch may have been a practical one as a boundary delineating the limits of the settlement area and/or as a barrier controlling access to the site. The presence of a wall on the outer side of the ditch has been taken to indicate an interest in hindering movement from the interior of the habitation area to the outside (Pappa 2007: 274). The excavators suggested that the ditch may in fact have been used to confine livestock within the enclosed communal area (Pappa *et al.* 2000: 284). Other uses such as a refuse area or an area for collecting water have also been suggested. Aside from its practical uses, however, the ditch must have had a great symbolic significance for the Makriyalos community. The ditch system was a massive earthwork which required great time and energy investment in its construction and successive episodes of renewal. Its construction and maintenance, therefore, were activities undertaken by a large group of people, most likely the entire community of Makriyalos. In this respect, the presence of the ditch symbolizes the common effort invested in its maintenance and was actively used in the creation and renegotiation of communal identity. The latter is also suggested by the interment of human remains in the fill of the ditches and mainly within Ditch A, an act that further established the communal identity and ownership of this impressive structural feature. It is interesting that the abandonment of the ditch system coincides with the abandonment of the settlement indicating that the former was an integral part of settlement/community life (Besios and Pappa 1998c: 20).

### 2.5.2. Makriyalos I. Habitation

Within the area demarcated by the ditch system, loose groups of pits of varying sizes (up to 5m in diameter) and function have been revealed (Plate 2.5; Besios and Pappa 1998a). According to the excavators, the larger pits represent habitation areas and the smaller refuse or storage pits. Due to erosion only the lower parts of these structures have survived (Besios and Pappa 1998b: 139). These pits represent the remains of circular semi-subterranean buildings with post-frame superstructure. Their interpretation as habitation areas is supported by the presence of postholes that most probably supported a roof over these structures, by paved areas and by hearths found within pits such as in pits 216 and 705 (Pappa 1997), while in the pit cluster O remains of internal structures and the roof were unearthed (Besios and Pappa 1998b: 139). The main pit clusters identified are K, KΛ, and O (Figure 2.2 & Figure 6.5; Pappa *et al.* 2000: 287).

### 2.5.3. Makriyalos I. The borrow pits

The third feature identified in MK I is large pits up to 30m in diameter (Figure 2.2; Besios and Pappa 1998a) created by large-scale earth removal. Such borrow pits have been identified at different locations in the MK I settlement. Two such features were revealed along the course of Ditch A (borrow pit in Sector K and borrow pit in Sector M), predating the construction of the ditch (Besios and Pappa 1998b: 138), while the large borrow pits identified in Sector Ξ (Pit 214) was in close proximity to Ditch A and the one in Sector Π (Pit 212) was located in the middle of the enclosure (Plate 2.6 & Figure 2.2).

Pit 212 is 30m in diameter and was made of a number of linked pits that were sealed by a thick layer of finds uniform in character (Besios and Pappa 1997: 217; Besios and Pappa 1998b: 140; Pappa *et al.* 2004). The fill of Pit 212 was exceptionally rich in finds, that included among others large amounts of pottery, faunal remains and ground stone tools (Figure 2.3). This striking concentration of material accounts for 42% of the pottery assemblage, ca. 50% of the animal bones (Pappa *et al.* 2004: 33) and 25% of the ground stone assemblage unearthed from Makriyalos I (see Section 6.2.4). The extremely rich fill of pit 212 was interpreted as the residue of a possible feast that involved a local or even possibly a regional community during which hundreds or even thousands of domestic animals were slaughtered (Pappa *et al.* 2004).

Pit 214, similar to Pit 212, was characterised by large concentrations of material. The fill of this pit, however, suggests different depositional practices than those linked to Pit 212(e.g., represents one of the main burial grounds during MK I, has deeper fill than Pit 212 and higher frequency of weathered pottery). Unlike the deposition of material in Pit 212, in Pit 214 deposition seems to have taken place gradually through different episodes of use (Besios and Pappa 1998b: 140; Triantaphyllou 1999, 2001; Urem-Kotsou 2006).

### 2.5.4. Makriyalos II. Ditches and borrow pits

Excavations revealed that during the second phase of the Makriyalos settlement space was organised by ditches, the course of which was difficult to determine due to partial excavation (Pappa and Besios 1999a: 183). Although the construction of the ditch located to the south-east shows similarities in construction with Ditch A of MK I and may have acted as an internal boundary, the MK II ditches seem to have had a less monumental character than their MK I counterparts (Pappa 2008). A natural watercourse 100m long and 10 m wide seem to have played a role similar to that of the ditches (Pappa and Besios 1999b: 114). Similar to MK I, large borrow pits were also in use during this phase, the main ones located in Sector H in the north-west area of the MK II settlement and on the edge of the habitation area. Large volumes of material were unearthed from the borrow pits in this area, the deposition of which seem to be linked to episodes of long-term activity (Figure 2.2; Besios and Pappa 1998b: 140).

### 2.5.5. Makriyalos II. Habitation

The settlement of the later phase of occupation was located on the north/northwest slope of the natural hill (Besios and Pappa 1997). The settlement organization during MK II differs greatly to that of MK I. In contrast with MK I, empty spaces between houses are not present and instead the pit-structures of this phase are tightly clustered together (Figure 2.2; Pappa and Besios 1999b: 114). On the basis of stratigraphic evidence two habitation sub-phases have been identified. In the first sub-phase of habitation ('sub-phase of pit-dwellings') large pits up to 5m in diameter were identified while the position of wattle and daub walls is indicated by the presence of postholes (Plate 2.7). Stone paved areas existed in open areas, and thermal structures (either in the form of hearths or ovens) were located both inside and outside the houses either singly or in clusters of three or four suggesting possible working areas and facilities shared by larger groups (Pappa 2007: 275). This phase of habitation was followed by rectilinear buildings that cut through the pits of the first phase ('sub-phase of rectilinear structures') (Plate 2.8; Pappa 2007: 275). These rectilinear structures were up to 15m long and consisted of two rooms divided by an internal wall (Pappa and Besios 1999a: 185).

## 2.6. Conclusions

In this chapter a synopsis of research in the Greek Neolithic was provided with an emphasis placed on key issues such as settlement patterns, social organization and acts of production and consumption. Relations in Greek Neolithic societies seem to have been played out in different levels: mainly at the level of the individual household and that of the local community. The spatial organisation of Neolithic settlements and the building practices encountered within them seem to relate to expressions of distinct identities and reflect the tension between collective solidarity and household independence. With regards Neolithic production systems and acts of consumption, it was argued that the nature of stone technologies and the role of ground stone tools has been approached in generalised terms. The suggestions put forward for this technological practice and the value of its products lack substance as they are not based on systematic studies. Instead, it was argued that contextualised studies focusing on smaller scale social units (household vs. community) provide a framework within which the significance of material practices in Neolithic Greece can be more fully understood.

The settlement of LN Makriyalos provides an excellent opportunity for a contextualised study of ground stone technology within this framework as it offers the most abundant evidence for both domestic and communal scales of activity. When combined with the quality of the excavation and its resultant assemblages this means that the site of Makriyalos provides an excellent opportunity to answer questions about the manner in which acts of ground stone production and consumption were organised within an individual settlement and concurrently may provide insight into the role and value of ground stone objects within the Neolithic society of Makriyalos and Greece as a whole.

# *CHAPTER THREE*

## *Establishing a methodology*

### 3.1 Introduction

This chapter presents the methodological issues involved in the analysis of the Makriyalos ground stone assemblage. As suggested in the introduction of this thesis ground stone technology has been under-theorised and its meaning has been seen as straightforward. The theoretical approaches that informed the study and the analysis of this assemblage will be discussed. Moving on from this the methodology used to record the assemblage will be discussed in full broken down according to the stages of the *chaîne opératoire*.

### 3.2 Choice of approach

#### 3.2.1 Biographical approach

As noted in the introduction of this thesis, one of the characteristics of previously conducted studies of ground stone assemblages from Greece is the partial approach to this set of material, with emphasis mainly placed on descriptive catalogues and aspects of typology and less frequently on manufacture. In this respect, ground stone tools have been approached mainly as 'finished' tools, as *static* products (Baysal and Wright 2005: 308).

Neither ground stone technology nor its products, however, can be seen as *static*. When ground stone technology is associated with the wider concept of technology, it becomes clear that it is a *dynamic* process which intertwines technological products with the human agents who are involved in their production and manipulation (Dobres and Hoffman 1999). More importantly, technology provides a setting for 'dynamic social interaction' that enables social practices to be carried forward (Dobres and Hoffman 1994: 226). These tools represent products that have been used in many different ways, to answer very different needs, and static typologies cannot shed light on their diverse character. Furthermore, studies restricted to typological or technological schemes tend to exclude from the discussion the active participants in the lithic technologies, that is the agents that produced and used these tools (Dobres and Hoffman 1999). Yet, as Mackenzie and Wajcman (1985: 3) have put it, '*a computer without programs and programmers is simply a useless collection of bits of metal, plastic and silicon*'. Similarly, lithics without those who produced and used them, their skill and knowledge, seem 'useless bits of stone'.

Thus ground stone technology should be perceived as a social practice through which knowledgeable agents materialise their understanding of the social order that structures a particular society (Dobres and Hoffman 1994; Dobres 2000) and as such it should be approached by concepts that have been applied to other technological schemes. In this sense the framework of this thesis draws upon the idea that ground stone technology is related to a sequence of *actions* that transform 'a substance from a raw material into a manufactured product' (van der Leeuw 1993: 240). Therefore, the products of this technological practice represent the products of *chaînes opératoires*, a concept that has been applied to this set of material, in contrast with chipped stone technology, only rarely (cf. Baysal and Wright 2002).

The potential of the *chaîne opératoire* can be maximised when seen in conjunction with the notion of 'object biography' (Kopytoff 1986; Gosden and Marshall 1999; Jones 2002). This biographical approach not only looks at the whole life cycle of objects (use life see Gosden and Marshall 1999: 169), but at the same time '*encompasses the idea that objects are used to construct and maintain social identities*' (Jones 2002: 84). Both objects and people have long histories that begin from the moment they come to life.

Their life journey involves a succession of phases and changes in their character during which they '*are constantly transformed*' (Gosden and Marshall 1999: 169). Their life histories are intertwined and unravelled in relation to each other; they '*inform each other*' (Gosden and Marshall 1999: 169). Thus objects acquire diverse meaning(s) through a diverse biography. At the same time, objects not only create '*a stage-setting to human action*' (Gosden and Marshall 1999: 169), but are actively engaged in the way people perceive their world and construct social relations and identities (Edmonds 1995; Hoskins 1998; Gosden and Marshall 1999; Dobres 2000; Jones 2002). Thus, as Jones (2002: 84) argues, the concept of biographies is '*a useful metaphor*' for considering the way(s) in which objects and people are woven together and '*how it is that social identities are expressed through the medium of artefacts over different stages of their use –lives*'.

To facilitate a study of the way artefacts and people are intertwined in the course of their lives, we need to study the 'entire life' of an object (Jones 2002: 85). Thus, a biography orientated approach would entail the study of the different episodes that relate to the ground stone sequence, from selection of raw material and procurement strategies, to manufacture, use, recycling and final deposition. These aspects are essential for understanding how ground stone assemblages are formed and what this practice could have entailed (Figure 3.1). The ground stone assemblage from Makriyalos offers the opportunity for such a biographical approach, not only due to its exceptional size but also due to the availability of detailed contextual data. By this means we can get a glimpse of the different biographical episodes and choices as they are reflected in the objects themselves.

### 3.2.2. Scales of analysis

Another issue that this thesis tries to deal with is how the analysis of ground stone assemblages can be achieved at different levels and how this may improve our understanding of this technological practice. Thus different scales of analysis (synchronic, diachronic, domestic, communal) will be applied so as to achieve a more detailed insight into the way ground stone tools may have been used and perceived in LN Makriyalos. As Dobres and Hoffman (1994: 213) have argued, '*an explicitly multiscalar research program can better grasp the complex interaction of factors* *operating at different scales and offers a flexible and appropriate framework for studying technological processes*'.

These different scales of analysis reflect potentially different social units ('household', local community, regional community) that existed simultaneously and interacted on a regular basis. Thus the question that is immediately posed is how these different social units interacted with the technology under consideration. To quote Jones (2002: 83), '*what we are interested in, then, is how material culture is used to create and maintain meaningful social relations that affirm the definition of identity and belonging at individual, local and wider scales*'. As seen in Chapter 2, Makriyalos offers plentiful information about both domestic and communal scales of activity allowing for this question to be addressed meaningfully.

The contextual information provided by the horizontal stratigraphy of the flat, extended settlement of LN Makriyalos will allow for an understanding of how activities were organised on an intra-site level, while the comparisons between the two phases of habitation may shed light on changes in the character of ground stone technology and the its associated practices over time. By following this approach there is a real prospect that the ground stone assemblage will shed light on the character of the Makriyalos community.

## 3.3. Analysis of the assemblage

In an attempt to decipher ground stone practice, a number of different attributes covering all stages of the lithic sequence have been recorded. The choice of approach determined to a large degree the type of analysis that was applied to the material. In the course of the analysis a mixture of metrical, typological, qualitative and contextual attributes were recorded.

### 3.3.1. Contextual variables

Two variables that would allow for the contextual analysis of the assemblage were recorded: artefact and unit number. With respect to artefact number, an archive for all finds from Makriyalos excavations has been created and each artefact has been allocated a unique finds number preceded by the Greek letters ΑΓ, which represent the first two letters of the Greek name of the site (ΑΓΙΑΣΜΑ), e.g., **ΑΓ** 1243. The unit number of each artefact relates to a specific excavation unit which allows the ground stone to be placed precisely within the excavated area, e.g., #K0412009 comes from spit 9 in grid square 41.2 of excavation sector K. When the artefacts were not retrieved by dry sieving, their spatial location was recorded three-dimensionally. A number of objects, however, come from surface collections; in this case the general area where the object was found is given, while in a few cases there is no contextual information.

### 3.3.2. Metrical analysis

The size and weight of ground stone objects is relevant to many stages of analysis from raw material procurement, through manufacture to use and discard. The metrical variables recorded include: maximum length, width and thickness. The measurements were taken to the nearest mm while the completeness of all these dimensions was recorded as well. Measurements were taken for all ground stone artefacts irrespective of whether they were complete or not. Artefacts recorded as complete are those retaining their entire shape and having no damage at all. In the case of edge tools, I also recorded the maximum width and thickness of the proximal end of the tool (butt end) in the manner described above, as well as the completeness of these dimensions. The length in all cases was measured as the maximum distance in a straight line from the proximal to the distal end, perpendicular to the wide axis of the tool. The maximum width was recorded as a straight line between the two margins perpendicular to the length, while the thickness was measured at the thickest part of the object (see Wright 1992a, Figure 3). The weight of all artefacts was recorded to the nearest gram.

### 3.3.3. Raw material selection and procurement

The study of the raw materials used by the inhabitants of Neolithic Makriyalos revolved around questions regarding the selection of rocks for use in different activities and the location of their sources.

A range of rocks with different characteristics was used in the production of ground stone tools. To assess whether different raw materials are preferentially associated with different types of tools, the physical properties of rocks that may relate to function and/or perceived value were recorded. This aspect may shed light on the possible reasons (functional, aesthetical) why such preferences were exercised. Attributes recorded were texture and colour. The texture of rocks (Blatt and Tracy 1996: 39) was recorded as follows:

a) fine-grained rocks with grains 1 mm or less,
b) medium-grained ones with grain size 1-5 mm, and
c) coarse-grained rocks with grains measuring from 5 mm to 3 cm.

The colour of rocks was recorded using the Munsell Soil Colour Chart. The Munsell Colour Chart was used in preference to rock colour charts to ensure comparability of results with other ground stone studies conducted in Greece.

Following rock identification guides (e.g., Jones 2000; Pellant 2000), interpreted with guidance from Dr M. Romano (University of Sheffield, Dept. of Geography), as well as identifications conducted by thin section for a previous project conducted by Dr S. Dimitriadis and T. Gerousi (1999), the raw materials present were classified into the three geological categories: *igneous, sedimentary and metamorphic*. For this purpose macroscopic examination was aided by a hand lens (10x) as well as a low power microscope (Leica Wild 6.5x -40x). This examination was conducted using artificial light. In a few cases, the identification of carbonate raw materials such as marble was tested by the use of dilute hydrochloric acid (effervescence indicating carbonate raw materials).

Regarding the sources of the rock specimens attested at Makriyalos, there are two possibilities to be explored: a) the procurement of material from outcrops through mining/quarrying and b) the use of river cobbles. These two possibilities, however, are not mutually exclusive, as both modes of procurement may have been employed simultaneously. The recording of the percentage of cortical/weathered surfaces on each tool could shed light on the procurement method(s) and the form in which these specimens entered the site (e.g., as nodules or (semi) finished products). Four groupings were used to characterise the amount of cortex/weathering present on the artefacts studied: 0-25%, 25-50%, 50-75%, 75-100%, while cases that could not be attributed to any of the previous groups were recorded as indeterminate.

An indication of possible sources has been offered by Mr G. Efstratiadis, a geologist who has mapped the area of Pieria for Greek Institute of Geology and Mineral Exploration (IGME). Identification of raw material availability was also assisted by the available IGME geological maps, while a survey of the wider Makriyalos area was undertaken in order to establish the types of raw materials available (Plates 4.2 & 4.3). In addition, Dr A. Krahtopoulou suggested that the marble pebbles and cobbles attested at Makriyalos occur in nearby streams and had presumably been brought to the settlement by human agency for use in construction or as raw material for tools.

Both aspects of raw material studies could be supplemented by petrological analysis based on microscopic examination of rock specimens from the site as well as of rock outcrops present in proximity to Makriyalos. Time constraints, however, did not permit this type of analysis to be conducted within the scope of this thesis.

### 3.3.4. Manufacturing process

Traces of manufacture are examined both to establish the processes which shaped ground stone artefacts and to determine where these processes were carried out. Attributes that might reveal information regarding the manufacturing process include the object category, the percentage of cortical surface (see above), visible manufacturing techniques, the degree of polishing, and subsequent modification of tools including the modification of the use-face. The first attribute distinguishes basic categories of material (tool types, unworked nodules, cores, debitage, debitage from the rejuvenation of use-faces (resharpening flakes)) [for details see Section 3.3.5.1.]. The other four attributes reflect the sequence of processes from early stages of manufacture through to finishing and subsequent modification of the tool and its use-face.

Manufacturing techniques were recorded separately for the different parts of all tool categories (e.g., edge tools: bit, body, margins, butt; grinding/abrasive tools: body and margins). The techniques recorded include: natural shape, ground, flaked, polished, ground and polished, pecked and polished, pecked and ground, drilled, and indeterminate surface.

Regarding the degree of polishing, five states were recorded based on the presence or absence of smooth surfaces reflecting light as well as on the amount of sheen attested on tools: not applicable, not well polished (not very smooth surface), well polished (smooth surfaces with spots of sheen), highly polished (extremely smooth surface which reflects light) and indeterminate.

The modification of the tool and its use-face was recorded as follows: no modification/not applicable, resharpening of edge tools (edge rejuvenation - see Wright 1992a), repecking of grinding tools (see Wright 1992a), modification by sawing (Moundrea-Agrafioti 1996), sawing and resharpening, and indeterminate.

Examination of these attributes should clarify whether certain techniques of manufacture were used selectively with specific tools or specific raw materials and should also reveal the extent to which use was made of formal tool categories or *outils a posteriori*[1] Furthermore, the recording of the percentage of cortical/weathered surfaces on each tool may show how extensively manufacturing techniques are employed in the transformation of raw materials into tools.

To assess the manufacturing sequence, and to establish whether ground stone tools were produced on-site or reached the site in a more or less finished state, poses many problems. Ground stone technology encompasses a wide range of tool types, from those that have been used in an unmodified fashion (e.g., grinders and hammerstones) to those that have gone through several manufacturing episodes (e.g., edge tools). It is obvious, therefore, that in some cases no manufacturing will have taken place while in others the manufacturing techniques will be largely concealed by the final stages of manufacture, the finishing touches (e.g., *polishing).* Furthermore, as the term ground stone technology implies, the main manufacturing technique employed in the production of most of these objects is grinding. Yet, the waste products of grinding (grits, see Wright 1992a: 57) cannot be documented archaeologically, making it difficult to assess the state in which these tools reached the site.

Nonetheless, ground stone assemblages may reveal some clear indications as to how tools came into being. The presence of unmodified nodules, as well as debitage from

[1] The term '*outils a posteriori*' refers to nodules that have been used as tools without any prior modification (Wright 1992a: 57).

initial modification of the raw material (e.g., flakes) and later stages of the shaping of tools, would be indicative of on-site tool production, while the presence of unfinished tools could reveal the manufacturing techniques employed before the 'final surface treatment' (finishing, see Wright 1992a: 57). Thus, there may be sufficient evidence to determine the locales of tool production and to unravel the processes entailed in the manufacture of some tool classes at least. It is vital, therefore, to acknowledge the importance of collecting nodules and debitage that relate to ground stone technology during excavations as this will improve our understanding of the way ground stone tool production was organised (cf. Baysal and Wright 2005: 308).

### 3.3.5. Use contexts

#### *3.3.5.1. Typological classification*

Continuing with the life cycle of an object, the next step is to establish the way(s) in which it was used and the intensity of use(s). One of the use-related attributes recorded is object category. The creation of a typological scheme in any project is inevitable since '*typologies do offer a set of commonly understood terms for the sharing of information about the characteristics of any particular assemblage*' (Conolly 1999: 10). In this sense the classification applied in this project would ensure comparability of results with other ground stone studies conducted in Greece.

During the analysis, however, issues arose concerning the applicability of various attributes and in particular of typological categories (cf. Healy 1994). It soon became clear that, when dealing with such a complex set of material which encompasses a wide range of artefacts, typological classification cannot always show adequately the dynamic character of the material under study. Thus one of the first issues to be confronted is how we classify the objects we study without creating rigid categories that obscure rather than illuminate their character.

One of the assumptions that many typological schemes carry with them is that certain shapes relate to specific functions (Adams 2002: 7-8). Yet, many objections have been raised to this 'form equals function' approach. It has been accepted that defining function/use through the form of tools should not be regarded a straightforward issue, as tool form does not always reflect the way the tool was actually used. Or, as Adams simply puts it, 'knowing the shape of something is not enough to determine its function' (Adams 2002: 8). The preference for a specific shape could be dictated by cultural choices, traditions and aesthetic reasons and not only by function, while there is no reason to assume that all objects with the same shape have been used in the same manner (for a discussion of difficulties in determining function with specific examples, see Adams 2002).

Thus, a flexible classification scheme needed to be applied which would not create rigid typological categories and thus obscure the diverse character of ground stone technology. A generic classification system was applied in this project, therefore, in an attempt to avoid implicit assumptions regarding the use of objects (e.g., grinding slab instead of millstone which might imply the use of the tool only in food-related activities). This system was built on typological schemes employed by other researchers in the Old and New World (Wright 1992a; Adams 2002). Following Adams (2002: 15) the classification of the material applied in the study of the Makriyalos assemblage is mainly 'activity-based'. General object categories were created based either on the shape of the object or on the character of the activity the tool was used for, judging from the wear patterns (see below). The classification of artefacts according to their shape is not taken to indicate function. This classification scheme is very productive as no information is lost regarding tool shapes that have been widely referred to in other projects (e.g., axes and adzes), while the possible use(s) of the different categories is indicated by wear patterns.

Use wear analysis, involving macroscopic and/or microscopic examination, may reveal which mechanisms and actions modified the use-faces of tools (Adams 2002: 27, 45; cf. Hamon 2006). During the analysis of the Makriyalos assemblage, following Adams (2002), some wear patterns were identified macroscopically that enabled the identification of possible tool use(s) and the classification of artefacts. For instance, percussive marks (impact fractures - Adams 2002: 30) on use-faces would indicate percussive activities, e.g., use as a hammer, while the presence of striations and sheen was regarded as evidence of smoothing/grinding activities.

High power microscopic[2] analysis was not regarded as appropriate for this project as the size of the assemblage would preclude microscopic study of more than a small sample of the material. As mentioned earlier, the aim of this thesis is to apply a contextual approach that requires the study of a big assemblage with detailed contextual information. Furthermore, there are certain post-depositional factors which could affect use wear analysis, for instance the degree of preservation, artefact recovery, cleaning and storage (Levi Sala 1986). There are also limitations on the results that can be produced by this type of analysis as it is not always possible to define the type of material the tools were used against. For these reasons, the possibility of microscopic analysis of a small sample of the assemblage was also ruled out.

The general object categories and sub-categories that were distinguished are:

- *Edge* tools: tools that have a working edge manufactured deliberately, mainly via abrasion (cf. Wright 1992a; cf. Alisoy 2002a; Elster 2003; Stroulia 2003). The sub-categories recorded are axes, adzes, chisels, indeterminate. Axes and adzes have traditionally been distinguished by their profile and they way they are hafted. Thus, axes have been defined by a symmetrical profile and a haft adjusted parallel to their working edge, while adzes have an asymmetrical profile and are hafted perpendicularly to their handle (cf. Elster 2003; Stroulia 2003). This definition, however, is problematic since there are examples that could be included in either of the two categories (e.g., tools with 'slightly asymmetrical' working edge profile, see for example Stroulia 2003), while the hafting of stone blades quite often cannot be documented archaeologically. Ethnographic examples have shown that axes and adzes may be used and hafted indiscriminately according to needs covered in each instance (Heider 1967). To avoid creating the above assumptions the term *celts* has been used in a few studies (cf. Stroulia 2003); in the current study the term *edge tools* is preferred as it describes a trait seen on these artefacts and does not imply a certain way of use. The term 'chisel' refers to tools with parallel margins and a working edge that is of either narrower or equal width to the margins. The term 'indeterminate' was used to describe objects that either are missing their

[2] In a few cases a low power stereo microscope (Leica Wild 6.5x - 40x) was used for the identification of wear patterns.

working edge or survive in a very fragmentary state and thus cannot be attributed to any of the other three categories or could be included in more than one category.

- *Percussive* tools: tools that have pecking marks (impact factures - see Adams 2002) on their surface created by pounding activities. Subtypes recorded include: hammer, mace-head (see Moundrea-Agrafioti 1996), indeterminate;
- *Perforators:* objects that have a depression (*cupule* - see Adams 2002: 182) on one or two opposed surfaces. The subtypes recorded are 'drill bases'/spindle bases (tools that bear evidence of wear created by rotation (of a spindle?) (see Adams 2002: 180-183), drills (tools with a protruding area with visible striations created through a circular movement (Plates 4.21, 4.22. 5.11), and indeterminate (tools that have depressions with no obvious rotation wear). In the former category clear drilling marks in the form of circular striations are attested in the depression (cf. Adams 2002: 182).
- *Grinding/abrasive* tools: tools employed in activities that involve altering '*contact surfaces though the mechanisms of abrasive wear, adhesive wear, and tribochemical wear*' (Adams 2002: 77). The subtypes recorded are as follows: abraders[3] (for a definition see Adams 2002: 79), polishers/smoothed stones (see Adams 2002: 91), grooved abraders (abraders with use-faces in the form of grooves), pestles (Adams 2002: 138), grinders (upper handheld tools used in conjunction with grinding slabs, cf. Wright 1992a; Alisoy 2002a), grinding slabs (lower stationary grinding tool, cf. Wright 1992a), mortars (tools with concave surfaces that have evidence for pounding and grinding, see Wright 1992a: 65; Adams 2002: 127) and indeterminate;
- *Multiple-use tools*: tools used in more than one activity concurrently. This category included the following subtypes: polisher/smoothed stone used as a hammer; pestle used as a hammer; grinder used as a hammer; grinding slab/grooved abrader; abrader/hammer.
- *Ornaments*: within this category the following subcategories were recorded: pendants, beads, rings and indeterminate. Rings represent a diverse category

[3] Another term used for this tool type is 'whetstones' (Adams 2002: 79).

and include artefacts that might have been used as bracelets, finger rings or in some cases pendants that have a ring form.

- *Miscellaneous*: a category which included a small number of artefacts that do not fit into the previous categories: weights, flakes from polished tools with retouched margins, chipped flaked core with ground platforms, rejuvenation flakes from polished tool, unworked nodules, cores for ground stone tools, waste by-products, rocks with holes made naturally, pitted/cupped stones. The latter category refers to pebbles or cobbles with one or two opposed depressions created by percussion (see Adams 2002: 136-137), which could relate either to use (e.g., anvils) (Adams 2002; Antonovic 2006: 26, catalogue 65-74) or to manufacture (e.g., unfinished rings). These artefacts appear in low numbers in Greek Neolithic excavations and have been traditionally recorded as 'drill base' or 'drill element' (εξάρτημα τρυπανιού) even though there are no clear drilling marks in their depressions. Admittedly, their function is unclear and for this reason in the current study they are recorded according to a common characteristic they all share (depression) and not to their possible use and thus are distinguished from objects with evidence of wear created by rotation.

To sum up, although typological studies have always been connected to a specific set of ideas, they cannot be dismissed from archaeological practice. They are to be conceived here as heuristic devices which, combined with other types of evidence, may shed light on tool use and facilitate comparison with other published assemblages, and more interestingly, on the extent to which tool use was correlated with form.

#### *3.3.5.2. Use*

Other use-related attributes recorded apart from the object category include the number and shape of the use-faces attested on tools, the degree of wear, the damage on the bit and on the butt area, the modification of the working surface(s) (see Section 3.3.4), and surface condition.

The number of use-faces was recorded as follows: *none* (for unused tools), *one*, *two adjacent* faces, *two opposed*, *more than two* faces, and *indeterminate*. The shape of use faces was recorded as: *irregular*, *flat*, *concave*, *straight*, *convex*, *lopsided*, *flat* and *convex*, *flat* and *concave*, *concave* and *convex*, and *indeterminate* (for fragmentary tools).

In addition, the degree of wear was recorded for different object categories. Adams (2002: 25) defines wear as '*the progressive loss of substance from the surface of a stone item as a result of the relative motion between it and another contact surface*'. In the current study six states were distinguished regarding the degree of wear attested on use-faces: *none* for tools that have no evidence of damage created through use, *light*, *moderate*, *heavy* wear, *worn out* use-faces (for definition, see Adams 2002: 25), and *indeterminate* for fragmentary use-faces. In cases where more than one use-faces were present the degree of wear was recorded separately for each face. It should be stressed, however, that the recording of wear poses some problems as wear patterns attested on the working surfaces of these tools may relate to the type of activity rather than to the extent that use-face was used for. Overall, the employment of ground stone tools in a variety of tasks makes it difficult to assess the wear patterns adequately.

The categories recorded for bit and butt damage are as follows: *absent*, *undamaged*, *damaged* (in the case of edge tools, when the working edge has obvious damage but the bit/butt survives to some extent), *crushed/destroyed* (in the case of edge tools, when bit/butt is completely destroyed), and *indeterminate*. For tool categories that have no bit and butt, all the information was recorded under the bit while under butt the state 'absent' was recorded.

Four states were recorded for surface condition: *burnt*, *good* (when the object surface is neither burnt nor altered), *altered* (where the original texture of the raw material has been altered by some means), and *indeterminate*.

These attributes reflect the extent of tool use. It is important to see which types of tool have been used and to what degree and then to try to see whether any relations exist between tool use and raw material, tool modification and raw material, or tool use and context.

#### *3.3.5.3. Reuse*

The term 'reuse' refers to tools that during their life cycle have been employed in a different set of activities and cannot function any longer in their initial use (e.g., an edge tool used as a hammer). Adams (2002: 21) has described this form of secondary use as *sequential* and distinguishes between this and *concomitant secondary use* attested in multiple-use tools (Adams 2002: 22)

The attributes that could throw light on the reuse of tools are: secondary object category and degree of wear caused by secondary use. Secondary object category and wear were recorded in the same manner as object type and wear (Section 3.3.5.2.). The questions of interest relate to the tool types that have been reused, whether there is any preferential selection of raw materials for tools to be reused and the size of reused tools.

### 3.3.6. Disuse/Final deposition

Attributes discussed previously (i.e. surface condition and degree of wear) are relevant to the study of the final stage of the use-life of ground stone objects. Worn out use-faces or heavy burning may indicate whether tools have entered a disused state. As Adams (2002: 43) points out, however, worn out tools could still be functional if recycled and used in a completely different context, for instance grinding stones recycled as building material. Another important aspect of disuse is the context where the tools have been deposited. Thus, a contextual approach could shed light on the character of tool deposition and increase our understanding of the reasons these tools were removed from circulation and use. According to Adams, possible ways through which artefacts stopped being actively used are discard, loss, caching and abandonment (Adams 2002: 42).

Another characteristic worthy of mentioning is the intentional destruction of tools. This aspect has been documented in a few cases where tools have been destroyed deliberately by damaging the use-faces or tools were broken into several pieces (for examples, see Adams 2002). In this case it is important to study the recovery context carefully and, if possible, to conduct a refitting analysis as well.

To sum up, the attributes recorded for this project are as follows (see also Table 3.1):

- Artefact No.
- Unit No
- Maximum Length
- Length Completeness
- Maximum Width
- Width Completeness
- Maximum Thickness
- Thickness Completeness
- Butt Maximum Width
- Butt Width Completeness
- Butt Maximum Thickness
- Butt Thickness Completeness
- Weight
- Colour (Munsell Soil Colour Chart)
- Raw Material
- Object Category
- Secondary Object Category
- Number of Use-faces
- Surface Condition
- Bit Damage
- Butt Damage
- Shape in Plan
- Shape in Section
- Shape of Use-face
- Percentage of Cortex/Weathered Surface
- Visible Manufacturing Techniques (Bit, Body, Margins, Butt)
- Degree of Wear-Primary Use
- Degree of Wear- Secondary Use
- Degree of Polishing
- Modification of Use-face

## 3.4. Conclusions

In this chapter the methodology employed in the recording and the analysis of the Makriyalos ground stone assemblage was presented in detail. It was suggested that ground stone technology, similar to other technologies, is a social practice and as such it should be informed by theoretical approaches/considerations that have been applied to other technological practices. It was argued that the meaning of ground stone technology is elucidated when studied through the concepts of *chaîne opératoire* and 'object biographies'. In addition, it was suggested that in order for the role and meaning of ground stone technology to be meaningfully addressed, this technology needs to be explored at different scales of analysis (synchronic, diachronic, domestic, communal). The site of Makriyalos provides an excellent opportunity to address these questions.

Furthermore, the attributes recorded in the course of the analysis were described in detail. These attributes cover the whole sequence of the life-history of stone objects from raw material selection to manufacture and use to final deposition. Moreover, it was suggested that a flexible classification scheme is required when studying ground stone objects which would not obscure their diverse character and meaning. In the following chapter the results of the analysis of the raw material selection and production sequences will be discussed.

# CHAPTER FOUR

## *The Chaîne Opératoire of the Makriyalos Ground Stone Assemblage: Raw Material Selection and Production Sequences*

### 4.1. The nature of the Makriyalos assemblage

The Makriyalos ground stone assemblage comprises 8842 artefacts in total, the majority of which have been attributed to the first and second phase of occupation (5330 and 3165 respectively), while a small number of artefacts (347) come from surface collections or levels dated to the historical period (Table 4.1). As described in Chapter 3, the assemblage was divided into seven main categories: edge tools, grinding/abrasive tools, perforators, percussive tools, multiple-use tools, ornaments, and miscellaneous artefacts; artefacts that could not be attributed to any of the previous categories were recorded as indeterminate (n=959). Excluding indeterminate cases, grinding/abrasive tools and edge tools make up 66% and 24% of the assemblage respectively, while the remaining categories each account for less than 4% (with perforators representing the smallest sample at 0.5%) (Table 4.2). Clearly the small size of the latter subsets limits their potential for diachronic study, but patterns of temporal distribution will be investigated whenever feasible.

## 4.2 Raw material procurement and selection

### 4.2.1 Raw material acquisition

The acquisition of raw materials for the production of stone tools is evidently the first stage in the life cycle of these objects. The selection of good quality material will determine to a large extent the success of the following stages of manufacture and use. Two modes of raw material procurement have been suggested: a) directly from quarries, and b) from secondary deposits (e.g., river beds) (e.g., Bradley and Edmonds 1993; Pétrequin and Pétrequin 1993; Pétrequin *et al.* 1998).

Procurement methods can be investigated by looking at cortical/natural surfaces present on artefacts and on un-worked material found on-site. Objects with cortical/weathered surfaces suggest material collected from streams, while products with no cortical surfaces may indicate quarried raw material or secondary material that has been extensively worked. The majority of products present on site have no cortex (edge tools: 354 objects; all other categories 394 objects) or no more than 25% cortex and only about 10% of ground stone artefacts have more than 50% of cortex surviving (Table 4.3). Cortical/weathered surfaces above 50% are most frequently encountered in quartz followed by metamorphic rocks and in particular marble, and are very infrequent in sedimentary and igneous rocks (Table 4.4). The relative frequency of cortical surfaces, however, is heavily affected by the extent of manufacture and/or use (see below).

The Makriyalos ground stone includes 95 nodules, 3 cores and 26 possible nodules, together representing less than 1.5% of the assemblage. The raw materials represented in the core/nodule category are those most frequent in the whole assemblage: serpentinite is most common followed by fine-grained igneous rocks, although sandstone with well cemented grains and marble are encountered less frequently as nodules than in the assemblage as a whole (Table 4.5).

The majority of nodules/cores have 75-100% cortex, consistent with the selection of stream pebbles/cobbles as raw material (Table 4.6). This argument could be further sustained by examining the plan and transverse section of the nodules since material from rivers and streams is more rounded in section and in plan due to natural weathering processes (contact with water and sand). Thus, excluding indeterminate cases, most of the nodules/un-worked material, if irregular, has rounded margins and smooth surfaces or is spherical/ovate in section (e.g., ΑΓ 20082, 20090, 20085, 20081, 20095, 20089, 20100, 20103, 20084, 19994, 13184, 4100, 20061) (Table 4.7).

One serpentinite example (ΑΓ 20028), however, differs greatly from material collected from river beds and probably has been quarried (Plate 4.1) (procurement of serpentinite through quarrying has also been suggested for the ground stone assemblage from Neolithic Dispilio, Macedonia, Stratouli 2002). This suggests that both strategies may have been practised at Neolithic Makriyalos. The presence of different types of un-worked material could indicate that only some people knew where good quality outcrops/sources existed or had the right contacts to acquire this type of material, while others used mainly material from rivers/streams. Furthermore, the method of raw material procurement (outcrops or river beds) may have been linked to the subsequent use and treatment of the final products. For example, Pétrequin *et al.* (1998: 282) suggested that in Irian Jaya 'only polished blades which are not produced for use in long distance exchange can be made from pebbles.'

Procurement from rivers and streams does not indicate, however, a lack of knowledge and understanding of the quality and properties of the material selected. As van Andel and Sutton (1987: 20) have argued, within streams, natural processes of erosion would have eliminated weathered surfaces and thus the less tough material (for a similar suggestion see also Strasser 2005). The process of natural weathering and erosion, however, is a continuum and as such the weathering of the rocks will start taking place again due to frost and other natural processes (V. Roubos pers. comm.). Thus, not all pebbles and cobbles within a stream/river are of equal quality and toughness. Yet within rivers there is an optimum, which means that there is a specific place within the river where rocks of very good quality will be located after all the weathered material will be eroded. Therefore, the people that collect raw materials for tool manufacture had an understanding of the different qualities of rocks that existed within the same river and had to find an area within that stream where the material had reached the optimum stage of the erosion process. It is obvious, therefore, that this requires great knowledge of the landscape and the processes that constantly transform it. In short, even when people choose their material from stream beds, there is always a selection process in place and a dialectic relationship between them and their surrounding landscape.

Generally speaking, this mode of procurement has been described as one requiring less time and effort in relation to quarrying and thus would have been more energy and time efficient. The process of finding good quality raw material, however, as illustrated in ethnographic work, is a rather time-consuming, difficult task requiring great experience and knowledge (see also Hayden 1987; Stout 2002; Risch 2008). Furthermore, the presence of outcrops near archaeological sites does not necessarily indicate that freshly quarried material was used for stone tool production. In their discussion of the appropriation of stone resources by the inhabitants of Franchthi, van Andel and Sutton (1987: 20) have suggested that raw material procurement from outcrops would have been hindered by the degree of weathering exhibited.

### 4.2.2. Raw material selection

#### *4.2.2.1. Geology*

Macedonia is characterised by a wide range of rocks; in geological terms the region is divided into the Rhodope massif (to the east), the Serbo-Macedonian massif, the Vardar (Axios) isopic zone to the west (Figure 4.1; Higgins and Higgins 1996: 106). The Rhodope and the adjacent Serbo-Macedonian massif are characterised by metamorphic and plutonic rocks (Higgins and Higgins 1996: 17, 106).

Makriyalos is located in the Vardar (Axios) zone which lies between the Serbo-Macedonian massif to the east and the Pelagonian zone to the west (Higgins and Higgins 1996: 17, 18). 'It is a complex zone that has been sub-divided by some geologists into separate zones. However, it is dominated by Mesozoic deep-water sediments and ophiolites, and is hence an old ocean basin, part of Tethys' (Higgins and Higgins 1996: 18). This zone is largely covered by the sediments of the Thermaikos graben (i.e., tectonic valleys) (Higgins and Higgins 1996: 108).

According to the geological map (IGME Katerini Sheet) (Figure 4.2), Makriyalos and its immediate vicinity are characterised by loose sediments (Aeolian deposits, deposits of Methoni-Makriyalos, the Aiginio-Kataha formation north of Makriyalos and the

Sfendami-Alonia formation west of Makriyalos). These formations consist of alternations of sands of different coarseness and clayey materials. South of Makriyalos extends the Sevasti-Kitros area characterised by fine to coarse grained cohesive sandstones (used as building materials in the recent past) and clays. Cohesive sandstones are also encountered in areas of the Methoni-Makriyalos deposits. West of the Sfendami-Alonia formation, a formation of conglomerates 200-250 m thick with pebbles up to 20cm in diameter has also been identified, but the geological map does not provide any more information about the rock types represented in this formation.

Further west towards the Pieria Mountains, Neogene sediments (clays, marls, sands and sandstones) continue, consisting mainly of loose sediments. According to the IGME map (Kolindros Sheet) the Neogene deposits locally include 'lenticular intercalations of conglomerates with cobbles of quartz, metamorphic and volcanic rocks', but there is no indication of the location of these conglomerates. The Pieria Mountains are characterised by the Almopian formation consisting of ophiolities, phyllites, schists and Upper Cretaceous limestones (Higgins and Higgins 1996: 109; IGME Kolindros Sheet). In particular, the Flysch-Phyllitic series (Upper Malm-Lower Cretaceous) consists of limestone, schist-gneiss, marble and dolomites and develops on ophiolitic rocks. The ophiolitic complex (Lias-Dogger) is characterised by serpentinized and weathered ultrabasic-basic rocks such as dunitic serpentinite, and at the margin of the ophiolites occur diabases (dolerite) and to a small extent diorites and microgabbros.

Further south, the Pelagonian zone is characterised by gneiss, schist, serpentinite and marbles, while in a small area granites are encountered (Higgins and Higgins 1996: 18; IGME Kontariotissa-Litochoro). According to the IGME map (Kontariotissa-Litochoro Sheet), the ophiolitic complex attested on the Pieria Mountain range extends towards Mount Olympus.

Volcanic rocks are not widely distributed in Macedonia and Thessaly (Pe-Piper and Piper 2002). For example, according to the geological map, a small concentration of trachytes and andesites occurs on the border with FYROM (IGME Skra Sheet), while the Koufalia sheet indicates outcrops of igneous rocks and an ophiolitic complex consisting of serpentinites, basalts, diabases, andesites and diorites. '... [F]resh andesitic volcanics ... do not have obvious westerly sources until one passes well beyond the metamorphic belt running down the eastern edge of mainland Greece. Even then there are ... no fresh andesitic volcanics until the Aegean arc is reached' (Dixon 2003: 146).

In fact during a survey of the distribution of raw materials in the wider area of Makriyalos (Southern Pieria) conducted by the author and Dr V. Roubos (Department of Civil and Structural Engineering, University of Sheffield), the rarity and in many cases the lack of igneous rocks and in particular of volcanic rocks in river/stream beds draining from the Mt Pieria and Mt Olympus (e.g., the Kallipefki/Ziliana stream, Lagorahi (Ritini, Mt Pieria), Petra-Foteina Gefyra stream) was particularly striking. The river beds yielded mainly metamorphic (e.g., different varieties of serpentinite, schist) and carbonate rocks ranging in size from pebbles to boulders. Dolerite was located in the Pieria mountain range (e.g., dolerite at 3.5 km on the road from Charadra to Elafina), but no volcanic rocks have been found in the survey area. During these surveys different serpentinite outcrops were identified, but in some cases the outcrop was heavily weathered (Plate 4.2 & 4.3).

The location of the Makriyalos settlement in a diverse geological area gave access to a wide range of rock types that is reflected in the rather large number of raw materials identified in the ground stone assemblage. Within this assemblage all three general rock categories – igneous, metamorphic and sedimentary- occur, but metamorphic and sedimentary rocks more frequently (41% and 37% respectively) than igneous (18%). Quartz, and very rare 'talc', fossilised bone and shell were also used for ground stone. In all, 23 rock types have been identified, but they are not distributed evenly among the different tool categories and phases of occupation. Sandstone with tightly cemented grains and marble, followed by serpentinite, are the most commonly attested rock types. Within igneous rocks dolerite and volcanic rocks (basalt/andesite) are also fairly common.

The question this geological diversity and availability raises is to what extent the use of different raw materials was selective and to what extent the reasoning behind this selectivity can be addressed. With regard to EN grinding and percussive tools, Perlès (2001: 241-242) has suggested that '*rocks with different mechanical processes had to be used to respond to these varied mechanical constraints. Even the most cursory* *examination of the rather poor literature provides indications of a differential use of raw materials and shows that Early Neolithic villagers did not pick up pebbles randomly*'. Thus one of the issues to be explored in this section is the relationship between raw materials and different tool categories. The physical properties of utilised rock types will be characterised in order to establish their suitability for tool production and use. This type of analysis may clarify whether the choices exercised relate primarily to the utilitarian properties of rocks selected or perhaps reflect preferences of a non-practical character. The second issue to be addressed relates to the diachronic use of natural resources as seen in raw material use between the two phases of occupation.

#### *4.2.2.2. Raw material selection for edge tools*

Within the edge tool assemblage, mainly metamorphic (50%) and igneous rocks (49%) are attested, while specimens attributed to the sedimentary group are rare (1%). 214 cases (11%) have not been positively identified (Plate 4.4). The selective use of raw materials for the production of specific tool types can be further demonstrated when the edge tool assemblage is broken down into more precise rock categories (Table 4.8). There is a clear preference for serpentinite, which is used for 41% of the 1679 edge tools (excluding cases of indeterminate raw materials); almost 88% of the serpentinite artefacts unearthed during the excavation are edge tools. Dolerite is the second most common rock type used for edge tools (13%), while basalt (7%) and generally fine grained varieties of igneous rocks (together 15%) are also frequent.

More interesting patterns of raw material selection emerge when the edge tool assemblage is broken down into axes, adzes and chisels (Table 4.9). In the case of axes, although serpentinite is most frequent (28%), there is a strong preference for igneous rocks (67%), and in particular for coarser-grained varieties (gabbro, diorite, dolerite), which are encountered two or three times as frequently as in adzes. Within the adze category, the preference for serpentinite is stronger (46%), but dolerite (9%) occurs quite frequently and fine-grained igneous lydite, basalt and andesite (16%) are attested more frequently than in axes or chisels. In the chisel assemblage, the selection of serpentinite is most marked (70%) and metamorphic rocks as a group make up 86%, while igneous rocks are employed relatively infrequently (14%). The Monte-Carlo Chi-square test indicated a highly significant result in the relation of raw materials and tool types (*df*= 57, p=0.000).

The temporal distribution of edge tools shows that similar choices of raw materials were made in both phases of the Makriyalos LN settlement, though the rock categories are unevenly distributed between the two phases. During Makriyalos I igneous rocks are more frequent than metamorphic (53% vs. 46%), although serpentinite is by far the most commonly used rock (36%). During Makriyalos II, the use of metamorphic rocks increases (55%) and that of igneous rocks declines (44%). When precise rock types are considered, there is an increase in the use of serpentinite in Makriyalos II, while the use of schist and basalt decreases (Table 4.10). The difference in the frequency of raw materials per phase is not affected by the frequency of axes, adzes and chisels in each phase (Table 4.11).

When the assemblages from both phases are broken down into axes, adzes, chisels, the same selectivity patterns noted previously for the whole assemblage (coarser grained igneous rocks for axes, fine grained igneous rocks for adzes, serpentinite for chisels) are also evident in the sub-assemblages of the two phases. Admittedly, the sample size of axes and chisels per phase is very small. Yet, the fact that the same patterns of raw material selection are repeated in each phase indicates that these patterns may reflect real choices and preferences. In addition, chi-square tests indicate that there is a significant relationship between raw materials and tool types in each phase (Tables 4.12 & 4.13).

This evident selection of specific rock categories for specific tool types is, *inter alia*, of considerable typological interest. The classification of edge tools following this tripartite system (based on the working edge profile and the relationship of the working edge to the haft), and its applicability to archaeological assemblages, has been questioned extensively (e.g., Heider 1967; Moundrea-Agrafioti 1981; Semenov 1985; Moundrea-Agrafioti 1996). This typological classification seems to have carried some real meaning in the everyday life of the people of Late Neolithic Makriyalos, however, since they chose different types of rocks for the production of each of these tool types. Moreover, the predominance of serpentinite in the chisel category is interesting in regard to Moundrea-Agrafioti's argument (1996: 104) that there is no raw material standardisation for chisels as they represent reworked axes and adzes. Traces of similar resharpening and sawing (see below, section 4.3.2) are found on some of the Makriyalos tools, but igneous rocks, although well represented among axes and adzes at Makriyalos, are used only infrequently in chisel manufacture. Even if some chisels do represent reworked axes and adzes, therefore, it is clear that serpentinite was actively selected for chisels. The preference of serpentinite for chisels does not relate to the degree/frequency of breakage (and thus the frequency of reworking) encountered in this raw material, as within indeterminate edge tools igneous rocks (55%) are represented more frequently than serpentinite (35%).

Furthermore, the fact that the preferred rock types for the production of specific tool categories are the same in both phases of habitation, suggest the existence of traditions that seem to have been followed throughout the history of the Makriyalos settlement showing a consistency in the appropriation of the same rock types. Finally, the use of basalt and fine grained igneous rocks is interesting considering their relative absence from the geology of this region. The decrease in their use in the MK II might indicate therefore changes in the strategies related to the procurement of these rocks (direct or through exchange mechanisms) that prohibited the acquisition of volcanic rocks during this phase.

#### *4.2.2.3. Raw material selection for grinding/abrasive tools*

In contrast to edge tools, a very different pattern emerges when grinding/abrasive tools are considered: sedimentary rocks predominate (58%), followed by metamorphic rocks (36%), while igneous rocks appear very rarely (4%). Sandstone with tightly cemented grains is the most common rock type (48%), followed by marble (23%) and gneiss (8%) (Table 4.14 & Plate 4.5).

The selective use of specific rock types can be further demonstrated by exploring the relationship between rock categories and grinding/abrasive tool types. Grinding slabs are preferentially associated with sandstone with tightly cemented grains (58%) although gneiss is also relatively frequent (15%). The small sample of abraders and grooved abraders indicates a preference for sedimentary rocks and in particular sandstone with tightly cemented grains. Marble is strongly preferred for grinders (82%), polishers (84%) and mortars (96%) and pestles were fashioned exclusively from igneous rocks. The Monte Carlo chi-square test gave a highly significant result between raw materials and tool types (df=138, p=0.000) (Table 4.15).

More interesting patterns emerge when the assemblages from the two phases are compared. In Makriyalos I a strong preference for sedimentary rocks (65%) and in particular for sandstone with tightly cemented grains (57%) is evident. In Makriyalos II, however, metamorphic rocks are almost twice as frequent (51%) as in MKI (29%), matched by a significant decrease in sedimentary rocks (Figure 4.3). More specifically, whilst the use of sandstone with tightly cemented grains decreases by half in relation to the first phase of habitation, marble, which represents the most frequently used rock in this phase (32%), and gneiss are twice as frequent as in Makriyalos I (Table 4.16). The same patterns are encountered in the selection of raw materials for different tool types in both phases of habitation. It is worth noting, however, that in the case of grinding slabs, although sandstone with tightly cemented grains is the most commonly used rock in both phases, during MK II its use declines and that of gneiss increases more than twofold (Table 4.17).

Clearly, the use of sandstone with tightly cemented grains was particular favoured in both phases of habitation for grinding slabs. In his study of millstones Runnels concluded that sandstone and andesite were commonly used with an increase in the use of andesite during the later Neolithic (LN & FN) (Runnels 1981: 103). Yet, in the Makriyalos assemblage the use of andesite/basalt and igneous rocks in general is very restricted (66 out of 2401 or <3%). Igneous rocks were preferentially selected, however, for fashioning pestles, a pattern also encountered in the multiple-use pestles/hammers assemblage (Section 4.2.2.7.). Similar to edge tools, during Makriyalos II some changes occur in the frequency of certain raw materials, that might relate to changes in the procurement methods.

#### *4.2.2.4. Raw material selection for percussive tools*

In the case of percussive tools, marble and quartz are only associated with hammers. Mace-heads, on the other hand, present an interesting collection of raw materials:

'talc[4]', coarser grained igneous rocks (granite, diorite, granodiorite, dolerite, weathered andesite (V. Roubos, pers. comm.), indeterminate coarse-grained rock with white feldspar and mica), serpentinite, schist, well cemented sandstone and the unique example of fossilised shell (Table 4.18 & Plate 4.6). In temporal terms, the size of the percussive tool assemblage per phase is too small and thus no definite results can be reached (Table 4.19 & 4.20).

#### *4.2.2.5. Raw material selection for perforators*

The small assemblage of perforators is characterised mainly by the use of marble for 'drill bases'/capstones used in drilling. In the case of drills, four are made of sandstone with well cemented grains and one of gabbro (Table 4.21).

#### *4.2.2.6. Raw material selection for ornaments and miscellaneous categories.*

For the production of ornaments, predominantly metamorphic rocks (94%) were used and in particular marble (72%) and serpentinite (19%). Marble was selected for bracelets and pendants, while serpentinite represents the main rock category used for beads (58%) (Table 4.22 & Plate 4.7). No variation is evident between MKI and MKII. Generally speaking, the raw materials used for ornaments seem to correspond with those in assemblages from other Greek Neolithic sites (Miller 1997). Miller (1997: 102-103) has suggested that materials employed for ornament production were of relative local origin, a suggestion that contradicts previous suggestions that ornaments (or rare goods) are produced from exotic raw materials (Perlès 1992). Marble is present in the geology of Pieria, but distant sources cannot be excluded, and different qualities of marble within the assemblage may thus correspond to different sources. In a recent study of marble bracelets/rings from LN Dispilio, it was suggested that the source for one of these marble bracelets was the island of Naxos (Ifantidis 2006: 51).

Marble was used very frequently for figure-of-eight weights weights (68%) and schist weights are also quite frequent (29%) (Table 4.23). Similar weights (97 artefacts) from the Neolithic site of Servia exhibit a much greater variation in raw materials, perhaps

[4] This raw material is white in colour and has a powdery feeling. It has not been possible to identify the exact rock type and it has been provisional described in this thesis as 'talc' following Dr Roubos' advice. For that reason throughout the thesis the rock name is used in quotes.

reflecting the availability of rocks in the nearby River Haliakmonas (Mould *et al.* 2000: 161-170).

All pitted stones are made of marble as is the unique example of a rock with a natural hole, while retouched flakes are from serpentinite (Table 4.23).

#### *4.2.2.7. Raw material selection for multiple-use tools*

Similar patterns to the ones seen previously for single use categories are attested. Marble was used extensively for grinder/hammers and polisher/hammers, while igneous rocks were preferentially selected for pestles/hammers (Table 4.24).

### 4.2.3 Assessing raw material properties and variability

> *'A study of technology is not complete without some knowledge of the properties of the raw materials utilized, and also, if possible, an inventory and similar knowledge of those which were not utilized.'*
>
> *(Goodman 1944: 416)*

> *'The physical properties of materials and the reasons that specific materials were used to make tools for specific tasks generally are neglected in standard ethnographies, ethnoarchaeologies, and archaeological analyses.'*
>
> *(Hayden 1987: 13)*

The Makriyalos assemblage is characterised by a large number of raw materials with great variation in their physical properties. Although the ground stone assemblage includes a large number of rock types, consideration should also – ideally – be given to which of the raw materials available locally have not been used in tool manufacture. This requires a very good understanding of the raw materials available in the area around Makriyalos. According to the geological maps (IGME sheets for Katerini, Platy, Alexandreia, Kontariotissa-Litochoro), Makriyalos and the surrounding area are characterised mainly by alluvial deposits created by streams that carry material from various parts of Mt Olympus and the Pieria Mountains. The maps, however, do not identify the different rock categories found within these alluvial deposits. Thus, at present, raw material selection can only be addressed in relation to the raw materials attested within the ground stone assemblage.

The metamorphic rocks attested in the Makriyalos assemblage mainly exhibit foliation (gneiss, schist and slate), although non-foliated varieties such as granulite and widely-used marble have also been encountered. Their grain size varies from fine to coarse. Serpentinite, the most common metamorphic rock used for edge tools, is a metamorphosed ultramafic rock where the ferromagnesian silicate minerals of olivine and pyroxene have been altered to serpentine minerals (Press and Siever 1986: 437; Blatt and Tracy 1996: 367). Its structure can vary from slightly to markedly schistose, while the grain size can vary from fine to coarse (Blatt and Tracy 1996: 367; Jones 2000: 212; Pellant 2000: 194). The metamorphic rock types used for edge tool manufacture are mainly fine- to medium-grained, while both foliated and non-foliated varieties are present.

The second geological category attested in the assemblage is sedimentary rocks, with both clastic and chemical varieties present. Clastic or detrital rocks are represented by different varieties of sandstone (fine- to coarse-grained sandstone with poorly to medium cemented grains and fine to medium-grained sandstone with well sorted and tightly cemented grains), and brown and red mudstone. Chemical rocks are represented by limestone, fossiliferous limestone, dolomite, travertine and flint. Sandstone with tightly cemented grains represents the most widely used rock category in the Makriyalos assemblage.

Igneous rocks represent the third geological category within the assemblage, among which two broad categories can be distinguished: coarse- (phaneritic rocks) and fine-grained (aphanites). The first category is comprised of the plutonic rocks granite, gabbro, diorite, pyroxenite and granodiorite. The fine-grained varieties are represented by the unique example of lydite, and the volcanic rocks basalt and andesite the texture of which can often be holocrystalline. In a few cases these rocks exhibit a porphyritic texture in which larger crystals (phenocrysts) are set in a finer grained matrix (Blatt and Tracy 1996: 518). The most common rock type is dolerite, a medium-grained variety of basaltic composition and holocrystalline texture (Jones 2000: 180). Igneous rocks are characterised by interlocking crystals set in a compact matrix with no banding or foliation.

A small number of artefacts are made of quartz. Different qualities of quartz have been identified in the assemblage, the main ones being citrine quartz and rose quartz. A few specimens are made of very good quality quartz (milky quartz). Different varieties of quartz have also been used extensively in chipped stone manufacture. Regarding possible sources, Skourtopoulou (1999: 122) suggested that quartz is 'associated with central and southern Macedonian lacustrine deposits and, in the case of Makriyalos, may have been found on the slopes of the Pieria mountain range'.

The different rock categories exhibit very distinctive textural features and thus present great variability in their physical properties. One of the raw material properties encountered in many lithic studies is hardness measured against the Moh scale (e.g., Moundrea-Agrafioti 1981; Perlès 2001; Stroulia 2003a). The Moh scale refers to the classification of 'the relative abrasiveness of minerals' tested by scratching (Attewell and Farmer 1976: 8-9; cf. Brown 1981;Goodman 1944: 417). As most rocks consist of a number of minerals with different properties, however, and only a few (such as flint and obsidian) represent monolithic rocks, this hardness test does not seem to be adequate. It should be noted that the hardness of a rock does not depend only on its mineral components, but mainly on 'the strength of the matrix bonding the grains or crystals in the stone' (Dickson 1981: 27; cf. Brown 1981: 97). Moreover, the choice of a relevant testing method should relate to processes directly involved in tool production. Thus, a hardness test that measures raw material behaviour under specific operational procedures, e.g. scratching, does not indicate satisfactorily response to operations employed in tool manufacture and use (Goodman 1944: 418; Dickson 1981: 27). Other methods have been developed that test hardness for specific operational procedures e.g., 'resistance to abrasive wear and resistance to penetration' (Goodman 1944: 417). Bearing these in mind, it would be expected that different properties would be favoured in the selection of rocks for the production of different tool types.

Goodman (1944) and Dickson (1981) have suggested toughness as a useful property when studying raw materials employed in edge tool manufacture and use, for instance the reaction of rocks to percussion flaking and pecking/hammering and use in percussive tasks. Toughness refers to 'that property or complex of properties which determines under what conditions the material will fracture' (Goodman 1944: 426, measured by the Paige Impact Tester). Following experimental work and highway engineering research, Dickson (1981: 27-31) concluded that fine-grained rock types are more durable to crushing than coarse-grained rocks. His experimental work has shown that fine-grained raw materials with holocrystalline or hypocrystalline texture, with small elongated crystals that do not follow a specific orientation, such as basalt, are best suited for the production of edge tools (hatchets) (Dickson 1981: 28; for a similar suggestion see also Hayden 1987: 18-19). Other rocks that could be defined as tough and thus be used efficiently in edge tool manufacture are highly metamorphosed sedimentary rocks with grains of a small size (Dickson 1981: 28). In addition, in his analysis of Australian edge tools (hatchets), Dickson incorporated the property of isotropy, which refers to the lack of 'directions of easy fracture along which the head might break under the impact of chopping' (Dickson 1981: 32). Rocks most commonly characterised by preferred orientation of grains or lamination are sedimentary and metamorphic ones.

Another potentially useful property is tensile strength, as has been illustrated in the study of the Neolithic axe trade in Britain (Bradley *et al.* 1992). As Attewell and Farmer (1976: 186) have argued, it is very difficult to create a rigid strength classification system for rocks, as strength and other properties of raw materials are largely affected by other parameters such as their composition, structure, texture, weathering, porosity and density. A general and indicative classification system may be formed, however, grading rock types from very weak (5-20MPa) to very strong (160-320MPa) (Table 4.25). Igneous and metamorphic rocks can exhibit the highest levels of strength while sedimentary rocks, due to their formation processes, are graded lower. Similar to Dickson, one of the conclusions that Attewell and Farmer reached in relation to porosity and texture (grain size and shape) is that the strength of fine-grained igneous rocks is greater than that of coarse-grained angular ones as they represent materials with crystals tightly held together and lower porosity (1976: 187-188).

At this stage of research, time and cost have not permitted the author to conduct similar tests for all the rock types identified in the Makriyalos edge tool assemblage, but an indication of strength measurements for the relevant rocks can be obtained from published sources (e.g., Lama and Vutukuri 1978). Values have not been found for serpentinite, however, probably because this rock type has not been used in engineering work and thus has not been tested. Moreover, as noted in a number of archaeological reports, the hardness of serpentinite specimens varies from soft to quite hard and has been graded from 3 to 6.5 on the Moh's scale (e.g., Moundrea-Agrafioti 1981; Perlès 2001; Stroulia 2003). This may be related to the great variation that serpentinite specimens can exhibit in texture, as exemplified in the Makriyalos and other Neolithic assemblages (e.g., Alisoy 2002b). This variability and lack of consensus regarding the hardness of serpentinite makes the characterisation of serpentinite difficult and calls for an in-depth analysis of the properties of this raw material that has been extensively used in edge tool manufacture.

Rock texture and in particular heterogeneous texture in terms of grain size and mineral composition is also very important in the selection of material for grinding activities. According to Schneider (2002: 40) rocks with a 'high proportion of relatively large and angular phenocrysts or grains within a groundmass or matrix of homogeneous finer-textured material' seem to have been preferred for milling (grinding tools). In addition, rocks characterised by 'a mineral composition formed by hard mineral grains evenly distributed in a softer matrix (different types of schist, conglomerate and sandstone), or a porous texture (volcanic rocks)' would be desired for efficient grinding (Risch 2002, 2008; R. Risch, pers. com.). Thus, sharp texture seems to have been a prerequisite for efficient grinding tools (Horsfall 1987: 340; Risch 2008), as indicated also by regular maintenance practices (repecking of use face). Risch has also suggested that upper and lower grinding tools should have different textural features and in effect should be made from different rocks. The upper component should have a more compact fabric and have a less abrasive texture than the lower grinding tool (Risch 2008). In his study of Spanish grinding tools, Risch (2002, 2008) noted that grinders were made either of materials with a homogeneous texture such as marble or contained high proportions of quartz such as mica schist.

With regards tools used for other purposes, such as herb-mashing, Horsfall's ethnographic work (1987) indicates that fine-grained rocks with consolidated grains and relatively smooth texture are preferred. Rocks for abrasive activities such as polishing are usually less hard (6 or less on the Moh scale) than those used for grinding cereals (Horsfall 1987: 340-341).

'Strength of grain bonding' is another important element in the selection of raw materials for grinding tools. It refers to 'the rate at which a grinding stone becomes dull. Very strong grain bonding will result in retention of dulled grains, or glazing, during use' (Horsfall 1987: 341), an aspect that is frequently attested in sandstone. Therefore, rocks such as basalt that retain their abrasive quality for longer periods (self-rejuvenation) and do not become dull, require less frequent maintenance of the use-face. This could also affect the use-life of the tools. According to Horsfall, the use-life of grinding tools relates to a great extent to the properties of the rocks used, with granitic and volcanic rocks exhibiting an average life of 15-20 years, and sandstone a shorter life (Horsfall 1987: 342). Rocks with strong bonding, however, produce less grit and thus the substance ground is not contaminated by rock particles, an element which might have been equally important in the selection of raw materials (Horsfall 1987; Schneider 2002).

Schneider (2002) has suggested that different communities with stone milling technology mostly favoured sandstones and extrusive volcanic rocks such as basalt and andesite for milling. During Hayden's (Hayden 1987) ethnographic work, it became evident that vesicular basalt 'with low densities of vesicles' was particularly preferred mainly because 'not as many mineral grains become incorporated in the maize dough as it is being ground' (Hayden 1987: 14). Furthermore, basalt would have required less frequent rejuvenation of the use-face than other raw materials such as sandstone, allowing a much longer period of use (Hayden 1987: 17; Wright 1998: 121).

Rock texture, hardness ('determined by the bonding of grain or crystal structure' Horsfall 1987: 345) and lack of flaws such as veins or stratification, greatly affect the ease with which raw materials can be worked and used. Generally speaking, igneous rocks are among the hardest materials and in that sense more difficult to work, but they also exhibit great durability that seems to have been favoured by the users of grinding tools in ethnographic contexts (see also Runnels 1981: 62-63; Horsfall 1987).

Finally, another important element in the choice of raw materials for grinding is 'the nature of the substance to be ground, how finely it is to be ground...' (Horsfall 1987: 340). Differences in rock texture could result in ground matter of different degrees of fineness (Horsfall 1987: 341). The way substances are processed (e.g., dry or moist/boiled state) or the different varieties of crops to be processed could also influence greatly the choice of raw material for grinding tools (Horsfall 1987; Stone 1994; Schneider 2002). For example, small size grains such as wild seeds are processed by combining crushing and grinding activities whereas large-size grains such as wheat and barley require shearing prior to grinding for the grains to be broken down. Shearing is better facilitated by the use of rough or vesicular stones, while non-vesicular stones are better for processing small seeds (Stone 1994; Schneider 2002). Therefore, the selection of raw materials could have been determined not only by functional constraints and rock textures with optimal characteristics but also by wider cultural choices that relate to the way foodstuffs are processed and consumed (e.g., grinding of boiled or dry (uncooked) grains) and potentially to the desired taste of food being processed.

One of the wider issues raised by this analysis is the nature and effect of our analytical categories on our understanding of the past. A good example of this is the way in which rocks and minerals have been classified. Whilst in many cases they may seem to be straightforward, the raw material categories employed in this analysis reflect understandings and concepts employed by modern geologists. Yet, even the categorisation of rocks by modern geology (e.g., classification of rocks based on grain size) might vary from one geologist to the next (cf. Barker 1990: 28). This categorisation is not the only way that the mineral world could be classified, however, and the different rock properties outlined here do not necessarily reflect a universal and diachronic understanding of how minerals and rocks might be perceived. Rocks could alternatively have been grouped and selected on the basis of other properties such as colour properties (colourful and versatile vs. lack of colour variation). This point was illustrated in Hayden's work in the selection of raw materials for the production of grinding tools in Guatemala. Hayden's informant in this project identified four different rock types that potentially could be employed in the manufacture of grinding slabs (metates) based on colour, vesicular composition and ease of working. Yet, all these four rock types petrologically belong to the same rock type (basalt) (Hayden 1987: 14-15). Hayden's work (1987: 14) indicates that classification schemes and understandings of rocks may vary between groups of people (e.g., tool producers and tool users). The classification and understanding of rocks is seen more as a process that involves handling and working with rocks rather than a rigidly fixed classificatory scheme (Hayden 1987).

Thus, it is important to acknowledge that our geological classifications are historically specific and culturally meaningful and that alternative understandings and perceptions of rocks could and have existed (see also Boivin 2004; and other chapters in Boivin and Owoc 2004). Rocks need to be considered as part of a wider landscape imbued with meaning and symbolism which formed the perceptions and understandings of the people of a given society.

## 4.3. The production sequences of ground stone artefacts

Following raw material selection the *chaîne opératoire* of ground stone objects involves the shaping of raw materials and their transformation into tools. In the following section the manufacturing sequence of the different tool categories, as evidenced in the Makriyalos assemblage and informed by ethnographic literature, will be presented.

### 4.3.1. Definition of manufacturing techniques

A range of techniques with different objectives has been employed at different stages of tool production: primary and secondary manufacture and tool modification (cf. Wright 1992a; Cooney and Mandal 1998). The latter stage refers to modification of the use-face or re-manufacture of the overall tool surface. Six techniques have been recorded (flaking, pecking, grinding, polishing, drilling and sawing) with a combination of these techniques (e.g., grinding and polishing) also present in a few cases.

Grinding involves the gradual wearing down and/or removal of rock particles through abrasion (Wright 1992a; Blitzer 1995). The resulting debitage of this process is grits (Wright 1992a), which cannot be documented archaeologically. Semenov describes grinding as a time-consuming, strenuous activity that requires persistence and 'some working knowledge' (Semenov 1985: 68).

Polishing, similar to grinding, is an abrasive technique that results in a smooth and lustrous surface, which reflects light (Runnels 1981; Wright 1992a; Blitzer 1995). Semenov (1985) argues that grinding and polishing have different objectives. Thus, whilst grinding is used in shaping and thus producing artefacts, polishing plays no manufacturing role as it 'merely affects the surface' (Semenov 1985: 70). Blitzer regards polishing as the last stage in an abrasion continuum, the other two being smoothing and grinding (Blitzer 1995: 423).

Other techniques used are the percussive techniques of pecking and flaking, and the abrasive techniques of drilling and sawing. Pecking is a technique that involves the removal of small-sized particles of the rock mass via direct percussion strokes from tools with rounded or convex surfaces such as hammers, allowing the transformed surface to acquire any desired shape (Coope 1979: 99; Runnels 1981: 256; cf. Semenov 1985: 68; Adams 2002: 272). According to Wright (1992a: 57), in the stage of retouch/thinning pecking becomes more 'gracile and regular in spacing'. The waste products of this procedure are limited to dust and small sized rock fragments (pecking fragments/"shatter" - Wright 1992a) that are extremely difficult (if not impossible) to identify and collect during excavation (Coope 1979; Blitzer 1995). Thus, the use of this technique can only be attested by the presence of impact fractures (*pecking* or *pecked* features Adams 2002) on the artefacts themselves. Only small amounts of material are removed with pecking and thus this technique is considered to be a lengthy one in relation to flaking (Coope 1979; Runnels 1981; Cooney and Mandal 1998); however, it does not involve as many risks (Coope 1979; Runnels 1981).

Flaking refers to the removal of chips or flakes by percussion or by applying pressure to a mass of rock (Runnels 1981: 255; Crabtree 1982; Blitzer 1995; Andrefsky 1998). The debris that is produced through this activity is either detached pieces with well defined characteristics of conchoidal fracture, such as a bulb of percussion and a striking platform (Andrefsky 1998), or pieces with 'even (planar) fracture' (Blitzer 1995: 423). Although both types of debris survive in the archaeological record, the chances of identification and thus recovery of the second type of products are much lower.

Drilling refers to the 'removal of particles via rotary motion of a pointed object directed at 90 degrees into a stable target' (Wright 1992: 57). Two methods of drilling can be inferred in this study. One way of creating a perforation was by turning an object in a circular movement. In most cases this process was performed on either side of the object to assist the perforation. Quite often, however, the drilling process was preceded by percussion which was used to define the area where the perforation should be, but also remove the unwanted material in less time.

Sawing refers to the cutting up of rocks and was employed at different stages of tool production and modification. The sawing technique has been recorded in various stone axe assemblages in the European Neolithic (e.g., Dradon 1967; Le Roux 1979; Moundrea-Agrafioti 1981; Cordier 1987; Prinz 1988; Kelterborn 1991; Ricq-de Bouard 1996; Cooney and Mandal 1998; Croutsch 2005; Leshtakov *et al.* 2007). Sawing represents a complex technique (*une technique complexe et difficile à obtenir* - Moundrea-Agrafioti 1981: 184) that requires great understanding of raw material properties and effort. According to Kelterborn (1991: 129) '*this invention* [sawing] *to gain more control over the fracture initiation, enables removal of excess volume in a more precise and less risky manner than by simple percussion. Furthermore, this technique saves considerable amounts of raw material*'. In previous studies the application of this technique has been associated mainly with raw material economy and/or the exotic/precious character of raw material used (cf. Leshtakov *et al.* 2007). A detailed synopsis of the history of research on sawing is provided by Croutsch (2005: 83-88).

There has been great discussion among researchers about the way sawing was executed and the tools employed during this process. The suggestions that have been put forward can be summarized as: sawing with flint blades, with string, with sandstone plaques, with wooden or bone blades, and with some sort of a mechanical device (Kelterborn 1991; Croutsch 2005).

Through experimental work, the results of which were directly compared to archaeological material, Kelterborn (1991) suggested that some of the above suggestions could be dismissed, at least for Swiss material. Among these were the string method and the use of flint saws for sawing rocks. According to Kelterborn the lack of grooves with parallel sides ('the parallel orientation of the flanges (alpha=0)' (1991: 135), the main characteristic of the use of string saws, indicates that this technique was not employed in the Swiss Neolithic. Similarly, the results of sawing experiments with flint saws and the lack of adequate archaeological evidence such as exhausted flint saws with a splintered appearance in archaeological sites, according to Kelterborn, argue against the use of flint saws in the Neolithic in the northern Alps (see however Strathern 1969 for the use of flakes for sawing large stone axes).

Regarding the Makriyalos assemblage, sawing has been attested on 127 cases in total that include cores, waste by-products and finished products (edge tools only, see Section 4.3.2). Two examples illustrate that sawing was used in raw material procurement to separate the required blank (rock matter) from the original nodule or outcrop by splitting. In both cases, part of a shallow and wide groove survives (AΓ 8272: 7.3x1.0x0.01cm; AΓ 7608: 5.0x2.6x0.1cm); one surface is sawn while that adjoining it is the broken surface of the nodule left after removal (Plate 4.8). Sawing during raw material procurement was also encountered in the Neolithic settlement of Dispilio, Kastoria, Macedonia (Stratouli 2002). Examples of this technique can be seen in modern quarries (Plates 4.3a, b & 4.8c).

Sawing, used in the subsequent stages of tool production and modification, was characterised by great attention to detail and precision, as indicated by the sequence of steps followed during the refashioning of edge tools using this technique These steps can be reconstructed from unfinished examples in the Makriyalos assemblage(Plate 4.9):

**Stage One**: Initially a shallow, narrow groove was created along the long axis to define where the tool would be cut. This stage was executed with a tool with a very thin edge, probably a flint blade, as can be seen in various examples in the Makriyalos assemblage (e.g., AΓ 8538, AΓ 3484, and AΓ 1967-with a second groove visible in places). For example, the unfinished groove seen on the surface of AΓ 8538 is 1.9cm long, 0.1cm wide and just 0.001cm deep.

**Stage Two**: The tool was then sawn by grinding, increasing the width and depth of the initial groove (e.g., AΓ1824). Often a second groove was created on the opposite side of the tool in order to delineate the exact area where the tool would be cut.

**Stage Three:** The groove created by sawing was increased in depth and width, in one of two ways:

a) The tool was sawn from one side only until the opposed surface was reached (simple cut -Kelterborn 1991: 130).

b) Opposing grooves were sawn until they met and then the tool was snapped in two (double cut - Kelterborn 1991: 130).

The grooves acquire a V-shaped profile and if Kelterborn's suggestion (grooves with no parallel sides preclude a string saw, see above) is correct, this indicates that the string method was not used in LN Makriyalos. Furthermore, previous suggestions of the use of flint saws (Moundrea-Agrafioti 1981) seem problematic, not only for the reasons stated by Kelterborn, but also because of the width of sawing grooves attributed to this stage that range from 0.8cm to 2.60cm. Furthermore, no flint tools with use-wear compatible with such tasks have been found in the Makriyalos knapped stone assemblage (K. Skourtopoulou, pers. comm.). Bearing these points in mind and following other archaeological and ethnographic examples (cf. Beek with Maika Mason 2002), I suggest that tools were sawn with stone slabs, with or without the aid of other abrasives (e.g., quartz sand) (Plate 4.10).

> *'Grasping the saw and using water as a coolant, the narrow cutting edge of the saw was drawn back and forth across the stone with long, slow strokes and an even pressure. To speed up the operation, quartz sand, which is harder than nephrite, was sprinkled into the cut to act as an abrasive saw...* (Beek with Maika Mason 2002: 101).

Stone saws could vary in size and raw material but sandstone seem to have been the most efficient rock type due to its abrasive properties (Beek with Maika Mason 2002: 102). In fact, the same properties made sandstone highly popular for abraders and grinding slabs (see section 4.2.2.3). In that sense, it would be surprising if people in

Makriyalos chose to use a material such as flint rather than sandstone in an abrasive operation such as sawing.

**Stage Four:** Efforts to erase traces of sawing by re-grinding/re-polishing the remaining lips of the groove are evident in a few cases implying an interest in the visual appearance of these tools.

The application of the sawing technique did not necessarily follow the same sequence of steps throughout the Neolithic; chronological and also regional variations may have existed in the way(s) the technique was executed and in the sawing toolkit used (cf. Croutsch 2005). The sawing technique and toolkit may also have varied according to the properties of the different raw materials employed for tool manufacture. For instance, rocks of greater hardness would take longer to saw. Different techniques and different sawing tools create grooves with different type of wear (P. Pétrequin pers. comm.), but such details are not normally given in excavation reports/publications, thus limiting understanding of the sawing technique. Furthermore, it is not always clearly stated in reports/publications whether sawing relates to the initial stages of raw material procurement or to modification processes, and which stages of the sawing process are evident in ground stone assemblages. Lastly, sawing has not always been identified as a manufacturing technique in Neolithic stone assemblages, instead tools with sawing marks (grooves) have been occassionally misinterpreted as grooved abraders/whetstones (e.g., Elster 2003: 183, 188, Figs. 5.20, 5.21, where two edge tools with sawing evidence on the margin have been interpreted as grooved stone/whetstones). Due to these problems, more detailed recording and analysis of sawing evidence on tools and debitage is necessary, therefore, to understand the use of this technique in the Aegean.

### 4.3.2. The production of edge tools

Six manufacturing techniques were used for the production and modification of edge tools: pecking, flaking, grinding, polishing, drilling, and sawing, while a combination of different techniques was also recorded (e.g., grinding and polishing). Natural surfaces are only rarely encountered in this tool type. All techniques (for sawing see section below) have been used on all parts of edge tools, though polishing is by far the most commonly used technique (Table 4.26). The proximal area of edge tools (butt), though mainly modified by polishing, presents greater variability in techniques used, with pecking and grinding being more frequent in this area than the rest of the surface of these tools. The presence of incomplete polishing/grinding, according to Semenov (1985), could be linked either to: a) an attempt to save time since grinding of specific raw materials such as flint requires remarkable amount of time and effort, and b) to improve the hafting of the tool as the rough surface created by pecking is well suited for fitting the tool firmly to a handle. No variation has been encountered in the techniques used for fashioning the different surface areas (bit, body, margins, butt) of axes and adzes, although chisels tend to have polished butts more frequently (Table 4.27). The same manufacturing techniques were used in both phases of habitation (Table 4.28).

Axes and adzes are more often trapezoid in plan and chisels rectangular/sub-rectangular. A correlation between shape in section and tool type has also been established: adzes are plano-convex in section, axes are ovate/spherical and chisels flat (*contra* Moundrea-Agrafioti 1996). A chi-square test indicated a highly significant relationship between shape in section/shape in plan and tool types (p=0.000) (Table 4.29). This difference in the shape in section between axes, adzes and chisels suggests that chisels cannot have simply been axes or adzes that were sawn in half, unless they had also been extensively modified by pecking, grinding and polishing. These correlations are encountered in both phases of habitation, indicating that the morphology of edge tools did not undergo any changes during the LN period.

The tendency to create highly finished surfaces on edge tools is –from the point of the tool analyst- very inconvenient as it obscures the previous steps in production (cf. Prinz 1988: 257). The production sequence of the Makriyalos edge tools can be reconstructed, however, based on archaeological evidence (e.g., semi-finished tools and rough-outs) and ethnographic work. The different manufacturing techniques correspond to different stages of the edge tool production sequence and can be broadly divided into primary and secondary production stages, and a tool modification stage.

The initial manufacturing stage involves the acquisition of the rightly shaped un-worked material and the creation of a rough-out. Although river cobbles of required size were most likely used, sawing was also used at this early stage mainly when the un-worked nodule did not have the required size. As evidenced in ethnographic work, for the rough shaping of raw materials pecking and flaking were employed mainly because these techniques could remove large quantities of rock in less time. The choice between the two techniques relates mainly to the properties of the raw materials worked and their initial form and size (pebbles, boulders, quarried or alluvial material). In the early stages of raw material shaping, rough flaking was occasionally used before pecking for the removal of pieces, which do not necessarily have flake characteristics (Coope 1979: 99).

In the Makriyalos assemblage flaking has been recorded only in few cases, while a number of flakes, some with retouched margins, have also been identified . Evidence for flaking on edge tools has been reported from other sites as well, e.g., Franchthi (Stroulia 2003: 9) and Neolithic Knossos, where it was attributed to the initial stages of tool production (Evans 1964: 229). The instances of flaking and pecking recorded in the Makriyalos assemblage relate mainly to the on-going modification of edge tools (see below) and only rarely to the initial stage of the reduction sequence (Plate 4.24). This is mainly due to the high degree of finishing encountered on this tool type. It has been argued previously that flaking is rarely attested in the Aegean Neolithic due to the raw materials used in edge tool manufacture (Moundrea-Agrafioti 1996; Perlès 2001: 233; Stroulia 2003). Yet, flaking has been used on similar raw materials (e.g., dolerite, basalt, andesite, gneiss) in other European assemblages (see for instance the Irish Stone Axe Project, Cooney and Mandal 1998) and therefore the use or not of flaking does not only relate to rock properties but instead may reflect personal or cultural choices.

After giving a rough form to the raw material, the next stages of manufacture involved the use of abrasive techniques to smooth the rough surfaces created by pecking (and/or flaking). Initially, grinding may have been achieved by rubbing the surface of the tool against harder surfaces. Ethnographic work, archaeological evidence and experimental research has shown that these hard surfaces could be provided by coarse-grained stones such as gneiss, quartz sandstones, and even the 'hard ground that contains silica sand' (Semenov 1985: 69). The grinding process would involve the use of abrasives of different textures, starting with coarser and moving to finer abrasives facilitated possibly by the use of water.

One of the objectives of grinding is to create a working face at one end of the tool that is a sharp edge, the main trait of edge tools. The vast majority of the Makriyalos edge tools have one working face, but a few have acute edges at both ends. In all of these cases, the butt area has been shaped similarly to the active use-face of the tool and thus both parts could have been used to perform similar tasks (AΓ382, 1448, 2146, 5315, 2096, 16318, 8059) (Plate 4.11). It is not always clear whether this was a deliberate choice made during initial manufacture or represents a decision made when the object was already in use. They are small sized tools and it is worth considering whether the use of the butt as an active use-face indicates an attempt to conserve the tool itself and prolong its use or even the raw material these tools were made of (mainly serpentinite). Consistent with this suggestion, the tools exhibit mainly heavy wear and some show evidence of resharpening (AΓ1448, 2146, 2096, 8059). All these cases have been dated to MK I and so might indicate a specific form of edge tool technology practiced – on a small scale- during the first habitation phase and not in MK II.

The manufacture of edge tools was finished with the application of polishing, an abrasive technique that created extremely smooth and often shiny surfaces. As noted earlier, in Makriyalos polishing is attested more often than any other technique and is used for all surfaces of edge tools. When edge tools are divided into sedimentary, metamorphic and igneous rocks, polishing is more extensive in metamorphic and igneous than in sedimentary rocks (though the latter based on a small sample). In sedimentary rocks, polishing does not seem to have been applied equally to all parts of the tool, while grinding appears to have been used more often in this geological category than in the other two (Table 4.30). Furthermore, the treatment of the proximal area (butt) shows that for metamorphic and igneous rocks polishing was the preferred technique and grinding for sedimentary ones. The butt of igneous rocks, however, was modified by pecking and grinding more frequently than that of metamorphic rocks. A chi square test has indicated a highly significant relationship between treatment of the proximal area and geological category (*df*=14, p=0.001) (Table 4.31).

Different degrees of polishing are also attested within the assemblage. Of all edge tools, excluding indeterminate cases, 41% exhibit a high level of polishing and 77% have been well or highly polished, but the degree of polishing varies significantly between rock categories (*df*=6, p=0.000) (Table 4.32). While 46% of metamorphic rocks and 39% of igneous rocks exhibit high polishing, only 12% of sedimentary rocks received a similar level of finishing. When specific rock types are considered, andesite has been highly polished most frequently (58%), while the majority of gabbro, serpentinite, andesite/basalt tools and the unique examples of granodiorite, gneiss, granulite and granite also occur within this category of polishing. Conversely, 50% of marble and 44% of sandstone products are not well polished, even though the few highly polished examples of sandstone edge tools, as well as polished surfaces created on other tool types (e.g., on grinding tools), testify that this type of sandstone could be polished (Table 4.33).

The production of edge tools quite often would finish with the secure adjustment of the tool into a haft (cf. Christopoulou 1994). The recovery of hafts in excavations is quite rare. Stroulia in her discussion of the Franchthi assemblage refers to the recovery of four antler sleeves and suggests that the rarity of these finds in Franchthi implies the use of other materials for haft production such as wood (2003: 14). At Makriyalos, there is both direct and indirect evidence for hafting. One antler sleeve, unearthed with part of a serpentinite tool still inside, provides direct evidence (Plate 4.12) (for other direct evidence for hafted edge tools see Tsountas 1908: 316-317; Moundrea-Agrafioti 1987: 249). The stone part of this composite tool is represented by the butt area whose small size indicates that it was most probably a chisel or a small edge tool (maximum surviving breadth of the tool was 0.7cm and maximum depth 0.5cm).

Indirect evidence for hafting includes AΓ 2456 with a highly polished perforation vertical to the long axis of the tool and penetrating the entire width (Plate 4.13). The surviving dimensions of the perforation are 3.6x2.0x0.78cm. The tool does not survive complete but is broken at the perforation, presumably because this creates a weak point (cf. Prinz 1988: 480). Mace-heads likewise are most found broken in half. Voytek (1990: 451) has argued, however, that this hafting technique would decrease 'the chances of loosening and breakage due to imbalance'. The interior of the perforation is highly polished, resulting possibly from use of binding material such as leather or some kind of adhesive substance, e.g., resin or beeswax (Stroulia 2003) (for the opening of similar perforations see below Section 4.3.4.).

This artefact is of particular importance as previously it had been suggested that Aegean shaft-hole axes were dated to the Bronze Age (e.g., Tsountas 1908: 320):

> *'The opening of a shafting hole in stone axes for affixing the straight handle which passes through the body of the tool gained ground* ***after the middle of the Early Bronze Age,*** *and perhaps constitutes the first indication of a specialised production of polished stone tools. This also has social implications, since certain such axe and mace-heads, of exceptional form and finish, must have been status symbols.'*
>
> (Moundrea-Agrafioti 1992: 175, emphasis added)

The Makriyalos example is dated to the later part of LN (MK II) (Pappa, pers. comm.). The rarity of this edge tool sub-type at Makriyalos and other Neolithic contexts raises questions regarding its provenance. Shaft-hole axes of Neolithic date have also been documented in other Balkan contexts, at Divostin II (Vinča culture) (Prinz 1988) and at Neolithic Selevac (later period of occupation) (Voytek 1990). Two more examples have been attributed to Phase II (5200-4600 BC) of the Sitagroi sequence (Elster 2003), but no examples have been reported from Neolithic sites in Thessaly or southern Greece. Moreover, although the raw material (dolerite) is common in the Makriyalos edge tool assemblage, the absence of other similar examples might imply that this artefact was not produced on-site. It may therefore represent an exchange object of Balkan origin.

Hafting is also indicated by the presence of a pecked surface around the butt area half way up the middle part of the tool body (e.g., AΓ 1441) (Plate 4.14a). This rough surface could have been the result of initial pecking that was never ground down or could be created after the polishing took place (e.g., AΓ1441). In this case, the latter is indicated by the fact that pecking cuts through the polished surface in places and it has been executed very carefully around the area where the polished surface finishes. This surface modification might have been necessary for the tool to fit a new haft. In a few cases hafting was facilitated by small concavities created by pecking near the butt area, on the body and/or on the margins (e.g., AΓ 3892 and AΓ 1529), by small grooves near the butt (e.g., AΓ 2176: 1.9x0.7x0.3cm) (Plate 4.14b,c) or by creating facets in the butt area which would allow secure adjustment of the tool inside the haft, (e.g., AΓ 1307 and AΓ 402). Finally, another hafting method identified at the Makriyalos assemblage is the creation of shallow grooves vertical to the long axis of the tool (e.g., AΓ 2220: 1.4x0.8x0.07cm, AΓ 13314: 2.3x0.4x0.14cm, AΓ 2418: 3.1x0.65x0.1cm, AΓ 4902: 3.2x0.8x0.2cm). The grooves are located on the upper part of the body of the tool and do not extend to the margins. Both ends of the groove have the shape of a reverse V (Λ).

The groove interiors are normally better polished than the rest of the tool surface (Plate 14.4d,e).

Hafting devices were not always used. Instead, edge tools were used with a hammer as is indicated by the presence of irregular and heavy percussive marks on the butt end, which in a few cases extend to the margins and/or the body area near the butt (e.g., ΑΓ 4566, ΑΓ 7335, ΑΓ 13520). Quite often these tools exhibit crushed or heavily damaged use-faces (e.g., ΑΓ 2162, ΑΓ 2163, ΑΓ 8544).

The manufacturing sequence described above shows the different stages followed for the production of edge tools, but this process was on-going as indicated by numerous examples of edge resharpening and tool modification. The same techniques were employed once more with similar objectives to prolong the use life of these artefacts. This is best seen in examples under partial or complete modification. ΑΓ 2086 is an olivine basalt edge tool under complete modification. In places the highly polished surface of the previous tool surface survives. Pecking and flaking have been used for rough shaping of the modified tool. This indicates that pecking and flaking were used in the initial stages of tool production. Numerous examples within the assemblage indicate complete modification of the tool surface by pecking the body and margins of the tools.

A large number of tools have been modified by sawing or resharpening use–faces (Table 4.34). Resharpening of dull use-faces is very frequent and often more than one episode of resharpening is attested on the same tool (e.g., ΑΓ 1486). During resharpening the use-face was pecked or flaked and a bevel was created which was then ground or polished to recreate a sharp edge (e.g., ΑΓ 15248) (Plate 4.15). Quite often use-faces exhibit evidence for resharpening and use wear suggesting that tools were used following maintenance activities (i.e., resharpening).

Sawing has been used either to split tools in half (Plate 4.9), to correct the overall dimensions of the tool (sawn margins) or to repair faults (e.g., ΑΓ 5084 sawn to repair breakage at the cutting edge) (Plate 4.16). Moundrea-Agrafioti (1981) has argued that sawing was applied to soft rocks only. In the Makriyalos assemblage, however, sawing has been applied to all geological categories. Serpentinite has been modified by sawing most frequently (15%), but igneous rocks (7%) and in particular fine-grained ones (9%)

have been modified by sawing relatively frequently as well (Table 4.35) (see also Dradon 1967 for sawing of hard rocks; Beek with Maika Mason 2002 for sawing of jadeite).

### 4.3.3. The production of grinding/abrasive tools

Four manufacturing techniques (pecking, grinding, flaking, polishing -sometimes in combination) have been identified on the body and margins of grinding/abrasive implements, although a large number of implements show no evidence of manufacture (Table 4.36). The vast majority of abraders, polishers, grooved abraders and grinders do not exhibit any manufacturing traces but have been modified only through use (Table 4.37 & Plate 4.5b,c).

Grinding slabs, although natural surfaces are frequent, have been modified on the body and mainly on the margin more often than the previous tool categories. The large number of indeterminate cases recorded (body: n=1077, margins: n=1273) is mainly a product of the fragmentary state in which these tools survive but also due to the fact that the body area represents the use-face that exhibits the most wear and thus most of the time it is not feasible to assess the manufacturing techniques used (if any) (Table 4.38). Similar to grinding slabs from other Aegean sites (cf. Runnels 1981; Stroulia 2005), manufacturing evidence was limited to the preparation of the active use-face by pecking (e.g., AΓ 18778) and the margins and the rest of body was left untreated. In a few cases, natural weathered/waterworn surfaces from the original boulders used to make grinding slabs can be distinguished on the margins or body of tools indicating that the material used for the Makriyalos grinding slabs was not quarried (for a similar suggestion for other prehistoric assemblages see Runnels 1981: 76). These natural boulders were shaped by rough flaking and/or pecking while in some cases grinding was also applied. From experimental work Risch has concluded that very irregular (pecked) grinding use-faces are less efficient ('grain fragments remained trapped in the pits') than a more even use-face levelled with a polishing stone (Risch 2002: 117, Fig. 5.2; Risch 2008).

In terms of morphological characteristics, the vast majority of grinding slabs are of indeterminate shape in plan view and the remainder are mainly irregular or sub-rectangular (Table 4.39). This is not consistent with Runnels' conclusion that ovate grinding slabs dominate in the Greek Neolithic and in particular the later part of the

Neolithic (LN & FN) (Runnels 1981: 101-102). Greater variability is indicated by the transverse section, with irregular, flat and plano-convex sections being most frequent (Table 4.39). The vast majority of grinding slabs have flat use-faces and a small number exhibit concave faces (Table 4.39). AΓ18259 and AΓ19752 exhibit a rim that surrounds the flat use-face and could have prevented the spillage of the ground matter (Plate 4.17) (cf. Elster 2003: 186). No morphological differences have been encountered between the two habitation phases indicating that, similar to edge tools, grinding slabs did not undergo morphological change in the LN. In relation to raw materials, flat use-faces are most frequent in all three geological categories, but concave use-faces are relatively frequent in sedimentary rocks and especially fine sandstone (Table 4.40) (see also Section 5.2.2.).

The Makriyalos grinding slabs (e.g., AΓ 13780, AΓ 18778) exhibit evidence of deliberate rejuvenation of the use-face in the form of shallow pitting that are evenly distributed. The dull surface regained its initial roughness by light pecking (cf. Risch 2008). Ethnographic research has shown that the frequency of maintenance activities varies greatly, from once every few days to once every year, depending on different factors such as texture of raw materials, processing techniques and intensity of use (Horsfall 1987: 341); usually only the use-faces of grinding slabs undergo maintenance whereas grinders remain polished (Risch 2008), a contrast widely encountered in the Makriyalos grinding assemblage as well. For the repecking of lower grinding tools various tools could have been used, for instance old or even broken edge tools or quartz pebbles (Horsfall 1987: 341).

Pecking, grinding and especially polishing were used for the production of pestles (and pestle/hammers), and natural surfaces are extremely rare (Tables 4.38 & 4.41). Conversely, the study of other ground stone assemblages in the Aegean Neolithic suggests that no effort was made to polish the surface of pestles which were shaped mainly by pecking (e.g., Achilleion - Winn and Shimabuku 1989). In morphological terms pestles are sub-rectangular or bell-shaped in plan view with ovate/circular sections and convex use-faces (Table 4.42 & Plate 4.18). No chronological variation is attested. Similar to pestles, mortars have been modified mainly by grinding and polishing (body and margins) and natural surfaces are relatively rare (Table 4.38 & Plate 4.19).

### 4.3.4. The production of percussive tools

More than 90% of hammers have been used without any prior modification (Table 4.43). The rare exceptions may represent tools reused as hammers (and classified as hammers because the original tool type cannot be determined with certainty). Hammers are mainly spherical/ovate in shape, largely reflecting the natural form of the cobbles used (Table 4.44).

Mace-heads, on the other hand, have been extensively modified as indicated by the complete lack of natural surfaces. They have been drilled and mainly ground on the area around the perforation (Table 4.43 & Plate 4.6). The perforation is vertical with a ground or sometimes highly polished interior, while drilling marks can be seen only rarely. The diameter of the perforations increases by 2-5mm from one end to the other (for instance in the case of ΑΓ 897, where the perforation survives intact, the diameter on one opening is 1.7cm and the opposed one 2.0cm). Mace-heads are very consistent in shape being spherical/ovate in plan and transverse section (Table 4.44), whereas mace-heads from other sites such as Knossos (Evans 1964) present greater variation in shape. There are also two examples in the Makriyalos assemblage (ΑΓ 311 & ΑΓ 4987) with flattened ends as if they were meant to be placed on a flat surface.

In relation to raw materials, mace-heads made of 'talc', metamorphic rocks and fossilised shell have received grinding in the area around the perforation while pecking has been recorded only on the surface of one 'talc' mace-head (ΑΓ 4819). Polishing has been employed for the modification of all igneous and sedimentary rocks (Table 4.45) but less intensively than for edge tools (Table 4.46). Only 20% of mace-heads are well or highly polished compared with 77% of edge tools.

The production sequence for mace-heads cannot be reconstructed for Makriyalos as no unfinished examples survive, but, unfinished examples from other sites (e.g., Divostin - Prinz 1988; Servia - Mould *et al.* 2000: 137) indicate the outer surface was worked prior to the drilling of the perforation. Partially drilled perforations also shed light on the type of drills used: hollow (tubular) drills (e.g., Servia and Divostin) or solid drills (e.g., Dimini and Sesklo). No drill-cores have been retrieved during the Makriyalos excavations, possibly indicating that solid drills have been used. With regard to tools used to drill similar perforations on shaft-hole axes, Prinz has suggested a large bird bone might have been employed with the aid of sand (Prinz 1988: 258; also Voytek 1990: 451). Tsountas (1908) has suggested that drilling was variously performed from one or both sides. In the former case, the diameter of the perforation of the two openings differs by a few millimetres. This variation in the diameter of the perforation has also been encountered in the Makriyalos mace-heads, indicating perhaps that the perforation was opened only from one side. This variation, also encountered in the Divostin shaft-hole assemblage, was interpreted as 'an eccentricity in the boring jig' that could have improved though the firmness of the shaft (Prinz 1988: 258). Yet, as this characteristic has been consistently encountered in perforations of both mace-heads and shaft-hole axes from different assemblages, it seems more than a peculiarity and probably relates to the boring method used and/or to the secure adjustment of the haft. The pecked example in the Makriyalos assemblage might represent an unfinished example as usually the body area of mace-heads is ground or polished or perhaps could be a different form of surface finish/decoration (Plate 4.6a).

### 4.3.5. The production of perforators

'Drill bases' (Plate 4.20), drills (Plate 4.21 & 4.22) and indeterminate perforators mainly exhibit natural surfaces. Indeterminate surfaces are also quite frequent due to the presence of sediments on the surface of these objects, but also to the fact that in a few cases it is not clear whether the marks visible relate to manufacture or use. Techniques attested are abrasive techniques, mainly grinding, and percussion, while drilling has been recorded as a possible manufacturing technique for three indeterminate cases. Drills exhibit smooth surfaces which could be a result of use (by holding the tool) as probably in the case of ΑΓ 6555 which is smooth in places, or of intentional grinding (e.g., ΑΓ 7310). In the case of ΑΓ 11917, it appears that the whole body surface is under modification as suggested by repecking overlying previous polishing (Table 4.47). Regarding the relationship between raw materials and manufacturing, as the overall assemblage is rather small (n=55) no coherent suggestions can be made for selection patterns.

### 4.3.6. The production of ornaments

Evidence for the production of ornaments comes mainly from finished objects. Similar to edge tools, the original stages of manufacture are often obliterated by the subsequent smoothing stages (grinding and polishing) (cf. Miller 1997). The principal manufacturing techniques employed are drilling, grinding and polishing (Table 4.48). Drilling is the most frequent technique on the body area, although drilling marks are not always visible on rings. Some possible unfinished rings indicate that the perforation was created at least in some cases by pecking (Plate 4.7). The central perforations of rings are very frequently ground or polished, an attempt to erase the irregularities created during drilling/pecking (similar attempts are encountered on edge tools when erasing sawing marks). The majority of beads and pendants have been polished, though the latter show more diversity in the techniques used for the rest of their surface. Rings were mainly smoothed by grinding (Table 4.49). Beads received a higher degree of polishing than pendants and rings, although only two beads and one pendant out of 125 ornaments were highly polished. In terms of raw material treatment, all rocks used in ornament production tend to be smoothed, but marble objects tend to be ground and serpentinite polished (albeit based on a small sample).

Drilling served a functional purpose (creating a hole and thus allowing suspension of the artefact), while abrasive techniques and in particular polishing were used as a means of decorating the artefacts by highlighting the colour properties of the raw materials used. It is also interesting, however, that the polished ornaments (mainly beads) are mostly well rather than highly polished, but this could be a result of the difficulty of polishing such small specimens.

### 4.3.7. Multiple-use tools

Within this category, a variety of tool types has been recorded. Most types do not show any manufacturing evidence in the body and margin and thus represents *outils a posteriori*.

## 4.3.8. Miscellaneous category

### *4.3.8.1. Weights*

These artefacts have received minimum modification as indicated by the large percentage of natural surfaces on the body (84%). On the margins, notches have been created mainly by pecking (65%) and less frequently by flaking (19%) (Table 4.50). Weights are mainly ovate in plan view and ovate/spherical in transverse section, reflecting the natural form of pebbles and cobbles used and so contradicting the view of Mould *et al.* (2000: 163) that these weights 'were probably quite labour-intensive to produce and therefore valuable'. Instead they seem to represent artefacts of a rather crude technology (Plate 4.23). No chronological variation in manufacturing techniques can be determined.

### *4.3.8.2. Retouched tools*

A small number of retouched flakes (n=13) were recovered, falling into two groups. The first group of five specimens (four of which are of serpentinite) retain the natural surface in their body area, but have retouched margins (ΑΓ 2165 also exhibits very limited polishing on the dorsal and ventral surface). These specimens seem to be flakes derived from the initial shaping of nodules (cobbles/pebbles) still retaining the weathered surface (primary manufacture).

The second group of eight specimens (mainly of serpentinite and igneous rocks) again have margins modified by retouch (perhaps edge damage in one case), but also bear traces of body modification: mainly polishing (63%), but also flaking, pecking and polishing, and pecking and grinding. This second group seems to be derived from a later stage of the manufacturing sequence (modification/refashioning stage), and mainly from polished edge tools, as is indicated by partially surviving cutting edges and/or margins (Plate 4.24a).

In both groups, the deliberate secondary modification (retouch) of these flakes is interesting, given the wealth of chipped stone tools from Makriyalos (Skourtopoulou 1999, 2006). This modification indicates an attempt to prolong the usefulness of raw materials in another context (for a discussion on raw material economy see also Voytek

1990 – Selevac where she discusses how the investment of labour into ground stone acquisition and production activities would have been more likely to provide long term usage of the tool material). These rather rare instances could, however, indicate an attempt to cover immediate needs, but that is rather unconvincing considering that local flint was available and it would flake better in relation to serpentinite and other igneous rocks. Therefore it is hard to imagine in functional terms why it would be necessary to utilise flakes from serpentinite when flint was readily available.

#### *4.3.8.3. Chipped stone cores*

Two cores have been recorded that relate to chipped stone technology. They are both made of quartz and show evidence of flaking. Both cores represent reused tools. One of the platforms of ΑΓ 8646 has been reused for grinding and ΑΓ 8654 was reused as a hammer.

#### *4.3.8.4. Pitted/Cupped stones*

The artefacts of this category have one or two opposed depressions (cupules) created by percussion, while the rest of the surface is natural.

### 4.3.9. Assessing the locus of production

With regard to the production of ground stone, two important questions need to be addressed: a) whether there is on-site production of any of the tool types encountered in the assemblage, and b) if so, what is its scale and character (e.g., small-scale, large–scale, domestic/specialised). With regard to ground stone production/edge tool production, Perlès (2001: 233) has argued that 'the manufacturing processes leave little in the way of archaeological signatures, unlike the shaping of chipped flint axes. Consequently, the extent of local manufacture is unclear'. Products from different stages of working (cores/nodules, waste by-products, end products) do appear in the Makriyalos assemblage but the majority of objects are finished products and those derived from earlier stages of the manufacturing process are much fewer.

The frequency of debitage products within the ground stone assemblage, however, is not necessarily representative of the actual population of such objects. Recovery conditions during excavation and identification issues should be taken into account as tools are more easily recognisable than un-worked nodules, while some flakes may have been included within the chipped stone assemblage[5], in particular those that have distinctive flake characteristics (e.g., a well defined bulb) or have retouched edges. Failure by excavators to identify and systematically collect debitage and products that relate to different stages of the manufacturing sequence clearly impedes our understanding of the *chaine opératoire* of ground stone technology.

Furthermore, as shown previously, some tool types (e.g., abraders, grinders, hammers) do not bear any evidence of deliberate modification prior to use and thus represent '*outils a posteriori*' (Jelinek 1976: 26; Wright 1992a: 57, fn 38), while others (i.e., edge tools, mace-heads, grinding slabs, pestles, mortars, weights, retouched tools, and ornaments) are the products of a formalised production sequence and thus can be classified into formal tool categories. All these objects have been deliberately modified to acquire their specific shape and surface finish and to function in specific activities.

To address the issue of on-site production, therefore, formal tool types must be seen in relation to working debitage. For the sake of clarity the different categories will be addressed separately. The relationship between finished tools and products of earlier stages of the manufacturing sequence will be addressed at two levels: a) by exploring the relationship of raw materials attested in either category, and b) by comparing the metrical dimensions of the different products.

#### *4.3.9.1. Edge tools*

With regard to edge tool production, Perlès (2001: 233) has argued that it is not clear whether specialised axe production took place in the Greek Neolithic. 'Specialised production would have entailed the exploitation of primary sources of raw material, a high output and wide trade networks' (Perlès 2001: 233). She has suggested that the limited needs for axes were covered within the limits of domestic production.

<u>Raw Materials</u>

The raw materials encountered in finished edge tools and debitage are broadly the same. Metamorphic and igneous rocks occur most frequently in each case (edge tools: 50% &

[5] For instance, during the analysis of the MK II chipped stone assemblage by K. Skourtopoulou *c.* 30 flakes from the production of ground stone artefacts were identified (K. Skourtopoulou, pers. comm.).

49% respectively; debitage: 42% & 40% respectively). In particular, serpentinite, the most common rock used for edge tools, is well represented in the debitage assemblage, while fine grained igneous rocks also appear quite frequently in both categories. Dolerite, the second most common rock type employed for edge tools (13%), however, and other coarser grained varieties of igneous rocks, occur rarely in the debitage assemblage (Table 4.51). In the case of marble, a number of marble pebbles and cobbles with no evidence of working have not been incorporated in this analysis since they could have been brought into the site either for tool use or for construction of architectural elements (e.g., paved floors). Serpentinite is the only rock type that appears in almost all types of debitage (nodules, waste-by products).

The correspondence in raw materials between finished products and debitage needs to be examined further by considering the dimensions of these objects.

Dimensions

To establish the relationship between debitage and finished products, only raw materials encountered in both categories have been taken into consideration. When all nodules (including possible nodules) and cores are compared with finished tools, an interesting contrast emerges (Figure 4.4). The weight distribution of edge tools and debitage based on 1691 objects in total shows that the vast majority of implements weigh less than 130g (87%). Within the debitage, however, 33% is heavier than 130g in comparison to 12% of edge tools. As seen in Figure 4.4 at the highest end of the distribution the highest peaks occur in the debitage category, which contrasts sharply with the distribution of finished products. This difference is consistent with these nodules representing raw material intended for the manufacture of edge tools of the range and size represented by the excavated assemblage, given that the finished products would weigh less than the un-worked raw materials.

Figure 4.4 includes both complete and incomplete specimens. Excluding of incomplete specimens reduces the sample radically to 147[6] tools and only 15 nodules. The mean weight of complete nodules (74g) is higher than that of complete finished tools (44g), however, and a Mann-Whitney test indicates that the difference between the two mean

[6] Within the edge tool assemblage reused implements were not included.

is significant (Table 4.52). The mean length, breadth and depth are likewise greater for nodules than finished edge tools and the same holds when the tools are broken down into axes, adzes and chisels (Table 4.52). The size of these nodules is thus consistent with their use in edge tool manufacture.

More meaningful results could be attained by comparing specimens of serpentinite, the most common rock type in both edge tools and nodules/cores. The average dimensions of complete objects indicate that the dimensions of nodules (n=3) are always higher than the finished products (n=76) (Table 4.53). This picture remains the same when the finished products are broken down into axes, adzes and chisels. Yet, the size of the nodule sample is extremely small for meaningful analysis. When both complete and incomplete implements are examined, it occurs that the majority of the material weighs less than 140g (84% for nodules and 93% for edge tools). Yet, 16% of serpentinite nodules weigh more than 140g in relation to 7% of finished products (Figure 4.5). Taking all of the above into account, it could be suggested that, although the sample size of serpentinite nodules is rather small, the overall dimensions of serpentinite objects could support an argument for serpentinite edge tool production from the un-worked material. This argument could be further supported by the presence of other forms of debitage such as serpentinite flakes and waste by-products.

Therefore, the size distribution of un-worked nodules of the rocks used to make edge tools, in conjunction to the presence of semi-finished implements and implements that are under complete modification, suggests that edge tool production was practiced locally at Makriyalos and that all different stages of the production sequence took place on-site. Considering, however, the length of occupation of the Makriyalos settlement (ca. 800 years), the quantities of debitage unearthed are very small to support specialised production and thus point towards small-scale production activities organised by small groups (households).

#### *4.3.9.2. Ornaments*

Raw Materials

Serpentinite is very commonly encountered in both ornaments and nodules/cores. Igneous rocks, though very frequent in nodules/cores, are almost completely absent from the ornament assemblage. Marble was widely used for ornament production. Un-worked marble cobbles/pebbles were collected during the excavation but have not been included in this analysis (see above). In some cases, however, the quality of marble used for the production of ornaments differs from the quality of the un-worked marble pebbles/cobbles unearthed and thus the latter might not have been employed in ornament manufacture (Table 4.54).

Dimensions

Raw materials attested in both finished products and debitage were selected, with the exception of marble. All finished products weigh less than 20gr, whereas only 27% of the debitage weighs under 20gr (Figure 4.6). The weight distribution thus again indicates that the un-worked material could have been used for the production of ornaments. This point may be further explored by examining raw materials that have been used extensively in the manufacture of ornaments. Serpentinite, as seen previously, is encountered in different types of debitage, but also represents the most common material for bead making (49%). Once again all finished products weigh much less than the un-worked serpentinite material (Figure 4.7).

Bearing all these in mind it could be suggested that the overall dimensions of the un-worked material or at least of certain rock types would permit its use in the production of such implements. To this end possible semi-finished objects that might represent ornaments in the process of manufacture need to be considered (e.g., AΓ 17750). Other forms of debitage such as cores and waste by-products, however, most likely relate to the manufacturing sequence of edge tools and not to other types of implements such as beads. This is mainly implied by the presence of sawing on cores and waste by-products, a manufacturing technique solely attested on edge tools.

#### *4.3.9.3. Pestles*

Raw Materials

Igneous (in particular fine-grained) rocks are well represented in pestles (including pestle/hammers) and nodules/cores (Table 4.55).

Dimensions

As previously, only raw materials that have been attested in both finished products and debitage were considered when comparing the two categories. In this case, the weight distribution of all implements (n=118) indicates that finished products tend to weigh more than un-worked material (Figure 4.8). The highest peaks for nodules occur in the categories of 0-50g (mainly below 30g) and 101-150g, whereas the highest peaks for pestles occur in the categories 51-100g and 101-150g. When only complete pestles and nodules/cores are considered, the mean weight of nodules seems to be slightly higher than that of pestles, but the sample of nodules is small and the standard deviation large indicating that the mean is not an accurate representation of the data. In fact, of the five complete nodules four weigh less than 120g, while the weight of complete pestles ranges between 135g to 370g (Table 4.56 & Figure 4.9). The dimensions of pestles do not correspond well with those of nodules, therefore, as the finished products tend to be heavier and larger.

This lack of correspondence between finished products and debitage is further supported when only specimens of igneous rocks (the most common geological category for pestles) are considered. When the complete dimensions of these implements are considered, it is obvious that the overall dimensions of tools are always higher than those of nodules/cores (Table 4.57). This picture remains the same when both complete and incomplete cases are examined (Table 4.58). Bearing this into account, it could be suggested that the un-worked igneous material and igneous pestles do not seem to be part of the same production sequence.

#### *4.3.9.4. Grinding slabs*

Raw Materials

Sandstone with tightly cemented grains, the rock most frequently used for grinding slabs, is relatively frequent within nodule/cores. A large number of other rock categories occur in both finished products and debitage, indicating that the raw materials of finished products and debitage correspond to a certain extent (Table 4.59). On the other hand, schist and gneiss, although common in grinding slabs, are not well represented in the un-worked material.

Dimensions

To compare dimensions of finished products and debitage, only rock types occurring in both categories were included. Complete grinding slabs are heavier than complete and incomplete nodules/cores, with almost no overlapping distribution (Figure 4.10). This suggestion is further supported by the comparison of mean length, breadth and depth values (Table 4.60).

The lack of correspondence between the overall dimensions of finished products and debitage, although based on a small sample, indicates that these do not represent products of the same reduction sequence. In addition, with the exception of one possible un-worked sandstone boulder (ΑΓ 10440), no waste by-products that relate to the shaping of boulders for the manufacture of grinding slabs have been found on-site. Yet, numerous examples indicate that maintenance of grinding slabs (repecking of use-faces) had taken place on-site. Bearing this in mind it could be suggested that the initial stages of grinding slab manufacture (shaping of boulders) took place away from the site (at the collection site/quarry?) and grinding slabs reach the site mainly as finished or potentially semi-finished products, while maintenance of these tools did take place on-site. Potentially, the possible un-worked boulder might indicate that, contrary to common practice, in some occasions un-worked material was brought back to the site.

### *4.3.9.5. Mace-heads*

Raw Materials

Raw material occurrence in mace-heads does not correspond greatly to raw materials encountered in nodules/cores, as 'talc', the most commonly used raw material for mace-heads does not occur in an un-worked state. Some of the raw materials used for mace-heads, however, appear on-site in an un-worked state and thus potentially might have been used in the manufacture of mace-heads (Table 4.61).

Dimensions

When examining the weight distribution of raw materials encountered in both categories it occurs that the distribution of un-worked material is more spread and the highest peak is in the category 51-100g, while the highest peak in the distribution of mace-heads (n=8) is in the category 151-200g. Yet, at the highest end of the distribution (above

250g) only un-worked material is encountered (Figure 4.11), which might have been employed in mace-head production. When the mean breadth and depth of finished products is considered, however, it occurs that finished products are larger than the un-worked material, indicating that they do not relate to the same production sequence (Table 4.62). In addition, no waste by-products such as drill cores from the production of mace-heads have been recovered during the Makriyalos excavation. Yet, the absence of drill cores might indicate that hollow-drills were not used in Makriyalos.

#### *4.3.9.6. Weights, retouched tools & mortars*

As seen above, the production of weights did not require much effort and could have easily been executed on-site. Marble cobbles were brought back to the site for different activities (e.g., paved floors, grinders) so raw material was available for making these artefacts. In fact, a possible unfinished marble example (ΑΓ 11792) has been recorded. Similar to weights, retouched tools are irregularly retouched flakes that could have easily been knapped on-site as needs arose.

In the case of mortars, although no waste by-products that relate to the manufacture of mortars have been found on-site, marble, the main material used, would have been available on-site and thus marble cobbles could have been used in the production of this tool type. Some mortars, however, may have entered Makriyalos as finished products considering that in some cases the quality of material and the quality of working (e.g., double mortar) differs from examples made from locally available cobbles (Plates 4.19 & 4.25).

## 4.4. Conclusions

This chapter has presented the results of the Makriyalos ground stone assemblage and focused on raw material selection and the production sequences of the different object categories. The Makriyalos ground stone assemblage is characterised by a wide range of rock types. As illustrated by the geological maps the high frequency of metamorphic and sedimentary rocks within the Makriyalos assemblage reflects to a great extent the character of the regional geology. Igneous rocks and in particular fine-grained varieties, however, although well represented in the Makriyalos assemblage, indicate raw materials whose sources are not so widely available and their procurement might be linked to different strategies.

The distribution of geological categories between different tool types, however, is not even. Rather, certain raw materials were favoured for the production of specific tool types in the Makriyalos ground stone assemblage e.g., igneous rocks for edge tools and pestles and sandstone with tightly cemented grains for grinding slabs. The abrasive qualities of sandstone were particularly valued for grinding tools (grinding slabs, abraders), while the strength and compact character of igneous rocks seem well fitted for their use in edge tools. Furthermore, it could be suggested that same selectivity patterns are evidenced in both phases of habitation (raw material standardisation), although the frequency of use of certain rocks such as basalt and gneiss differs greatly between the MK I and II.

Within the Makriyalos assemblage many tool types seem to have been used in an *ad hoc* fashion with minimal or no prior modification. These tool types contrast greatly with other tool categories such as edge tools and pestles that represent tools of a formalised production sequence requiring a considerable investment of time in their manufacture. The comparison of debitage with finished products indicates that different production sequences existed. It was suggested that all stages of edge tool production took place on-site whereas in the case of grinding slabs mainly the later stages of modification were performed in Makriyalos. Pestles, however, do not seem to relate to un-worked material unearthed during excavation.

The following chapter focuses on the next stages of the use-life of these objects and investigates patterns of their use and final discard and it concludes with a discussion that brings to light the whole biography of these objects, from raw material selection to use and final deposition.

*CHAPTER FIVE*

# *The Chaîne Opératoire of the Makriyalos Ground Stone Assemblage: Patterns of Consumption and Discard*

## 5.1. Introduction

Traditions of raw material use and manufacture are inextricably linked to consumption practices and discard mechanisms. The meaning(s) attached to technological practices and their products are negotiated through the choices made during the use and final deposition of these artefacts. Therefore, it is of great importance to look into the consumption and discard practices of ground stone in order to elucidate the meaning ground stone technology and its products held for the Neolithic community of Makriyalos. This chapter will investigate patterns of consumption and discard as seen through the analysis of the objects themselves. This chapter concludes with a discussion of the key elements of ground stone technology (incorporating the results reached in Chapter 4) and the choices reflected in the different stages of their biography -from raw material selection, through manufacture, use and final deposition- will be presented.

## 5.2. The consumption of the Makriyalos ground stone assemblage

### 5.2.1. Edge tools

The vast majority of edge tools have one use-face located at one end of the tool and only 0.4% of edge tools have two opposed ones. The frequency of convex, straight and lopsided use-faces is very similar overall, but there is a highly significant relationship between type of use-face and edge tool subtype (*df*=6, p=0.002) (Table 5.1). For axes the preferred use-faces are straight and convex, for chisels straight and lopsided, and for adzes straight, convex and lopsided.

Edge tools could have been employed for a wide range of tasks, ranging from woodworking and craft making to butchering meat and clearing land and, have often been regarded as an 'all-purpose tool' (R and S. Bulmer 1964 quoted in Strathern 1969: 314). Variability in the shape of the use-face, therefore, may also indicate some differentiation in the tasks each type was employed for.

According to Stroulia (2003: 19), convex use-faces might relate to the use of cobbles/pebbles for edge tool production. In addition, convex use–faces 'offered a significant technical advantage, since an angular connection of the working edge to the sides of the celt could have created fatal points of stress during use' (Stroulia 2003: 19). Lopsided faces might relate to partial modification of the use-face where damage has occurred by resharpening (Stroulia 2003: 21). In some cases, however, the lopsidedness of use-faces might relate to use e.g., tools used against plants (shrubbery) with the edge placed parallel to the plants (M. Edmonds, pers. comm.). In the Makriyalos assemblage some tools exhibit one face that is flat and the other curved (turning inwards). As seen for instance on AG 15166, this represents a conscious manufacturing choice as the curved edge was created by resharpening and thus modifying substantially the angle of the original use-face (Plate 5.1). Thus this type of use-face might have been useful for certain tasks. In other cases, use-faces have been shaped in such a way as to become pointed (e.g., AG 1954) possibly indicating use in a drilling/perforating activity such as shell ornament manufacture (Plate 5.2).

Wear on edge tools was not recorded as an attribute but information about the type of wear was recorded in the notes taken for each artefact. Thus it is not possible to quantify the frequency of different types of wear on edge tools, although some qualitative and semi-quantitative observations can be made. It should be noted that the identification of wear is based on macroscopic analysis, aided with a hand lens or microscope (Leica x40) when needed.

One of the common types of wear on the use-face of edge tools is *chipping*, which ranges from light (e.g., AG 11974, 3397, 5082, 5224, 1954), and in some cases seen only under a microscope (e.g., AG 4824), to very heavy (e.g., AG 4716, 5110, 8543, 15191, 5318, 8543, 15072, 2305, 5283) (Plate 5.3). In addition, chipping might be unifacial or bifacial (e.g., AG 13501, 8604) and extend over the whole cutting edge or only part of it (e.g., AG 4643, 4707 - heavily chipped in the middle part of the edge; AG 6835 – chipped in places; AG 4669- chipped in centre of edge; AG 2253- half of cutting edge chipped), indicating that 'different parts of the edge were at different times exposed to the resistance of the worked material' (Stroulia 2003: 22). In a few cases chipping is very regular and the edge becomes *denticulated/serrated* (e.g., AG 6556, 4822, 5322, 2103- bifacial). This may represent a manufacturing trait, however, and not the end result of use, as serrated edges might have been useful for processing animal products (e.g., cutting meat) (Stroulia 2003). The other common type of wear seen on the edges of these tools is a *ground* edge that has become blunt through use and occasionally exhibits some light percussive wear (pitting) (e.g., AG 2136). Hayden (1987: 96-97) suggested that celts could have been used for the repecking of worn out grinding use-faces. Such a use would result in a blunt cutting edge (rounded and battered cutting edges) (Hayden 1987: 97, 100). Other possible uses that could result in a blunt edge are hide-dressing, scraping, or pottery burnishing (Stroulia 2003).

Occasionally, the edge is *flattened* (a very narrow flat zone is created on the edge) with (e.g., AG 6578) or without chipping (e.g., AG 2438, 231, 5282, 16324). Another type of wear seen on these tools is *damage on one or both corners* of the active edge (e.g., AG 6582, 1950, 1953, 2027, 6579, 6652 (both), 8495 (one)). A few examples have deep unifacial (e.g., AG 1827) or bifacial (e.g., AG 2223) *striations* (long or short) on the use-face (e.g. AG 3414, 2223, 1827, 881). These striations are clearly distinguished, mainly by their depth, from striations created by grinding/polishing. Finally, a few tools retain a *sharp* edge that could have been used. Most of these cases show evidence for resharpening indicating that these tools were in fact modified and curated for further use that, for some reason, did not take place.

Among tools that retain part of the use-face, 72% exhibit heavily used or worn out use-faces and only 4% use-faces with light wear (Table 5.2). The state of preservation of edge tools (excluding reused cases) points in a similar direction, with 50% exhibiting crushed/completely destroyed bits, 26% damaged bits and only 24% use-faces that survive complete (Table 5.3). A very similar picture is encountered on the butt end of the tools, 54% of which are crushed/completely destroyed, 21% damaged and only 26% intact. The state of preservation of these tools thus indicates extensive use in tasks that required heavy impact force.

The analysis has indicated a highly significant relationship between degree of wear and tool type (*df*=6, p=0.000). Heavy wear is frequent in all three types but chisels have light and moderate wear more often (43%) than axes (16%) and adzes (25%), while worn-out faces are more frequent in axes (37%) and adzes (29%) than chisels (16%) (Table 5.4). Chisels, thus, seem to have been used in lighter tasks. Chisels also retain their use-faces intact more often than axes and adzes in which damaged use-faces are much more frequent, suggesting that damage to bits and butts took place at least partly during use, rather than in deliberate breaking of the tool (Table 5.5).

It has been argued that the function of edge tools depends on their size and in particular their length (e.g., Moundrea-Agrafioti 1981; Sugaya 1992; Cooney and Mandal 1998: 39; Alisoy 2002b; Stroulia 2003) and on this basis, tools of small or exceptionally large size have been labelled symbolic or non-functional (cf. Skeates 1995).

The 337 Makriyalos edge tools with complete length range from 1.8cm to 14.4cm, with an average length of 4.9cm ($\sigma$ = 1.88) (Figure 5.1). 51% of the tools have a length between 3cm and 5cm, and only 1% of tools are longer than 10cm. Edge tools with complete width range from 0.6 to 6.9cm with a mean value of 3.5cm ($\sigma$ = 1.12) (Figure 5.2). Tools with complete thickness range from 0.3 to 5.2cm with an average thickness of 2.1cm ($\sigma$ = 0.88) (Figure 5.3). According to Moundrea-Agrafioti's size classification system (length: short = <4; medium = 4-8cm; long = >8cm) (Moundrea-Agrafioti 1981: 199-200), the Makriyalos assemblage falls mainly into the medium category (57%), followed by the short category (36%) and the long (7%). Overall these figures are comparable with those given for the length of edge tools in other Neolithic Aegean sites (Table 5.6). Notable exceptions from prehistoric Greece are a diabase axe from Anemodouri, Peloponnese, that measures 27.8cm in length and weighs more than 1.5 kg, a serpentine axe from Nea Nikomedia that is 27.5cm long, and a few others that measure between 15 and 20 cm (Sugaya 1992: 72, fn 3; Mould *et al.* 2000). Overall, Aegean stone edge tools have a relatively small size, especially when compared with their Northern European counterparts (cf. Edmonds 1995).

In the Makriyalos assemblage large edge tools seem to have been used more heavily than small ones: 55% of tools of 2-4cm long are heavily used or worn out, rising to 69% of tools 4-6cm long, 86% of 6-8cm long and 84% of a small sample 8-10cm long. Conversely, light and moderate wear is 14-16% among tools 6-10cm long, rising to 45% of those 2-4cm long (Table 5.7). This trend is further reinforced by considering broken tools. While only 41% of the 337 complete edge tools are more than 5cm long, 47% of the 829 tools of incomplete length (but complete width) are more than 5cm long. This latter figure of course underestimates the proportion of broken tools that was originally more than 5cm long. Big tools clearly tend to break more often than smaller tools and so were presumably used in heavier tasks requiring greater impact force.

It is also interesting to examine the correlation between degree of wear and surface treatment. As seen previously (Section 4.3.2) polishing is the most frequent technique for the modification of all parts of edge tools. It has been suggested that a high degree of polishing could reflect the non-functional character of tools (e.g., Strasser and Fassoulas 2003-2004), but the Makriyalos edge tools were evidently used on a regular basis to perform practical tasks. When the relationship between degree of wear and degree of polishing is examined (Table 5.8), 75% of highly polished tools exhibit heavily used or worn out use-faces and so are by no means non-functional 'symbolic' tools.

Another important issue to explore is whether different raw materials have been employed for tasks of a different character. One way to address this is by looking at the size and in particular the length of different rock categories. A comparison between the dimensions of metamorphic edge tools with the overall length results shows that the former with a mean length of 4.331 ($\sigma$ =1.58) are in general shorter. The longest tool is 10.2cm long. Yet, the presence of tools with incomplete length above 11cm indicates that longer metamorphic edge tools have existed. Similar, the width of complete metamorphic tools ranges from 0.6 to 6.0 (mean width: 3.049, $\sigma$ = 1.1788), but incomplete cases with larger width indicate that wider metamorphic tools were also available. Igneous axes tend to be bigger than the average dimensions (mean length: 6.117cm $\sigma$= 0.1988; mean width: 3.933cm $\sigma$= 0.8578; mean thickness: 2.472 $\sigma$= 0.7636). One suggestion for the difference in the average length of igneous and metamorphic edge tools might be the fact that metamorphic rocks have been used extensively for chisels which tend to be smaller in relation to axes and adzes and this would obscure the length distribution of metamorphic edge tools. Among adzes with complete length, igneous specimens are significantly larger than metamorphic adzes (Table 5.9). But does difference in size indicate also different use?

This issue could be further explored by looking at the relation between raw materials and degree of wear. Metamorphic adzes are more often lightly or moderately used and igneous tools more often worn out. A chi-square test was performed indicating a significant relationship between degree of wear and geological category ($df$=6, $p$=0.002) (Table 5.10). Similarly, metamorphic adzes more often retain intact use-faces and igneous ones more often exhibit crushed/completely destroyed use-faces (Table 5.11). Hence, adzes of igneous rocks were apparently used more often for tasks that required heavy impact force, although destroyed use-faces and a large proportion of heavily used metamorphic adzes indicate that percussive tasks were not accomplished exclusively with the toughest materials available.

When the degree of wear of edge tools is seen in chronological terms, although in both phases tools with heavily used use-faces are more common, tools attributed to MK I show worn out use-faces more frequently (Table 5.12).

As suggested in Section 4.3.2, edge tools frequently underwent maintenance activities to repair dull/heavily used use-faces and thus prolong the use-life of these tools. Stroulia (2003) in her discussion of the edge tool assemblage from Franchthi suggested that the small size of tools represents a manufacturing choice rather than the result of intensive resharpening. Moreover, she suggested that large celts do not show much evidence for resharpening and concluded that small celts do not represent a later stage in the use-life of initially larger celts. She based this conclusion mainly on the highly significant correlations between dimensions which she considered to indicate that resharpening was not intensive enough to alter significantly the proportions of the tools (Stroulia 2003: 16, 18).

There is abundant evidence for resharpening larger edge tools in the Makriyalos assemblage: of 136 tools with complete length above 4.6cm 67% have been resharpened and 6% have been modified by sawing and resharpening. For tools longer than 8cm (n=17), 71% have been resharpened. Yet, there are highly significant correlations between the length, width and thickness of edge tools (Table 5.13) which, according to Stroulia (2003: 16), indicate that '*resharpening was not practised intensively enough to have a dramatic impact on the proportions of these tools*'. The proportions of the Makriyalos tools were also frequently modified, however, by sawing the tool lengthwise on one or both margins and thus reducing the width. Moreover, the number of tools modified by sawing is underestimated as sawing traces have frequently been erased by regrinding/repolishing the margins. Indeed sawing could have been used to 'correct' the proportions of tools shortened by resharpening. Therefore, it is not possible to determine the extent of resharpening and use by solely considering the dimensions of artefacts.

Finally, a number of edge tools show pounding marks on the bit resulting from their reuse as hammers, or have heavily abraded use-faces through their reuse as pestles or pestles/hammers (e.g., AG 6748, 8479). An uncommon but interesting form of reuse is seen in the case of three edge tools (AG 5158, AG 2173 and AG 5223) which have been reused as grooved abraders. AG 5223 is an igneous edge tool – originally probably an adze- with a missing edge and damaged butt area, exhibiting a wide groove (5.2x1.5x0.2cm surviving dimensions) along its long axis formed during its reuse as a grooved abrader. The interior of the groove is well polished, with visible striations along the long axis and was possibly used for polishing bones tools (Plate 5.4). The area where the original use-face was (i.e., cutting edge) shows evidence for resharpening, while the tool also bears evidence for burning. Thus, this tool seems to have had a rather long history with a series of different episodes of use, maintenance, reuse prior to its final deposition and subsequent removal from circulation. Finally, an another interesting aspect attested in the reuse of edge tools is flakes that have been struck from edge tools whose margins were retouched in order to be used possibly in tasks similar those that chipped stone were used for (see also Section 4.3.8 & Plate 4.24a).

To sum up, edge tools of varying sizes were used extensively as indicated by the heavily used and worn out use-faces; use-faces with light wear are very rare (2.0%). Chisels were employed in lighter tasks than axes and adzes. Although tools made of different rock categories were used heavily, igneous rocks more frequently exhibit evidence for use in tasks requiring heavy impact force.

### 5.2.2. Grinding/Abrasive tools

Grinding/abrasive tools were employed either as active tools for grinding other tools/surfaces (e.g., grinders) or in a passive manner for grinding substances and/or other objects on their use-faces (e.g., grinding slabs), but, the distinction between different categories is not always clear-cut.

#### *5.2.2.1. Grinding Slabs*

The Makriyalos grinding slabs are almost equally divided between those with one use-face and those that exhibit wear on multiple faces, mainly on two opposed use-faces (Table 5.14). The frequency of tools with one use-face, however, is exaggerated by the fragmentary character of the assemblage and the frequency of tools with two opposed use-faces increases substantially to 74%, when only specimens with complete thickness are selected.

The presence of multiple use-faces on grinding slabs may suggest extensive use. When only grinding slabs with two opposed use-faces are considered, however, it occurs that similar wear patterns are evident on either use-face (Table 5.15). This may suggest that the grinding slabs were manufactured with two use-faces from the beginning of their use-life and their users used both faces to a similar extent and did not start using the second use-face after the first was worn out. This might indicate that the different working faces of the grinding slabs were used for processing different materials/substances that did not create massively different wear patterns on the use-faces or for grinding grains to varying degrees of coarseness (cf. Elster 2003: 186). This is consistent with differences in the shape (use-faces with different morphology e.g., flat and concave) or treatment of use-faces: for example on AG 14332, one use-face is completely polished and could have been used as a *polissoir* while the opposed use-face has been pecked.

The number of use-faces encountered on grinding slabs varies between geological categories. Sedimentary and igneous rocks (though the later based on a small sample) exhibit single use-faces twice as frequently, whilst metamorphic rocks exhibit multiple use-faces more frequently. A chi-square test has indicated a highly significant result ($df$=2, p=0.000) (Table 5.16). This is also consistent with the degree of wear exhibited by different geological categories. All raw materials were used extensively, but sedimentary rocks exhibit moderate wear more frequently whilst igneous and metamorphic rocks indicate more intensive use ($df$=6, p=0.000) (Table 5.17 & Figure 5.4). Igneous and metamorphic rocks were also repecked more frequently than sedimentary ones (Table 5.18).

In addition, there seems to be a relationship between the shape of the use-face and raw material use (Table 5.19). Although flat use-faces are most common among all geological categories, concave use-faces occur more frequently in sedimentary rocks and in particular fine-grained sandstone. The Monte Carlo chi-square test has indicated a significant relationship between the two variables ($df$=*12*, p=0.000). This might indicate that grinding slabs of different raw materials were preferred for different activities.

No temporal variation was encountered in the number and shape of use-faces, but, similar to edge tools (see above), grinding slabs with worn-out use-faces are significantly more frequent in MK I (42%) than MK II (29%) ($df$=3, p=0.000) (Table 5.20). Consistent with this contrast, the frequency of repecking on grinding slabs is significantly and substantially higher for MK I than MK II ($df$=1, p=0.000) (Table 5.21).

Regarding the purposes for which they were used for, grinding slabs have traditionally been linked to the processing of cereals and other food substances (cf. Runnels 1981; Dubreuil 2004: 1613), but this is by no means their only function. Grinding slabs could have been used to grind a variety of substances. Ethnographic research indicates use in grinding substances such as maize, coffee, salt, calcite, roasted beans, herbs, pigments for pottery making, 'acorns, pine nuts, roots, tubers, fruits, beans, bark' (Horsfall 1987; Wright 1994: 241). Dubreuil's experimental work has shown that the processing of different substances (e.g., ochre, oily vegetables, cereals and meat) produces distinct wear patterns on the use-faces of these tools (Dubreuil 2004: 1616). Her study of Natufian assemblages suggested that grinding tools were used for plant (legumes, cereals) and mineral processing. The function of grinding slabs may thus be inferred from their size, wear patterns, and their recovery context while ethnographic accounts may provide an insight into the possible activities such tools may have been used for (Runnels 1981; cf. Miller 2002).

With regards the size of grindings slabs and their possible function, Risch (2008) has suggested that an adequate use-face for efficient grain processing should measure more than 250cm$^2$. The length of the complete Makriyalos lower grinding tools ranges from 19.8cm to 32.0 and their width from 11.0 to 19.5 (Table 5.22a). The presence of incomplete tools with bigger dimensions (e.g., maximum recorded length: 35.3cm and maximum recorded width: 24.0cm) suggests that slightly larger grinding slabs were also available. The surface area of the complete Makriyalos grinding slabs varies between just over 200cm$^2$ and less than 600cm$^2$ but examples with complete width and incomplete length equal or above 15cm suggest that tools with larger surface areas may have also existed (e.g., AΓ 18415) (Table 5.22b, c). This indicates that these tools could have been employed in the processing of foodstuffs and in particular cereals, but grinding slabs of different sizes might have been used for different activities. In her study of grinding slabs in Tichitt, Roux has distinguished four types based on dimensions and function (Roux 1985). Grinding slabs used for grinding grains had average length 43cm and average width 27cm, whereas grinding slabs for other plant processing were smaller (mean length: 27cm, mean width: 19cm) (Roux 1985: 41). Wright (1992b: 72-73), among others, has suggested that the size of the use-face correlates with the processing rates for the production of groats. According to Runnels (1981: 251) small grinding slabs (30cm long) allowed for a processing rate of c.3hr/kg of coarse flour and he concluded that '*the small size of the Neolithic grinding slab and handstone seems suited more to the grinding of small quantities of cereals into grits for porridge or flat bread*' (Runnels 1981: 153). Therefore, the size of grinding slabs might reflect the activity these were used for (e.g., for grain processing), but could also be linked to choices that relate to types of plants to be processed and/or the quantity of food that needed to be produced.

Furthermore, the types of wear encountered on grinding slabs are informative about possible uses and may include abrasive and percussive wear, striations, and staining/colouring (cf. Runnels 1981: 146; Adams 2002). Such traces of use seen on these surfaces reflect mainly the last activities they were used for, frequently obliterating traces of earlier uses (Runnels 1981). Unfortunately, certain uses of these tools do not leave archaeological traces (e.g., in Trichitt worn out grinding slabs are re-used for the tenderising of meat, an activity that does not create specific use-wear on the surface (Roux 1985: 38)).

Abrasive wear is very frequent on the active surfaces of the Makriyalos tools as a result of grinding substances. In a few examples, polish has developed on use-faces (e.g., ΑΓ 19760, ΑΓ 4418) which might result from the processing of oily substances (e.g., nuts, meat, fish) (Dubreuil 2004) or from intensive use of the use-face. Striations were more difficult to identify on the use-faces mainly due to the nature of the raw materials. Striations were also encountered on a limited number of grinding slabs in the analysis conducted by Runnels who took this to indicate 'no special orientation in use' (1981: 147; cf. Risch 2008). Moreover, due to the fragmentary character of the Makriyalos grinding slabs (e.g., missing margins), it was often impossible to determine the direction of striations in relation to the long axis of the tool. Therefore, the kinetics related to the use of the tool could not be established. Among the few examples showing striations is ΑΓ 13205, which has visible striations in two areas: longitudinal striations on the centre of the use-face indicating back and forth movement, but also lateral striations near the margins suggesting possibly multiple directions of use or potentially indicating the use of the tool in more than one activities involving different kinetics.

In some of the Makriyalos lower grinding tools abrasive wear are combined with percussive wear. Percussive wear (pecking bruises - Runnels 1981: 221) results from the use of the tool in a pounding activity (e.g., nuts or ochre - Runnels 1981), but also from crushing/breaking grains or hard substances during grinding (see also Section 5.2.2.2.). Percussive wear is distinguished from pecking used to sharpen the use-face (manufacturing or maintenance traces) mainly by the extent and the location of the wear. Percussive wear has a localised character and does not extend to the whole use-face. Occasionally a concavity might be created on the use-face due to concentrated pounding activity.

Variation in foodstuffs (seed size and hardness) may influence the kinetics employed in processing. According to Stone (1994: 682) processing of small-sized foodstuffs such as wild seeds involves crushing and rotary grinding for the seeds to break resulting in '*striations in multiple, random directions and crushing on the handstone and the base stone*'. In the case of large-grain foodstuffs, processing involves reciprocal grinding so that grains can be broken down through '*a shearing and grinding action*' (Stone 1994: 683). This type of movement results in striations along the long axis of grinding slabs and vertical to the long axis of grinders.

A number of grinding slabs bear traces of red colour on their use-faces, sometimes mainly visible under the microscope (e.g., ΑΓ 15112). As traces of colour were unevenly distributed on the grinding face and were located only on the surface and not throughout the rock specimens, they were regarded as non-naturally occurring staining that may have resulted from human activity (cf. Logan and Lee 1993). This suggests that grinding slabs (in conjunction with upper grinding tools, see Section 5.2.2.2.) were employed for mineral/pigment processing (for other examples of Aegean grinding slabs with traces of red staining/colour see Runnels 1981: 149).

Grinding slabs could have also been used extensively in other technical tasks such as the manufacture of shell and stone ornaments. As seen in Section 4.3.6 grinding and polishing are the main manufacturing techniques employed for the production of the Makriyalos stone ornaments. Furthermore, in Makriyalos *Spondylus Gaederopus* shells are encountered in different stages of the production sequence from unworked material to finished rings indicating therefore that working of this material took place on-site (Besios and Pappa 1997: 219; Pappa in press). Shells including *Spondylus Gaederopus* shells were transformed into finished objects (e.g., *Spondylus* rings) through grinding and/or polishing and thus grinding slabs may have been used extensively for such tasks (cf. Runnels 1981: 151). By analogy with ethnographic and experimental observations, Miller (1997; 2002) has shown that grinding slabs and other grinding tools (e.g., grooved abraders, see Section 5.2.2.5.) would have been used throughout the production sequence of shell beads and bracelets made from *Spondylus Gaederopus*. She suggested that 93% of the time invested in shell bead manufacture was spent on grinding and polishing (Miller 2002: 46). As she rightly points out, however, this function of grinding slabs has been ignored by archaeologists (Miller 2002). In one of her experiments, she used andesite with flat surfaces without modifying them prior to use and concluded that flat use-faces were preferred for grinding shell beads while the wear patterns on the grinding tools attested to a smooth surface in the area where more intensive grinding took place (Miller 1997: 105-106). This type of wear is also produced from other grinding activities, however, making it almost impossible to distinguish between the different activities on the wear pattern alone (Miller 1997).

Grinding slabs could also have been used in the production of edge tools, another object category for which, as seen previously, grinding and polishing played a very important role. Striations parallel to the long axis on the body and margins of edge tools indicate a reciprocal movement (back and forth) which could have been executed on the use-faces of grinding slabs. Within the Makriyalos assemblage there are fourteen objects that deserve special mention. They are made of sandstone with tightly cemented grains (6), marble (4), schist (3) and indeterminate (1). Thirteen of these fourteen examples have flat use-faces that are well polished in a regular manner over the whole face. None of these tools shows any evidence of repecking nor any indication that faces were originally rough (e.g., ΑΓ 17513). The failure to repeck completely smooth faces and the use of marble, a raw material of very uniform texture and lacking the grainy character of other raw materials used for grinding slabs, together suggest these fourteen objects were employed as for fine grinding and polishing in the later stages of edge tool production (*polissoirs*) (Plate 5.5).

The recovery context of grinding slabs may also shed light on possible uses. In Makriyalos, grinding slabs have been recovered from different types of contexts (for a detailed discussion, see Chapter 6). In addition, the Makriyalos archaeobotanical analysis has revealed a wide range of plant species [cereals (einkorn, emmer, new type glume wheat, and the rare bread/macaroni wheat), barley, lentils, fig, terebinth and flax seeds] (Valamoti 2004), some of which might have required processing through grinding. In a few cases, grinding slabs were unearthed from contexts that also produced large amounts of plants such as pit 414-589 located in the MK II habitation area, (Valamoti 2004).

Regarding the use-life of grinding slabs, it has been suggested on the basis of ethnographic work that raw material determines the life-span of the tool. It was suggested that grinding slabs made of volcanic rocks have an average life-span of 20 years whilst sandstone slabs have a shorter use-life (Horsfall 1987: 342). Finally, although the raw materials for grinding slabs at Makriyalos were acquired off-site and at not inconsiderable cost in effort, there is no evidence for the re-use of grinding slabs in other activities, other than the possible re-use of some broken grinding slabs as upper grinding tools.

#### *5.2.2.2. Grinders*

Moderate use of the Makriyalos grinders is indicated both by the degree of wear exhibited (Table 5.23) and by their transverse sections, which mainly retain the ovate/spherical shape of natural cobbles. Most grinders are of metamorphic rocks, making analysis of the degree of wear and dimensions in different geological categories unreliable. Most grinders exhibit one or two opposed use-faces (Table 5.24 & Plate 4.5b, c).

Wear traces on the use-faces of these tools include abrasive wear, striations, and staining. Abrasive wear ranges from scanty (i.e., small areas that have been smoothed) retaining the natural shape of the cobble (e.g., ΑΓ 13996), through surfaces that are smooth with spots of sheen to highly polished surfaces. This was taken to indicate the degree of wear, so that tools with polished use-faces were recorded as worn-out. Polish, however, could also result from use against a soft organic material such as skin (Adams 1988, 1989, 2002; Stroulia 2005; R. Risch pers. comm.). Dubreuil suggested that several upper tools recorded as 'handstones' from Hayonim Cave had not been used in a grinding activity, but instead exhibited wear similar to that from hide-processing. The use of pebbles for hide-processing (skin cleaning and softening) is attested in ethnographic accounts (Adams 1988 and references cited there). Lustrous surfaces, however, can result during the processing of oily substances. For instance, Adams' experimental processing of sunflower seeds produced sheen on the use-face resembling that produced during hide-processing (Adams 1989: 265, 272).

Polishing on use-faces may be accompanied by striations (e.g., ΑΓ 15679, 16343, 17103, 19310) or not (e.g., ΑΓ 18637). Striations vertical or diagonal to the long axis of the tool have been identified (by eye or under the microscope) on a few marble and igneous specimens (e.g., ΑΓ 13175, 13452, 15304, 15206, 15231, 8582). In some cases, however, striations are multidirectional (ΑΓ 15116, 15207, 15703/4) suggesting rotary movement and/or movement in a variety of directions (Risch 2008). Similar to grinding slabs, abrasive wear can be combined with percussive marks and are the result from crushing grains.

Similar to grinding slabs, staining/colouring was also encountered on the use-faces of grinders. A few examples had traces of red colour indicating use in mineral processing (ΑΓ 2016) (Plate 5.6).

In a few cases a ridge has been created on the use-face as a result of use indicating the exact area of the tool being in use during the activity (e.g., ΑΓ 14515, 3852, 8649 13438, 13240, 13765, 19783). The area defined by the ridges is flat and suggests possible use against a flat area (i.e. used against a lower grinding tool with a flat use-face). In a number of cases the natural convexity of cobbles used has decreased and tools have become flattened (e.g., ΑΓ 13089, 14594). This also suggests that the upper grinding tools were used against flat lower surfaces.

Few grinders (9%) show evidence of reuse in another activity and mainly in a percussive one (8%) as a sequential re-use exhibiting heavy percussive wear (e.g., ΑΓ 14155). Occasionally the tool continued in use as a grinder even after the tool was broken (e.g., one of the two use-faces of ΑΓ 15311 was broken and then reused for grinding).

### *5.2.2.3. Grinding slabs and grinders: working tool sets*

Adams has argued that upper and lower grinding tools (*manos* and *metates*) need to be seen as a single category as they need to be used in conjunction with each other and thus form a composite tool (Adams 2002: 98-99). Therefore, a technical correspondence between upper and lower grinding tools in terms of size, shape of use-face and raw material use is to be expected (Risch 2008). The relatively small size of the Makriyalos grinding slabs indicates their use in conjunction with small sized upper tools (one-hand *manos*) (cf. Baysal and Wright 2005: 318-319). The use of small sized grinders ("fist-sized cobbles") has likewise been suggested for Franchthi where grinding slabs are found in association with such tools (Runnels 1981: 110). The length of the Makriyalos grinders peaks at 6-8cm while the width of grinding slabs peaks at 10-12cm (Figure 5.5) (cf. Stone 1994: 337 use of grinders with length shorter than the width of slabs). Adams has suggested that the use of grinders shorter than the width of the lower grinding tool affects the shape of the use-face of the grinding slabs resulting in the creation of concave faces on the lower grinding tool (Adams 1993; Adams 1999: 482).

The Makriyalos grinding slabs, however, have mainly flat use-faces (Table 4.39) (grinding slabs with flat use-faces predominate in other Neolithic sites (e.g., Sitagroi - Elster 2003; Thermi B Thessalonikis - personal observation). This contrast between upper and lower grinding tools could be interpreted in a number of ways. According to Roux flat use-faces allow for more efficient grinding, whereas concave ones (about 4-5cm deep) restrict grinding to the bottom of the use-face (Roux 1985: 37; a move from basin, to trough, to flat mano-metate grinding sets in New World was interpreted as an increase in grinding efficiency - Adams 1993; cf. Biskowski 2003). In addition, the use of grinding tools with flat use-faces might reflect a conscious choice to improve processing strategies. Adams' experimental work indicated that flat/concave grinding sets worked better for processing soaked kernels and seeds, whereas dried kernels/seeds could not easily be confined to the use-face (Adams 1999: 486). Through experimental studies and technological analysis of grinding tools she concluded that variation over time in the shape and size of such tools related to variability in processing techniques rather than increased dependency on maize (Adams 1999: 492-493). Preference for flat use-faces may also have improved the nutritional value of the ground matter as '*such slabs are known to reduce food to smaller particles, and according to nutritionists, the smaller the particles, the more nutrients are released*' (Dubreuil 2004: 1626; cf. Wright 1992b: 55). Finally, kinetics and intensity of use may affect the shape of the use-face. There are some indications for the use of rotary grinding in the Makriyalos assemblage (multidirectional striations on the use-face of grinders). Circular/rotary movement would affect a wider area of the use-face, whereas reciprocal grinding would restrict the movement to the middle of the use-face.

Therefore, when considering the morphological correspondence between upper and lower grinding tools, we need to bear in mind that factors other than the shape of the upper tool might have influenced the morphology of the use-faces.

When considering the correspondence of upper and lower grinding tools another aspect to consider is the abrasive ability of the raw materials employed (Risch 2008). Risch (2008) has suggested that variation in the raw material properties of upper and lower grinding tools (e.g., grinders of a more compact character are used against a grinding slab of a more abrasive character) result in a more efficient processing of the grain (cf. Stone 1994). This may also be suggested for the Makriyalos grinding tool assemblage as raw materials with different qualities (marble for grinders, sandstone with tightly cemented grains and schist for grinding slabs) have been selected for upper and lower grinding tools. (cf. Stone 1994: 691)

Bearing all this in mind it could be suggested that in LN Makriyalos upper and lower grinding tools were used in conjunction with each other for a wide range of grinding activities. Cereal processing was probably restricted to the processing of small quantities of cereals into groats to cover the needs of a small number of people. An indication for this, is also provided by the archaeobotanical remains as ground barley has been identified in two Early Bronze Age sites in Macedonia that correspond to a kind of bulgur (Valamoti 2002; Valamoti 2003: 99). The treatment and the size of the use-face of grinding toolkits also suggests that these may have been used for processing seeds, nuts and other plants to be possibly incorporated in the recipes of the Makriyalos community. Yet, grinding tools and grinding slabs in particular also functioned in non-food related activities and thus were incorporated in technical activities of imperative value to the LN community of Makriyalos (e.g., mineral processing and edge tool production). In that respect the Makriyalos grinding slabs were 'multipurpose tools' (Runnels 1981: 153; Runnels 1985).

### *5.2.2.4. Mortars & pestles*

Mortars have a concave use-face (basin) that 'confines an intermediate substance that is worked with a pestle in some combination of crushing, stirring, or pounding strokes' (Adams 2002: 127). The Makriyalos mortars are small with a shallow basin usually less than 2-3cm deep (e.g., ΑΓ 1244: ca. 1.3cm deep, 1363: 1.6cm deep) and ca. 10cm in diameter (e.g., ΑΓ 5131: 9-10cm) and thus could have held only small quantities of material (Plate 4.19).

Use-wear includes impact fractures (e.g., ΑΓ 11859, 11860 (also polished), 4212, 4685 5720, 5723) caused by crushing and striations from stirring (e.g., ΑΓ 1423, 11964, 3095, 4985 multiple directions, 9543) while some examples have no visible wear (e.g., ΑΓ 11824, 1255). In the case of ΑΓ 19711 crushing was combined with stirring/grinding and thus the impact fractures have become rounded/smooth. Staining/colouring has been recorded on the unique double marble mortar (ΑΓ 926 with traces of red colour on one use-face) (Plate 4.25) and possibly on ΑΓ 4933. The Makriyalos mortars seem to fall within the 'pebble mortar' category described by Adams (2002: 128) and have been used moderately mainly for mixing and processing soft substances rather than crushing. Some of these tools might have been used as containers, but quite frequently only small pieces of the rim survive, so that wear patterns in the basin cannot be assessed.

Pestles are mainly used to pulverize material. According to Adams (2002: 138) their size may indicate their intended function, with larger pestles used for breaking and crushing, and smaller ones for crushing, grinding and stirring. Observed use-wear includes abrasion (ΑΓ 19817: use-face ground; ΑΓ 3926: use -faces smooth with spots of sheen) and percussive marks. Percussive marks range from pitting (e.g., ΑΓ 6815, 8284) to heavy/deep impact fractures (e.g., ΑΓ 16358, 14934, 3617). ΑΓ 3934 is ground and has slight percussive marks, while on ΑΓ 8093 fine pitting with abrasive wear was observed on the use-face. In some cases percussive activity took place after grinding (sequential use: no grinding evidence on top of percussive wear, e.g., ΑΓ 14949, 15244, 2101 8578) and in some examples percussive wear was recorded on the shaft (e.g., ΑΓ 8137).

One example is worthy of comment. AΓ 4562 is a pestle/hammer made of dolerite and has two opposed use-faces one of which exhibits percussive marks that extend over the body area (Plate 4.18, top photo). It comes from habitation pit 66 (Trench P0462) and it represents the largest such example from the site. The size (21.5cm long) and weight (1500g) of this tool suggests that it could not have been used with the stone mortars found on-site.

Mortars could have been used with stone pestles to perform grinding activities but the use of wooden equivalents cannot be excluded. The use of wooden pestles might be more appropriate for certain activities depending on the nature of the material to be processed. For instance in modern villages in Northern Greece (e.g., Poimeniko, Prefecture of Evros) where mortars are employed for the processing of sesame seeds, the local women prefer to use the wooden haft of a metal axe as a pestle as it is considered more adequate than metal pestles (personal observation).

Ethnographic accounts indicate use of mortars, similar to grinding slabs, for processing a variety of substances such as 'tobacco, berries, seeds, nuts, acorns' (Wright 1994: 241), while in ancient Mesopotamia mortars were used *inter alia* for the processing of cereals, spices and sesame seeds. As noted above, some of these foodstuffs (e.g., cereals or acorns) could have been processed with grinding slabs, making it difficult to link particular tool types to processing of specific food substances (Wright 1994: 241; Wright 2000).

#### *5.2.2.5. Grooved Abraders*

The diagnostic characteristic of this tool type is a use-face in the form of a groove (see also reused edge tools). In the Makriyalos assemblage two types of grooved abraders can be distinguished based on the shape of the use-face: those with V-shaped grooves and those with U-shaped ones. According to Adams (2002), the shape of the groove indicates the type of use to which the tool has been put. Thus, V-shaped grooved abraders could have been employed in the manufacture of tools with pointed use-faces such as awls and needles or for blunting the edges of lithic tools (Adams 2002: 82) while U-shaped ones could have been used for producing wooden shafts such as wooden spindles for spinning fibre, wooden or reed arrow-shafts, but also stone beads and bone tools (Adams 2002: 84). Grooved abraders could have been used in the production of disc beads for grinding more than one bead at a time, a use that has been documented in various ethnographic studies (Miller 1997; Adams 2002).

Adams (2002: 86) has suggested that the wear seen on the interior of the groove may indicate the kinetics employed during use. For instance, longitudinal striations suggest a reciprocal movement, as seen for instance on AΓ 5223, whereas striations perpendicular to the long axis of the groove indicate that the shaft was polished by rotating it inside the groove (Adams 2002: 86). Similar wear patterns are encountered on the Makriyalos bone tool assemblage (V. Isaakidou, pers. comm.) potentially indicating the use of the grooved abraders in the manufacture of these tools. The Makriyalos examples exhibit grooves with polished interiors (e.g., AΓ 8264), irregular interiors (AΓ 18552) while some examples have one groove (e.g., AΓ 17520) (Plate 5.7) and others multiple grooves (e.g., AΓ 6811) (Plate 5.8). The width of the grooves range from 0.5cm to 2.5cm and the depth from 0.1cm to 0.6cm. Adams (2002: 84) regards tools with U-shaped grooves as intentionally modified tools (*'strategically designed'*) whereas the V-shaped ones mostly represent *outils a posteriori* For the Makriyalos assemblage, however, such a distinction was not considered appropriate, because the grooves often seem to be the result of use or cannot be attributed between use and manufacture, and because both U-shaped and V-shaped grooves appear on the same tools.

### *5.2.2.6. Abraders/Polishers*

Abraders and polishers alike exhibit mainly multiple use-faces (69% and 65% respectively) but have been moderately used (Table 5.25 & Plate 5.9). The Makriyalos abraders have a rough texture which would have enabled the removal of material from the surfaces they were used against, while polishers tend to have smooth textures and may have been used in the final stages of the production of other object categories such as pottery burnishing (cf. Adams 2002: 79-80, 91-92). Burnishing of pottery was common in both phases of occupation and small tools would have been easier to use on surfaces of limited size. Tools that could have been used for this purpose include AΓ 16224 (Plate 5.9b) and AΓ 13524 (R. Risch, pers. comm.).

### 5.2.3. Percussive tools

#### *5.2.3.1. Mace-heads*

Mace-heads have entered archaeological reports as objects whose function eludes us and consequently have been interpreted as 'prestige objects' [unknown use - Moundrea-Agrafioti 1996: 104; enigmatic objects (*ρόπαλα*, weights, scepter) - Stroulia 2005: 575]. Yet, some of the Makriyalos mace-heads show irregular percussive wear on their body clearly indicating use in a percussive activity (Plate 5.10). Yet, their distinct appearance and the fact that none appear heavily used may suggest that they fulfilled another role and were not purely used in the same fashion as other percussive tools.

#### *5.2.3.2. Hammers*

Hammers have been used with moderate intensity as indicated by the high proportion of tools with light (10%) and moderate wear (73%) and one use-face (72%). Hammers of sedimentary and igneous rocks are rare and there is no difference in degree of wear between metamorphic and quartz hammers, although metamorphic hammers are much more likely than quartz to have multiple use-faces (Table 5.26). There is almost no evidence for the re-use of these tools in other activities.

### 5.2.4. Drills

Five drills have been identified in the Makriyalos assemblage. These objects of varying sizes have a protruding area of the shaft where striations of a circular movement are visible (Plates 4.21 & 4.22). To my knowledge no similar objects have been reported from other Aegean Neolithic and prehistoric sites (also A. Moundrea-Agrafioti, pers. comm., S. Andreou, pers. comm.). Therefore their use eludes us but some suggestions could be made for their possible use. As shown in Plate 4.21 (bottom right photo) the end of the shaft of the drill is damaged suggesting use against a hard surface such as antler, the transformation of which into tools (e.g., hafts) has been attested at Makriyalos (Isaakidou 2003: 234). Another possibility to consider is the use of these drills for the perforation of mace-heads and the shaft-hole axe. As suggested in Section 4.3.4. no drill cores have been unearthed during the Makriyalos excavations which might be taken to indicate that solid drills were used for the opening of these perforations. The dimensions of the drills and those of the perforations of the mace-heads do not correspond very well. For instance, one of the drills (ΑΓ 15187 Plate 4.22a) has a diameter that ranges from 3.6cm (upper part of the shaft) to 2.6cm (middle part of the shaft) to 1.6cm (bit of the shaft) while the diameter of the perforation of the complete mace-head is on one opening is 1.7cm and the opposed one 2.0cm (see also Section 4.3.4.). Yet, as the example of ΑΓ 7310 (the shaft of which has not been formed very well) suggests that smaller drills have existed at LN Makriyalos (Plate 5.11) and thus the use of the drills in the *chaîne opèratoire* of the Makriyalos mace-heads and the shaft-hole axe cannot be precluded.

### 5.2.5. Weights

According to Mould *et al.* (2000: 162) these objects suggest '*the intention of securely attaching rope or some form of twine around the stone for a standard function*'. These weights probably were not used in weaving as the crudely worked notches would damage a fine string. Instead, they suggested a use as stone nets. The location of Makriyalos near the sea could justify such interpretation.

### 5.2.6. Temporal Patterns of Use

All ground stone categories are present in both phases at LN Makriyalos, but some quantitative contrasts are evident. During MK I there is more pronounced use of grinding/abrasive tools as 74% of the assemblage has been attributed to this tool category. In MK II, however, grinding/abrasive tools decrease (57%), whilst the frequency of all other tool types increases, in some cases twice or three times more (e.g., percussive and multiple-use tools) (Table 5.27). The variation in the tool frequencies between the two phases seems to relate to the frequency of grinding/abrasive indeterminate tools which decreases radically from 23% in MK I to just 9% in MK II (Table 5.28). In addition, there is a significant difference in the mean width of the grinding slabs of both phases (the MK I tools are smaller) suggesting that the variation in the relative frequency of grinding slabs between the two phases is a product of fragmentation (see Chapter 6 for a detailed analysis of depositional practices in MK I and MK II).

## 5.3 Disuse of artefacts

Analysis of ground stone assemblages suggests that the disuse of ground stone objects is by no means a straightforward issue. Removing an object from its original context of use theoretically implies the end of the use-life of this object, but objects can be incorporated through recycling into new activities/contexts of use, thus extending their use-life albeit in a different form. For instance, grinding slabs incorporated into walls indicates their disuse as grinding tools, but at the same time their re-use as building material. In the Makriyalos assemblage, two conditions may indicate the disuse of artefacts: fragmentation and burning.

### 5.3.1. Fragmentation patterns

Grinding tools are particularly fragmentary in relation to other object categories: only 7 out of 2484 grinding slabs (0.3%) are intact. Although breakage in a few cases is due to post-depositional parameters (e.g., excavation damage), the vast majority of the tools were broken in the distant past, as indicated by the presence of sediments on the broken surfaces (e.g., ΑΓ 19641, 17166, 19660, 19649) and by colour variation between freshly broken surfaces and those damaged in the past. Only 11 (0.4%) out of 2484 grinding slabs retain their length intact, 7% have complete width and 57% their complete thickness. As might be expected, therefore, fragmentation is greatest for the largest and least for the shortest dimensions (Table 5.29). Nonetheless, the difference between the three dimensions is perhaps more marked than would be expected simply from accidental breakage, especially given that bedding in sedimentary rocks and schistocity in some metamorphic rocks usually parallels the long axis of tools, favouring incomplete thickness. Moreover, perhaps contrary to expectations, fragmentation patterns do not differ significantly between the three geological categories ($df=2$, $p=0.071$), suggesting that the physical properties of the raw materials have not influenced the rate of breakage (Table 5.30).

This high level of breakage is unrelated to degree of wear (Table 5.31) and anyway the Makriyalos grinding slabs have not been used to such an extent as to be vulnerable (by reaching extreme thinness). Furthermore, the small overall dimensions of the fragmented grinding slabs (Table 5.32a) and the high occurrence of indeterminate grinding tools broken in extremely small pieces (Plate 5.12) raises the possibility that the Makriyalos grinding tools were routinely 'decommissioned' by deliberate breakage.

The significance of these results is highlighted when compared to the very different results from analysis of the ground stone assemblages from two Neolithic sites (Thermi B and DETh) located in the same region (Central Macedonia) (Figure 5.6). As the analysis of all three assemblages was undertaken by the author, problems of different recording and classification systems are eliminated (see also Wright 1994: 248), though the DETh sample (n=21) is admittedly very small. The frequency of grinding slabs with complete thickness is 89% at Thermi B (95% at DETh) compared with 57% at Makriyalos. This difference in fragmentation patterns is even more pronounced when width is considered, with 38% complete specimens at Thermi B (and 62% at DETh) compared to only 7% at Makriyalos. This contrast is unchanged when only grinding slabs of similar raw materials (schist, gneiss, igneous rocks) are compared, suggesting that fragmentation cannot be interpreted in terms of raw material properties. Finally, when the overall dimensions of the grinding slabs from the three sites are compared, it is clear that the Makriyalos slabs survive in a more fragmentary state and are broken into much smaller pieces (Table 5.32).

Although a number of ground stone objects seem to have reached a state of disuse through heavy use, therefore, the high occurrence of fragmented grinding slabs suggests that these tools were damaged not in normal use but through acts of deliberate breakage.

### 5.3.2. Burning

That 14% of tools bear evidence of burning is interesting given that none of those studied have an obvious pyrotechnic function. Burning is significantly more frequent in broken than unbroken artefacts (*df*=1, p=0.000) (Table 5.33), suggesting that it is related to discard at the end of the use-life of objects.

Burning is not equally distributed between different object categories (Table 5.34), but is absent in ornaments and perforators and well represented in edge tools, multiple-use tools and especially grinding/abrasive tools. Grinding slabs mainly have blackened use-faces from burning and only rarely appear to be crazed. Some of these examples may have been burnt in cooking, similar to slabs used for baking bread-like foods in recent times in the Evros district of NE Greece or for cooking meat, a practice encountered nowadays in Southern France (Plate 5.13). Burnt edge tools, however, seem to be crazed more frequently and this cannot be linked to any possible use of edge tools (Plate 4.14d, e). Furthermore, the relatively high frequency of burnt edge tools makes burning by accident less likely. It is tempting, therefore, to speculate that some of these tools were deliberately destroyed by burning.

## 5.4. Discussion: Choosing meaningful materials, making powerful tools...

### 5.4.1. The selection of raw materials

Although a wide variety of raw materials was exploited for the Makriyalos ground stone assemblage, certain types of rocks were clearly selected for fashioning specific tool categories: serpentinite and igneous rocks for edge tools, sandstone and marble for lower and upper grinding tools respectively, serpentinite and marble for ornaments, and only igneous rocks for pestles. These rock types have contrasting properties that render them more or less suitable for different *practical* tasks and for *non-utilitarian* (symbolic, aesthetic) purposes. The different properties of rocks provided a series of affordances, which were drawn upon through the working of rocks into desired tools and ornaments and the selection of different raw materials for different objects may thus reveal something of the understanding, knowledge and skill that the stoneworkers possessed.

A heterogeneous texture, in terms of grain size and mineral composition, is favoured in various societies for the production of grinding tools (e.g., Hamon 2006). The selection of sandstone and secondarily gneiss for lower grinding tools at Makriyalos thus conforms to the utilitarian demands of efficient grinding. Moreover, following Risch's (Risch 2002, 2008) suggestion that upper and lower grinding tools should have different textural characteristics, then the use of marble -(a raw material with a more homogenous and less abrasive texture) for upper grinding tools would have further enhanced grinding efficiency.

Basalt and andesite are the materials best suited to grinding, however, due to their rough surface, self-rejuvenating character and limited tendency to contaminate the substance ground with rock particles. Their limited use for grinding at Makriyalos, therefore, raises some questions. These rocks are absent from the local geology and so costs of transportation, especially for tools that are heavy and difficult to carry over long distances, might have been considered prohibitive. Yet, during the Neolithic grinding tools made of andesite from the island of Aegina were exchanged over large distances (Runnels 1981; Runnels 1985). Furthermore, while igneous rocks are very durable, they are also among the hardest rocks and so are labour-intensive and time-consuming to work. The selection of raw materials for grinding tools could thus be explained in practical terms: i.e., selection of materials with required textural characteristics that were also locally available and easily worked.

Igneous rocks *were* used extensively for edge tool manufacture. Igneous rocks, and in particular fine-grained varieties such as basalt, are materials with tightly held crystals and thus are considered particularly tough. The density and toughness of these raw materials suggest that an ability to withstand the effects of great percussive force was a desired characteristic of edge tools (*contra* Perlès 2001: 232). In this respect, it could be argued that the selection of igneous rocks was functionally driven. Edge tools are also smaller than grinding tools and so the transport costs of this non-local material may have been considered less prohibitive.

Edge tools as a group are used with direct or indirect percussion or pressure and have been associated mainly with woodworking tasks, ranging from tree felling to clearing shrubbery, but also with skin and bone working, while other uses such as digging and finer tasks such as trimming the end of bows cannot be excluded (Blackwood 1950: 23; Edmonds 1995: 53; Perlès 2001: 232). This range of activities implies that materials able to withstand impact force would be desirable (see below). Interestingly, however, the preferred raw material for these implements is serpentinite which, although presenting great variation in its properties, cannot be regarded as tougher than igneous rocks. Thus, its extensive use raises some questions.

The extensive use of serpentinite is a wider phenomenon documented in the whole of the Greek Neolithic (Moundrea-Agrafioti 1996: 104; Perlès 2001: 232). It has been suggested that the transformation of serpentinite into edge tools would require less time and effort due to its 'soft' character (Moundrea-Agrafioti 1981: 182; Stroulia 2003: 5), but this 'softness' would have an impact on the efficiency of the tool. Tougher materials than serpentinite would be better suited for many of the tasks listed above. Moreover, the schistocity evident in quite a few serpentinite edge tools from Makriyalos is parallel to the length of the tool, making it vulnerable to any impact force and thus limiting the tasks it could be employed for (cf. Dickson 1981: 32).

The extensive use of serpentinite for chisels is also interesting because evidence of sawing on their margins and different episodes of resharpening show that effort and time were invested in their manufacture (see below). This seems to contradict previous suggestions of the employment of 'time-saving procedures' (Perlès 1992: 131, Table 5). Anyway, if the primary motive of the Neolithic inhabitants of Makriyalos was to acquire and use a material whose modification did not involve great effort or time investment, they could have chosen pebbles from nearby streams which with a modified edge (and thus minimal input) could have been equally efficient for tasks performed by chisels (cf. Adams 2002: 153).

Differential selection of rock types for different categories of edge tool is particularly interesting. The traditional assumption, that axes were used for heavy chopping tasks (e.g., tree felling) (cf. Adams 2002: 166), adzes for working a range of materials, and chisels for finer carpentry, has recently been challenged by the counter-suggestion that all three 'types' were indiscriminately used for an overlapping range of functions (e.g., Moundrea-Agrafioti 1981: 197-239; Semenov 1985: 126-134; Perlès 2001: 232-236). At Makriyalos, contrasting patterns of raw material selection (coarser-grained igneous rocks for axes; fine-grained igneous rocks for adzes; serpentinite for chisels) suggest that these three morphological types are not just archaeological categories, but were perceived as different by their makers. The materials chosen, however, do not entirely match functional expectations. In the case of axes, rocks resilient to impact force would be expected, but coarser-grained rocks were favoured which, due to the larger crystals set in their matrix, are likely to withstand impact force less well than the finer-grained alternatives. Yet the latter category and in particular basalt, which represent the toughest rocks in the Makriyalos assemblage, are preferentially used for adzes supposedly employed in lighter tasks. This implies that the choice of raw materials was not shaped merely by functional considerations.

When considering raw material choices, it is equally important to see the preferences exercised in relation to materials not selected for edge tool manufacture. As noted previously, the sedimentary rock used for edge tool manufacture is mainly sandstone with tightly cemented grains. This raw material, which represents the most common material in the assemblage, is very compact and tough and reacts well to impact force as indicated by the high frequency of pecking and repecking attested on the use-faces of grinding slabs (cf. Dickson 1981: 28; for the use of sandstone axes see also Cooney and Mandal 1998; Elster 2003). Hence, its texture does not seem to preclude use for the production of edge tools. Yet, it has been employed only rarely in the production of such implements at Makriyalos.

A similar situation is attested in the case of marble, the second most common material in the assemblage. This material, though infrequent within the edge tool assemblage, appears to have been used extensively in percussive and grinding activities. Dixon has suggested that marble would be relatively easy worked into edge tools and could take high polish, but that marble axes would have been 'short-lived' (Dixon 2003: 140; for use of marble axes see also Elster 2003). Marble could have been used, however, for lighter tasks performed by chisels and small sized adzes and serpentinite edge tools. Moreover, its use for small sized implements would be less time-consuming (in comparison to reworked axes and adzes) since an edge could be given easily to pebbles and cobbles that have the desired shape (Plate 5.14). Therefore, when considering arguments put forward for the selection of serpentinite due to its softness, the choice not to use marble cannot be explained in practical terms alone.

An artefact that deserves mention is one specimen made of flint. In the Greek Neolithic, in contrast to northern European Neolithic lithic traditions, flint edge tools seem to be scarce. The lack of flint axes has also been noted in other areas where flint was locally available such as Sicily, Southern Italy and Turkish Thrace (Leighton 1989: 145; Erdogan, pers. comm.). Perlès has argued that during the Greek Early Neolithic no flint axes have been attested, while flint seems to have been used only in the absence of other appropriate raw materials (Perlès 2001: 232-233). The rarity of flint edge tools is rather interesting as flint was used extensively for the production of chipped stone tools, while high quality flint circulated over long distances in the Greek Neolithic from the Early

Neolithic (Perlès 2001: 232). These circulation patterns seem to have expanded during the Late and Final Neolithic period (Moundrea-Agrafioti 1996: 103). In the case of Makriyalos the chipped stone assemblage comprises a variety of raw materials including high-quality flints such as 'honey' flints (Skourtopoulou 1999: 123).

Thus the question that arises is why flint has not been used more extensively in the production of edge tools in Makriyalos and in the Greek Neolithic in general. One issue relates to the physical properties of flint: though it is graded at 7 on the Mohs scale, its brittle character would make it vulnerable to impact force (Dickson 1981: 27; Perlès 2001: 233). Edge tools could have been employed, however, in other non-percussive tasks. Moreover, the extensive use of flint axes in northern European contexts indicates that the properties of flint in no way prevent its use for the production of edge tools. Another practical issue may have been the lack or limited availability of nodules of the required size for the production of edge tools, but the size of honey flint blades could reach and in a few cases exceed 10-12 cm in length (e.g., Tringham 2003: 84), whereas the mean length of edge tools within the Makriyalos assemblage does not exceed 4.9cm. Moreover, the high quality of flaked flint artefacts shows that the Neolithic inhabitants of Greece possessed the required technical know-how, experience and craftsmanship to produce flint edge tools. Therefore, while the paucity of flint edge tools could relate to practical reasons (properties, availability), this needs also to be considered in parallel to the strong selectivity patterns encountered within edge tools that indicate strong cultural choices and traditions in the selection of particular raw materials for specific tool categories.

Certain raw materials, therefore, seem to have had a greater appeal to the Neolithic people of Makriyalos for the production of edge tools while others such as marble, sandstone with tightly cemented grains and flint were not considered to be appropriate for the production of these tool types. Interestingly, however, these selectivity patterns reflect preferences that cannot be interpreted solely on practical grounds.

This suggestion is further reinforced when we look at material choices for other categories of ground stone technology. If the choice of raw materials in the Makriyalos ground stone traditions related solely to their utilitarian properties, then it is difficult to explain why igneous rocks were not used more frequently for percussive tools as well but instead marble is repeatedly employed for such tasks. Yet, the holocrystalline texture of igneous rocks would be well suited for percussive tasks that require tough and dense materials (Voytek 1990: 444; Dixon 2003: 139). From a functional perspective, therefore, it is unclear why the people of Makriyalos did not use such tough materials for percussive tasks more frequently, but instead chose to use them preferentially with edge tools.

Similarly, during both phases of habitation igneous rocks were selectively used by the community of Makriyalos for fashioning pestles although other materials such as sandstone, gneiss, schist, marble could have been used instead (see for instance the variability attested in raw material use for pestles at Sitagroi, Elster 2003). Considering the high availability of all these rock types within the Makriyalos ground stone assemblage and in the wider landscape, it is apparent that the choice of igneous rocks for pestles is ultimately a social choice, a cultural preference that goes beyond pragmatic explanations. In the case of ornaments, bracelets are fashioned almost exclusively from marble and beads mainly from serpentinite. Again these choices do not necessarily relate to practical reasons (ease of working, soft character of rocks) but rather to cultural understandings that determine which materials are *appropriate* to be used for the creation of which object categories. Similar ideas of *appropriateness* seem to have been expressed in the selection of animal bones for the manufacture of bone tools (Isaakidou 2003).

To sum up, the Makriyalos ground stone assemblage exhibits clear raw material selection patterns that seem to reflect in some cases practical considerations (e.g., grinding slabs), while in other cases such as edge tools and pestles the selection of rocks used does not seem to have been driven purely by functional reasons. Furthermore, established ideas and traditions seem to have existed in the community of Makriyalos according to which specific materials are considered to be *appropriate* for the production of different objects, ideas that seem to have been voiced in the choice of raw materials in other Neolithic communities in the Aegean as well (cf. Perlès 2001: 3, 242). This evident selection of raw materials should be seen in relation to the surface treatment these objects received.

### 5.4.2. The surface treatment of ground stone tools

Different traditions of working stone coexisted in Neolithic Makriyalos that were characterised by varied and distinct technological choices throughout the production sequence (e.g., degree of modification and standardisation of products, preferential employment of techniques for different object categories). Generally speaking, stone–working traditions at Makriyalos may be divided between objects of an expedient character that show little or no manufacturing traces (*outils a posteriori*) and products of a formalised production sequence.

Putting aside *outils a posteriori*, objects of formalised production reflect distinct traditions of working stone. Grinding tools lack consistency in the techniques employed for their modification. Investment of time and effort in grinding slabs is restricted to deliberate modification of the use-face (initial preparation and maintenance) and of the margins, with a large number of tools showing no modification. Marginal modification needs to be considered in relation to a previous observation that the initial shaping of grinding slabs was probably executed at the collection site, where redundant material would be removed thus reducing the size of the boulders/tools to be transported to the site. Thus, the character of production and steps followed reflect mainly practical considerations that required minimal investment in the production of grinding tools.

By contrast, edge tool production was much more formalised and exhibits a high degree of standardisation in the techniques employed and in final tool morphology. With regard to morphology, there is a clear distinction in transverse section between axes (ovate/spherical), adzes (plano-convex) and chisels (flat). Given the strong correlation between Length and Thickness (Table 5.13), the plano-convex shape of adzes is arguably a manufacturing choice and not the result of later modification of the tool (i.e., the tool was not sawn perpendicular to its long axis), which would result in a weaker correlation between Length and Thickness. This observation supports the inference, based on differential selection of raw materials for axes, adzes and chisels, that this typological classification is not an archaeological artefact.

When manufacturing techniques are considered, polishing is the most frequently attested technique for the modification of all parts of edge tools (bit 95%; body 87%; margins 87%; butt 72%) and was applied to all rock categories. Yet, evidence of polishing is more extensive in metamorphic and igneous than in sedimentary rocks. In sedimentary rocks, polishing does not seem to have been applied equally to all parts of the tool and the butt area was modified more frequently by grinding, a technique used more often in this geological category than in the other two. Furthermore, differences between rock categories in degree of polishing seem unrelated to properties (in particular hardness) affecting ease of polishing. Elaborate polishing was applied to hard/tough materials such as fine-grained andesite/basalt and gabbro and the unique examples of granodiorite, gneiss, granulite and granite, and also to serpentinite, but not to softer rocks such as marble.

Considerable effort was also expended in repairing these tools, as indicated by time-consuming sawing and multiple episodes of resharpening. As argued in Section 4.3.1, sawing requires great understanding of raw material properties as well as effort, while the sequence of steps followed in the Makriyalos assemblage suggests that precision and control were particularly valued during this process. Furthermore, the sawing of both hard and soft rock types clearly shows that the difficulty of application to different raw materials did not preclude the use of this manufacturing technique.

Two interesting points can be made from the above analysis. First, there is a clear interest in creating smooth surfaces on *all* parts of an edge tool regardless of the raw material used. It has been argued elsewhere that grinding/polishing strengthens the edge and reduces friction on impact with wood (Dickson 1981: 32; Edmonds 1995: 51), but at Makriyalos polishing extends over the whole tool surface and this cannot be explained by functional reasons. On the contrary, a ground or polished surface near the butt makes hafting more difficult; the rough surface created during the pecking stage would be better suited to fitting a tool firmly to its handle (Dickson 1981: 32; Semenov 1985: 69).

This implies that the creation of a smooth and often lustrous surface was a desirable trait in edge tools. Both grinding and polishing are time-consuming and strenuous activities that require persistence and 'some working knowledge' (Semenov 1985: 68). Yet, people chose to increase the time and effort spent in making tools to add a characteristic that does not seem to match the 'efficiently balanced' production argued for by Perlès (1992: 134). The fourth stage of the sawing technique, during which traces of sawing (i.e. lips of sawn grooves) are obliterated by regrinding/repolishing the surface of the tool, further underlines the importance attached to the creation of smooth surfaces in the manufacturing of edge tools. An obvious interest in prolonging the life of edge tools, as well as the level of formality, precision and control exercised in their production and maintenance, further suggests that these implements were particularly valued by the community of Makriyalos (*contra* Perlès 1992).

Evident interest in surface finish is also encountered in other products of ground stone technology such as pestles, mace-heads and ornaments. In the case of pestles, the shaping of the tool mainly by polishing was by no means required for its efficient use and other techniques such as pecking could have been used, as is the case in other Neolithic Aegean assemblages. Yet, the smoothing and polishing of the surface of pestles seem to have been regarded as important at Makriyalos, again contradicting previous suggestions of the employment of 'time-saving procedures' in the production of 'utilitarian' tools (Perlès 1992).

Similarly, ornaments display care in manufacture and surface finishing, an observation also made for other Neolithic assemblages of ornaments (cf. Perlès 2001: 221). Perlès has suggested that the production of beads and pendants represents two distinct categories where '*the skills required and the technical constraints in the production ... are different*' (Perlès 2001: 221). Yet, in the Makriyalos assemblage, the same techniques have been employed in the production of beads, pendants and rings and no clear differences are detected between the different ornament types. The production of mace-heads (and the shaft-hole axe if it indeed belongs to the Neolithic) required skill and knowledge of rock properties, while the drilling of holes suggests a labour-intensive activity with great control and craftsmanship. Effort was invested in smoothing the body of these examples but, in contrast to edge tools, very few received a high level of polishing. This is perhaps surprising, given previous suggestions regarding the distinct character of these artefacts as 'prestige objects' (Moundrea-Agrafioti 1996: 103). Elster (2003: 190-191) suggested that mace-heads were imbued with symbolical significance expressing 'force and power'. Admittedly the production of such artefacts involved a laborious process, which may suggest an interest in creating an object that was meant to be visibly powerful, which might have also been achieved by adjusting a handle to the mace-head and increasing the visibility of the object (Elster 2003: 190).

The Makriyalos analysis has shown that both edge tools and 'prestige' objects (ornaments and mace-heads) show great similarities in terms of raw materials used and manufacturing techniques. Yet, interestingly enough, these categories are seen in opposition in the literature. Edge tools are mainly regarded as 'utilitarian' objects, with a few exceptions (e.g., the long polished axes from Nea Nikomedeia), whilst ornaments and mace-heads are considered to have a social/symbolic character as their only function is to *adorn* their owners/users and give them a special status (cf. Perlès 1992; Miller 1997). Rodden and Rodden (1964b: 604, cited in Perlès 2001: 287) have suggested that one ornament category, earstuds, represent objects of 'special value' and meaning due to the effort and time invested in their manufacture. Yet, in the Makriyalos assemblage, the same care and effort was invested in the working of edge tools. Thus, how can the former category be considered socially valuable and meaningful and the latter as lacking any social value? Systematic study of the manufacturing sequence of edge tools suggests that their production involved great effort, time and skill that presumably mirrors their high value for the Neolithic community of Makriyalos.

Polishing was evidently a very important stage in the *chaîne opératoire* for the Makriyalos edge tools. The enhanced visual appearance of the rocks, the lustrous surface created, might have been regarded as an important, perhaps required, element in the production of a successful tool (*contra* Dixon 2003: 140). This obvious concern with the appearance of edge tools may be linked with another physical property of rocks, their colour.

### 5.4.3. The colour properties of rocks

Colour is a physical property of rocks that has not been discussed extensively in the context of lithic technology in Aegean archaeology. Yet, the colour properties of different raw materials have been discussed in relation to axe making and exchange in other European Neolithic assemblages, suggesting that the visual appearance of axes may have been of great significance(e.g., Edmonds 1995; Cooney 2002). As has been argued elsewhere (Edmonds 1995: 51; Cooney 2002: 95), grinding and polishing not only create a smooth and shiny surface, but also enhance the colour properties of rocks. The extensive use of polishing for aesthetic purposes has also been documented in ethnographic work. Toth *et al* (1992) have argued that the Langda axe makers polish all the visible parts of their tools up to the point where they will be hafted. Furthermore, they also apply pigments such as red ochre on the surfaces of these tools for aesthetic or symbolic purposes, an act that has been widely practiced in other societies as well (Toth *et al.* 1992).

The varied levels of polishing on different materials may be considered in relation to their colour properties. The colour scheme of serpentinite is the most diverse, ranging from light green to dark green, grey/green and black/green, while the variable tones of greenish colour attested on the same artefact also make this raw material more striking. Regarding igneous rocks, Cooney (2002: 98) has suggested that the grinding/polishing process highlights the presence of naturally occurring 'streaks, speckles or spots'. Thus, within the Makriyalos assemblage, the presence of feldspars in gabbro, diorite, granodiorite, dolerite and porphyritic andesite and basalt would be emphasized, creating an interesting contrast with the darker matrix of these rocks (Cooney 2002: 98). In the case of basalt, there are examples with red veins (chromium) that are mainly highly polished or well polished, as are the visually distinctive gneiss and pink granite adzes (Plates 4.4, 4.14b & 4.16). In essence, a well polished surface allows the textural elements of the rocks to be emphasized and distinguished, acting as a mirror to internal properties not easily seen in unworked rocks.

This colour variability contrasts greatly with the relatively uniform colour of the sandstone and marble tools. Most of the sandstone specimens have a grey brown colour (Plate 5.15), while the marble specimens are white (Plate 5.14). It is tempting to suggest that the limited polishing of sandstone and marble tools is related to their uniform colour, thanks to which the end result of grinding/polishing would not be as visually striking as in the case of the igneous and serpentinite tools. This observation is further supported by the fact that rings that are made almost exclusively from marble tend to be ground and not polished. As Taçon (2004: 31) has argued in another context '*things that are bright and colourful are often especially potent*'. Perhaps, therefore, the well cemented sandstone and marble were not used extensively in edge tool production mainly due to aesthetic reasons and not for obvious practical ones. This difference in the treatment of edge tools implies that tools of different rock types (colourful vs. non colourful) were considered as two distinct categories with different value.

A similar concern for the creation of a visually distinctive appearance through the selection of colourful rocks and/or grinding/polishing is displayed by other classes of ground stone technology such as ornaments and mace-heads. As has been argued elsewhere (Karali 1996: 165), bright colourful stones with interesting colour patterning (as well as colourful shells) were widely used for ornaments in the Aegean Neolithic. At Makriyalos, 58% of beads are made of serpentinite. If we accept that the selection of raw materials for bead making relates mainly to their colour properties (Miller 1997), the clear selection of serpentinite for edge tools should be approached in similar terms.

In the case of mace-heads, it has been suggested that these are made from uncommon materials with impressive colours not encountered in other ground stone types (cf. Moundrea-Agrafioti 1996; Stroulia 2005: 575). At Makriyalos, however, although 'talc' does not appear in any other tool type and in that sense is an uncommon raw material, igneous rocks and serpentinite were used extensively especially for edge tools (cf. Edmonds 1998), as well as for mace-heads. Within the Makriyalos assemblage, some of the rock types used have striking colours (e.g., serpentinite) or interesting colour patterning (e.g., AG 4545 of weathered andesite, the black and white colour patterns of which create an impressive visual contrast) (Plate 4.6b). Maybe all the igneous rocks were selected, therefore, for their physical properties (coarse-grained texture) that create a visual contrast, with light coloured minerals set against a darker matrix. In this case the choice of raw materials may be explained on aesthetic grounds.

In this context the frequent selection of marble for rings and white 'talc' and fossilised shell for mace-heads raises some questions. The use of 'talc' and fossilised shell needs to be considered in other terms, for their uniform white colour does not create a similar visual impact (Plate 4.6a, c). Fossilised shell may have attracted interest because it combined the hardness of stone with the visual appearance of shell (the lines on the surface perhaps recalling *Spondylus* artefacts). The selection of marble for rings needs to be considered in relation to another object category, the rings of *Spondylus Gaederopus* shell. At Makriyalos, *Spondylus* has been unearthed in an unworked state, as semi-finished objects and as finished products (mainly rings), indicating on-site manufacture (Pappa *in press*). *Spondylus* rings are mainly white in colour and thus the extensive use of marble for stone rings might represent a deliberate reference to *Spondylus* rings in another material of similar colour. What renders this suggestion even more significant is the chronological distribution of marble and *Spondylus* rings: marble rings are more frequently encountered during MK I but their use decreases in MK II when the use of *Spondylus* rings increases dramatically. The use of these raw materials, therefore, might reflect other connotations that do not necessarily relate to visual contrasts.

### 5.4.4. Consumption patterns

The production of edge tools indicates a measure of special treatment. With regard to their use, a number of observations can be made. It has been suggested that a high degree of polishing could reflect the non-functional character of tools ('lustrous polish'= symbolic function - see Strasser and Fassoulas 2003-2004: 9-10) but the Makriyalos edge tools had been used on a regular basis to perform practical tasks. In fact, the number of tools with light wear is very low, while the condition of these tools suggests extensive use in tasks requiring heavy impact force. When the relationship is examined between the degree of wear and the degree of polishing, highly polished tools very frequently exhibit heavily used or worn out use-faces and are by no means unused, non-functional and 'symbolic' tools. The employment of edge tools in practical tasks is further supported by the fact that breakage rates are more common in bigger tools, suggesting their use in tasks requiring greater impact force, whilst chisels and small sized edge tools in general were employed mainly for lighter tasks.

Bearing all the above in mind it could be argued that the function of tools and their usability cannot be judged solely by their size (i.e. very large or small size tools = non-functional, symbolic tools). Even though the Makriyalos edge tools have a rather small size, they also have a rather long use life which has seen different episodes of resharpening and modification. As the wear on the cutting edge of ΑΓ 8729 exemplifies, the small size of a tool (L=1.8cm) does not necessarily make the tool less functional, but it could result in the tool being used in a different activity where different working logistics are in place. As shown in Section 5.2.1., the size and shape of objects may relate to changes in their use and therefore their meaning and significance. We should avoid, therefore, making simplistic equations such as large or small axes equalling purely symbolic objects. Indeed, even the very large axes found in Nea Nikomedeia show signs of use (Sugaya 1992: 72). In that respect classifications based on physical characteristics (e.g., size and shape) are not always adequate. Other types of evidence should be considered before any suggestions are made for the character of the tools.

An issue to be considered is why people chose to use tools of such a small size and invest time in their modification and reworking. It could be argued that these tools do not represent just functional objects. The different episodes of resharpening, sawing to alter or restore the overall proportions of tools, and careful finishing of the surface indicate that users/owners were willing to invest time and effort in the maintenance of tools they most likely used on a daily basis to accomplish practical tasks but that probably also represented personal belongings, of often distinctive appearance (Edmonds 1995: 103), recalling episodes and stories in their own lives or others associated with the history of the tool. Thus these tools may have acted as constant reminders of past lives while also serving practical everyday needs. In this respect, the widely used dichotomy between 'utilitarian'/'functional' and 'symbolic'/'social' objects becomes meaningless (cf. Edmonds 1995: 53; Karimali 2005: 200).

Wear on the use-faces of Makriyalos grinding slabs indicates use in a wide range of activities, so differences in the shape/treatment of use-faces may be linked to different uses. For instance, roughening of the use-face by pecking might have been intended for grinding plants to varying degrees of coarseness. Variation in the texture of the ground matter allows for variation in the recipes and dishes prepared by different individuals or social groups (Adams 1999: 479-480).

Apart from processing food-stuffs, traces of red colour on the use-faces of upper and lower grinding tools at Makriyalos indicate preparation of pigment, smooth use-faces probably result from polishing edge tools, and production of shell and stone ornaments are other possible uses.

Therefore, grinding tools were incorporated in the production of food, essential tools, pigments and probably ornaments and so were multipurpose. Moreover, grinding was as much a social practice as a practical activity. Performed in different locations and social contexts, it provided an opportunity for knowledge of grinding techniques to be transmitted knowingly (in the form of advice) or unintentionally (through observation) from knowledgeable agents (e.g., older generation) to novices (e.g., younger generation). Knowledge of how to position one's body in relation to the grinding slab, how to employ the whole body and not only the arms, how to grind in rhythmic manner would be important for the quality of the finished product, for the ability to sustain long spells of labour, and for learning culturally approved ways of working (Adams 1999 and personal observation) (Plate 5.16). '*Practised and taken on board at a household and community level, basic skills in the making and using many tools may have contributed in a largely routine way to the reproduction of broad age and gender categories*' (Edmonds 1998: 260-261). More formally, as a means of transforming natural materials such as seeds, rocks and shells into valued substances (food) and objects (tools, ornaments), grinding may have been implicated in initiation rites or in preparation for major rites of passage (for an ethnographic example see Kirk-Green 1957).

Clearly, both edge tools and grinding tools represent valued and multifunctional technologies that were embedded in the everyday life of the Makriyalos community. Despite intensive use, recurrent maintenance and occasional repair, however, many/some of these tools did not reach the end of their use life simply because they were worn out or broken.

### 5.4.5. Falling out of use

The analysis of the Makriyalos assemblage highlighted certain aspects of the final disuse of both grinding slabs and edge tools that point towards acts of deliberate damage. These two tool categories seem to have been removed from circulation by different means: fragmentation and burning.

Given the distant location of rock sources and consequent effort involved in procuring raw materials for tools possibly weighing up to 10kg, it is striking that such a large proportion of the Makriyalos grinding tools were broken. Chapman (Chapman 2000: 94) has suggested that '*breakage of what are, by definition, substantial stone artefacts is* *not necessarily to be expected during the normal working life of a set of grinding stones! Cases are reported of the extreme thinness of grinding stones after exceptionally heavy use but this is quite different from the transverse or, more rarely, longitudinal fracture of querns and rubbers.*' The Makriyalos grinding slabs were not worn to extreme thinness and the fragmentation patterns recorded do not support breakage during normal use. Moreover, the breakage of grinding slabs into very small pieces, so that they could not have functioned in their previous form, suggests deliberate decommissioning.

Grinding slabs in extremely fragmented state have also been found at Kitrini Limni, Kozani (Macedonia). According to Stroulia the percentage of broken grinding slabs far exceeds the expected number. '*Pieces 4, 5, or 6 cm in diameter are very common in this category*' (Stroulia 2005: 576, my translation). She further suggests that this cannot simply be explained as accidents taking place between episodes of use when tools were being moved from one place to the other within the site (for other cases of deliberate destruction of grinding slabs, see Hamon 2006: 143-144).

This argument for deliberate breakage of objects is further reinforced by the treatment other broken objects received. Among ornaments, rings seem to have been broken more frequently than any other sub-type. Chapman and Gaydarska (2007) have suggested that acts of deliberate fragmentation of objects and in particular of shell rings were employed in Neolithic communities facilitating a process of 'enchainment' that created links between people. Ifantidis (2006) has a made a similar suggestion for the deliberate breakage of such objects in Neolithic Dispilio. In LN Makriyalos, the margins of one of the marble rings have been ground after the ring was broken in half. This allowed reforming of the ring into a new object, albeit one that could not have functioned in the same manner as in its original/prior form. Whilst it is not clear whether or not the original breakage was intentional clearly the object still held significance after its breakage.

Edge tools were taken out of circulation by burning, perhaps because broken edge tools could have been (and often were at Makriyalos) reworked into smaller tools and therefore would not have been removed irreversibly from circulation. This is also suggested by an example of a broken edge tool that was re-polished in the broken area presumably in order to continue to be in use (Plate 5.17). Burnt edge tools, on the other hand, could not have functioned for their original purpose. Chapman (2000: 93-94) has suggested that the completeness of edge tools carried symbolic connotations (see for instance axe hoards). If so, it could be argued that burning was a means of symbolically 'killing' axes and adzes and removing them from use without breaking them or altering their original form A further indication that the shape of edge tools had symbolic connotations is the reproduction of the form of axes and adzes in materials other than stone e.g., clay axes and adzes at Neolithic Achilleion and Nea Nikomedeia (Winn and Shimabuku 1989; Sugaya 1992: 74, fn 14; for other examples of axe/adze replicas see also Lillios 1997: 157-158). Moreover, the axe/adze form is a common representational motif in both archaeological and ethnographic contexts suggesting that it held great potential to act as a potent symbol (Edmonds 1995).

Moreover the material itself from which edge tools were made might have contributed to the symbolic significance of these tools. More systematic studies of ground stone technology and edge tools in particular suggest more complicated mechanisms by which materials moved across the landscape than previously thought. Thus it has been suggested that both local and non-local materials were used which could have been acquired either through direct procurement or through exchange mechanisms (cf. Melfos *et al.* 2001; Dixon 2003; Elster 2003; cf. Strasser and Fassoulas 2003-2004). Therefore, edge tools and their materials become a medium for social interaction linking different communities but are also linked to a wider landscape imbued with meaning and symbolism which formed the perceptions and understandings of local communities.

Acts of deliberate destruction are not alien in other contexts of the Greek Neolithic or the Balkans (Chapman 2000; Chapman and Gaydarska 2007). A similar suggestion for deliberate destruction of artefacts either by fire (*Spondylus* artefacts) or by deliberate breakage (*Spondylus* rings) has been suggested by Halstead (1993) for LN Dimini while Tomkins (Tomkins 2007: 189-190) noted the deliberate destruction of ceramic vessels (and stone figurines from the same context) in EN Knossos. This could suggest the deliberate breakage of artefacts was a common practice in the Aegean Neolithic, a practice that perhaps invoked different means of destruction (fire or breakage/fragmentation) according to the character of these artefact categories and meanings attached to their use

One possible interpretation of such deliberate breakage (and burning in the case of edge tools) is that such tools were linked to the life-cycles of their users and were destroyed, for example, at their death (Brück 2006: 297). The tradition, in different regions of modern Greece, of a woman bringing a sickle, or loom, or cooking utensils as part of her dowry may be a useful analogy. 'However, deliberate breakage was not simply a symbolic act but was thought to facilitate transformation from one state to another' (Brück 2006: 297). As argued previously, in the case of Makriyalos the idea of transformation is extremely well linked with the practical/actual use of grinding tools. The significance of the fragmentation of grinding slabs and its active use in the creation of communal and household identities will be examined in more detail in Chapter 6.

## 5.5. Conclusions

A critical assessment of the *chaîne opératoire* of ground stone production at Makriyalos clearly reveals that the resulting objects were far from mundane artefacts but were instead active media for expressing choices informed by cultural understandings of *appropriateness*. Although edge tools, mace-heads, ornaments, pestles and grinding slabs result from production sequences with varied degrees of formalisation, the final treatment of these tools indicates that all categories were imbued with symbolic significance which, however, was played out in two distinct ways. To quote Edmonds (1998: 257) '*investment in production cannot be taken as a definitive index against which to assess value or symbolic content...*'. Edge tools and grinding tools represent two distinct technological traditions, that saw intensive practical use but that were also imbued with symbolism manifested throughout the sequence of production, consumption and final discard. This symbolism might have been linked to different forms of agency and contributed to the creation of different forms of social identity. It is interesting to see whether these distinct traditions were also imprinted in deposition practices. These issues will be explored in the following chapter through a detailed spatial and contextual analysis.

# CHAPTER SIX

## Contextualising Ground Stone Technology: the Spatial Analysis of the Makriyalos Assemblage

### 6.1. Introduction

As highlighted in Chapter 3, ground stone artefacts have traditionally been seen merely as static implements and only rarely have the spatial associations with other cultural artefacts and their contexts of deposition been investigated thoroughly. Yet, this type of analysis is fundamental to acquire an insight into the way(s) in which these implements were used and perceived. This approach may also shed light on the activities that took place in different contexts. The potential for such analysis of ground stone assemblages from other prehistoric sites in the Aegean is usually limited by the modest size of the sample and by lack of contextual resolution.

In this chapter, the ground stone assemblage from Makriyalos will be placed in context. As described in Chapter 2, the site of Makriyalos presents great variation in the types of contexts identified during excavation, so spatial analysis has been conducted at different levels using different scales of analysis. The analysis proceeds from the large scale, e.g., comparison of Phase I context types, to the small-scale discussion of specific contexts. Since study of stratigraphy is still in progress, the contextual data are incomplete and so some of the results reached have a preliminary character.

## 6.2. Makriyalos I

The majority of ground stone attributed to Makriyalos I (MK I) comes from stratified contexts, while all three general context types (habitation, ditches, borrow pits) have given large assemblages allowing for meaningful comparison between 'domestic' and 'communal' areas of activity (Figure 6.1). Of 5330 objects attributed to MK I, more than 80% comes from communal areas and only 13% from habitation areas (Table 6.1).

### 6.2.1. Comparisons between habitation contexts, the ditch system and borrow pits

All seven general tool categories (edge tools, percussive tools, perforators, grinding/abrasive tools, multiple-use tools, ornaments and miscellaneous) are present in the habitation area, borrow pits, and ditches, and are distributed evenly among the three contexts (Table 6.2). Edge and grinding/abrasive tools, however, present distinct patterns of spatial distribution. Edge tools occur more frequently in habitation areas (32%) and less frequently within borrow pits (18%) and ditches (13%). Grinding/abrasive tools, on the other hand, are encountered mainly within the ditch system and borrow pits, making up almost 80% of the material from these contexts compared with only 60% in domestic contexts (Figure 6.2). A chi-square test indicated a highly significant relationship between object categories and contexts of deposition ($df$=12, p=0.000) (Table 6.2).

More interesting patterns emerge when these general tool categories are broken down into sub-categories (Table 6.3). Axes, adzes and chisels occur more frequently in the habitation contexts, but grinding/abrasive tools present greater variation in their contexts of deposition. Grinding slabs appear more frequently within borrow pits (39%) and the ditch system (35%) and less frequently in habitation (29%). Upper grinding tools are encountered twice as frequently in the ditch system (15%) as in habitation contexts (7%) and make up an intermediate 10% of the material from borrow pits. It should also be noted, although samples are small, that the only three mortars found in MK I come from communal areas (two from borrow pit 212 and one from Ditch Γ) but that pestles and abraders are more frequent in habitation contexts. In the case of percussive tools, hammers are attested most frequently within habitation contexts (but still make up only 1.5%), whilst all the examples of mace-heads are encountered within communal areas. Rings are more frequent in the ditches while all other ornament types are equally distributed between the three contexts. Finally, manufacturing debris (e.g., core, waste by–products) is evenly distributed between communal and habitation areas. Even if we regard the distribution of rare categories as fortuitous, therefore, the following contextual associations seem clear: edge tools - habitation; grinders - ditches; grinding slabs - communal areas (Figure 6.3).

No variation is encountered in the distribution of raw materials for edge tools between the three contexts (Table 6.4). When grinding slabs are considered, most raw materials are distributed evenly among context types, but fine grained sandstone is twice as frequent in habitation contexts and ditches as in borrow pits, while gneiss is more common in the ditches (Table 6.5). In the case of grinders, marble is the most frequent rock in all three contexts, but makes up 85-90% of the material from the ditches and borrow pits, compared with only 58% in habitation areas. The grinders from the habitation contexts present greater diversity in raw materials, with quartz appearing much more frequently here than in the other two contexts (Table 6.6). A chi-square test indicated a highly significant relationship between upper and lower grinding tools and contexts of deposition.

The edge tools from all three contexts of deposition present great similarity in terms of size, morphology, fragmentation patterns, frequency of maintenance techniques, surface condition and degree of use (Tables 6.7 & 6.8). The degree of surface polish, however, differs significantly between contexts ($df$= 6, p=0.013): highly polished surfaces are more frequent in the ditches (52%) than habitation or borrow pits (44%), whilst surfaces that are not well polished are most frequent in habitation contexts (Figure 6.4).

The grinding slabs from all three context types seem rather similar in terms of overall dimensions, morphological characteristics, manufacturing techniques, number of use-faces, degree of use and maintenance. Moreover, similar fragmentation patterns between contexts suggest that the spatial variation encountered in the deposition of grinding tools is not an artefact of the fragmentary character of these tools. Grinding slabs generally survive in a good condition, but habitation contexts have significantly higher frequency of slabs with evidence for burning (26%) ($df$=2, p=0.000) (Table 6.9), while the only two complete grinding slabs from MK I were found in Ditches A and Γ. The grinders also do not present much contextual variation in morphological characteristics, overall size, degree of use and overall condition. In this case, the ditches have significantly higher proportion of tools with evidence for burning (Table 6.10).

These broad contextual patterns will now be explored at a more detailed level.

### 6.2.2. Habitation

Within the area demarcated by the double ditch system a series of pits and pit groups was unearthed that according to the excavators represents habitation areas (the larger pits) and smaller refuse or storage pits. Their interpretation as habitation areas is supported by the presence of postholes that most probably supported a roof over these structures, while hearths have been found within pits 216 and 705 (Pappa and Besios 1999b).

In total, 692 ground stone objects have been attributed to MK I habitation contexts deriving mainly from specific pits and only 144 objects from units simply attributed to habitation (21%). The pits can be grouped into clusters, of which the most important are pit clusters KΛ, Λ, and O, with 123, 64 and 87 ground stone objects respectively (Figure 6.5). In addition to these clusters, relatively large concentrations of material have been attested in the isolated pits 258 (n=46) and 281 (n=26). The following analysis will focus mainly on pit clusters KΛ, Λ, and O and secondly on the material from pit 258. These assemblages are rather small (though larger than most assemblages used in such analyses, see for instance Risch 2008 for a spatial analysis based on 28 grinding tools in total), but may allow some suggestions to be made concerning the character of these structures and the way activities, relevant to ground stone technology, were organised and practised within this community.

The excavator (Pappa 2008) has interpreted the larger pits as habitation areas and the smaller pits as subsidiary pits (storage and/or refuse pits) on the basis of the size and nature of the deposits within each pit. Ground stone objects tend to be concentrated on the larger pits within each cluster such as pits 742 (n=34) and 292 (n=25) in pit cluster KΛ, pit 402 (n=38) in pit cluster Λ or pits 95-121 (n=36) and 93-96 (n=20) in pit cluster O (Figure 6.6). Yet the frequency of material within each pit does not relate solely to the size of the pit (diameter and depth) as suggested by the almost complete absence of tools from pit 404 contrary to pit 402 of almost equal size (for dimensions of pits see Pappa 2008: 179-180).

The analysis of the assemblages reveals a rather uniform picture that seems to be repeated throughout the habitation area. All general object categories are distributed relatively evenly within the three main pit clusters, with the exception of the absence of perforators from all clusters and the extremely limited presence of percussive tools (Table 6.11 & Table 6.12). The objects, though the vast majority survive in an incomplete state, are otherwise in good condition (Table 6.13). Edge tools from the three pit groups present great similarity in terms of manufacturing techniques (mostly polishing), and in the extent of use and degree of polishing. Highly polished tools with heavy wear are frequent in all three habitation clusters. Grinding slabs from clusters ΚΛ, Λ and O are similar in their overall dimensions, number of use-faces and morphology, with a tendency for flat use-faces. Evidence of maintenance is less frequent for grinding slabs than edge tools but there is evidence of maintenance for both tool categories in all contexts except for grinding slabs in pit cluster Λ (Table 6.14a, b).

Regarding the raw materials found, a wide range of rock types from all three geological categories occurs in each of the three clusters and isolated pits, with no clear variation in their distribution between pit clusters (Table 6.15). The lack of spatially distinct distribution of raw materials might be taken to indicate that the different households exploited similar or even the same natural resources. Thus procurement strategies might have involved unrestricted access to both local and non-local resources. If this was the case, the use of similar resources for the production of tools may have emphasised concepts of similarity rather than difference between the individual households.

This patterning in the spatial distribution of material is important for two reasons. The overall homogeneity attested in the distribution of the material is important as it reaffirms the interpretation of these pit clusters as places of analogous character (habitation areas), in which similar activities were repeatedly practised. Each pit group contained a minimum of two to three lower grinding tools and three to four upper grinding tools (based on the different raw materials recovered in each cluster). Grinding slabs with multiple use-faces may indicate that the same tools were used for different grinding activities (e.g., grain processing, mineral processing). In fact, a number of grinding tools show traces of red colour on their use-faces that could relate to the processing of minerals. Multiple uses of these slabs might also be indicated by evidence for use with fire possibly suggesting a use in baking. Baking as a cooking technique is also suggested by large shallow vessels that have been found in the MK I habitation clusters (Urem-Kotsou and Kotsakis 2007: 237). Furthermore, the relatively small size of the grinding slabs (the complete examples weigh up to 5 kg, while the heaviest almost complete tool weighs 9 kg) stresses the portable character of these tools suggesting that they could have been easily moved from one location to another, from inside to outside or *vice versa*, depending on specific circumstances (e.g., weather conditions and tasks to be performed) (for a similar suggestion see also Baysal and Wright 2005).

Edge tools represent the second most commonly attested category of objects within the clusters of pits. The largest concentration of edge tools (n=16) within the MK I habitation pits is encountered in pit 742 (ΚΛ). The wear on the use-faces of the edge tools from habitation contexts ranges from light chipping to heavy chipping while in some cases the cutting edges have become blunt. This might indicate that, similar to grinding slabs, edge tools could have been used for a variety of tasks, such as light and heavier woodworking (ranging from carpenting to tree felling), animal skin processing, butchering, bone working, or digging (Blackwood 1950: 23; Edmonds 1995: 53; Skeates 1995: 288; Perlès 2001: 232).

In addition, the presence of debitage, different types of abraders (e.g., grooved abrader found in pit 745 (ΚΛ)) and polishers confirms that the habitation area was not used only for the processing of edible substances, but also for the production and repair of tools and for the production of other sets of material culture such as bone tools. This suggestion is further supported by the presence of tools that show evidence for on-going manufacture and maintenance processes (repecking, resharpening, sawing) within pits of Phase I (e.g., ΑΓ 4641 from pit 93-96 and ΑΓ 4643 from pit 95-121 in pit group O).

These observations are consistent with the suggestion that small social units, *households,* organised grinding, woodworking and other activities on a small scale. Each *household* possessed their own toolkit, equipped to cover a range of activities from plant processing to craft working and thus accommodate their individual needs. The rather small size of grinding slabs and of their use-faces indicates that only small amounts of plants could be processed at a time, potentially being indicative of the size of the social unit that used these tools and/or of the domestic character of these activities. The high proportion of flat use-faces may, therefore, indicate an attempt to maximise the potential amount of product to be processed each time. This suggestion is further supported by the moderate size of cooking vessels that could have been used for the preparation of food for a rather small number of people (Urem-Kotsou and Kotsakis 2007: 239). Overall, the distribution of products of ground stone technology within these groups of pits reinforces previous suggestions that these structures represent 'separate households' (Pappa 2007: 274-275).

### 6.2.3. The ditch system

Two parallel ditches (Ditch A and B) encircling the settlement and a third ditch (Ditch Γ) located within the enclosed area have been found. The deep Ditches A and Γ, though excavated on uneven scales (Figure 6.5), have given almost the same amount of ground stone (932 and 868 objects respectively), whilst the shallow deposits of Ditch B have been extremely poor (35 objects), a contrast paralleled in other sets of material culture. Analysis will focus, therefore, on the ground stone from Ditches A and Γ.

Two phases have been identified in the construction of Ditches A and Γ. The comparison of the two phases could potentially reveal chronological differences in the deposition of artefacts within the same contexts. At this stage of research, it was only possible to compare the two phases of Ditch Γ, mainly due to the absence of similar stratigraphical data for Ditch A. Phase A of Ditch Γ is represented mainly by the deposits of pit 326 (P054) and pit 328 (P064), while the rest of the material from Ditch Γ dates to the second phase of construction. Out of the 858 artefacts unearthed from Ditch Γ, 156 have been attributed to Phase A, 710 to Phase B and two objects come from unphased deposits. No differences were detected, however, between the ground stone assemblages of the two phases of Ditch Γ. One interesting aspect that was noted, however, was the large number of burnt ground stone objects from Phase A derived from pit 326, an observation also paralleled by the pottery assemblage (Pappa et al. 2000: 286).

#### *6.2.3.1. Comparison between Ditch A and Ditch Γ*

All seven general object categories are encountered in both ditches and in most cases are evenly distributed between the two contexts, but there is highly significant variation in the distribution of edge and grinding/abrasive tools (*df*=6, p=0.000). Grinding/abrasive tools are more frequent in Ditch Γ (85%) than Ditch A (73%), whereas edge tools are twice as frequent in Ditch A (18%) as in Ditch Γ (8%) (Table 6.16). Moreover, the distribution of object sub-categories demonstrates that this variation is primarily due to indeterminate edge tools and adzes being more frequent in Ditch A and indeterminate grinding/abrasive tools in Ditch Γ (Table 6.17).

Despite the variation noted in their distribution, the edge tools from both ditches are very homogenous in terms of morphological characteristics, raw material use (Table 6.18), surface condition, damage attested on their use-faces and degree of use, degree of polish and level of modification (resharpening, sawing). The character of the grinding/abrasive tool assemblage is equally uniform between the two ditches in terms of manufacturing techniques, overall shape, fragmentation patterns, number of use-faces and degree of use. There are some differences, however, in the raw materials employed for lower grinding tools. Metamorphic rocks and in particular gneiss occur almost twice as often in Ditch Γ (30% vs. 17%), whilst sedimentary rocks are encountered more often within Ditch A (a chi square test again indicated a significant relationship between raw materials and contexts of deposition) (Table 6.19). Significant variation is also attested in the surface condition (*df*=1, p=0.000) and modification of use-faces (*df*=1, p=0.001) of grinding slabs with Ditch Γ exhibiting twice as many artefacts with evidence for burning and repecking as Ditch A (Figure 6.7a, b).

As noted above, indeterminate grinding/abrasive tools are more frequent in Ditch Γ. When compared to those from Ditch A, they are very similar with regards to fragmentation patterns, degree of use, raw materials used, and overall dimensions. The variation in the frequency of indeterminate grinding/abrasive tools between the two ditches, therefore, is not an artefact of the fragmentary character of this material. As is the case with lower grinding tools, however, Ditch Γ has higher proportions of indeterminate grinding tools with evidence for burning.

The homogenous character of the ground stone assemblages from Ditch A and Ditch Γ may suggest that in some respect the two ditches played a similar role, mainly representing areas where materials from the habitation contexts were regularly discarded. The uniform character of the two ditches corresponds to the uniformity attested in the different habitation clusters. Hence, if different households discarded unwanted material into the nearest ditch, then the assemblages from the ditches should show no variation.

### *6.2.3.2. Ditch A: Comparison of different sectors*

Ditch A, excavated on a relatively large scale, also has potential for spatial (horizontal) analysis of the ground stone material. This may shed light on the character of this large earthwork that encircled and defined the settlement of MK I.

The ground stone assemblage is distributed rather unevenly between the different sectors of Ditch A (Figure 6.8). The largest group of material comes from Sector Ξ (37%), followed by Sector K (25%) and Sector Λ (21%). The material is also unevenly distributed within each sector. For example, 56% of the ground stone material from Sector Ξ comes from trench Ξ071 (n=192) which has the largest concentration of material in Ditch A (representing 21% of the ground stone artefacts from this ditch). A similar concentration of material was found in Sector K and in particular in trench K027, where 110 artefacts make up 47% of the material from this sector and 12% of the total Ditch A assemblage. In Sector Λ, although the distribution of material is more even, larger concentrations are encountered in trenches Λ011 (n=45, 23%) and Λ014 (n=38, 19%). It seems, therefore, that some areas of Ditch A were preferred over others for the deposition of ground stone tools.

Differences have also been noted in the character of the material deposited within the different sectors. All seven generic object categories are found in all three main sectors but edge tools and ornaments are twice as frequent in sectors K and Λ, whilst grinding/abrasive tools and in particular grinding slabs are more frequent in Sector Ξ. Grinders are slightly more frequent in sector K and indeterminate grinding/abrasive tools are encountered more often in sectors K and Ξ (Table 6.20 & 6.21). In addition objects from Sector Λ more frequently show evidence for burning (23%) than those from Sector K (14.5%) or Sector Ξ (13%) (Table 6.22).

When the small edge tool assemblages from the three Ditch sectors are considered, some variation may be suggested in the distribution of raw materials. Igneous rocks are much less frequent in Sector Ξ (27%) and metamorphic rocks much more frequent (73%), than in Sectors K (51% and 49%) and Λ (58% and 49%) (Table 6.23). With regards to surface condition, contrary to the situation attested for all objects within the three sectors, Sectors K and Ξ have a higher frequency of burnt edge tools than Sector Λ (Table 6.24).

In the case of grinding slabs, there is no difference in overall dimensions and degree of use, but there is significant variation in the distribution of raw materials (df=4, p=0.002) (Table 6.25). Although sedimentary rocks are the most common category employed, in Sector K the percentage of sedimentary is significantly lower and that of metamorphic and igneous rocks higher. Finally, Sector Λ in contrast to edge tools has significantly higher frequency of grinding slabs with evidence for burning (Table 6.26).

The grinders from the three sectors do not present variation in terms of degree of use and overall dimensions. Regarding surface condition, similarly to grinding slabs and in contrast with the edge tools, Sector Λ has twice as many grinders with evidence for burning.

### 6.2.4. Borrow Pits

Within the MK I settlement five areas have been identified as borrow pits (pit 212, pit 214, pit 342, K027, borrow pits in Sector M). This section will focus on borrow pits 212 (Sector Π) and 214 (Sector Ξ) due to the large size of their assemblages (1335 and 873 objects respectively). The assemblages from these two pits represent among the largest such concentrations in either phase of the Makriyalos settlement and that from pit 212 represents the largest concentration of ground stone from a single context from prehistoric Greece. Pit 212 is characterised by the deposition of large quantities of material at the bottom of the pit within a short period after it was initially cut (Pappa *et al.* 2004).

Pits 212 and 214 are very similar in the types of tools deposited but significant variations have been noted in the distribution of object categories (*df*=6, p=0.013) (Table 6.27). Although grinding/abrasive tools, the most common category in each context, are equally distributed between pits 212 and 214, edge tools and ornaments occur more frequently in borrow pit 212 and multiple-use tools are more frequent in pit 214. Specific object types also present some differences in their distribution. Grinding slabs occur in similar proportion in either context, while grinders (and grinder/hammers) are twice as frequent in pit 214 as in pit 212 and indeterminate grinding/abrasive tools occur slightly more frequent in pit 212. Finally, mace-heads and mortars appear only in pit 212 (though this is based on a tiny sample) (Table 6.28).

The edge tool assemblages from the two contexts are very similar in terms of dimensions, raw materials, surface condition, manufacturing techniques, overall morphology and butt damage In the case of bit damage, however, edge tools from pit 212 survive in a better condition: 31% retain the bit area intact compared with only 17% in pit 214 (*df*=2, p=0.025) (Table 6.29). Similarly, there is a higher proportion of edge tools with light or moderate wear in pit 212 (23%) than in pit 214 (6%), whereas tools with worn out use faces are more frequent in pit 214 (*df*=3, p=0.018) (Table 6.30). Edge tools from pit 212 also show significantly higher frequencies of modification (resharpening and sawing) (80%) than those from pit 214 (51%) (Table 6.31).

Grinding slabs from pit 212 and 214 present some variation in terms of their dimensions. The Mann-Whitney test procedure was used to compare the mean weights of grinding slabs from the two pits. A low significance value for the test (p=0.002) indicates that there is a significant difference between the two means (Table 6.32). Thus the grinding slabs from pit 212 are heavier than those from pit 214. They present great similarity, however, in terms of raw materials, fragmentation patterns, surface condition, manufacturing techniques, degree of wear, and frequency of repecking. No variation was noted in fragmentation patterns and overall dimensions of the grinding/abrasive indeterminate assemblage from the two contexts suggesting that the variation in their distribution is not artefact of the fragmentary character of the material.

The grinders from the two pits are very similar in overall dimensions, raw materials (mostly marble), number of use-faces, surface condition, damage (the vast majority in each pit being incomplete), morphology, their expedient character, and degree of use (more than half in each context bearing moderate wear).

The study of the stratigraphy of pit 212 is well advanced, allowing for a more in-depth analysis of the material within this context. Three layers have been identified: layer 1, the topsoil, with 50 ground stone tools; layer 2, characterised by a concentration of shells, with 193 ground stone artefacts; and layer 3 with a 10-cm thick 'carpet' of finds (Pappa *et al.* 2004: 19) containing 954 ground stone objects (Figure 2.2).

The layers exhibit many similarities in terms of artefact condition, fragmentation patterns and degree of use. The vast majority of the material from all three layers is damaged, while burnt tools appear in similar proportions (*c.* 13%). The three layers have similar proportions of tools but layer 3 has more indeterminate grinding/abrasive tools (29% vs. 18%), although lower grinding tools and grinders are evenly distributed between the layers. The overall similarity of the material from levels 2 and 3 suggests that the upper level was formed under the same circumstances as the basal 'carpet' of finds.

### 6.2.5. Summary

Generally speaking, the analysis of the ground stone assemblage from Makriyalos I has revealed a homogenous picture for different contexts, but distinct patterns in contextual variation have been also identified. Throughout the preceding analysis, the distributions of all recorded attributes have been consistently tested at various levels and contextual relations, but only results that are statistically significant have been presented here. It must also be born in mind that, due to the large number of variables and contexts analysed many 'significant' results were to be expected. Nonetheless, certain patterns invite further discussion, because they involved very substantial differences or because similar results recurred in different analyses:

1. Grinding/abrasive (grinding slabs and grinders) and edge tools are unevenly distributed among different contexts (e.g., MK I habitation and communal contexts, Ditch A variation between different sectors).

2. Uneven distribution of object categories with evidence for burning between different contexts and between different areas of MK I settlement.

3. Uneven distribution of highly polished edge tools between contexts.

Variation has also been attested in other attributes analysed such as variation in raw materials for edge tools between the different sectors of Ditch A, but this variation is considered of lesser significance, because of the small sample used in the analysis or the patchy character of the results reached. In the discussion that follows the most significant patterns identified will be discussed and interpretations suggested.

## 6.3. Discussion: The spatial distribution of the Makriyalos I ground stone assemblage

The analysis of the ground stone from Makriyalos I has highlighted contextual variation in deposition, especially of edge tools, grinding slabs and grinders. This in turn may shed light on previous interpretations of the spatial organisation of the settlement: in particular, on the identification of habitation contexts as 'domestic' areas, in contrast with the 'collective' borrow pits and with the ditches, that served as collective boundaries but may initially have been dug by a series of small workgroups, each potentially drawn from those inhabiting a cluster of habitation features. This contrast between 'domestic' and 'collective' contexts may correspond to differences in the kinds or scales of activities taking place in each, to preferential use of some contexts (e.g., the boundary ditches) as refuse disposal areas, or to more overtly ideological distinctions between 'private' and 'public' space. As a first step towards exploring these issues, contextual variation in the distribution of ground stone is examined in terms of three overlapping themes - discard, ownership/curation and location of activities.

### 6.3.1. Discard

In terms of discard practices, it might be expected that products of an expedient technology, tools with worn out use-faces and those that are broken would be removed from habitation contexts and discarded possibly in communal areas. Variation in the spatial distribution of ground stone objects, therefore, would reflect variation in their use-life. In the case of Makriyalos I this is consistent with the high proportions of expedient grinders in communal ditches. Yet, contrary to the expectations of the discard model, the ground stone assemblages from habitation contexts, the ditch system and borrow pits show no variation in the degree of use or fragmentation patterns and, indeed, the only two complete grinding slabs in Makriyalos I come from Ditches A and Γ. Moreover, burnt edge tools appear with similar frequency in all three context types. Therefore, discard practices do not adequately explain the variation attested in the distribution of ground stone objects between the different contexts.

### 6.3.2. Curation/Ownership

Closely linked to patterns and practices of discard are practices of curation and ownership. Studies in ethnography have suggested that a strong sense of individual ownership can occur through the manufacture and subsequent use of edge tools (Pétrequin and Pétrequin 1993). This sense of ownership defies purely utilitarian understandings of tools. This is well illustrated by the manner in which, in some cultures, worn out or broken axes are carried back to a settlement, even when used further afield (G. Politis, pers. comm.). As Toth *et al* (1992: 70) have observed, '*the ax makers say they ''feel sorry'' for their handiwork and take pains to bring it* [the axe] *home for final discard*'. In contrast to this strong sense of individual ownership in the case of axes, grinding tools within some cultures have been shared by different households (Graham 1994). This practice also occurred within 20th Century Greek villages where it was facilitated by the predictability and limited duration of the tasks for which the tools were used.

Whilst these variations in the sense of ownership of different tools have been observed ethnographically, it remains to be seen whether similar concerns can be identified in the Makriyalos assemblage. In this case the analysis of the production sequences of edges tools has indicated that they exhibit a higher degree of investment in both production (polishing) and reworking (resharpening and sawing) than was expended on grinding slabs and grinders (expedient tools). Furthermore, the differences in the amount of polishing on edge tools may also indicate the role of personal aesthetics in their manufacture. Unlike grinding tools edge tools were also probably used for a much wider variety of tasks taking place across a large spatial range. Therefore the practicalities of their use may have facilitated their personal ownership as they were routinely carried around by individuals for use in an array of daily tasks.

An alternative avenue of investigation into ideas of ownership is also provided by a few edge tools with the Makriyalos assemblage that carry evidence of perforations, which were perhaps drilled to hang the object around the neck. In the case of ΑΓ 17720 the object is a broken tool, and it is tempting to suggest that, when the tool broke, its owner decided to alter its normal mode of use, but to continue its use-life by wearing it as a pendant. Similar transformations of edge tools into ornaments associated with 'the body, person and personality of particular individuals' (Skeates 1995: 291) has also been shown in other contexts in prehistory.

If there was a strong link between ornaments and personal ownership within Makriyalos I, it might be expected that their distribution should be biased towards domestic contexts. In Makriyalos I, however, ornaments have a higher frequency within communal areas. Similar patterns occur with the link between time investment in production and depositional contexts. Some objects of elaborate and formal production sequences, such as mace-heads and mortars are only found in communal contexts, whilst expedient objects such as abraders and hammers are more commonly found in habitation areas. In addition, highly polished edge tools occur more frequently in ditches than in domestic areas. When these patterns are taken together it tends to suggest that issues of ownership and curation practices alone do not satisfactorily explain the distribution of ground stone objects.

### 6.3.3. Location of activities

Another aspect that may shed light on variations in the distribution of ground stone objects is the contrasting *loci* of different activities. Admittedly, the study of the location of different activities would be greatly facilitated by the presence of fixed structures such as working platforms and immobile grinding stations (cf. Wright 1992b: 81; 2000: 92). Yet, such structures have not been identified in the Makriyalos I settlement. It should be noted, however, that according to the excavator (Pappa 2008: 198) the fill of the habitation pits relates to their use and not to the discard of material following their use. In addition, the fill of Pit 212 does not seem to have been disturbed following the initial deposition as indicated by 'articulated part-skeletons of dogs' and conjoining fragments of ceramic vessels (Halstead 2007: 39) and of grinding tools.

The distribution of ground stone tools in the MK I habitation clusters revealed a homogenous picture suggesting that diverse activities such as grinding and the working of stone, skin, bone and wood might all plausibly have taken place within domestic contexts. The higher frequency of grinding slabs with evidence of burning from a possible use for baking, a slightly higher proportion of multiple-use tools and more frequent finds of grinding slabs with traces of colour from mineral processing offer possible hints that a wider range of activities took place in domestic than communal contexts, but the latter two observations are based on small samples. In all, tool categories and the presence of debitage indicate that a wide range of activities took place on a small scale within the habitation area.

Grinding slabs were probably used not only for processing of grain and minerals within habitation contexts, but also for large-scale processing of staple foods for communal events taking place in or near the borrow pits. The pottery assemblage and faunal remains from Pit 212 attest to large-scale preparation and consumption of animal-based foods (Pappa *et al.* 2004: 32), while the archaeobotanical data (Valamoti 2003) and the ground stone assemblage from this context might suggest the same for plant-based foods. Pit 212 accounts for 25% of all ground stone objects from MK I, while tools that could have been employed in food processing make up more than 70% of this sub-assemblage. The grinding tools may thus have been closely linked to the events taking place in or near Pit 212.

The relatively small grinding slabs from Pit 212 may indicate the small-scale preparation of edible substances prior to communal events, a view shared by analysis of the capacity of cooking and serving vessels from this context (Urem-Kotsou 2006). No variation in size, manufacturing techniques or raw materials is attested between tools from habitation contexts and the context of Pit 212, while their small size makes them also portable and so they may easily have been moved from one location to another to accommodate the needs of particular events. Grinding tools employed during communal events, therefore, may have been tools used by individual households during daily events that would have been easily transferred to communal areas when required. This suggestion is also supported by the homogenous character of cooking vessels found in both habitation and communal contexts indicating that 'the same cooking vessels were used in the preparation of feasting food and in the cooking of domestic meals' (Urem-Kotsou and Kotsakis 2007: 242).

The preparation of food, therefore, seems to have been carried out on a small scale in communal areas with several people (representing different households?) taking part simultaneously in grinding activities allowing for greater interaction between the actors involved. This point is well illustrated by ethnographic research. Graham (1994: 53-54, 70) has suggested that, for their celebrations and drinking parties, female residents of the Rarámuri settlement in Northwestern Mexico grind large quantities of corn. During these festivities it is common for grinding tools (metates) to be carried to specific areas, so that more women can take part in food processing. This change in location of food processing activities enables more interaction between the women involved, allowing them to socialise while they work.

To a significant degree, however, the location of activities does not satisfactorily explain the variation in the distribution of tools from Makriyalos I. If this were the case then the distribution of grinding slabs and grinders should be complimentary rather than contrasting. Similarly, it would be expected that the distribution of mortars and pestles should match each other. Mortars, however, occur only in communal areas, whilst pestles are more common in habitation areas. It should be noted that the potential use of wooden pestles cannot be excluded; their use would alter any expected patterning.

### 6.3.4. Deposition as purposeful 'statement'

As has been show, differences in the distribution of grinding and edge tools in habitation and communal areas cannot be explained solely by models of discard and curation practices and the locations of activities. Commonly discussions of artefact discard and deposition emphasise utilitarian concerns 'such as the effort involved, physical hindrances and reuse value (Baysal and Wright 2005: 321). It should be realised, however, that cultural understandings of what constitutes rubbish and social norms towards disposal and cleanliness are of equal importance in how different cultures choose to dispose of artefacts (Baysal and Wright 2005). Artefact disposal need not even be considered permanent, for example usable objects are disposed in the Raramuri refuse area with the understanding that they can be retrieved later as required (Graham 1994). This act represents not only disposal but also storage and has therefore been described as 'provisional discard' or 'passive storage' (Graham 1994, 72).

Importantly, the disposal of objects may also be linked to deliberate acts of deposition and thus may be employed as an active medium for the negotiation of social relations. As Halstead (2007: 39) has argued *'The mass disposal of this material* [in pit 212] *could be interpreted either as a practical solution to the generation of a large volume of refuse or as a symbolic reinforcement of the importance of, presumably, a series of major consumption events'*. Bearing in mind Halstead's statement, it should be noted that the large number of grinding slabs represented in the Pit 212 assemblage goes beyond the needs of individual households and even the local community especially when the average duration of the use-life of such tools is taken into account. In this respect, the Pit 212 grinding assemblage is 'wasteful' in character.

An aspect of great interest is the condition of the grinding tools deposited within Pit 212. A large number of these tools survive in a very fragmentary condition and as noted in Chapter 5 the fragmentation patterns cannot be explained simply through the use of these tools. Furthermore, within the deposit of Pit 212 indeterminate grinding tools occur more frequently in layer 3 (the thick 'carpet' of finds) suggesting that the breakage of grinding tools into very small pieces was linked to the events taking place in relation to Pit 212.

Within the context of Pit 212, fragmentation of grinding tools takes on a different meaning. If, as suggested, the grinding tools found in Pit 212 belonged originally to individual households, then their symbolic significance flows from their representation of the household contribution to communal events. After their use in a communal event and subsequent breaking into pieces, they cease to belong to individual people/households and are transformed into objects symbolizing a wider community. Their deliberate fragmentation and their deposition in a context with feasting debris represent a symbolic act that brings closure to a significant communal event and must be understood as a deliberate act of conspicuous consumption. The fact that no human bones have been found in the context of Pit 212 indicates that the communal feasting events were not linked to mortuary rites (Triantaphyllou 2001) and thus it is unlikely that the fragmentation of grinding tools in this context to reflect artefacts deliberately 'killed' at the time of their owner/user's death. The deposit of this pit represents, therefore, a 'timemark', an objectification of a set of social relations, evoking past memories and the creation of a new or renewed social order (Hodder 2004). Thus, as Brück (2006: 297) has suggested, acts of deliberate breakage allowed 'transformation from one state to another', a transformation of the relationship from individual to collective and from the household to the community as a whole. Grinding activities and grinding tools in general are well linked with the idea of transformation as these tools were actively used for the transformation of different materials to valued objects and substances (see Chapter 5).

Thus, in this context household identities are masked/subdued and the creation of communal identity is actively projected. Similar acts of identity transformation from the individual to the collective have been suggested for the disposal of the dead in MK I (Triantaphyllou 1999). Triantaphyllou suggested that the disposal of disarticulated burials in the ditch placed emphasis on 'the communal and the primacy of *group identity* over the individual' (1999: 131, original emphasis). The fragmentation of grinding tools should perhaps be considered in relation to the disarticulated bones as part of a transformation process that played an important role in the reproduction of the Neolithic community of Makriyalos.

Therefore, the value of grinding tools and the meaning of grinding activities during these events in which social relationships were forged and strengthened and group identities were shaped, can assume added connotations. Grinding activities, an otherwise everyday mundane task, acquire a different meaning when performed for larger groups of people in an event imbued with social and symbolic significance.

In addition to the above, the uneven distribution of material among the different sectors of Ditch A, with large concentrations in trenches Ξ071 (n=192) and K027 (n=109), and preferential association of particular tool types with specific sectors, e.g., edge tools with sectors K and Λ, grinding/abrasive tools and in particular grinding slabs with sector Ξ, and grinders with sector K suggest that further conventions seem to have governed the deposition of material during the MK I habitation. The unusual quantities of ground stone within trenches Ξ071 and K027 of Ditch A may suggest that these areas for some reason were perceived as more appropriate for the deposition of ground stone material. Moreover each of these areas seems to have been regarded as more fitting for the deposition of different types of tools.

The distribution of edge and grinding tools among the different sectors of Ditch A could thus indicate that these were formal deposits, deliberately located in relation to the ditch. It has been suggested that the ditch represents a large scale earthwork dug in segments and that different households might have been responsible for the original excavation and upkeep of different segments of the ditch (Andreou *et al.* 2001: 295; Halstead 2006: 15). In this light, variation in the distribution of material might indicate that different groups (households) chose to deposit particular types of material culture in different places. The deposition of artefacts within the ditch might have been regarded as a medium for social display, communicating a message that would have been understood by the contemporary people. Therefore, it is possible that the selection of communal areas and in particular of the ditches for the deposition of highly polished edge tools was linked to the visible nature of the context of deposition making the act a form of conspicuous consumption.

Bradley (2005) refers to a similar pattern of deposition in the ditch of the Neolithic causewayed enclosure at Etton, southern England: To quote:

> '*Different segments of that ditch contained different kinds of offerings, and individual assemblages may have had a distinctive layout, with items of particular significance placed against the causeways providing access to the site... Individual segments of the earthwork may have been created and maintained by separate parts of the community ... Such features had probably been surrounded by a rim of spoil so that people could view the material displayed within them. Indeed these deposits varied so much from one part of the site to another that Pryor describes them as purposeful 'statements'(1998: 357-8)*' (Bradley 2005: 114, 116).

Both ditches at Makriyalos I and Etton seem to have been regarded, therefore, as places of special virtue and were imbued with a special meaning. The symbolic character of Ditch A is also stressed by its use as the main burial ground during the first phase of habitation (Triantaphyllou 2001). Another point worthy of mention is the concentration of material in K027. This is interesting because in this area a borrow pit had preceded the construction of the ditch (Pappa and Besios 1999b: 114). The selection of this specific area of the ditch for the deposition of a large number of ground stone objects could thus relate to the particular history of this area and to specific traditions that the occupants were following. Thus, Ditch A, an otherwise communal feature which defined the settlement of Makriyalos I, might not have been perceived as a feature with a uniform character along its length. Like the objects deposited into it, the ditch too had a biography, a history of labour and people associated with different sections of its length.

Variations in the quantity and type of material deposited in the different sectors of Ditch A have also been noted in the study of pottery. Urem-Kotsou (2006: 155-156) has reported that Sector Ξ yielded larger quantities of pottery than Sectors K and Λ, a pattern paralleled in the distribution of ground stone. Also of interest is the higher frequency of drinking cups in Sector K and their low occurrence in Sector Ξ. According to Urem-Kotsou (2006), the cups represent containers of a rather individual character that possibly stress the individuality of their user. Similarly, analysis of the ground stone assemblage has shown that edge tools, and the small sample of ornaments and mace-heads occur more frequently in Sectors K and Λ than in Sector Ξ. As noted previously, edge tools similar to ornaments and mace-heads seem to have been perceived as personal objects of a more individual character. It may then be significant that elements of material culture that stress individual identity were deposited/discarded in the same areas of the Ditch A and seem to have been contrasted with the deposition of grinding slabs which seem to have been linked to more communal uses.

Ditch A represents a large-scale earthwork that both delineated the boundaries of the MK I settlement and defined symbolically its community (Kotsakis 1999; Pappa and Besios 1999b). This communal feature was of great interest to the community of Makriyalos as indicated by the continuous maintenance through the re-digging of the different sections of the ditch. More importantly, it represents a feature that remained visible and in use throughout the use-life of the settlement (Pappa 2008: 194) and thus the deposition of material within the ditch might have be seen as a medium to express individual/household identities by placing deliberate deposits in relation to the ditch.

Similar to the suggestions made for Pit 212 and the meaning of grinding tools in that context, it may be argued that gradually after the deposition of material within Ditch A expressions of individual identity were transcended through the appropriation of this communal landmark and object deposition emphasises a move towards a 'group identity' (Triantaphyllou 2001: 63). The deposition of ground stone artefacts in Ditch A, along with the disposal of the deceased, enabled the negotiation of social relations among the different social groups of the Makriyalos community and more importantly became a medium of transformation of individual to collective identities.

It may be suggested, therefore, that both Ditch A and Borrow pit 212 represent deposits of a special meaning, actively linked to the negotiation and reinforcement of communal identity. They do so by deploying objects that are directly linked to aspects of daily life 'but provide them with a new emphasis' (Bradley 2005: 119). Events of a symbolic/special significance need not be seen in contradiction to events of daily life, for 'rituals were constructed out of the materials of domestic life' (Bradley 2005: 119). Overall the deposition of ground stone objects during the first phase of habitation suggests an interest in the reinforcement of collective identities while different strategies (e.g., large-scale earthworks, events of conspicuous consumption, deliberate deposition of objects and disposal of the dead in communal areas) seem to have been employed for asserting social cohesion.

## 6.4 Makriyalos II

From the phase II settlement, the vast majority of ground stone artefacts again comes from stratified contexts. In contrast with phase I, however, the majority of the ground stone comes from habitation contexts (n=1489) and borrow pits (n=1193), whilst the material derived from Ditches Δ and E is very limited (n=76) (Figure 6.9). This contrast reflects the more modest dimensions of the phase II ditches and the more limited scale on which they were excavated. Excavation also revealed a natural watercourse which, according to the excavators, might have acted as a boundary for the Makriyalos II settlement (Pappa and Besios 1999b: 114; Pappa 2008: 210). This feature produced 229 artefacts and will be treated separately in the following analysis. Within MK II, three areas have been identified as borrow pits: Sector Δ, Pit 174 (Sector Ξ) and Sector H. The borrow pits in Sector H have given more than 85% of the material attributed to this type of context. As a result, the following discussion will concentrate mainly on comparison between habitation, borrow pits in Sector H and the watercourse, whereas the small sample from the ditches will be dealt with more briefly.

### 6.4.1. Comparison between habitation area, Sector H borrow pits and watercourse

All general tool categories occur in each of the three main contexts, but ornaments and perforators are missing from the small ditch sample. The distribution of general categories has revealed an interesting pattern. In contrast with phase I, habitation contexts and borrow pits have similar proportions of all general object categories, but differ from the watercourse. Edge tools, percussive tools and ornaments are much more frequent in the watercourse and grinding/abrasive tools much less so; the watercourse is the only context in which edge and grinding/abrasive tools occur in similar numbers (Table 6.33 & Figure 6.10). In the ditches, grinding/abrasive tools are by far the most common category (66%). A chi-square test indicated that these differences between contexts in the frequencies of general object categories are highly significant ($df$=18, p=0.001).

When the distribution of specific object categories is considered, all subtypes of edge and percussive tools, weights and ornament occur more frequently in the watercourse, pestles (and pestle/hammers) and grinders more frequently in the habitation levels, and grinding slabs more frequently in borrow pits and ditches, whereas mortars mainly occur in habitation and the watercourse. Finally, debitage from stone working (nodules, cores, waste by-products, flakes with or without retouch) is encountered in all four contexts (Table 6.34).

Artefacts with evidence for burning are evenly distributed between the four contexts, but different categories of burnt objects are associated with different contexts. Burnt edge tools are three times more frequent in the domestic arena, whilst burnt grinding/abrasive and percussive tools occur more frequently in borrow pits in Sector H (Table 6.35).

Significant differences are also attested in the condition of artefacts (excluding edge tools – see below) between the different contexts. Habitation (23%)the watercourse (25%) and the ditches (22%) contain almost twice as many artefacts with no damage as the borrow pits (13%) ($df$=3, p=0.000) (Table 6.36). This might indicate that objects with some potential for further use were kept within the habitation area while the borrow pits acted at least on some occasions as a refuse area. In fact, all eight complete or almost complete MK II grinding slabs come from habitation contexts (ΑΓ 13080-Pit 16β, ΑΓ 13216, ΑΓ 13224, ΑΓ 13277-pit 712, ΑΓ 13319- Pit 414-589, ΑΓ 13460 & 14446- Pit 583-585, ΑΓ 14531-Pit 739). Tools with heavily used and worn-out use-faces, however, are evenly distributed in all contexts.

When the overall dimensions of edge tools are compared, it occurs that the tools from habitation levels differ from those in borrow pits and the natural watercourse. The Kruskal-Wallis test indicated a significant difference (p=0.000) in the length of edge tools between the different contexts (Table 6.37). This variation might indicate that tools in habitation areas represent tools of a more usable state and with a bigger potential for further use. No morphological variability, however, is encountered in the edge tool assemblages from the different contexts.

The use of raw materials for edge tools is fairly similar for the three contexts, in terms of both general and specific geological categories (Table 6.38). Despite the difference noted in the frequency of burnt edge tools among the recovery contexts, the degree of damage on the bit and butt area of edge tools varies little between the three contexts as does the degree of use (in all three contexts, the majority of tools had been used heavily).

As regards manufacturing techniques, polishing is by far the most common technique in all contexts. Highly polished tools are most frequent in habitation levels (Table 6.39), perhaps hinting that people chose to curate in the domestic arena objects in which they had invested more time and effort. The evidence for resharpening and sawing indicates that processes of maintenance and repair were performed for tools in all contexts and there does not seem to be any correlation between degree of polishing and maintenance/repair.

Comparison of the overall dimensions of lower grinding tools indicates that the material from the habitation area tends to be substantially larger than that from the borrow pits. The material from the watercourse was not taken into account due to the extremely small size of its sample (n=35). The Mann-Whitney test for two independent samples indicates that the difference in the width of lower grinding tools from the two contexts is highly significant (p=0.000) indicating that the material from the habitation contexts was deposited whilst in a better condition, as seems to have been the case for edge tools (Table 6.40). This is also supported by the state of preservation of these tools as tools with complete width are twice as frequent in habitation as in borrow pits in Sector H ($df$=1, p=0.003) (Table 6.41), while, as noted above, all examples of complete grinding slabs come from the habitation area.

Sedimentary and metamorphic raw materials are evenly distributed between habitation areas and borrow pits, but igneous rocks are preferentially associated with habitation while no igneous rocks were found within the small watercourse sample (Table 6.42). No technological and morphological variation is encountered, with flat use-faces being by far the most common type in all contexts. Tools have been used to similar extent in all contexts (Table 6.43) and the distribution of single and multiple use-faces is very even between recovery contexts. In terms of maintenance practices, repecking is attested in both contexts in similar frequencies (14%), consistent with the picture for the repair/maintenance of edge tools.

No variation is attested in overall size, raw material use, manufacturing techniques and morphological characteristics of grinders from habitation contexts and borrows pits.

### 6.4.2. Makriyalos II habitation

As mentioned in Chapter 2, Makriyalos II is characterised by a densely occupied habitation area that differs greatly from the MK I habitation area. Single pits and pit complexes with hearths are the main architectural features attested in this area. Contrary to MK I, the dense character of the MK II habitation makes it difficult for pit clusters to be distinguished. The habitation area may be sub-divided, for heuristic purposes, into two areas based on the density of architectural features: the north-western area and the eastern area (for a similar division of space see Skourtopoulou 2006).

The great majority of pits and pit groups contain ground stone products. Most pits in both areas have less than five products each (Figure 6.11), but some pits exhibit a higher concentration (more than 20 products): eastern area: pits 24 (n=49), 40 (n=25); north-western area: pits 360 & 555 (n=23), 413-552 (n=31), pit A (n=29), 414 (n=30). Most of these pits are linked with fixed structures, such as the numerous hearths and paved areas as well as postholes, suggesting that activities linked to ground stone technology were practised more intensively within or near these architectural elements. It should be noted that these 'concentrations' of ground stone material are independent of the volume of earth excavated. For example, pit 632 (north-western area) with eleven products has a diameter of not more than two metres. On the other hand, pits 20-46 and 161 (north-western area) have yielded no more than eight products, even though they are 4-5m in diameter and *c.* 30cm deep. Equally, pit Z with a diameter of *ca.* 4m is the largest within its pit-complex and yet contained no ground stone products.

Overall, the two areas do not differ in terms of tool types and therefore activities carried out and in general condition of artefacts (surface condition and damage patterns). Both finished products and debitage from manufacturing (nodules, flakes, waste by-products) have been unearthed from pits in each area indicating that ground stone technology was practised widely. Likewise, edge tools are widely distributed within pits and pit complexes with the majority of pits in both north-western and eastern areas of habitation having 1-3 edge tools, and only a few pits with a larger concentration of edge tools (>4). The largest concentration is encountered in pit A with sixteen edge tools -the largest such concentration within a single pit in the second phase of habitation (Figure 6.12). Grinding tools are also found in low quantities within the habitation pits of each area (ca. 1-3 grinding slabs and equal numbers of grinders per pit).

The edge tool assemblage from the two areas exhibits great homogeneity in overall dimensions and morphological characteristics, surface condition, and degree of maintenance. The inhabitants of both areas of habitation have employed the same rock types for the production of their edge tools, which might indicate that the same or similar raw material sources were being appropriated by the wider community. Although both areas have similar proportions of tools with worn out use-faces, the eastern area of habitation has significantly more tools that have been used heavily

(49%) than the north-western area (28%), which also more often has tools with light and moderate wear (*df*=3, p=0.009) (Figure 6.13).The eastern area also has more tools with highly polished surfaces (53% vs. 41%) (*df*=3, p=0.028) (Table 6.46). The variation in the degree of polishing between the two areas may indicate variation in terms of style and level of investment in the production of edge tools between the inhabitants of the two areas.

In the case of upper (grinders, grinders/hammers[7]) and lower grinding tools the homogeneity of the two areas is reflected in overall size and shape of tools, raw material use, manufacturing techniques, degree of use, surface condition and fragmentation patterns. It should be noted that four examples of complete grinding slabs were unearthed from the north-western area of occupation. The repecking of worn out use-faces is more frequent in the eastern area (25% vs. 8%) (*df*= 1, p=0.000) (Table 6.47), in contrast with the almost equal proportions of resharpening and sawing of edge tools in the two areas.

Another issue that was highlighted during the analysis relates to debitage debris from the manufacture of ground stone products that has been unearthed from various areas within the habitation area that in essence attests to the on-site practice of this technological scheme. This point is further reinforced by the study of the chipped stone technology which has revealed that stone knapping was practiced widely within the habitation area and debitage was repeatedly found within the majority of pits and pit groups (Skourtopoulou 2006: 62). The presence of debitage in communal areas and especially in the borrow pits H might relate to material that have been discarded during cleaning of habitation pits (cf. Skourtopoulou 2006: 70).

Moreover, the fact that both facets of stone working (ground and knapped stone) were practiced within the same contexts of daily life, points towards the idea that these two technologies might not have been perceived as two distinct activities, but rather as closely linked with each other.. This close relationship between ground and knapped technology is further supported by the distribution of ground and knapped stone within the habitation area (Figure 6.11 & 6.14). In both cases the majority of pits were characterised by the presence of both ground and knapped stone products with a large

[7] Grinders/hammers were included in the analysis of grinders so as to increase the sample size.

number of pits having less than five products of either type of stone products. In addition, most of the pits, that have produced high frequencies of knapped stone, are characterised by similar quantities of ground stone. Finally, there are some pits that show larger concentrations of ground stone than knapped stone and vice versa. It should be noted, however, that it is not possible to directly compare the quantities of ground and chipped stone objects since ground stone tools have a longer use-life and thus are expected to occur in smaller quantities at a given site (cf. Perlès 1992: 141).

The relationship between ground and knapped stone could be also addressed through the nature of the activities performed with the different tools. Skourtopoulou has suggested that the chipped stone assemblage indicates 'a rather limited range of tool-related activities' ranging from 'the possible working of hard materials (stone or shell)..., and the working of soft materials such as hide as well as .... the cutting of plants using blades' (Skourtopoulou 2006: 62, 64). Similarly, a range of different types of activities is represented by the ground stone assemblage, such as woodworking activities performed with edge tools, grinding of edible and non edible substances (e.g. pigments), as well as activities contributing to other craft technologies e.g., polishers for pottery burnishing, grooved abraders for the manufacture of bone tools, grinding tools for the polishing of edge tools and the production of shell ornaments (cf. Miller 2002). It is clear that some of these activities correlate to ones performed by knapped stone as well and in that sense they should be perceived as the means of the same technical procedures (e.g., production of shell ornaments, see Miller 2002; Plate 6.1). To sum up, it could be suggested that the distribution of ground stone resembles that of knapped stone indicating a technical coordination of ground and knapped stone technology in terms of contexts of production and use.

Among the pits with the highest frequencies of material, pit 24, a subterranean dwelling with evidence for storage (Plate 6.2), was the most unique in character as it has given the largest single concentration of ground stone among the MK II habitation pits with 49 artefacts in total. The unique character of this pit has been stressed through the analysis of other categories of material culture. In particular the study of pottery has indicated that pit 24 yielded the largest concentration of Dimini painted pottery (Vlachos 2002), a type of decorated pottery that according to ceramic petrographic analysis was imported from the Thessalian settlement of Dimini (Hitsiou 2003). Moreover, the analysis of knapped stone has shown that the assemblage of this pit was characterised by the highest frequency of high quality blade tools (Skourtopoulou 2006). It has been suggested that the deposition of large quantities of material in this pit are linked to intentional events taking place after the end of the use-life of the pit. In terms of the ground stone assemblage composition no variation is attested between this context and others of Phase II although the large quantity of material found within this pit may suggest that it was regarded fitting for some reason to place large numbers of previously used ground stone objects along with other artefacts within this context.

Finally, ground stone has also been associated with an area where pit clusters (571, 572, 573, 574 & 413/552, 559, 551) are surrounded by numerous hearths and paved areas (Pappa and Besios 1999b, 1999a). As Figure 6.11 highlights larger concentrations of ground stone artefacts are linked to this area. This possibly un-roofed area has strong indications for its use as a communal working area as suggested by the study of other sets of material such as knapped stone (Skourtopoulou 2006; Pappa 2008). Therefore, many daily activities such as food processing, cooking and craft making could have taken place at least on some occasions in an outdoors area and may have involved more than one households allowing for greater social interaction between different social actors (cf. Wright 2000: 111-112).

### 6.4.3 Summary

Similar to MK I, the analysis of the ground stone assemblage from Makriyalos II has revealed a homogenous picture for different contexts, but distinct patterns in contextual variation have been also identified. As in the analysis of the phase I assemblage, the distributions of all recorded attributes have been consistently tested at various levels and contextual relations, but only results that are statistically significant have been presented here. Nevertheless, certain patterns invite further discussion:

1. Uneven distribution of object categories between recovery contexts (e.g., edge tools and ornaments are associated with watercourse).

2. Uneven distribution of raw materials between different contexts (e.g., igneous rocks for lower grinding tools occur in habitation).

3. Contextual variation in deposition of burnt objects between different MK II contexts.

4. Variation in the size of artefacts and in their state of preservation between different contexts (MK II grinding slabs and edge tools from habitation are larger than tools from borrow pits in Sector H).

5. Uneven distribution of highly polished edge tools between and within contexts.

In the following discussion the most significant patterns identified will be discussed and interpretations will be put forward.

## 6.5. Discussion: The spatial distribution of the Makriyalos II ground stone assemblage

Similar to MK I, some variations have been attested in the distribution of object categories between the MK II recovery contexts. Contrary to MK I, borrow pits and habitation contexts are very similar in terms of tool types encountered, and both contrast with the watercourse assemblage, which is preferentially associated with edge tools, ornaments and percussive tools (especially mace-heads).

As argued previously, variations in the deposition of artefacts might reflect practices of discard, curation, ownership or the location of activities. In comparison to MK I, some of the MK II material does fit more closely with the proposed models in respect to the closely linked practices of discard and curation. Although heavily used tools are evenly distributed between the MK II recovery contexts, variations have been noted in the condition of objects between the different contexts. Tools from the habitation area were deposited whilst in a better condition and thus in a more usable state than those found in the borrow pits in Sector H. In addition, all complete or almost complete grinding slabs come from habitation contexts. Similarly, Skourtopoulou (2006: 62, 66) notes that knapped stone material from the habitation area exhibits 'still active edges for tools and debitage products' and thus is differentiated from material that has been discarded. Moreover, highly polished edge tools and igneous grinding slabs which were possibly procured from sources located further away from Makriyalos – thus both representing tools of greater investment- occur more frequently in the habitation area. Taking all this into account it could be suggested that curation strategies were in place in Makriyalos II and therefore people chose to keep tools with potential value for future use in habitation areas, whilst the borrow pits in Sector H were used as a possible refuse area at least on some occasions (cf. Skourtopoulou 2006). Yet, as with the MK I material, these models do not easily fit with the patterning of the material in all cases. For example, those tools linked with a stronger sense of ownership, in this case edge tools, mace-heads and ornaments, occur more frequently in the communal context of the watercourse rather than in habitation contexts. Furthermore, the presence of undamaged objects in the watercourse (and the ditches) indicates, similar to MK I, that the deposition and the discard of artefacts cannot be adequately approached in practical terms alone.

The complex array of issues associated with deposition and discard are further highlighted by variations revealed in the surface condition of tools among the different contexts. Different types of objects with evidence for burning are linked to different contexts: burnt edge tools occur more frequently in habitation, while grinding slabs and percussive tools occur in greater proportions in Sector H borrow pits. This may suggest that burning is not related simply to the type of context, but to the treatment different object categories received within different contexts. The high frequency of burnt edge tools is a rather intriguing pattern as the use of edge tools does not entail activities with fire. As suggested in Chapter 5, however, this aspect might relate to an intentional act of destroying these tools and removing them irrevocably from circulation as burnt edge tools could not have functioned for their original purpose. A similar case for the intentional 'killing' of edge tools has been put forward for the Franchthi Cave assemblage (Stroulia 2003). Stroulia has suggested that small edge tools were deliberately broken into pieces retaining part of the use-face (edge) and one margin (Stroulia 2003: 23-24). In that sense, these acts are imbued with symbolic meanings possibly marking the end of the tool's use-life or even the life of the household or the people that were linked to it. Of greater interest, however, is the fact that during MK II this symbolic act is associated with the domestic arena. These issues will further be discussed in the following section comparing the differences between MK I and MK II.

## 6.6. Makriyalos I and Makriyalos II comparisons

### *6.6.1. Habitation*

The assemblages from both phases of the Makriyalos settlement indicate that a range of activities were performed within the limits of the habitation area which included both food processing activities as well as tool manufacture and maintenance. Furthermore, the distribution of the ground stone assemblages in the MK I and MK II habitation areas reveals a uniform picture (pit clusters O, ΚΛ, Λ in MK I; north-western and eastern area in MK II) indicating that the same tool types are repeated and consequently the same tool-related activities seem to have been carried out within the different areas of the domestic space. The recurrence of tool production debris and sets of tools points towards the suggestion that production and consumption throughout the LN period were organised on a small scale by relatively small sized groups. In that sense, the distribution of ground stone in both phases of occupation reaffirms previous suggestions for the existence of separate *households*. This suggestion is further reinforced by the study of knapped stone which, as seen previously, suggests a comparable pattern with similar assemblages of tools and debitage repeated among the different pits of Makriyalos II (Skourtopoulou 2006). Admittedly, the denser arrangement of structures in the MK II habitation area makes the identification of separate habitational units difficult. Yet, the repetitive deposition of debitage and tools throughout the habitation and the evidence for separate covered architectural units interpreted as domestic spaces (e.g., pit A) suggests the existence of separate social units (i.e. households) (cf. Skourtopoulou 2006; Pappa 2008)

The distribution of the ground stone assemblages within the MK I and MK II habitation areas indicates different attitudes towards the deposition of stone during the two phases of occupation. In MK II most pits have less than five products each and only seven pits in total have given a concentration of ground stone more than 20 products. Moreover, the presence of still usable tools within the MK II habitation area contrasts with the even distribution of heavily-used and broken artefacts noted during MK I. Bearing this in mind it could be suggested that during the MK II there was a tendency for the occupiers of these pits to follow different depositional and curation practices such as cleaning the interior of the pits more frequently and keeping objects with potential for future use within habitation.

Finally, both in MK I and MK II habitation areas different types of raw materials are evenly distributed possibly suggesting equal access to similar or even the same resources by all members of the community. As argued previously, this might be seen as a means of maintaining a sense of shared identity and belonging, allowing for social cohesion. Perhaps, it also indicates that at this point there was no particular group within the society who controlled access to these raw materials.

### *6.6.2. Borrow Pits*

Variations were also encountered in the character of the ground stone assemblages from the MK I and MK II borrow pits. The MK II borrow pits exhibit increased proportions of all object types other than grinding/abrasive ones (Table 6.48). This variation mainly reflects the radical decrease of indeterminate grinding/abrasive tools from 25% from MK I to 10% in MK II. Moreover, edge tools from Pit 212 show significantly higher proportions of burning in relation to borrow pits in Sector H (Table 6.49).

These differences in the character of the material between the borrow pits further supports the changes in the character of the borrow pits and in the acts that relate to the accumulation of material within them in either phase (Pappa 2008). As seen previously, the borrow pits in Sector H seem to represent material accumulated through the general use of the area as a refuse area. Pit 212, on the other hand, was associated with the accumulation of debris from particular type of events (feasting episodes) that took place within relatively short periods of time. Thus, the use of pit 212 is linked to events that were imbued with symbolic significance through which collective identities and ideas of belonging were reinforced and renegotiated. In this context, the deposition of material (tools, pottery, animal bones) on a large scale is symbolically-laden and could be characterised as an act of conspicuous consumption. The symbolism of these acts was further reinforced though the destruction of certain categories in a more dramatic way (i.e. fragmentation of grinding tools and destruction of edge tools through fire).

### 6.6.3. General comparison between Makriyalos I and Makriyalos II

During the analysis of the distribution of ground stone in MK I and II some differences have arisen indicating that both similarity and variation characterises the way daily practices were performed by the inhabitants of the MK I and II and the significance that ground stone tools held. In both phases there seem to be preferential deposition of certain object categories within different contexts: in MK I edge tools are more frequent in habitation areas, while ornaments and grinding tools are more common in contexts of a communal character; in MK II edge tools and ornaments are found more frequently within the watercourse, a feature with communal character, while habitation and borrow pits are very similar in terms of assemblage composition. Moreover, the distribution of grinders also changes over time from tools mainly found within ditches in MK I to a preferential association with habitation contexts in MK II. In addition, mortars that, during MK I, are found only within communal areas, in the subsequent phase are more frequent in habitation levels.

Variations have also been attested in the condition of ground stone at the time of deposition between the two periods. Thus while in MK I there is not a clear differentiation between the three contexts in terms of fragmentation and degree of wear, in MK II ground stone implements in a more usable condition were kept within habitation areas while the borrow pits might have acted at least at some occasions as a refuse area, a suggestion also supported by the study of the chipped stone assemblage (Skourtopoulou 2006).

Finally, another aspect that should be highlighted relates to the degree of polished surfaces on edge tools. The MK I assemblage indicates that highly polished tools are more frequent in the ditches, while during MK II they are more frequent in habitation levels. In addition, although in MK I burnt edge tools are evenly distributed among habitation and communal areas, in MK II they are preferentially associated with the domestic contexts.

Hence when comparing the MK I and MK II material it is clear that there are strong differences in the deposition of key ground stone categories. It remains to try to understand the significance of these differences and the manner in which they reflect changes in Makriyalos society as a whole. Within Phase I, the concept of the community was strengthened and shared identities were actively reinforced through a range of material practices including the creation and maintenance of the large ditches, large scale communal feasting events and the placement of burials within Ditch A (Triantaphyllou 1999, 2001). During this phase, there is an evident emphasis placed on acts of deposition conducted in communal contexts (feasting Pit 212 and the concentration of material within certain areas of Ditch A), which need to be seen as purposeful 'statements' and as acts of conspicuous consumption that were actively manipulated for the maintenance of collective identity. Furthermore, these acts were given weight through the fragmentation of grinding tools and the destruction of edge tools, which as argued previously represented the contribution of individual households to the communal events. Yet, the presence of fragmented grinding tools and burnt edge tools in the domestic arena might suggest that at certain occasions during this time people chose to replicate these practices of deliberate destruction in the domestic arena where they would have been viewable by fewer people. Alternately, people may have chosen to deposit grinding and edge tools that were perhaps deliberately destroyed during a communal event at a later date within habitation areas. These acts may well be linked to the negotiation of identities in a different context (i.e. domestic arena) and potentially at a smaller scale (local community).

In contrast to this, within Phase II there is a greater emphasis on domestic contexts as suggested by the densely occupied habitation area, the volume of material unearthed from it, the more modest dimensions of the ditches and the tendency for burials to be located within the habitation area (Triantaphyllou 2001: 63-64). The identity of the individual household is also manifested architecturally as structures in the latter phase include a new form of above-ground rectilinear buildings up to 15m long (Pappa and Besios 1999b) emphasising more overtly the separation of the household from the wider community. The deposition of ground stone artefacts within the habitation area takes on a different meaning. The evident interest in keeping still usable tools in the habitation pits, the deposition of highly polished edge tools and the deliberate destruction of these tools within these areas may all represent acts that emphasise the identity of smaller social units (households). Similar suggestions for acts of symbolism during this phase have been suggested for the deposition of knapped stone. As Skourtopoulou has argued these acts do not seem to contradict daily routines, rather these practices seem to have coexisted within habitation contexts, where daily domestic life evolved (Skourtopoulou 2006: 67-69). The emphasis on domestic contexts in terms of both architecture and material practices in MK II may reflect the gradual erosion of collective obligations and a shift towards independent households (Halstead 1995, 2006). This shift in emphasis may also explain why the fragmentation of grinding tools decreases radically, suggesting that the sense of a communal identity, to which it was linked, may also have started to erode. It would appear, therefore, that the focal points for key depositional events shifted from communal to domestic areas between Phase I and Phase II.

Despite the above, it is still clear that the importance of community was not entirely eroded as witnessed by higher proportions of ornaments, mace-heads and edge tools deposited within the Phase II watercourse. Whilst, the status of this feature is hard to ascertain, it is still clear that deposition of personal objects in outside 'communal' locations may be linked to ideas of community. Alternately, they may have provided highly visible contexts in which individuals or households could display their ability to consume various forms of artefacts.

## 6.7. Conclusions

The analysis of the spatial distribution of the Makriyalos ground stone assemblage during phase I and II has offered an insight into the way ground stone technology was incorporated in the life of the Makriyalos community. The repetitive deposition of tool categories among the MK I and MK II habitation areas suggests that activities linked to ground stone technology were organised at a small scale, possibly by individual households. In addition, distinct patterns in contextual variation have been also identified. It was argued that the deposition of ground stone objects in both phases of habitation cannot be approached solely in terms of practices of discard and curation/ownership, or as contrasting *loci* of activities. Instead, the deposition of artefacts may have been regulated by other conventions and may have been actively manipulated at different times in order to stress individual, household and collective identities.

Therefore, in both phases of the Makriyalos settlement both domestic and collective identities were actively expressed and were constantly negotiated through material practices, but there seems to be a change in focus during the later part of the habitation with greater emphasis placed in the domestic arena. This may be viewed in relation to Halstead's argument for the gradual erosion of collective obligations during the end of the Neolithic and a shift towards domestic isolation (Halstead 2006). Attitudes towards ground stone technology, therefore, may be approached to a certain extent through wider models put forward for the Greek Neolithic stressing the tension between domestic and collective scales of identity (Halstead 1995, 2006; Kotsakis 1999; Tomkins 2004). Ground stone artefacts, along with other aspects of material culture, were actively manipulated in expressing domestic and collective identities and rights, and negotiating the tensions arising between the local community and its constituent groups (households) facilitating the social reproduction of the Makriyalos community.

# CHAPTER SEVEN

## Conclusions

*'In the earlier part of the nineteenth century or possibly as late as the fifties the Tuhoe Tribe obtained two fine slabs of nephrite from the Waikato natives, giving in exchange for them a large drove of pigs...These slabs were taken to Rua-tahuna, great preparations were made for the cutting of them: extensive cultivations were made, the land being cleared, the felled bush burned, large quantities of potatoes etc. grown, quantities of forest food products collected and preserved, and houses built to accommodate the workers and friends. Then, the people of Tuhoe collected from far and near, and assisted in the labour of cutting up the blocks of greenstone. Such occasions were much enjoyed social gatherings. The slabs were cut up into pieces, from which mere, hei-tiki and other items were fashioned.'* (Best quoted in Beck with Maika Mason 2002: 105)

## 7.1. Introduction

As highlighted throughout this thesis, products of ground stone technology from the Neolithic of Greece have rarely been analysed in any detail. Discussions of ground stone, when published, rarely go beyond incomplete descriptive accounts to focus on the activities performed with these tools, and the implications and contexts of their use. The products of ground stone technology are seen as mundane *static* objects devoid of meaning and lacking real significance. The aim of this thesis, therefore, was to move away from incomplete accounts of ground stone technology and static typologies of finished objects. Furthermore, contrary to previous studies that focused on selected categories of ground stone artefacts, such as edge tools and/or grinding tools (e.g., Moundrea-Agrafioti 1981; Runnels 1981), it was considered essential to apply a holistic approach, encompassing a wide range of stone objects attributed to what is traditionally defined as 'ground stone technology'. Hence, ground stone technology was investigated as a social practice focusing on the biography of artefacts from raw material selection, to manufacture, use and final deposition. The premise underlying this thesis is that a contextual approach could contribute to understanding the ways in which the production, consumption and discard of ground stone artefacts were structured within different forms of social practice. Embedded in different scales of social interaction, ground stone objects articulate different meanings and social understandings. The aims of the thesis were materialised through the study of the rich ground stone assemblage from the LN settlement of Makriyalos.

## 7.2. Technological choices

The analysis of the *chaîne opératoire* of the Makriyalos ground stone assemblage revealed diverse technological choices that were expressed throughout the cycle of production and use.

The Makriyalos ground stone assemblage exhibits clear patterns of raw material selection that in some cases (e.g., use of sandstone for grinding slabs) seem to reflect practical considerations, but in other cases (e.g., use of igneous rocks for edge tools and pestles) do not seem to have been driven purely by functional reasons. The differential use of rock types for axes, adzes and chisels along with distinct morphologies for each type suggest that these archaeological categories may have had a real meaning to prehistoric people. Moreover, consistent use of the same raw materials throughout the habitation history of Makriyalos indicates established ideas and traditions regarding which materials were considered *appropriate* for the production of different objects. Similarly selective use of raw materials is observed in other Neolithic communities in the Aegean.

In common with other sets of material culture such as chipped stone artefacts and pottery (Skourtopoulou 1999, 2006; Hitsiou 2003), the inhabitants of Makriyalos employed local and distant raw materials, from secondary sources and possibly also quarried material, for ground stone. Local and distant raw materials may have been procured by different social mechanisms (e.g., direct procurement and exchange respectively), that may well have served for the movement of fine pottery, raw materials for chipped stone tools and perhaps archaeologically invisible resources such as textiles and people.

Different stone working traditions characterised by varied and distinct technological choices throughout the production sequence coexisted at LN Makriyalos. Stone technology at Makriyalos ranges from objects of an expedient character, that show no manufacturing traces (*outils a posteriori*), to those resulting from a formalised production sequence. Considerable investment is evident (e.g., in the use of selection of time-consuming techniques such as polishing and sawing) in the appearance of some ground stone objects (i.e. edge tools, pestles, ornaments, mace-heads). Indeed, systematic analysis of 'social/prestige objects' (e.g., ornaments, mace-heads) and (often heavily used) edge tools revealed no sharp distinction in terms of raw material use or manufacturing techniques, indicating that categories such as symbolic/social and functional do not reflect accurately the value these objects might have had for Neolithic communities (*contra* Perlès 1992).

Regarding the *locus* of ground stone production, it was argued that some contrasts may be detected between the different categories. That all stages of edge tool production took place on-site is suggested by un-worked nodules, waste by-products, rough-outs and semi-finished tools. Lower grinding tools, on the other hand, seem to have received initial shaping off-site at the collection site, while maintenance activities took place on-site. In the case of pestles, no clear correlation between un-worked material and finished objects was established. With due allowance for recovery and identification issues, it may tentatively be suggested that different implements were linked to distinct production sequences.

The wear patterns identified on the Makriyalos edge tools include working edges that exhibit different degrees of unifacial or bifacial chipping, while in some cases the edge has become denticulated/serrated, ground edges (blunt) with light pitting, and unifacial or bifacial striations. The majority of edge tools have heavily used use-faces and a large number has damaged or crushed/destroyed bits. Chisels seem to have been used for lighter tasks than axes and adzes. Overall, tools of bigger size tend to break more often than smaller tools indicating their use for heavier tasks requiring greater impact force. Grinding slabs tend to have two-opposed flat use-faces more frequently. Variations in the treatment of use-faces (e.g., interest in maintaining the rough texture of the use-face in some cases contrasts with cases with a completely smooth and/or polished use-face and no indication of pecking or re-pecking is evident), as well as wear patterns such as abrasive and percussive wear and staining/colouring (traces of colour were noted in both upper and lower grinding tools) suggest the possible use of these tools for a wide range of activities such as plant-processing, mineral-processing, and possibly manufacture of shell and stone ornaments and of tools (axes, adzes, chisels). Therefore, edge tools and grinding tools were 'multipurpose tools' that were incorporated in a wide range of activities central to the survival and social reproduction of Neolithic communities.

Some objects did not reach the end of their use-life, however, simply through normal use. Rather, it seems that grinding slabs and edge tools were deliberately removed from circulation, by fragmentation and burning respectively. Thus different objects were subject to different means of destruction, a distinction perhaps related to the activities these tools were used for and the way(s) they were perceived by the inhabitants of Makriyalos. Intriguingly, this deliberate destruction is not paralleled at two other sites in the same region, LN Thermi B and MN DETh, but has been noted for the grinding tools at M. N. Galanis (Kitrini Limni basin, Kozani, Macedonia) (Stroulia 2005). The deliberate destruction of these tools may have been linked, therefore, to certain social occasions that took place in some settlements and not others.

## 7.3. Spatial analysis

Understanding of the *chaîne opératoire* of the Makriyalos ground stone assemblage has been significantly enriched by the spatial analysis of the assemblage. As illustrated in Chapter 2, the LN settlement of Makriyalos provides a rare opportunity for comparing different contexts of activity and discard that relate to practices on a different scale (i.e., habitation/domestic vs. communal/public). The spatial analysis indicated distinct depositional patterns of different categories of ground stone within and between the two phases of the Makriyalos settlement. During MK I edge tools are preferentially associated with habitation areas and grinding tools with communal ones, while in MK II edge tools and ornaments occur more frequently in the watercourse suggesting a difference in the way these tools were perceived or in the social context of their use.

### 7.3.1. Small scale practices and the creation of individual identities

Analysis of the spatial distribution of the ground stone assemblage has also offered significant insights into the way(s) these implements were incorporated into the social life of the Makriyalos community. The repetitive deposition of material repertoires in the MK I pit clusters and in MK II pits suggests that some (daily?) practices were organised at a small scale, at the level of something like an individual *household*. Each *household* possessed its own toolkit, equipped to cover a range of activities from plant processing to craft working and thus meet their day-to-day needs. Un-worked material and debitage was widely distributed (spatially) in both phases of habitation, indicating a lack of specialised working areas for the production of ground stone objects (i.e. workshops). Rather, production seem to have been organised at a small-scale and at the level of the individual household (i.e., domestic production). These observations are in agreement with the analysis of other sets of material culture, such as pottery and chipped stone (Skourtopoulou 2006; Urem-Kotsou 2006). Consistent with this argument, the small size of the Makriyalos grinding slabs and of their use-faces indicates that only small amounts of plants could have been processed at a time, implying that a small social unit used these tools in activities of a domestic character. Likewise, cooking vessels are of a moderate size suitable for the preparation of food for a small number of people (Urem-Kotsou 2006; Urem-Kotsou and Kotsakis 2007).

In addition, the fact that no spatial variation has been attested in the distribution of rock types within the habitation area of both phases of habitation suggests that different households exploited similar or even the same sources and presumably had access to the same mechanisms of procurement. Bearing this in mind it is clear that analysis of the distribution and character of the Makriyalos ground stone assemblage contributes to the wider discussion about the nature of Greek Neolithic societies and supports the argument for the subdivision of Neolithic communities into smaller social units and suggests the existence of a basic household unit that organised food and craft production (Chourmouziadis 1993; Halstead 1995, 1999; Kotsakis 1999, 2006).

The portable character of grinding tools also has implications for the social context and conditions under which grinding was performed. The lack of fixed food-processing facilities (e.g., milling stations/grinding platforms) at Makriyalos might indicate that the location of food processing and other tasks involving grinding was flexible, perhaps allowing greater social interaction during everyday practices. Through these interactions, traditions of working and using stone will have been passed on, intentionally or unintentionally, from experienced actors to younger members of the community, and social knowledge and social structures will have been reinforced. These daily activities of a seemingly mundane character will thus have been powerful mechanisms of communication, an arena of social interaction that enabled the social reproduction of the Makriyalos community.

### 7.3.2. Large-scale practices and the creation of communal identities

Ground stone implements were also consumed at a larger scale during events of a more public character. Ground stone tools and associated practices were implicated in acts imbued with social and symbolic significance that involved the local and probably the regional community as well. The deposition of large amounts of material in the context of the 'feasting' Pit 212 represents an act of conspicuous consumption that reinforced communal identities and contributed towards social cohesion and group stability. Similarly, practices of ground stone deposition within the ditch system evoke symbolic meanings: while Ditch A represents a landmark that emphasises communal effort and planning, differences in the deposition of material between the various sectors of Ditch A may indicate attempts by individual social groups/households to express their particular identity. This might also be suggested by the deposition of edge tools within the same sectors of the ditch as drinking cups (Urem-Kotsou 2006), which are thought to be associated with individuals.

Within these communal events, household and collective identities were in constant negotiation and interplay. Similarities in the size and form of grinding slabs and pottery vessels between habitation contexts and the feasting Pit 212 (Urem-Kotsou and

Kotsakis 2007: 242) suggested that these objects were transferred from household to communal contexts for these public events. In this manner the contribution of labour and material input of individual households was very much in evidence during these communal feasting events. In this respect the meaning of the fragmentation of the grinding tools within the feasting pit adopts a new significance. The material input of individual households, in the form of grinding slabs, was transformed through their deliberate fragmentation to symbolise the wider community. The identity of the grinding slab as an individual object was lost through the process of destruction as therefore was its association with an individual household. The act of deposition of a large number of fragments of different grinding slabs, pottery and animal bones served to shift emphasis from household to collective identities. The sheer quantity of material may have acted as a statement of the strength of the community as a whole. Similar forms of the construction of identity may also be indicated by the treatment of human bone on the site with disarticulated bones commonly being placed into the settlements enclosing ditches (Triantaphyllou 1999).

Within the second phase of Makriyalos various forms of evidence point towards a shift away from the collective towards the primacy of household identity. This is supported by the presence of a new form of architecture denoted by larger and above ground rectilinear buildings and the use of habitation contexts for burials. Within the ground stone assemblage this shift in emphasis is revealed by the more frequent deposition of still usable tools, more highly polished edge tools and burnt edge tools within domestic areas compared to MK I. Contrary to the destruction of grinding tools in MK I, the presence of burnt edge tools in domestic contexts in MK II suggests that those acts of deliberate destruction had also shifted from communal to household arenas. In general, there is a lower frequency of fragmented tools within MK II perhaps suggesting that the practice of fragmentation and the creation of communal identities it was linked to was of lesser importance.

Ground stone implements, therefore, were actively employed in the creation and negotiation of identities at Neolithic Makriyalos. More importantly, these implements were media for expressing varied and distinct identities (individual vs. communal) that could be transformed easily through the contexts of practice they were employed in. The meanings of these objects were as fluid as were the relationships they reflected. Hence, the analysis of the Makriyalos ground stone assemblage contradicts previous suggestions for the predominantly utilitarian character of stone tools in the Greek Neolithic. As it was clearly demonstrated, the value and symbolic significance of objects with varied levels of investment in their production was derived from their use within daily activities.

### 7.3.3. Technology as a social practice: material entanglements and networks of actions

Clearly, as this thesis has demonstrated, ground stone tools represent a valued technology that was embedded in the everyday life of the Makriyalos community, and they need to be considered as part of a network of actions, social actors, materials and places. The diverse roles played by this set of material would have provided important links to other activities carried out at the Makriyalos settlement. More importantly, as the quote at the beginning of this chapter indicates, ground stone technology provides an important means of linking different individuals through networks of actions or 'network of entanglements' (Hodder 2004: 47; Conneller 2008). For instance, performance of a grinding task would have required different activities and would have engaged more than one individual: selection and collection of raw material for the production of grinding tools, techniques and objects used in the transportation of material back to the site, grinding tool manufacture, cultivation of land for the procurement of cereals to be processed, containers for storing processed matter, cooking pots and so on. Thus, 'technological artefacts and gestures connect people and draw them into social networks' (Conneller 2008: 166).

## 7.4. Future Considerations

The current study of the way(s) ground stone technology was practiced by the Neolithic community of Makriyalos is by no means exhaustive. As pointed out in Chapter 3, one of the aims of this thesis was to conduct a *multi-scalar* analysis and see how the technology under consideration operated at different scales of interaction. For the results of this thesis to be truly meaningful they need to be addressed on a broader scale as well. The importance of a regional analysis is highlighted by the comparison of fragmentation patterns at Makriyalos with those at Thermi B and DETh. In addition, a refitting study of grinding tools found in Pit 212 could prove valuable. For example, it would be of interest to consider whether all parts of these grinding tools were deposited or whether certain fragments were retained for use or deposition elsewhere, either on-site (e.g., in habitation areas) or off-site. Beyond these small-scale and regional studies the wider significance of ground stone also needs to be investigated. It is hoped that this detailed contextual study has indicated the potential for the analysis of this type of material. This form of analysis now needs to be applied on a much wider scale both spatially and chronologically, without which the true significance of these results cannot be assessed. As a first step the analysis of material from sites with good contextual information from across Greece should be prioritised to formulate large-scale understandings of variation in technological practice founded upon detailed micro-scale analysis. We also need to examine the links between this region and the Balkans and Anatolia as similarities in other forms of material culture have been noted (Pappa and Besios 1999b). Finally, it would be of great importance to investigate the way(s) ground stone technology was organised and practiced on a broader chronological scale, from the EN to FN, in order to assess how changes in societal organisation affect this technological practice.

It is hoped that this thesis has demonstrated the potential of ground stone technology in making sense of how the members of a Neolithic community organised their lives in everyday events and events of a less frequent character, but also of how their technological traditions became an active medium for expressing their identities. This thesis was about people and how they came to terms with the world they inhabited through use of meaningful and socially situated technological practices. Ultimately, the aim of this thesis was to place ground stone technology in its context of practice and meaning and to approach this diverse technological system '*as if people mattered*' (Dobres 2000: 96).

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